SECTION 230000 - GENERAL HVAC REQUIREMENTS

PART 1 -GENERAL

1.01 SUMMARY

A. Related Documents:

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

2. The requirements listed in this document are applicable to Divisions 23 specifications.

B. Commissioning:

1. An independent third-party Commissioning Agent will document completion of the Mechanical/HVAC Systems for the project. The Division 23 Mechanical/HVAC Contractor is a member of the Commissioning Team and will facilitate completion of the Commissioning process. Refer to section 01 91 13 “General Commissioning Requirements” for the project Commissioning requirements and roles and responsibilities for each member of the Commissioning Team.

1.02 WARRANTIES

A. Warrant all materials, workmanship and equipment against defects for a period of one year after the date of substantial completion. Certain equipment shall be warranted beginning at the time of substantial completion or for longer periods of time as specified in those divisions of the Project Manual. Repair or replace, at no additional cost to the Owner, any item which may become defective within the warrant period. Any manufacturers’ warranties concerning any item installed will run to the benefit of the Owner. The Contractor agrees not to void or impair, or to allow Sub-Contractors to void or impair, any warranties regarding products or items installed as part of this project. The repair of faulty workmanship shall be included in the contract.

B. Provide as base bid extended warranty as needed to accommodate any temporary use of any and all equipment prior to substantial competition. During this period, units shall be run at 100 percent outside air. Coordinate operation of unit with Engineer and appropriate subcontractors to verify capacity and run conditions.

1.03 QUALITY ASSURANCE

A. Source Limitations: To fullest extent possible, provide products of same kind, from a single source.

1. When specified product are available only from sources that do not, or cannot, produce a quality adequate to complete Project requirements in a timely manner, consult with Architect and Owner to determine most important product qualities before proceeding. Qualities may include attributes, such as visual appearance, strength, durability, or compatibility. When a determination has been made, select products from sources producing products that possess these qualities, to fullest extent possible.

B. Compatibility of Options: If Contractor is given option of selecting between two or more products for use on Project, select product compatible with products previously selected, even if previously selected products were also options.

1. Each contractor is responsible for providing products and construction methods compatible with products and construction methods of other contractors.

a. If a dispute arises between contractors over concurrently selectable but incompatible products, Architect shall determine which products shall be used.

C. Comply with all State and local codes and ordinances.

D. Make application, obtain and pay for all required permits and certificates of inspection of the work.

E. Required access for servicing and maintenance shall be provided for all equipment (valves, specialties, filters, etc.) Provide architectural access panels as required.

F. Manufacturer's Qualifications: Firms regularly engaged in manufacture of equipment of types, materials, and sizes required for the project, whose products have been in satisfactory use in similar service for not less than five (5) years.

G. Installers Qualifications: Firm with at least three (3) years of successful installation experience on projects with equipment installation work similar to that required for project.

1.04 INTERPRETATION OF DOCUMENTS

A. All questions from contractors or subcontractors as it pertains to contract documents during the bidding phase or construction shall be submitted to the Engineer for clarification. Clarification will be issued through official written correspondence. Verbal interpretation or explanation not issued in the form of an addendum or supplemental instruction shall not be considered part of the bidding documents or contract. The Engineer shall be the sole judge regarding interpretations of conflicts within contract documents.

B. If any ambiguities should appear in the contract documents, request clarification from the Engineer before proceeding with the work. Failure to obtain clarification may result in work not being accepted by the Engineer. Should a conflict occur within the contract documents, the Contractor is deemed to have estimated the more expensive way of doing the work.

1.05 PERMITS, FEES, AND NOTICES

A. Secure and pay for permits and governmental fees, licenses, and inspections necessary for proper execution and completion of the Work, and for Owner to occupy and operate systems.

B. Comply with and file notices required by laws, ordinances, rules, regulations, and lawful orders of public authorities applicable.

1.06 CODES

A. The work shall be performed by persons skilled in the trade involved and shall be done in a manner consistent with normal industry standards. All work shall conform to all applicable sections of currently adopted editions of all applicable codes. The contractor is responsible for verifying the local codes in the jurisdiction with which the work is performed and installing the work as listed by said codes.

1.07 PROJECT COORDINATION AND LAYOUT

A. The contractor is responsible for laying out and coordinating all work prior to installation. Produce coordination documents incorporating all mechanical, fire protection, electrical and other trades in conjunction with the building structure and architectural features. Coordinate all routing of systems prior to installation. Payment for changes due to pre-fabricating or moving of piping, ductwork, conduit, cable trays, equipment, or any other mechanical, electrical, plumbing, or technology system due to lack of coordination will not be approved.

B. Documents produced by Specialized Engineering Solutions are diagrammatic in nature. Not all system offsets are shown to accommodate final elevations and avoid interference with all other building structural, architectural, mechanical, electrical, fire protection, and technology systems. Include in base scope of work, offsets necessary to negotiate the building appropriately.

C. Specifications list specialties, valve, damper, and systems installation requirements in addition to what is shown on drawings. Not all valves, dampers, and accessories are shown on drawings.

1.08 EQUIPMENT ELECTRICAL CONNECTIONS

A. Electrical connections identified are for the specific equipment manufacturer and model scheduled, and includes equipment furnished by this trade or furnished by other trades under these contract documents. If the Contractor chooses to provide equipment found acceptable from a different manufacturer and model than that scheduled but listed as equivalent in the specifications, or otherwise accepted by the Architect/Engineer, include electrical connection revisions associated with that manufacturer’s electrical connection requirements in bid. Upon approval of a manufacturer and model other than that specifically scheduled, request clarification of the required electrical connection revision from the Engineer for incorporation into the electrical design and construction documents. If the necessary revision is found to require extensive design modification by the Engineer, provide the Engineer reasonable compensation for incorporation of the selected manufacturer’s equipment into the project design.

B. Coordinate short circuit current ratings of equipment electrical components to meet or exceed fault levels calculated at the equipment location by the Fault and Coordination study performed under the electrical sub-contract. Where this study is not required by the contract, short circuit current ratings of equipment shall meet or exceed the short circuit current rating of the branch source electrical panel serving the equipment.

1.09 SALVAGE RIGHTS

A. The Owner shall have first salvage rights to all items removed. If Owner refuses salvage, Contractor is responsible for disposal.

1.10 OPERATION AND MAINTENANCE MANUALS

A. Manuals to be bound in 3 ring binders and include:

1. Title page with project name and location and date of submittal.

2. Title, Name, address, and telephone number all contractors and suppliers.

3. Table of contents with corresponding tabs to mark sections.

B. Manual to contain the following:

1. Equipment record document submittal.
2. Warranty details, expiration dates, and contacts.
3. Licensing requirements including inspection and renewal dates.
4. Equipment location.
5. Operating manuals including wiring and control diagrams.
6. Operating procedures.
7. Precautions against improper use.
8. Startup shutdown and switchover procedures.
9. Emergency procedures.
10. Schedule for routine cleaning and maintenance.

C. Provide the Operation and Maintenance manuals as hardcopy, electronically and on a thumb drive. Provide a thumb drive of the scanned record drawing redlines, in addition to the hardcopy.

1.11 OPERATOR TRAINING

A. Schedule and conduct complete owner training for every system and associated piece of equipment. Operating and maintenance manuals shall be complete and accepted by owner and engineer prior to training. Coordinate a training session which will include the Owner/Owner's Representatives and all Sub-Contractors or equipment representatives needed to explain and train on the system. A training agenda shall be submitted prior to training. The agenda shall be reviewed and amended as necessary by the Engineer and Owner. Cover all information submitted in the operation and maintenance manual.

1.12 ALLOWANCES

A. Include in bid, appropriate allowances for material and labor for pulley changes on equipment, impeller changes on pumps, and air baffles necessary in air handling equipment.

1.13 PROJECT CONDITIONS

A. Participate in the development of infection control risk assessments and perform work in strict compliance with the work plan developed in conjunction with the Owner and all other Contractors. Take great care in performance of work to limit dust and debris. Aid in the erection of dust-free partitions and work within confines. Environments to include but shall not be limited to negative pressure partitions, HEPA filtered air, pressure and particle monitored environments.

END OF SECTION 23 00 00 230000

SECTION 230500 - COMMON WORK RESULTS FOR MECHANICAL

PART 1 -GENERAL

1.01 SUMMARY

A. Section Includes:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Sleeves.
5. Escutcheons.
6. Grout.
7. Concrete bases and housekeeping pads.
8. Demolition.
9. Equipment installation requirements common to equipment sections.
10. Supports and anchorages.

B. Related Sections include the following:

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
2. The requirements listed in this document are applicable to Division 23 specifications

C. Commissioning:

1. An independent third-party Commissioning Agent will document completion of the Mechanical/HVAC Systems for the project. The Division 23 Mechanical/HVAC Contractor is a member of the Commissioning Team and will facilitate completion of the Commissioning process. Refer to section 01 91 13 “General Commissioning Requirements” for the project Commissioning requirements and roles and responsibilities for each member of the Commissioning Team.

1.02 SUBMITTALS

A. Not required.

1.03 QUALITY ASSURANCE

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

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

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."

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

3. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified without additional cost. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.04 DEFINITIONS

1.05 FINISHED SPACES: SPACES OTHER THAN MECHANICAL AND ELECTRICAL EQUIPMENT ROOMS, FURRED SPACES, PIPE AND DUCT CHASES, UNHEATED SPACES IMMEDIATELY BELOW ROOF, SPACES ABOVE CEILINGS, UNEXCAVATED SPACES, CRAWLSPACES, AND TUNNELS.

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

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

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

D. 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.

PART 2 - PRODUCTS

2.01 PIPE, TUBE, AND FITTINGS

A. Refer to individual Piping Sections for pipe, tube, and fitting materials and joining methods.

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

2.02 JOINING MATERIALS

A. Refer to individual Piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

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

D. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.

E. Welding Filler Metals: Comply with AWS D10.12.

F. Solvent Cements for Joining Plastic Piping:

1. ABS Piping: ASTM D 2235.

2. CPVC Piping: ASTM F 493.

3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

4. PVC to ABS Piping Transition: ASTM D 3138.

2.03 DIELECTRIC FITTINGS

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

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

C. Dielectric Unions: Not permitted.

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

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

2.04 MECHANICAL SLEEVE SEALS

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

B. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

C. Pressure Plates: Reinforced nylon polymer. Include two for each sealing element.

D. Connecting Bolts and Nuts: Type 316 Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.05 SLEEVES

A. Steel Pipe:

1. Pipe sizes through 10 inch: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

2. Pipe sized 12 inch and greater: ASTM A 53, Type E, Grade B, wall thickness no less than 0.375 inches, galvanized, plan ends.

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

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

1. Underdeck Clamp: Clamping ring with set screws.

2. Sleeve length: as required to extend through structure.

2.06 ESCUTCHEONS

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

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

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

1. Finish: Polished chrome-plated.

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

1. Finish: Polished chrome-plated.

2.07 GROUT

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

1. Characteristics: Post-hardening, volume-adjusting, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications.

2. Design Mix: 5000-psi, 28-day compressive strength.

3. Packaging: Premixed and factory packaged.

2.08 CONCRETE BASES AND HOUSEKEEPING PADS

A. Form Materials:

1. Comply with Building Code and ACI 347. Design, erect, support and maintain forms to safely carry all superimposed loads until such time as such loads can be safely supported by the concrete work. Construct formwork to shape, sizes and dimensions as required to ensure accurate alignment and elevation, and level and plumb finished concrete work.

2. Nails, spikes, lag bolts, through bolts, anchorages: Sized as required of strength and character to maintain formwork in place while placing concrete.

B. Concrete:

1. Cement:

a. ASTM C150, Type I/II or ASTM C595 Type IS.

b. 3000-psi, 28-day compressive-strength concrete

2. Aggregate:

a. Coarse aggregate for stone concrete: ASTM C33, with maximum size 3/4 in.

b. Fine aggregate: Clean, durable sand, uncoated, grains free from silt, loam, and clay. Graded from fine to coarse with 95-100 percent by weight passing a No. 4 sieve and 3-8 percent passing a No. 100 sieve. ASTM C33 with following maximum permissible limits for deleterious substances, measured in percentage by weight: clay lumps 1.00; coal and lignite 0.25; materials finer than No. 200 sieve 3.00.

3. Controlled concrete proportioned as outlined in Section 5.3 ACI 318, unless specified otherwise. Allowable design stresses are based on minimum 28-day compressive strength indicated.

4. Proportions of aggregate to cement shall produce non-segregating plastic mixture of consistency required to be worked readily into corners and angles of forms and around reinforcement with method of placement employed. Accomplish variations in consistency by changes in proportioning of mix with changing W/C (water/cement) ratios established.

C. Concrete reinforcement materials:

1. New, free from rust, and complying with the following:

a. Bars for reinforcement: A615, grade 60; stirrups and ties grade 60. 2.

b. Wire fabric: 6” x 6”, W1.4-W1.4 welded wire fabric complying with ASTM A185. 3.

c. Bar supports: "Bar Support Specifications," CRSI Manual of Standard Practice, Type: plastic tipped accessories.

d. Tie Wire: Cold drawn steel; ASTM A-82.
1) Supports for reinforcement: Provide supports including bolsters, chairs, spacers and other devices for supporting and fastening reinforcing bars and welded wire fabric in place. Use wire bar type supports complying with CRSI recommendations.

PART 3 - EXECUTION

3.01 BUILDING ELEMENTS

A. Where required for the removal or installation of elements within Contractor’s scope, Contractor shall include all necessary building element removal, modification, and reinstallation required to facilitate work. Such building elements include but are not limited to ceilings, floors, walls, roofs, doors, beams, piping, ductwork, conduits, and lights. Elements shall only be removed to the extent required to facilitate work and shall minimize the impact to the facility.

B. Where building elements are not required to be removed but are subject to potential damage during the execution of Contractor’s work, Contractor shall protect building elements from damage.

C. Where building elements are removed and reinstalled or subject to potential damage, Contractor shall walk construction area prior to work with Owner and document condition of building elements and finishes prior to work. Contractor shall restore all building elements and finishes to their original condition noted during the walkthrough. Items not documented shall be considered in “as new” condition.

D. Where building elements must be modified prior to reinstallation to accommodate new work and such modification is not specifically indicated on the plans, Contractor shall obtain Owner approval prior to making modifications. Failure to obtain approval shall not be grounds for additional compensation.

E. Contractor shall coordinate all building element removal and reinstallation with Owner. Where removal constitutes a significant impact to the Owner's operations, such work shall be performed during off hours as defined by the Owner. Significant impacts include but are not limited to utility shutdowns, facility access, occupant safety, occupant comfort, and noise.

3.02 PIPING SYSTEMS - COMMON REQUIREMENTS

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

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

C. Drainage piping shall not be routed over the following spaces. Where this is unavoidable, the drainage piping shall be accompanied by 18 gauge galvanized, sealed, 2" deep secondary containment drain-pans with moisture sensor alarms.

1. Electrical rooms.
2. Communication/IT rooms.
3. Food preparation rooms.
4. Food serving areas.
5. Food storage areas.
6. Central Services/sterile processing department
7. Operating rooms.
8. Pharmacy clean rooms and medication storage areas.
9. Other locations identified on the plans.

D. Pressurized piping containing liquid shall not be routed over the following spaces or within one foot laterally from the edge of electrical and electronic/IT equipment in other spaces. Where this is unavoidable, the piping shall be accompanied by 18 gauge galvanized, sealed, 2" deep secondary containment drain-pans with moisture sensor alarms. Pressurized piping dedicated to equipment in the spaces listed below shall not require drain pans provided that it is not within one foot laterally of the edge of electrical and electronic/IT equipment.

1. Electrical rooms.
2. Communication/IT rooms.
3. Operating rooms.
4. Other locations identified on the plans.

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

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

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

H. Install piping to permit valve servicing.

I. Install piping at indicated slopes.

J. Install piping free of sags and bends.

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

L. Install piping to allow application of insulation.

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

N. Install escutcheons for penetrations of walls, ceilings, and floors.

O. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions.

P. Installation of Install manufactured stack sleeve fittings and field installed water dams for pipes passing through concrete floor and roof slabs.

1. Install manufactured stack sleeve fittings per manufacturers recommendations.

2. As an alternate to manufactured stack sleeve fittings field installed water dams may be used. Construct field installed water dams to meet either of the following criteria:

a. Steel pipe with flange water dam: construct water dam by welding together Schedule 40 steel pipe and steel flange to be watertight. Cut flange from flat steel of same thickness as pipe wall. Flange ring width shall be a minimum of 1 inch and inside diameter of dam shall be 1 inch larger than outside diameter of piping or its insulation, whichever is larger. Top of water damn to be 4 inches above the finished floor. Permanently anchor dam flange to the floor and seal the flange-to-floor joint watertight.

b. Steel water dam: Construct dam by inserting end of Schedule 40 steel pipe or sheet steel fully into a groove approximately 13 mm 1/2 IN deep. Permanently anchor dam flange to floor and seal the flange to floor joint watertight.

3. Seal annular space around piping and insulation.

4. Maintain fire and smoke ratings at pipe penetrations of fire/smoke rated building elements.

5. Provide stack sleeve fittings or water dams around pipes penetrating the floor above rooms requiring drain/drip pans and in wet areas, including but not limited to the following:

a. Mechanical rooms.

b. Sterile Processing Areas.

c. Locations indicated on plans.

Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.

2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

S. Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with UL listed through penetration firestop systems. Refer to Division 07 Section "Through-Penetration Firestop Systems" for materials.

T. Verify final equipment locations for roughing-in.

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

3.03 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and other Specification Sections specifying piping systems.

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

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

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

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

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

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

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

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

3.04 PIPING CONNECTIONS

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

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3. Install dielectric flange or nipple fittings to connect piping materials of dissimilar metals.

3.05 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

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

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

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

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

3.06 CONCRETE BASES AND HOUSEKEEPING PADS

A. Furnish and install concrete bases and housekeeping pads (not specifically indicated on the Drawings or in the Specifications of either the General Construction or Mechanical work as provided by another Contractor) for all floor mounted equipment provided.

B. All concrete bases and housekeeping pads shall be reinforced in accordance with ACI 315.

C. Existing concrete bases and housekeeping pads may be used for new equipment. Where concrete base or housekeeping pad is too small to accommodate new equipment, do not extend concrete base or housekeeping pad; demolish concrete base or housekeeping pad and provide new housekeeping pad.

D. Forms:

1. Construct forms to the exact sizes, shapes, lines and dimensions as required to obtain accurate alignment, locations, grades, level and plumb work in the finished structures.

2. Chamfer exposed external corners and edges.

3. Inserts, embedded parts and openings:

a. Provide formed openings where required for work embedded in or passing through concrete.

b. Coordinate work of other sections in forming and setting openings, slots, recesses, chases, sleeves, bolts, anchors, and other inserts.

c. Install accessories in accordance with manufacturer's instructions, level and plumb. Ensure items are not disturbed during concrete placement.

4. Form removal:

a. Do not remove forms and bracing until concrete has sufficient strength to support its own weight, and construction and design loads which may be imposed upon it.

b. Do not damage concrete surfaces during form removal.

5. Cleaning:

a. Clean forms to remove foreign matter as erection proceeds.

b. Ensure that water and debris drain to exterior through clean out ports.

c. During cold weather, remove ice and snow from forms. Do not use deicing salts. Do not use water to clean out completed forms, unless formwork and construction proceed within heated enclosure.

E. Reinforcement:

1. Before start of concrete placement, accurately size and place concrete reinforcement in accordance with ACI 315, positively securing and supporting by concrete blocks, metal chairs or spacers, or metal hangers.

2. Clearance: Clear space between bars and cover for bars shall conform to the Requirements of ACI 318.

3. Splicing:

a. Horizontal bars:
1) Place bars in horizontal members with laps at splices in accordance with the Contract Documents and the Requirements of ACI-318 (Latest Edition).
2) Bars may be wired together at laps.
3) Wherever possible, stagger the splices of adjacent bars.

b. Wire fabric:
1) Make splices in wire fabric at least 1-1/2 meshes wide.

c. Other splices:
1) Place required steel dowels and securely anchor into position before concrete is placed.

4. Coordinate placement with conduits, piping, inserts, sleeves or other items.

F. Concrete Bases and Housekeeping Pads: Anchor equipment to concrete bases and housekeeping pads according to equipment manufacturer's written instructions.

1. Construct concrete bases and housekeeping pads not less than 4 inches larger in both directions than supported unit. Concrete bases and housekeeping pads shall be nominal 4 inches thick unless indicated otherwise on plans and details. Where a base is less than 12 inches from a wall, extend the base to the wall.

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.

3. Place, install and secure anchorage devices. Use manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

5. Curing:

   a. Keep forms in place for a seven-day curing period. Keep top exposed concrete surface wet and forms moist. Loosen forms to allow curing water to run down between concrete and forms.

3.07 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

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

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

3.08 GROUTING

A. Mix and install grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors.

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

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

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

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 23 05 00 230500

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR MECHANICAL

PART 1 -GENERAL

1.01 SUMMARY

A. Related Documents:

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

1.02 SUBMITTALS

A. None.

1.03 CLOSE-OUTS

A. None.

1.04 COORDINATION

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

1. Motor controllers.

2. Torque, speed, and horsepower requirements of the load.

3. Ratings and characteristics of electrical supply circuit and required control sequence.

4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

2.02 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 50 feet above sea level.

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

2.03 POLYPHASE MOTORS

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

B. Efficiency: NEMA premium efficiency, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.

2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.

2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Rolled steel or cast-iron construction. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

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

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.

2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.

3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.

4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

L. Provide factory installed bearing protection ring, AEGIS or equal on all motors powered by VFD.

2.04 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.

2. Split phase.

3. Capacitor start, inductor run.

4. Capacitor start, capacitor run.

5. Electronic commutation.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type or electronic commutation type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type or electronic commutation type.

E. Electronic commutation motors shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted on the motor or by a 0-10 VDC signal.

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

PART 3 - EXECUTION

3.01 ROTATING EQUIPMENT FIELD ALIGNMENT

A. All coupled rotating equipment over 1 horsepower shall be laser-aligned, using a dual receiver coupling laser aligner or other approved laser alignment equipment after installation. Thermal growth calculations shall be made where appropriate to reflect operating conditions. If applicable, equipment, structure, and attached piping thermal growths shall be considered in addition to operational effects such as oil wedge, pressure/vacuum pull-down, etc. to insure in service alignment tolerances are achieved. The acceptable in-service alignment tolerances shall be determined by the equipment manufacturer. Where no value is given, tolerance shall be 0.0005”. The installing contractor must check for and correct any soft foot conditions before attempting the laser alignment of any coupled rotating equipment. The soft foot tolerance is the differential at any foot on the equipment. Fluid film bearing machine shafts shall be level while in service.

B. A record of the final alignment settings, alignment setup, alignment tolerances, machine ID/Name, date of alignment, and alignment technician ID shall be printed and signed by the technician responsible for the alignment. Calculations for thermal effects and other operational considerations shall be attached to this printout. A copy shall be forwarded to the Owner and Engineer for review and acceptance. The accepted copy shall be included in the final Operation and Maintenance Manuals.

C. A minimum of two jacking bolts shall be installed at each hold-down bolt position to facilitate controlled movement in the axial (in line with the shaft, perpendicular to the bolt body) direction and “horizontal” (perpendicular to hold-down bolt body and axial direction). The jacking bolts must be positioned so that they do not interfere with the installation and removal of shim packs.

D. Hold-down bolts shall be tightened using a calibrated torque wrench in at least three stages (50%, 80%, and 100% of final torque value), each stage following a “cross” pattern. After alignment and tightening of hold-down bolts, all jacking bolts shall be backed-off ~0.100” and locked with jam nuts.

END OF SECTION 23 05 13 230513

SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR MECHANICAL PIPING

PART 1 -GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Metal-bellows expansion joints.
2. Expansion compensators.
3. Flexible-hose expansion joints.
4. Packed slip expansion joints.
5. Pipe bends and loops.
6. Alignment guides and anchors.

1.03 DEFINITIONS

A. BR: Butyl rubber.

B. Buna-N: Nitrile rubber.

C. CR: Chlorosulfonated polyethylene synthetic rubber.

D. CSM: Chlorosulfonyl-polyethylene rubber.

E. EPDM: Ethylene-propylene-diene terpolymer rubber.

F. NR: Natural rubber.

G. PTFE: Polytetrafluoroethylene plastic.

1.04 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping system fluids, materials, working pressures, and temperatures.

B. Capability: Products shall absorb 200 percent of maximum axial movement between anchors.

1.05 SUBMITTALS

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

B. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and bends.

2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.

3. Alignment Guide Details: Detail field assembly and attachment to building structure.

4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

C. Welding certificates.

D. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.

E. Maintenance Data: For pipe expansion joints to include in maintenance manuals.

1.06 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. Steel Shapes and Plates: AWS D1.1, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.01 EXPANSION JOINTS

A. Metal-Bellows Expansion Joints: ASTM F 1120, circular-corrugated-bellows type with external tie rods.

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

a. Adsco Manufacturing, LLC.

b. Flexicraft Industries.

c. Flex-Pression, Ltd.

d. Flex-Weld, Inc.

e. Hyspan Precision Products, Inc.

f. Metraflex, Inc.

g. Senior Flexonics, Inc.; Pathway Division.

h. Unaflex Inc.

2. Metal-Bellows Expansion Joints for Copper Piping: Single- or multiple-ply phosphor-bronze bellows, copper pipe end connections, and brass shrouds.

3. Metal-Bellows Expansion Joints for Steel Piping: Single- or multiple-ply stainless-steel bellows, steel pipe end connections, and carbon-steel shroud.

4. Minimum Pressure Rating: 150 psig, unless otherwise indicated.

5. End Connections: Flanged or welded.

B. Expansion Compensators: Double-ply corrugated steel, stainless-steel, or copper-alloy bellows in a housing with internal guides, antitorque device, and removable end clip for positioning.

END OF SECTION 23 05 16 230516

SECTION 230523 - GENERAL-DUTY VALVES FOR MECHANICAL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:

1. Ball valves.
2. Butterfly valves.
3. Check valves.
4. Gate valves.
5. Globe valves.

B. Valves for specialty applications are specified in sections applicable to those services. This includes but is not limited to:

1. Fire protection.
2. Medical gas.
3. High purity water.

C. Related Sections:

1. Division 02 water distribution piping Sections for general-duty and specialty valves for site construction piping.
2. Divisions 23 mechanical piping Sections for specialty valves applicable to those Sections only.
3. Division 23 Section "Mechanical Identification" for valve tags and schedules.

1.02 SUBMITTALS

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

1.03 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance: ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

C. NSF Compliance:

1. NSF 61 for valve materials for potable-water service.

2. NSF 372: Drinking water system components – lead content for valve materials for potable-water service.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES

A. Refer to Part 3 for applications of valves.

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

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:

1. Gear Actuator with Handwheel: For quarter-turn valves NPS 8 and larger.

2. Handwheel: For valves other than quarter-turn types.

3. Handlever: For quarter-turn valves NPS 6 and smaller.

4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article. Where chainwheel is required, gear actuator with handwheel shall be used for quarter turn valves in lieu of handlever.

E. Valves in Insulated Piping: With stem extensions and the following features:

1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows full operation of valve without breaking the vapor seal or disturbing insulation.

2. Butterfly Valves: With extended stem.

F. Valve-End Connections:

1. Valve end connection shall match the joints specified for the associated piping systems used.

a. Flanged: With flanges according to ASME B16.1 for iron valves.

b. Grooved: With grooves according to AWWA C606.

c. Solder Joint: With sockets according to ASME B16.18.

d. Threaded: With threads according to ASME B1.20.1.

G. Valves intended for domestic water service shall be certified lead-free per NSF standards.

2.02 BRASS/BRONZE BALL VALVES

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

1. Anvil.
2. Conbraco/Apollo.
3. Hammond Valve.
4. Jamesbury; a subsidiary of Metso Automation.
5. Kitz Corporation.
6. Milwaukee Valve Company.
7. Sharpe Valve.
8. Watts.

B. Two-Piece, Brass/Bronze Ball Valves:

1. Description:
   a. Standard: MSS SP-110.
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Forged brass.
   f. Seats: PTFE or TFE.
   g. Stem:
      1) Blowout proof.
      2) Stainless steel.
      3) Brass.
   h. Ball:
      1) Stainless steel.
      2) Chrome plated brass
   i. Port:
      1) Full.
      2) Regular

2.03 IRON, LUGGED BUTTERFLY VALVES

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

1. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
2. Bray Controls; a division of Bray International.
3. Conbraco Industries, Inc.; Apollo Valves.

4. Conbraco.
5. Crane Co.; Crane Valve Group; Stockham Division.
6. Crane/Centerline.
7. DeZurik Water Controls.
8. Hammond Valve.
9. Milwaukee Valve Company.
10. NIBCO INC.
11. Sharpe Valve.
12. Sure Seal.

B. 200 CWP, Iron, Lugged Butterfly Valves:

1. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange, bubble tight shut-off.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat for water systems: EPDM.
   f. Seat for systems containing glycol and petroleum products such as fuel oil: NBR.
   g. Stem: One- or two-piece Type 416 stainless steel.
   h. Disc: Aluminum bronze.
   i. Disc: Type 316 Stainless steel.
   j. Disc: Nickel plated ductile iron.

2.04 HIGH-PERFORMANCE BUTTERFLY VALVES

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

1. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
2. Bray Controls; a division of Bray International.
3. Cooper Cameron Valves; a division of Cooper Cameron Corp.
4. Crane Co.; Crane Valve Group; Flowseal.

5. Crane Co.; Crane Valve Group; Stockham Division.
6. DeZurik Water Controls.
7. Hammond Valve.
8. Jamesbury; a subsidiary of Metso Automation.
9. Milwaukee Valve Company.
10. NIBCO INC.
11. Sharpe Valve.
12. Sure Seal.
13. Xomox Corporation.
14. Spence.

B. Lugged, High-Performance Butterfly Valves:

1. Description:
   a. Standard: MSS SP-68.
   b. Temperature Rating: 500 deg F.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange, bubble tight shut-off.
   d. Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
   e. Seat: Reinforced PTFE with titanium and type 316 stainless steel.
   f. Stem: Stainless steel; offset from seat plane.
   g. Disc: Carbon steel.
   h. Service: Bidirectional.
2. Class 150:
   a. Pressure Rating: 160 psig at 500 deg F.
3. Class 300:
   a. Pressure Rating: 480 psig at 500 deg F.

2.05 BRONZE SWING CHECK VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.

2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
4. Hammond Valve.
5. Kitz Corporation.
6. Milwaukee Valve Company.
7. NIBCO INC.
8. Powell Valves.
9. Red-White Valve Corporation.
10. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 125, Bronze Swing Check Valves:

1. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 200 psig.
   c. SWP Rating: 125 psig saturated.
   d. Body Design: Horizontal flow.
   e. Body Material: Bronze.
   f. Disc: Bronze.

C. Class 150, Bronze Swing Check Valves:

1. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 300 psig.
   c. SWP Rating: 150 psig saturated.
   d. Body Design: Horizontal flow.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Disc: Bronze.

2.06 BRONZE SILENT CHECK VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
4. Hammond Valve.
5. Kitz Corporation.
6. Milwaukee Valve Company.
7. NIBCO INC.
8. Powell Valves.
9. Red-White Valve Corporation.
10. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 125, Bronze Silent Check Valves:

1. Description:
   a. Standard: MSS SP-139.
   b. CWP Rating: 250 psig.
   c. Body Design: In-line lift type, spring actuated.
   d. Body Material: Bronze.
   e. Disc: PTFE.

2.07 IRON SWING CHECK VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
4. Hammond Valve.
5. Kitz Corporation.
6. Legend Valve.
7. Milwaukee Valve Company.
8. NIBCO INC.
9. Powell Valves.

10. Red-White Valve Corporation.
11. Sure Flow Equipment Inc.
12. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
13. Zy-Tech Global Industries, Inc.

B. Class 125, Iron Swing Check Valves with Metal Seats:

1. Description:
   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 24, CWP Rating: 200 psig.
   c. SWP Rating: 125 psig saturated.
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Trim: Bronze.
   g. Gasket: suitable for temperature and service.

C. Class 150, Iron Swing Check Valves with Metal Seats:

1. Description:
   a. Standard: MSS SP-136.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 250 psig.
   c. SWP Rating: 150 psig saturated.
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 395, ductile iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: suitable for temperature and service.

D. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:

1. Description:
   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Design: Clear or full waterway.

e. Body Material: ASTM A 126, gray iron with bolted bonnet.

f. Ends: Flanged.

g. Trim: Composition.

h. Seat Ring: Bronze.

i. Disc Holder: Bronze.

j. Disc: PTFE or TFE.

k. Gasket: suitable for temperature and service.

E. Class 250, Iron Swing Check Valves with Metal Seats:

1. Description:

a. Standard: MSS SP-71, Type I.

b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.

c. NPS 14 to NPS 24, CWP Rating: 300 psig.

d. SWP Rating: 250 psig.

e. Body Design: Clear or full waterway.

f. Body Material: ASTM A 126, gray iron with bolted bonnet.

g. Ends: Flanged.

h. Trim: Bronze.

i. Gasket: suitable for temperature and service.

2.08 IRON SILENT CHECK VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.

2. Crane Co.; Crane Valve Group; Jenkins Valves.

3. Crane Co.; Crane Valve Group; Stockham Division.

4. Hammond Valve.

5. Kitz Corporation.

6. Legend Valve.

7. Milwaukee Valve Company.

8. NIBCO INC.

9. Powell Valves.
10. Red-White Valve Corporation.
11. Sure Flow Equipment Inc.
12. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
13. Zy-Tech Global Industries, Inc.

B. Class 125, Iron Silent Check Valves with Metal Seats:

1. Description:
   a. Standard: MSS SP-125.
   b. CWP Rating: 200 psig.
   c. Body Design: In-line lift type, spring actuated.
   d. Body Material: ASTM 126, gray iron.
   e. Trim: Stainless steel.
   f. Gasket: suitable for temperature and service.

C. Class 250, Iron Silent Check Valves with Metal Seats:

1. Description:
   a. Standard: MSS SP-125.
   b. CWP Rating: 400 psig.
   c. Body Design: In-line lift type, spring actuated.
   d. Body Material: ASTM 126, gray iron.
   e. Trim: Stainless steel.
   f. Gasket: suitable for temperature and service.

2.09 BRONZE GATE VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Stockham Division.
3. Hammond Valve.
4. Kitz Corporation.
5. Milwaukee Valve Company.

6. NIBCO INC.

7. Powell Valves.

8. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 125, NRS Bronze Gate Valves:

1. Description:

a. Standard: MSS SP-80, Type 1.

b. CWP Rating: 200 psig.

c. SWP Rating: 125 psig saturated.

d. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.

e. Stem: Bronze.

f. Disc: Solid wedge; bronze.

g. Packing: suitable for temperature and service.

h. Handwheel: Malleable iron.

C. Class 125, RS Bronze Gate Valves:

1. Description:

a. Standard: MSS SP-80, Type 2.

b. CWP Rating: 200 psig.

c. SWP Rating: 125 psig saturated.

d. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.

e. Stem: Bronze.

f. Disc: Solid wedge; bronze.

g. Packing: suitable for temperature and service.

h. Handwheel: Malleable iron.

D. Class 150, NRS Bronze Gate Valves:

1. Description:

a. Standard: MSS SP-80, Type 1.

b. CWP Rating: 300 psig.

c. SWP Rating: 150 psig saturated.

d. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.

e. Stem: Bronze.

f. Disc: Solid wedge; bronze.

g. Packing: suitable for temperature and service.

h. Handwheel: Malleable iron.

E. Class 150, RS Bronze Gate Valves:

1. Description:

a. Standard: MSS SP-80, Type 2.

b. CWP Rating: 300 psig.

c. SWP Rating: 150 psig saturated.

d. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.

e. Stem: Bronze.

f. Disc: Solid wedge; bronze.

g. Packing: suitable for temperature and service.

h. Handwheel: Malleable iron.

2.10 IRON GATE VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.

2. Crane Co.; Crane Valve Group; Jenkins Valves.

3. Crane Co.; Crane Valve Group; Stockham Division.

4. Flo Fab Inc.

5. Hammond Valve.

6. Kitz Corporation.

7. Legend Valve.

8. Milwaukee Valve Company.

9. NIBCO INC.

10. Powell Valves.

11. Red-White Valve Corporation.

12. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

13. Zy-Tech Global Industries, Inc.

B. Class 125, Iron Gate Valves:

1. Description:

a. Standard: MSS SP-70, Type I.

b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.

c. NPS 14 to NPS 24, CWP Rating: 150 psig.

d. SWP Rating: 125 psig saturated.

e. Body Material: ASTM A 126, gray iron with bolted bonnet.

f. Trim: Bronze.

g. Disc: Solid wedge.

h. Packing and Gasket: suitable for temperature and service.

C. Class 150, Iron Gate Valves:

1. Description:

a. Standard: MSS SP-128.

b. NPS 2-1/2 to NPS 24, CWP Rating: 250 psig.

c. SWP Rating: 150 psig saturated.

d. Body Material: ASTM A 395, ductile iron with bolted bonnet.

e. Ends: Flanged.

f. Trim: Bronze.

g. Disc: Solid wedge.

h. Packing and Gasket: suitable for temperature and service.

D. Class 250, Iron Gate Valves:

1. Description:

a. Standard: MSS SP-70, Type I.

b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.

c. NPS 14 to NPS 24, CWP Rating: 300 psig.

d. SWP rating: 250 psig saturated.

e. Body Material: ASTM A 126, gray iron with bolted bonnet.

f. Ends: Flanged.

g. Trim: Bronze.

h. Disc: Solid wedge.

i. Packing and Gasket: suitable for temperature and service.

2.11 BRONZE GLOBE VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.

2. Crane Co.; Crane Valve Group; Stockham Division.

3. Hammond Valve.

4. Kitz Corporation.

5. Milwaukee Valve Company.

6. NIBCO INC.

7. Powell Valves.

8. Red-White Valve Corporation.

9. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 150, Bronze Globe Valves:

1. Description:

a. Standard: MSS SP-80, Type 1.

b. CWP Rating: 300 psig.

c. SWP Rating: 150 psig saturated.

d. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.

e. Stem: Bronze.

f. Disc: Bronze.

g. Disc: PTFE or TFE.

h. Packing: suitable for temperature and service.

i. Handwheel: Malleable iron.

C. Class 125, Bronze Globe Valves:

1. Description:

a. Standard: MSS SP-80, Type 2.

b. CWP Rating: 200 psig.

c. SWP Rating: 125 psig saturated.

d. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.

e. Stem: Bronze.

f. Disc: Bronze.

g. Disc: PTFE or TFE.

h. Disc: PTFE or TFE.

i. Packing: suitable for temperature and service.

j. Handwheel: Malleable iron.

2.12 IRON GLOBE VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
4. Hammond Valve.
5. Kitz Corporation.
6. Milwaukee Valve Company.
7. NIBCO INC.
8. Powell Valves.
9. Red-White Valve Corporation.
10. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
11. Zy-Tech Global Industries, Inc.

B. Class 125, Iron Globe Valves:

1. Description:

a. Standard: MSS SP-85, Type I.

b. CWP Rating: 200 psig.

c. SWP rating: 125 psig saturated.

d. Body Material: ASTM A 126, gray iron with bolted bonnet.

e. Trim: Bronze.

f. Packing and Gasket: suitable for temperature and service.

C. Class 150, Iron Globe Valves:

1. Description:

a. Standard: MSS SP-85.

b. CWP Rating: 250 psig.

c. SWP rating: 150 psig saturated.

d. Body Material: ASTM A 395, ductile iron with bolted bonnet.

e. Trim: Bronze.

f. Packing and Gasket: suitable for temperature and service.

D. Class 250, Iron Globe Valves:

1. Description:

a. Standard: MSS SP-85, Type I.

b. CWP Rating: 500 psig.

c. Steam pressure rating: 250 psig saturated.

d. Body Material: ASTM A 126, gray iron with bolted bonnet.

e. Trim: Bronze.

f. Packing and Gasket: suitable for temperature and service.

2.13 CHAINWHEELS

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

1. Babbitt Steam Specialty Co.

2. Roto Hammer Industries.

3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.

2. Attachment: For connection to butterfly valve stems.

3. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. [Include zinc coating.]

4. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 EXECUTION

3.01 EXAMINATION

A. 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.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

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

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

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

3.02 VALVE INSTALLATION

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

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

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

D. Install valves in position to allow full stem movement.

E. In mechanical spaces, install chainwheels on operators for all manually operated valves NPS 8 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

F. Install swing check valves for proper direction of flow and in horizontal position with hinge pin level.

G. Provide extended stems on insulated piping systems to extend handle above insulation.

3.03 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.04 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. Unless indicated otherwise, use the following:

1. Shutoff Service, Except Steam and Steam Condensate: Ball and butterfly valves.

2. Throttling Service, Except Steam and Steam Condensate: Ball or butterfly valves.

3. Pump-Discharge Check Valves:

    a. NPS 2 and Smaller: Bronze silent check valves.

B. Select valves, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends. Valves with soldered ends may be used in water systems only where soldered joints are permitted in other sections.

2. For Copper Tubing, NPS 2-1/2 and above: Flanged ends. Valves with grooved ends may be used in water systems only where grooved mechanical joints are permitted in other sections.

3. For Steel Piping, NPS 2 and Smaller: Threaded ends.

4. For Steel Piping, NPS 2-1/2 and above: Flanged ends. Valves with grooved ends may be used in water systems only where grooved mechanical joints are permitted in other sections.

C. Select valves to meet or exceed maximum anticipated maximum system operating pressure for intended service. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR MECHANICAL

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Pipe positioning systems.
8. Equipment supports.

B. Related Documents

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
2. The requirements listed in this document are applicable to Divisions 23 specifications.

1.02 SUBMITTALS

A. Action Submittals

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

B. Informational Submittals

1. Current ICC-ES reports for post-pour concrete inserts.
2. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
   a. Trapeze pipe hangers.
   b. Metal framing systems.
   c. Pipe stands.
   d. Equipment supports.
   e. Thermal hanger saddles and shields.

f. Pipe positioning systems.

g. Steel and copper hangers and supports.

h. PVC, polypropylene and similar piping lacking rigidity hangers and supports.

1.03 CLOSE-OUTS

A. None.

1.04 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

3. Design hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

1.05 DEFINITIONS

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

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

C. ASME B31.9: Building Services Piping.

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

1. AAA Technology & Specialties Co., Inc.

2. Bergen-Power Pipe Supports.

3. B-Line Systems, Inc.; a division of Cooper Industries.

4. Carpenter & Paterson, Inc.

5. Empire Industries, Inc.
6. ERICO/Michigan Hanger Co. (Caddy-Pentair).
7. Globe Pipe Hanger Products, Inc.
8. Grinnell Corp.
9. GS Metals Corp.
10. National Pipe Hanger Corp.
11. PHD Manufacturing, Inc.
12. PHS Industries, Inc.
13. Piping Technology & Products, Inc.
14. RICO Manufacturing.
15. Thermal Pipe Shields.
16. Tolco, Inc.
17. Value Engineered Products.

2.02 PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Hanger Rods and Hardware: Continuous-thread rod, nuts, and washer made of [304] [316] stainless steel.

C. Copper Pipe/Tube Hangers and Supports

1. Split ring hangers and clamps.

D. Materials:

1. Provide appropriate materials and protective coatings to prevent failure from environmental and galvanic corrosion.

2. Material that comes in contact with pipe shall be compatible with piping material so that neither has a deteriorating effect on the other.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

F. Hanger Rods: Continuous-thread rod, nuts and washer made of stainless steel.

2.03 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.04 METAL FRAMING SYSTEMS

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

1. B-Line Systems, Inc.; a division of Cooper Industries.

2. ERICO/Michigan Hanger Co. (Caddy-Pentair).

3. Tolco, Inc.

4. Unistrut.

B. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.

2. Standard: MFMA-4.

3. Channels: Continuous slotted steel channel with inturned lips.

4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.

5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

6. Coating: Suitable for piping system supported.

2.05 THERMA-HANGER SADDLE AND SHIELD INSERTS

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

1. Carpenter & Paterson, Inc.

2. ERICO/Michigan Hanger Co. (Caddy-Pentair).

3. Pipe Shields, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield to cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield to cover the lower 180 degrees of pipe.

F. Insert Length: Extend a minimum of 2 inches, or greater as recommended by manufacturer, beyond sheet metal shield for piping operating below ambient air temperature.

G. Fire Rating: 25/50 rated flame/smoke plenum rated.

2.06 FASTENER AND ANCHORING SYSTEMS

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

1. B-Line Systems.
2. Empire Industries.
3. ERICO.
4. Hilti, Inc.
5. ITW Ramset/Red Head.
6. Masterset Fastening Systems, Inc.
7. MKT Fastening, LLC.
8. Powers Fasteners.
9. Simpson Strong - Tie

B. Post-pour concrete inserts shall be selected based on “cracked concrete” applications, shall be installed in accordance with manufacturers’ requirements and shall be designed for “cracked concrete” in accordance with Appendix D of American Concrete Institute (ACI) standard 318 and have a current ICC-ES report.

C. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used. Must be designed and approved for “cracked concrete” in accordance with Appendix D of American Concrete Institute (ACI) standard 318 and have a current ICC-ES report.

D. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless- steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used. Must be designed and approved for “cracked concrete” in accordance with Appendix D of American Concrete Institute (ACI) standard 318 and have a current ICC-ES report.

2.07 PIPE STANDS

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

1. B-Line.
2. Eberl RTS.
3. ERICO.
4. MIFAB.
5. MIRO.
6. OMG.
7. PHP.
8. Pipe Prop.
9. Unistrut.

B. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

C. Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

D. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made form structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.08 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.09 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

B. Use premanufactured equipment supports on [new and] existing roof systems.

2.10 MISCELLANEOUS MATERIALS

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

PART 3 EXECUTION

3.01 HANGER AND SUPPORT INSTALLATION

A. Do not support piping, ductwork equipment, or systems from metal roof decking material.

B. Where powder actuated or mechanical expansion hangers are used, notify Owner one week in advance of installation.

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

D. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

E. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

G. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick 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.

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

H. Pipe Stand Installation:

1. Pipe Stand Types: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

I. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. See Division 22 Section "Plumbing Fixtures" for requirements for pipe positioning systems for plumbing fixtures.

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

K. Equipment Support Installation: Fabricate form welded-structural-steel shapes.

L. 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.

M. Anchor piping at appropriate location and utilize guides to allow proper pipe expansion where expansion loops or expansion joints are used.

N. Install lateral bracing with pipe hangers and supports to prevent swaying.

O. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, 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.

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

Q. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

R. Insulated Piping:

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. Provide protection saddle shield insert, minimum 4 inch, 180 degrees.

c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

d. Insert Material: Length of at least as long as protective shield.

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

S. All piping when supported by non-rigid hangers in excess of 18 inches in length shall be braced against movement in any direction.

T. PVC, polypropylene, and other plastic piping: Follow pipe manufacturer's recommendations for hanger type, support, and spacing. Hanger material must be chemically compatible with the plastic pipe material.

3.02 EQUIPMENT SUPPORTS

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

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

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.03 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers 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/D1.1M 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 so contours of welded surfaces match adjacent contours.

3.04 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches and taper ends.

3.05 PAINTING

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

3.06 HANGER AND SUPPORT SCHEDULE

A. Comply with MSS SP-69 for all pipe-hanger selections and applications.

B. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

C. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

D. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers, and metal framing systems and attachments for general service applications.

E. Use padded hangers for piping that is subject to scratching.

F. Use thermal-hanger shield inserts for insulated piping and tubing.

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

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

2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.

3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.

4. 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.

5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.

6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 4.

7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 4.

8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.

9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 4.

10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.

11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.

12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.

13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

14. 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 or carbon-steel plate.

15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.

16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.

18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.

19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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

1. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

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

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.

4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

5. Steel Weldless Eye Nuts (MSS type 17): For 120 to 450 deg F piping installations.

J. Building Attachments: Unless otherwise indicated and except as specified in piping system 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.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

6. C-Clamps (MSS Type 23): For support of pipes to NPS 4, attached to structural shapes. Provide retaining strap.

7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.

11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.

    b. Medium (MSS Type 32): 1500 lb.

    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

K. Saddles and Shields: Unless otherwise indicated and except as specified in piping system 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 in writing by manufacturer to prevent crushing insulation.

3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

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

M. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use powder-actuated fasteners or mechanical-expansion anchors rated for “cracked concrete” instead of building attachments where required in concrete construction.

O. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 230529

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR MECHANICAL

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

B. The requirements listed in this document are applicable to Divisions 23 specifications.

1.02 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Housed spring mounts.
5. Elastomeric hangers.
6. Spring hangers.
7. Spring hangers with vertical-limit stops.
8. Pipe riser resilient supports.
9. Resilient pipe guides.
10. Restrained vibration isolation roof-curb rails.
11. Seismic snubbers.
12. Restraining braces and cables.

1.03 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: 120 MPH .
2. Building Classification Category: IV.
3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: D.

2. Assigned Seismic Use Group or Building Category as Defined in the IBC: [I] [II] [III].

   a. Component Importance Factor: 1.5.

1.04 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

   a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.

   b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic [and wind] forces required to select vibration isolators, seismic [and wind] restraints, and for designing vibration isolation bases.

   a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors.

2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.

3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

4. Seismic[- and Wind]-Restraint Details:

   a. Design Analysis: To support selection and arrangement of seismic [and wind] restraints. Include calculations of combined tensile and shear loads.

   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors.

d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Coordination Drawings: Show coordination of seismic bracing for piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

D. Welding certificates.

E. Qualification Data: For [professional engineer] [and] [testing agency].

F. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data [performed by an independent agency].

G. Field quality-control test reports.

H. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage or preapproval by agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 PRODUCTS

2.01 VIBRATION ISOLATORS

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

1. Ace Mountings Co., Inc.

2. Amber/Booth Company, Inc.

3. California Dynamics Corporation.

4. Isolation Technology, Inc.

5. Kinetics Noise Control.

6. Mason Industries.

7. Vibration Eliminator Co., Inc.

8. Vibration Isolation.

9. Vibration Mountings & Controls, Inc.

B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant [neoprene] [rubber] [hermetically sealed compressed fiberglass].

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Restrained Mounts: All-directional mountings with seismic restraint.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

E. Spring Isolators : Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.

6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

F. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.

3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

4. Minimum Additional Travel: 50 percent of the required deflection at rated load.

5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

G. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.

2. Base: Factory drilled for bolting to structure.

3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel up or down before contacting a resilient collar.

H. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

I. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

J. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.

8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

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

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

2.02 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS

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

1. Amber/Booth Company, Inc.

2. California Dynamics Corporation.

3. Isolation Technology, Inc.

4. Kinetics Noise Control.

5. Mason Industries.

6. Thybar Corporation.

7. Vibration Eliminator Co., Inc.

8. Vibration Isolation.

9. Vibration Mountings & Controls, Inc.

B. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic[and wind] forces.

C. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic [and wind] forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly.

D. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch- thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic[or wind] restraint.

a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.

b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

c. Minimum Additional Travel: 50 percent of the required deflection at rated load.

d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

a. Resilient Material: Oil- and water-resistant [standard neoprene] [natural rubber] [hermetically sealed compressed fiberglass].

E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

2.03 VIBRATION ISOLATION EQUIPMENT BASES

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

1. Amber/Booth Company, Inc.

2. California Dynamics Corporation.

3. Isolation Technology, Inc.

4. Kinetics Noise Control.

5. Mason Industries.

6. Vibration Eliminator Co., Inc.

7. Vibration Isolation.

8. Vibration Mountings & Controls, Inc.

B. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.04 SEISMIC-RESTRAINT DEVICES

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

1. Amber/Booth Company, Inc.

2. California Dynamics Corporation.

3. Cooper B-Line, Inc.; a division of Cooper Industries.

4. Hilti, Inc.

5. Kinetics Noise Control.

6. Loos & Co.; Cableware Division.

7. Mason Industries.

8. TOLCO Incorporated; a brand of NIBCO INC.

9. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by [an evaluation service member of ICC-ES] [OSHPD] [an agency acceptable to authorities having jurisdiction].

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least [four] times the maximum seismic forces to which they will be subjected.

C. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.

2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.

3. Maximum 1/4-inch air gap, and minimum 1/4-inch- thick resilient cushion.

D. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

E. Restraint Cables: [ASTM A 603 galvanized] [ASTM A 492 stainless]-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

F. Hanger Rod Stiffener: [Steel tube or steel slotted-support-system sleeve with internally bolted connections] [Reinforcing steel angle clamped] to hanger rod.

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

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

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

J. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

K. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.05 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.

2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.

3. Baked enamel or powder coat for metal components on isolators for interior use.

4. Color-code or otherwise mark vibration isolation and seismic- and wind-control devices to indicate capacity range.

PART 3 EXECUTION

3.01 EXAMINATION

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

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

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

3.02 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.03 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:

1. Install seismic snubbers on equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

C. Piping Restraints:

1. Comply with requirements in MSS SP-127.

2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.

3. Brace a change of direction longer than 12 feet.

D. Install cables so they do not bend across edges of adjacent equipment or building structure.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.

6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.04 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

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

3.05 FIELD QUALITY CONTROL

A. Testing Agency: [Owner will engage] [Engage] a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.

3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.

4. Test at least [four] of each type and size of installed anchors and fasteners selected by Architect.

5. Test to 90 percent of rated proof load of device.

6. Measure isolator restraint clearance.

7. Measure isolator deflection.

8. Verify snubber minimum clearances.

9. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

10. Air-Mounting System Operational Test: Test the compressed-air leveling system.

11. Test and adjust air-mounting system controls and safeties.

12. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.06 ADJUSTING

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

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

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.

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

3.07 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 01 Section "Demonstration and Training."

3.08 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

A. Refer to drawings for schedules.

END OF SECTION 230548

SECTION 230553 - MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

B. The requirements listed in this document are applicable to Divisions 23 specifications.

1.02 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Stencils.
6. Valve tags.
7. Warning tags.
8. Fire/smoke wall penetration labeling.
9. Wiring/Cable labels.

1.03 SUBMITTALS

A. Action Submittals:

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

B. Informational submittals.

1. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label. Equipment Label Schedule shall be approved by the Owner prior to labeling.
2. Valve numbering scheme: Approved by Owner prior to labeling.
3. Valve Schedules: For each piping system to include in maintenance manuals. Provide electronic Excel document to Owner in addition to hard copy in operation and maintenance manuals.
4. Warning Tags: For each warning tag, submit proposed wording, size, and arrangement.

PART 2 PRODUCTS

2.01 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Stainless-steel minimum 2-inch by 3/4-inch, mechanically fastened.

B. Plastic Labels for Equipment:

1. Plastic minimum 2-inch by 3/4-inch, black with white letters, mechanically fastened. Size shall increase appropriately for larger equipment.

C. Label Content: Owner shall designate all labeling names. Label shall include description of areas served.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

A. Red plastic with yellow letters mechanically fastened.

B. Label Content: Include caution and warning information, plus emergency notification instructions.

2.03 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive, applied with adhesive directional tape.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using full name designations per Drawings, [pipe size,] and an arrow indicating flow direction. Steam per systems shall bear pressure designation. Domestic water system shall bear water temperature designation.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

2. Lettering Size: Per ASME/ANSI A13.1.

2.04 DUCT LABELS

A. Stenciled and painted on ductwork [inside] [and] [outside] insulation. Black in color. Paint to comply with ASME/ANSI A13.1.

B. Duct Label Contents: Include identification of duct service using full name designations per Drawings, [duct size,] and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.

2. Lettering Size: At least 6 inches high.

C. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

D. Letter Color: Comply with Novant Health Standards .

E. Background Color: Comply with Novant Health Standards.

F. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

G. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

H. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

I. Fasteners: Stainless-steel [rivets] [rivets or self-tapping screws] [self-tapping screws].

J. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.05 FIRE BARRIER PENETRATION

A. Provide sticker complying with [facility standard][and] penetration sealant product requirements listing product, date, company name, and initials of installer. Sticker to be minimum 3-inch by 5-inch and red in color. Stickers to be affixed both sides of wall.

2.06 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.

1. Stencil Material: [Aluminum] [Brass] [Fiberboard] [Fiberboard or metal] .

2. Stencil Paint: Exterior, gloss, [alkyd enamel] [acrylic enamel] black unless otherwise indicated. Paint may be in pressurized spray-can form.

3. Identification Paint: Exterior, [alkyd enamel] [acrylic enamel] in colors according to ASME A13.1 unless otherwise indicated.

2.07 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Fasteners: Brass [wire-link or beaded chain; or S-hook] [wire-link chain] [beaded chain] [S-hook].

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2. Provide additional Excel format electronic version of schedule to Owner.

2.08 WARNING TAGS

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

1. Size: [3 by 5-1/4 inches minimum] [Approximately 4 by 7 inches] .

2. Fasteners: [Brass grommet and wire] [Reinforced grommet and wire or string].

3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

4. Color: Yellow background with black lettering.

2.09 WIRING/CABLING IDENTIFICATION

A. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound, cable/conductor markers with preprinted numbers and letter.

B. Colored Adhesive Marking Tape for banding Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mils thick by 1 inch to 2 inches in width.

PART 3 EXECUTION

3.01 COORDINATION

A. Coordinate equipment designation labeling with Owner before procuring labels.

3.02 INSTALLATION

A. Where working in existing mechanical spaces, match existing identification scheme and labeling techniques [including full painting of systems and equipment].

B. Single family and Group R2 of Type IV construction are not required to identify piping.

3.03 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.04 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.05 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09 Section "[Interior Painting] [High-Performance Coatings]."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels [with painted, color-coded bands or rectangles] [, complying with ASME A13.1,] on each piping system.

1. Identification Paint: Use for contrasting background.

2. Stencil Paint: Use for pipe marking.

C. Locate pipe labels where piping is exposed in above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.

5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment and in equipment rooms.

7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Pipe Label Color Schedule:

1. Meet ASME/ANSI A13.1.

2. Match existing facility standard.

3. Refrigerant Piping.

3.06 DUCT LABEL INSTALLATION

A. Do not stencil exposed ductwork in finished spaces.

B. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Match existing facility standard.

C. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction. Lettering to be larger as needed for proper identification because of distance from normal location of required identification.

D. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system. Reduce to 25 feet in equipment rooms.

3.07 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; faucets; convenience and lawn-watering hose connections. List tagged valves in a valve schedule.

B. Where valve location exceeds reasonable distance from floor, valve tag to be extended down to within 24 inches of finished ceiling height.

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

1. Valve-Tag Size and Shape: Match existing facility standards

   a. Refrigerant.

2. Valve-Tag Color: Match existing facility standards

   a. Refrigerant: [Natural] [Green] .

3. Letter Color: Match existing facility standards

   a. Refrigerant.

   b. Hot Water.

3.08 WARNING-TAG INSTALLATION

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

1. Exhaust Fans:

   a. Exhaust from areas containing hazardous materials.

2. Vents:

   a. Medical gas manifold vents.

3.09 FIRE/SMOKE WALL PENETRATION LABELING

A. Affix label at every rated fire and/or smoke wall penetrated with mechanical piping and duct systems, both sides of wall.

3.10 WIRE/CABLE LABELING

A. Install identification devices in accordance with manufacturer's written instruction and requirements of NEC.

B. Alarm Circuit Identification: Tag or label conductors as follows:

1. For control and communications/signal wiring, use colored marking tape and/or wire/cable designation tape markers at terminations in wiring boxes, troughs, and control cabinets. Use consistent colors and/or letter/number conductor designations throughout on wire/cable marking tape.

2. Match identification markings with designations used in equipment shop drawings, Contract Documents, and similar previously established identification schemes for the facility's electrical installations.

3. Identify Junction, Pull and Connection Boxes: Identification of systems and circuits shall indicate system and identity of contained circuits on outside of box cover. Labeling shall be 3/8-inch Kroy tape or Brother self-adhesive label color-coded same as conduits or permanent magic marker (color coded), neatly hand printed. In rooms that are painted out, provide labeling on inside of cover.

C. Provide typed legend of wire/cable wiring indicating tag, color, system, signal, starting room name and ending room name.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 -GENERAL

1.01 SUMMARY

A. Section Includes:

1. Testing, adjusting, and balancing of:

a. Air systems.

b. Heating systems.

c. Cooling systems.

d. Plumbing systems.

2. Measurement of initial operating condition of final systems.

3. Measurement of final operating condition of systems.

1.02 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. ADC: Air Diffusion Council.

C. AMCA: Air Movement and Control Association.

D. ASHRAE: American Society of Heating, Refrigeration, and Air-Conditioning Engineers.

E. NEBB: National Environmental Balancing Bureau.

F. SMACNA: Sheet Metal and Air Conditioning Contractors National Association.

G. TAB: Testing, adjusting, and balancing.

H. TABB: Testing, Adjusting, and Balancing Bureau.

I. TAB Specialist: An entity engaged to perform TAB Work.

1.03 REFERENCES

A. AAAB: National Standards for Total System Balance, 2002.

B. ADC: Test Code for Grilles, Registers, and Diffusers, ADC-1062, 1984.

C. AMCA: Publication 302-90; Field Performance Measurement of Fan Systems.

D. ASHRAE: 207 HVAC Applications Handbook; Chapter 37 – Testing, Adjusting, and Balancing.

E. ASHRAE/ANSI: Standard 111-2008; Testing, Adjusting, and Balancing of Building HVAC Systems.

F. NEBB: Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems, Seventh Edition, 2005.

G. SMACNA – HVAC Systems: Testing, Adjusting, and Balancing; Third Edition, 2002.

H. TABB: International Standards for Environmental Systems Balance.

1.04 SUBMITTALS

A. Within 15 days of Contractor's Notice to Proceed, submit the following documentation:

1. Qualification Data: Within 45 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

2. Contract Documents Examination Report: Within 45 days of Contractor`s Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

3. Sample report forms.

4. Instrument list.

B. Within 30 days of Owner's Acceptance of Substantial Completion, submit the following documentation:

1. Certified TAB reports.

2. Instrument calibration reports, to include the following:

a. Instrument type and make.

b. Serial number.

c. Application.

d. Dates of use.

e. Dates of calibration.

3. Schematic drawings for each system showing:

a. System components.

b. Balancing devices.

c. Testing locations.

1.05 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC, NEBB, or TABB. Entity shall have a minimum of 1 years experience. TAB Contractor shall not be or associated with the installing contractors. Work shall be performed in accordance with the requirements of the references listed at the start of this section.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC, NEBB, or TABB.

2. TAB Technician: Employee of the TAB contractor and who is certified by AABC, NEBB, or TABB as a TAB technician.

B. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.

2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard TAB contractor`s forms compliant with certifying organization.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.06 WARRANTY/GUARANTEE

A. The TAB Contractor shall include an extended warranty of 90 days after Owner receipt of completed balance report, during which time the Owner may request a recheck of terminals, or resetting of any outlet, coil, or device listed in the test report. This warranty shall provide a minimum of 16 man hours of onsite service time. If it is determined that the new test results are not within the design criteria, the TAB Contractor shall rebalance the system according to the design criteria.

B. Warranty/Guaranty must meet one of the following programs:

1. TABB International Quality Assurance Program.

2. AABC National Project Performance Guarantee.

3. NEBB Conformance Certification.

1.07 COORDINATION

A. Notice: Provide seven days` advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on distribution systems have been satisfactorily completed.

PART 2 -PRODUCTS (NOT APPLICABLE)

PART 3 -EXECUTION

3.01 GENERAL REQUIREMENTS

A. All procedures must conform to a published standard listed under “References”. All equipment shall be adjusted in accordance with the manufacturer’s recommendations. Any system not listed in this section but installed under the Contract Documents shall be tested, adjusted, and balanced using a procedure from a published standard listed under “References”.

3.02 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems` designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems` output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. 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.

2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA`s "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

Q. Examine motor driven equipment to verify rotation in proper direction.

R. Ensure all access doors are closed and caps are in place.

S. Report any deficiencies to the Architect/Engineer. Clearly identify any issues that prevent proper balancing. Beginning of work indicates acceptance of existing conditions.

3.03 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.

2. Automatic temperature-control systems are operational.

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 indicated conditions for system operations can be met.

3.04 INSTALLATION TOLERANCES

A. Adjust supply, return, and exhaust air-handling systems to +10%/-5% of scheduled values.

B. Adjust outdoor air intakes to +5%/-0% of scheduled values.

C. Adjust air inlets and outlets to +5%/-0% of scheduled values.

D. Adjust fume exhaust systems to +3%/-0% of scheduled values.

E. Adjust supply and exhaust air-handling systems used for space pressurization to +/- 5% of scheduled values while maintaining proper pressurization.

F. Adjust piping systems to +/- 10% of scheduled values.

G. Adjust plumbing systems to +/- 10% of indicated values.

3.05 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Duct Accessories."

2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."

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

C. Take and report testing and balancing measurements in inch-pound (IP) units.

D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, plugging test hours, and restoring thermostats and other set point sensors to specified settings.

3.06 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems` balancing devices. Recommend changes and additions to systems` balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

C. Final Report:

1. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

    a. Include a certification sheet at the front of the report`s binder, signed and sealed by the certified testing and balancing engineer.

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

    c. Pump curves.

    d. Fan curves.

    e. Manufacturers` test data.

    f. Field test reports prepared by system and equipment installers.

    g. Other information relative to equipment performance; do not include Shop Drawings and product data.

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

    a. Title page.

    b. Name and address of the TAB contractor.

    c. Project name.

    d. Project location.

    e. Architect`s name and address.

f. Engineer`s name and address.

g. Contractor`s name and address.

h. Report date.

i. Signature of TAB supervisor who certifies the report.

j. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.

k. Summary of contents including the following:
   1) Indicated versus final performance.
   2) Notable characteristics of systems.
   3) Description of system operation sequence if it varies from the Contract Documents.

l. Nomenclature sheets for each item of equipment.

m. Data for terminal units, including manufacturer`s name, type, size, and fittings.

n. Notes to explain why certain final data in the body of reports vary from indicated values.

o. Test conditions for fans and pump performance forms including the following:
   1) Settings for outdoor-, return-, and exhaust-air dampers.
   2) Conditions of filters.
   3) Cooling coil, wet- and dry-bulb conditions.
   4) Face and bypass damper settings at coils.
   5) Fan drive settings including settings and percentage of maximum pitch diameter.
   6) Settings for supply-air, static-pressure controller.
   7) Other system operating conditions that affect performance.

3. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

   a. Quantities of outdoor, supply, return, and exhaust airflows.

   b. Water and steam flow rates.

   c. Duct, outlet, and inlet sizes.

   d. Pipe and valve sizes and locations.

   e. Terminal units.

   f. Balancing stations.

   g. Position of balancing devices.

4. Air Handling Equipment Test Reports: For all equipment that delivers air for the purpose of heating or cooling, include the following:

   a. Unit Data:
      1) Unit identification.
      2) Location.

3) Make and type.
4) Model number and unit size.
5) Manufacturer`s serial number.
6) Unit arrangement and class.

b. Fan Test Reports for each fan.

c. Test Reports for each heating and cooling component.

d. Other Test Data (Indicated and Actual Values):
1) Total air flow rate in cfm.
2) Static pressure profile indicating pressure drop across each individual section in inches wg.
3) Inlet static pressure in inches wg.
4) Discharge static pressure in inches wg.
5) Outdoor airflow in cfm.
6) Return airflow in cfm.
7) Outdoor-air damper position.
8) Return-air damper position.

5. Coil Test Reports: For each duct mounted coil and coil installed in air handling equipment, include the following:

a. Coil Data:
1) System identification.
2) Location.
3) Coil type.
4) Number of rows.
5) Fin spacing in fins per inch o.c.
6) Make and model number.
7) Face area in sq. ft.
8) Tube size in NPS.
9) Tube and fin materials.

b. Test Data (Indicated and Actual Values):
1) Air flow rate in cfm.
2) Average face velocity in fpm.
3) Air pressure drop in inches wg.
4) Outdoor-air, wet- and dry-bulb temperatures in deg F.
5) Return-air, wet- and dry-bulb temperatures in deg F.
6) Entering-air, wet- and dry-bulb temperatures in deg F.
7) Leaving-air, wet- and dry-bulb temperatures in deg F.
8) Water flow rate in gpm.
9) Water pressure differential in feet of head or psig.
10) Entering-water temperature in deg F.
11) Leaving-water temperature in deg F.

6. Electric Heating Coil Test Reports: For each duct mounted electric coil and electric coil installed in air-handling equipment, include the following:

a. Unit Data:
1) System identification.
2) Location.
3) Coil identification.
4) Capacity in Btu/h.
5) Number of stages.
6) Connected volts, phase, and hertz.
7) Rated amperage.

8) Air flow rate in cfm.
9) Face area in sq. ft.
10) Minimum face velocity in fpm.

b. Test Data (Indicated and Actual Values):
1) Heat output in Btu/h.
2) Air flow rate in cfm.
3) Air velocity in fpm.
4) Entering-air temperature in deg F.
5) Leaving-air temperature in deg F.
6) Voltage at each connection.
7) Amperage for each phase.

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

a. Fan Data:
1) System identification.
2) Location.
3) Make and type.
4) Model number and size.
5) Manufacturer`s serial number.
6) Arrangement and class.
7) Sheave make, size in inches, and bore.
8) Center-to-center dimensions of sheave, and amount of adjustments in inches.

b. Motor Data:
1) Motor make, and frame type and size.
2) Horsepower and rpm.
3) Volts, phase, and hertz.
4) Full-load amperage and service factor.
5) Sheave make, size in inches, and bore.
6) Center-to-center dimensions of sheave, and amount of adjustments in inches.
7) Number, make, and size of belts.

c. Test Data (Indicated and Actual Values):
1) Total airflow rate in cfm.
2) Total system static pressure in inches wg.
3) Fan rpm.
4) Discharge static pressure in inches wg.
5) Suction static pressure in inches wg.
6) Motor voltage at each connection.
7) Motor amperage for each phase.

8. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

a. Report Data:
1) System and air-handling-unit number.
2) Location and zone.
3) Traverse air temperature in deg F.
4) Duct static pressure in inches wg.
5) Duct size in inches.
6) Duct area in sq. ft..
7) Indicated air flow rate in cfm.
8) Indicated velocity in fpm.
9) Actual air flow rate in cfm.

10) Actual average velocity in fpm.
11) Barometric pressure in psig.

9. Air-Terminal Reports: For each air inlet or outlet, include the following:

a. Unit Data:
1) System and air-handling unit identification.
2) Location and zone.
3) Apparatus used for test.
4) Area served.
5) Make.
6) Number from system diagram.
7) Type and model number.
8) Size.
9) Effective area in sq. ft.

b. Test Data (Indicated and Actual Values):
1) Preliminary air flow rate in cfm.
2) Final air flow rate in cfm.
3) Percent of design air flow rate.

10. Air-Terminal Unit Reports: For air terminal units connected to air handling equipment or exhaust fans, include the following:

a. Unit Data:
1) System and air-handling-equipment identification.
2) Location and zone.
3) Room or riser served.
4) Coil make and size.
5) Coil balancing valve manufacturer and model.
6) Motor horsepower, voltage, and full load amperage for fan powered units.

b. Test Data (Indicated and Actual Values):
1) Cooling maximum flow rate in cfm.
2) Heating maximum flow rate in cfm.
3) Minimum flow rate in cfm.
4) Coil Entering-air temperature in deg F.
5) Coil Leaving-air temperature in deg F.
6) Motor voltage and amperage for fan powered units.

11. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

a. Unit Data:
1) Unit identification.
2) Location.
3) Service.
4) Make and size.
5) Model number and serial number.
6) Water flow rate in gpm.
7) Water pressure differential in feet of head or psig.
8) Required net positive suction head in feet of head or psig.
9) Pump rpm.
10) Impeller diameter in inches.
11) Motor make and frame size.
12) Motor horsepower and rpm.
13) Voltage at each connection.
14) Full-load amperage and service factor.

15) Seal type.

b. Test Data (Indicated and Actual Values):
1) Static head in feet of head or psig.
2) Pump shutoff pressure in feet of head or psig.
3) Actual impeller size in inches.
4) Full-open flow rate in gpm.
5) Full-open pressure in feet of head or psig.
6) Final discharge pressure in feet of head or psig.
7) Final suction pressure in feet of head or psig.
8) Final total pressure in feet of head or psig.
9) Final water flow rate in gpm.
10) Voltage at each connection.
11) Amperage for each phase.

12. Flow Measuring Station:

a. Unit Data:
1) Unit identification.
2) Service.
3) Location.
4) Manufacturer and model.
5) Serial number.
6) Size.

b. Test Data:
1) Flow rate.
2) Pressure drop.

13. Positive Airflow Test:

a. General Data:
1) Room identification.
2) Adjacent spaces.

b. Test Data:
1) Occupied supply, return, exhaust flows.
2) Unoccupied supply, return, exhaust flows.
3) Measured pressural differential.

14. Fire, Smoke, Fire/Smoke Dampers:

a. Unit Data:
1) Damper identification number.
2) System.
3) Type.
4) Size.
5) UL assembly number.
6) Location of damper and access room.
7) Fusible link temperature rating.
8) Manufacturer and model.

b. Test Data:
1) Operation pass/fail/reset.

15. Plumbing Systems:

a. Pump Data:
1) Unit Data:
(a) Drawing symbol.
(b) Service.
(c) Manufacturer, size, and model.
2) Test Data:
(a) Flow rate (gpm); specified and actual.
(b) Pump head; specified, operating, and shutoff.
(c) Suction pressure; operating and shutoff.
(d) Discharge pressure; operating and shutoff.
(e) Final frequency of motor at maximum flow rate (on pumps driven by VFD).

b. Electric Motors:
1) Unit Data:
(a) Drawing symbol of equipment served.
(b) Manufacturer, model, and frame.
(c) Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
2) Test Data:
(a) Measured: Amp for each phase.

c. Balancing Valve:
1) Unit Data:
(a) Drawing symbol.
(b) Service.
(c) Location.
(d) Size.
(e) Manufacturer and model.
2) Test Data:
(a) Flow rate (gpm); specified and actual.
(b) Pressure drop; specified and actual.

16. Instrument Calibration Reports:

a. Report Data:
1) Instrument type and make.
2) Serial number.
3) Application.
4) Dates of use.
5) Dates of calibration.

3.07 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.

2. Check the following for each system:

a. Measure airflow of at least 10 percent of air outlets.

b. Measure water flow of at least 10 percent of terminals.

c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.

d. Verify that balancing devices are marked with final balance position.

e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner's representative.

2. The TAB contractor`s test and balance engineer shall conduct the inspection in the presence of Owner's representative.

3. Owner's representative shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.

2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor`s final payment.

D. Prepare test and inspection reports.

3.08 ADDITIONAL TESTS

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

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230700 - MECHANICAL INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes mechanical insulation for mechanical system components, including the following:

1. Insulation Materials:

a. Cellular glass

b. Flexible elastomeric.

c. Mineral fiber.

d. Polystyrene

2. Fire-rated insulation systems.

3. Adhesives.

4. Mastics.

5. Lagging adhesives.

6. Sealants.

7. Factory-applied jackets.

8. Field-applied jackets.

9. Tapes.

10. Securements.

11. Valve and specialty fitting wraps.

B. Related Documents

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

2. The requirements listed in this document are applicable to Divisions [21][,] [and] [22][,] [and] [23] specifications.

1.02 DEFINITIONS

A. ASJ: All-service jacket.

B. FSK: Foil, scrim, kraft paper.

C. PSK: Metalized polypropylene scrim kraft.

D. FSP: Foil, scrim, polyethylene.

E. PVDC: Polyvinylidene chloride.

F. SSL: Self-sealing lap.

G. MICA: Midwest Insulation Contractor's Association.

H. Indoor: Outside surfaces are inside building within conditioned space or insulated building envelope.

I. Outdoor: Outside surfaces are exposed to weather or outside ambient air temperatures. This includes concealed locations such as ventilated attics, uninsulated soffits, and other locations not protected by the insulated building envelope.

J. Concealed: Outside surfaces are isolated from room ambient air conditions by physical barrier.

1. Concealed items are typically accessed through suspended ceilings, through access doors, or by cutting and patching.

2. Listed below are examples of spaces that typically contain concealed items:

a. Walls.

b. Partitions.

c. Chases.

d. Shafts.

e. Ceiling spaces.

f. Attics

g. Crawl Spaces

K. Exposed: Outside surfaces are not isolated from room ambient air conditions by physical barrier.

1. Exposed items are typically accessed directly from within a room or space.

2. Listed below are examples of rooms/spaces that typically contain exposed items:

a. Mechanical rooms.

b. Tunnels.

c. Rooms without ceilings.

1.03 HOT AND COLD WATER SYSTEM REQUIREMENTS

A. Insulation specified for hot water equipment and piping includes all systems that operate at temperatures greater than 105 deg F, with and without glycol. This includes the following:

1. Domestic hot water

2. Domestic hot water recirculating.

B. Insulation specified for cold water equipment and piping includes all systems that operate at temperatures less than 60 deg F, with and without glycol. This includes the following:

1. Domestic cold water.

1.04 SUBMITTALS

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

B. Application schedule.

C. Field quality-control inspection reports.

1.05 QUALITY ASSURANCE

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

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

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

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

C. MICA Standards Manual, current edition.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

B. Material shall be sealed and protected from dirt, debris, and moisture throughout staging and construction.

1.07 COORDINATION

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

B. Coordinate installation and testing of heat tracing.

C. Verify and document compliance with all local, state, and applicable energy codes.

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

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

2.02 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds. Products shall be certified no voc and low odor.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

C. Insulation materials in contact with austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.

1. Products:

a. Cell-U-Foam Corporation; Ultra-CUF.

b. Pittsburgh Corning Corporation; Foamglas Super K.

2. Block Insulation: ASTM C 552, Type I.

3. Special-Shaped Insulation: ASTM C 552, Type III.

4. Board Insulation: ASTM C 552, Type IV.

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

6. Preformed Pipe Insulation with Factory-Applied [ASJ] [ASJ-SSL]: Comply with ASTM C 552, Type II, Class 2.

7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

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

1. Products:

a. Aeroflex USA Inc.; Aerocel.

b. Armacell LLC; AP Armaflex.

c. Rubatex

d. K Flex USA

e. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory applied FSK or PSK jacket. Thermal conductivity (k-value) at 100 deg F is 0.30 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.

1. Products:

a. CertainTeed Corp.; Duct Wrap.

b. Johns Manville; Microlite.

c. Knauf Insulation; Duct Wrap.

d. Manson Insulation Inc.; Alley Wrap.

e. Owens Corning; All-Service Duct Wrap.

H. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

1. Products:

a. Johns Manville; HTB 23 Spin-Glas.

b. Owens Corning; High Temperature Flexible Batt Insulations.

I. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. For equipment applications, provide insulation with factory-applied FSK or ASJ jacket. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article. Coordinate subparagraph and list below with Part 2 "Manufacturers" Article. Retain "Available" for nonproprietary and delete for semiproprietary specifications.

1. Products:

a. CertainTeed Corp.; Commercial Board.

b. Fibrex Insulations Inc.; FBX.

c. Johns Manville; 800 Series Spin-Glas.

d. Knauf Insulation; Insulation Board.

e. Manson Insulation Inc.; AK Board.

f. Owens Corning; Fiberglas 700 Series.

J. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

1. Products:

    a. Fibrex Insulations Inc.; FBX.

    b. Johns Manville; 1000 Series Spin-Glas.

    c. Owens Corning; High Temperature Industrial Board Insulations.

    d. Rock Wool Manufacturing Company; Delta Board.

    e. Roxul Inc.; Roxul RW.

    f. Thermafiber; Thermafiber Industrial Felt.

K. Mineral-Fiber, Preformed Pipe Insulation:

1. Products:

    a. Fibrex Insulations Inc.; Coreplus 1200.

    b. Johns Manville; Micro-Lok.

    c. Knauf Insulation; 1000(Pipe Insulation.

    d. Manson Insulation Inc.; Alley-K.

    e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.

3. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.

L. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied [ASJ] [FSK jacket] complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in Part 2 "Factory-Applied Jackets" Article.

1. Products:

    a. CertainTeed Corp.; CrimpWrap.

    b. Johns Manville; MicroFlex.

    c. Knauf Insulation; Pipe and Tank Insulation.

    d. Manson Insulation Inc.; AK Flex.

    e. Owens Corning; Fiberglas Pipe and Tank Insulation.

M. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.

1. Products:

a. Dow Chemical Company (The); Styrofoam.

b. Knauf Insulation; Knauf Polystyrene.

2.03 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

C. Cellular-Glass, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

F. ASJ, PSK, FSK, and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

G. PVC Jacket Adhesive: Compatible with PVC jacket.

2.04 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II. Color shall match insulation color. Service shall match insulation application vapor permeance and installation environment.

2.05 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

2.06 SEALANTS

A. Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates. Color shall match insulation or jacket color. Service shall match insulation application, vapor permeance, and installation environment.

2.07 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

4. PSK Jacket: Metalized white polypropylene, fiberglass-reinforced kraft paper backing; complying with ASTM C 1136, Type II.

5. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

6. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

2.08 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Adhesive: As recommended by jacket material manufacturer.

2. Color: White. [Paint exterior systems to match surroundings. Color selected by Architect.]

3. Color: Color shall match identification/painting system.

4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

C. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

D. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

E. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.09 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136 and UL listed.

1. Width: 3 inches.

2. Thickness: 11.5 mils.

3. Adhesion: 90 ounces force/inch in width.

4. Elongation: 2 percent.

5. Tensile Strength: 40 lbf/inch in width.

6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK and PSK Tape: Vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136 and UL listed.

1. Width: 3 inches.

2. Thickness: 6.5 mils.

3. Adhesion: 90 ounces force/inch in width.

4. Elongation: 2 percent.

5. Tensile Strength: 40 lbf/inch in width.

6. FSK or PSK Tape Disks and Squares: Precut disks or squares of FSK or PSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Width: 2 inches.

2. Thickness: 6 mils.

3. Adhesion: 64 ounces force/inch in width.

4. Elongation: 500 percent.

5. Tensile Strength: 18 lbf/inch in width.

D. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Width: 3 inches.

2. Film Thickness: 4 mils.

3. Adhesive Thickness: 1.5 mils.

4. Elongation at Break: 145 percent.

5. Tensile Strength: 55 lbf/inch in width.

E. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Width: 3 inches.

2. Film Thickness: 6 mils.

3. Adhesive Thickness: 1.5 mils.

4. Elongation at Break: 145 percent.

5. Tensile Strength: 55 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:

1. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, [1/2 inch] [3/4 inch] wide with [wing seal] [closed seal] [wing or closed seal].

2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Install pins, hangers, and securements according to manufacturer's installation recommendation.

2.11 VALVE AND SPECIALTY FITTING WRAPS

A. All valves, strainers, autoflow valves, circuit setters, ball valves, balancing valves, and combination valves, etc., in chilled water, heating hot water, and steam systems shall be insulated with a factory fabricated removable and reusable cover.

B. Type 1:

1. Insulation shall have a minimum k- factor .26, using fiberglass blanket. Flame and smoke spread shall be 25/50 per ASTM E-84.

2. Outer jacket shall be made of material equal to DuPont Tychem® QC, overlapping and completely covering the insulation with seams joined by tabs made from hook and loop fasteners (Velcro). Butt ends shall have sewn-in-place elastic.

3. Outer jacket shall overlap adjoining sections of pipe insulation.

4. Installation shall not require the use of any special hand tools.

5. Manufacturers: No Sweat Valve Wraps, Inc., or approved equal.

C. Type 2:

1. Flame Spread Index <25, smoke developed index <50 per ASTM E 84.

2. Thermal conductivity tested per ASTM C225. Minimum K-factor shall be 0.48 at 200 deg F.

3. Fiberglass insulation core meets ASTM C553, Type VI requirements.

4. Meets ASTM C1695-10 Standard Specification for fabrication of flexible removable and reusable blanket insulation for hot service.

5. Manufacturers: Auburn manufacturing, Inc., or approved equal.

D. Type 3:

1. Manufacturers: ThermaXX or approved equal.

2. Insulation:

a. Box Type Jackets:
1) High/low-temperature insulation blanket formed of silica Aerogel and reinforced with a non-woven, glass-fiber batting.
2) Insulation must be hydrophobic.
3) Estimation of maximum use temperature 1200 deg F.

b. Non-Box Type Jackets:
1) Glass mat, Type E needled fiber. 1/4 inch, 1/2 inch at 9 LB/CF and 1 inch at 11.3 LB/CF.
2) Estimation of maximum use temperature 1200 deg F.

c. All insulation materials shall be non-asbestos.

3. Jacket:

a. Pipe Side:
1) PTFE fiberglass composite jacketing, 16.5 oz/sq yd minimum.
2) Estimation of maximum use temperature 600 deg F.

b. Exterior Side:
1) PTFE fiberglass composite jacketing, 16.5 oz/sq yd minimum.
2) Estimation of maximum use temperature 600 deg F.

4. Thread:

a. Begins to decompose at about 800 deg.

b. Does not melt.

c. Diameter: 0114.

d. Break Point: 35 lbs.

5. Construction:

a. Double sewn lock stitch with a minimum 4 to 6 stitches per inch. Jackets shall be sewn with two (2) parallel rows of stitching using thread in Article 2.12, Subparagraph D.4. The thread must be able to withstand the skin temperatures without degradation.

b. Hog rings, staples, and wire are not acceptable methods of closure.

c. No raw cut jacket edges shall be exposed.

d. Jackets shall be fastened using hook and loop (Velcro) straps and 1 inch slide buckles.

e. All stitching will be done with thread in Article 2.12, Subparagraph D.4.

f. Provide a permanently attached aluminum or stainless steel nameplate on each jacket to identify its location, size, and tag number.

g. Provide a stainless steel or brass grommet at the low point of each jacket, in wet areas for moisture drain (on horizontal jackets as required).

h. The insulation shall be designed to prevent sweating in the space between the cold metal surface and the inner layer of insulation. To this end, during jacket fabrication, the layers of insulating mat shall be placed in an overlapping pattern.

i. All jacket pieces which match mating seams must include an extended 2 inch flap constructed from the exterior fabric and shall be secured using hook and loop closure (i.e., Velcro) parallel to the seam.

j. Insulation must be sewn as integral part of the jacket to prevent shifting of the insulation.

6. Jacket Performance and Insulation Thickness:

a. Insulation Thickness: Match adjacent piping insulation requirements.

E. Type 4:

1. Manufacturers: ThermaXX LLC or approved equal.

2. Insulation:

a. Box Type Jackets:
1) High-temperature insulation blanket formed of silica Aerogel and reinforced with a non-woven, glass-fiber batting.
2) Insulation must be hydrophobic.
3) Estimation of maximum use temperature 1200 deg F.

b. Non-Box Type Jackets:
1) Glass mat, Type E needled fiber. 1/4 inch or 1/2 inch at 9 lb/cf and 1 inch at 11.3 lb/cf.
2) Estimation of maximum use temperature 1200 deg F.

c. All insulation materials shall be non-asbestos.

3. Jacket:

a. Hot Side:
1) PTFE fiberglass composite jacketing, 16.5 oz/sq yd minimum.
2) Estimation of maximum use temperature 550 deg F.

b. Cold Side:
1) PTFE fiberglass composite jacketing, 165 oz/sq yd minimum.
2) Estimation of maximum use temperature 600 deg F.

4. Thread:

a. Begins to decompose at about 800 deg.

b. Does not melt.

c. Diameter: 0114.

d. Break Point: 35 lbs.

5. Construction:

a. Double sewn lock stitch with a minimum 4 to 6 stitches per inch. Jackets shall be sewn with two (2) parallel rows of stitching using thread in Article 2.12, Subparagraph E.4. The thread must be able to withstand the skin temperatures without degradation.

b. Hog rings, staples, and wire are not acceptable methods of closure.

c. No raw cut jacket edges shall be exposed.

d. Jackets shall be fastened using hook and loop (Velcro) straps and 1 inch slide buckles.

e. All stitching will be done with thread in Article 2.12, Subparagraph E.4.

f. Provide a permanently attached aluminum or stainless steel nameplate on each jacket to identify its location, size, and tag number.

g. Provide a stainless steel or brass grommet at the low point of each jacket, in wet areas for moisture drain (on horizontal jackets as required).

h. The insulation shall be designed to prevent sweating in the space between the cold metal surface and the inner layer of insulation. To this end, during jacket fabrication, the layers of insulating mat shall be placed in an overlapping pattern.

i. All jacket pieces which match mating seams must include an extended 2 inch flap constructed from the exterior fabric and shall be secured using hook and loop closure (i.e., Velcro) parallel to the seam.

j. Insulation must be sewn as integral part of the jacket to prevent shifting of the insulation.

6. Steam trap and steam trap station jackets must be constructed in a box shape for removal and replacement inspection ease. Jacket Performance and Insulation Thickness:

a. Insulation Thickness: As required to touch temperature.
1) Exterior of all jacket <120 deg F.

PART 3 EXECUTION

3.01 EXAMINATION

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

1. Verify that systems and equipment to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

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

3.02 INSTALLATION

A. Install insulation after completion of pressure testing.

3.03 PREPARATION

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

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

3.04 COMMON INSTALLATION REQUIREMENTS

A. Where vapor barrier is breeched by fastener, seal to maintain vapor permeance.

B. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

C. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.

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

E. Install insulation with longitudinal seams at top and bottom of horizontal runs.

F. Install multiple layers of insulation with longitudinal and end seams staggered.

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

H. Keep insulation materials protected and dry during application and finishing.

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

J. Install insulation with least number of joints practical.

K. For all cold systems operating below ambient temperature, provide continuous vapor barrier. Seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. Insulate all system components the same as connecting piping and ductwork to eliminate condensation.

3. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

4. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

5. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

M. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install 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 2 inches o.c.

a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.

5. Where vapor barriers are required, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

N. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

O. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

P. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

Q. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.

2. Testing agency labels and stamps.

3. Nameplates and data plates.

4. Handholes.

5. Cleanouts.

R. MICA plate numbers referenced are provided to clarify the scope of installation. Install Insulation and accessory components per applicable MICA and manufacturers recommendations.

3.05 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Below-Grade Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.

4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

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

F. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.

2. Pipe: Install insulation continuously through floor penetrations.

3.06 DUCT AND PLENUM INSULATION INSTALLATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure per manufacturer's installation recommendations.

3.07 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Secure insulation per manufacturer's installation recommendations.

B. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.

2. Fabricate boxes from [galvanized steel] [aluminum] [stainless steel], at least [0.040 inch] [0.050 inch] [0.060 inch] thick.

3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.08 GENERAL PIPE INSULATION INSTALLATION

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

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

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Identify all specialties with labels on exterior of insulation.

2. Install preformed sections or cut, miter, and bond all elbows and tees to provide continuous quality fitting contour.

3. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

4. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

5. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

6. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

7. For services not specified to receive a field-applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

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

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

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.09 CALCIUM SILICATE INSULATION INSTALLATION

A. Insulation Installation on Boiler Breechings and Ducts:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.

2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.

2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

3.10 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are required, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.

4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of 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 same thickness as pipe insulation.

4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

E. For all system components without factory applied jackets, cover insulation with factory furnished jacketing material appropriate for service and application.

3.11 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of 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 same thickness as pipe insulation.

4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.12 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

3. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of 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. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 2inch, and seal joints with flashing sealant.

C. Blanket and Board Insulation Installation on Ducts and Plenums: Secure per manufacturer’s installation recommendations.

1. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

2. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.13 POLYSTYRENE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.

2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.

3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed section of polystyrene insulation to valve body.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

3.14 FIELD-APPLIED JACKET INSTALLATION

A. Where fiberglass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.

3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.

2. Install lap or joint strips with same material as jacket.

3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket 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-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install 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.

E. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.

2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.

3. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.

4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch-circumference limit allows for 2-inch-overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.

5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.15 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous UL-listed fire rating.

B. Penetrations through fire rated walls and floors shall be installed with UL listed through penetration fire stopping system specific for the fire-rated insulation system manufacturer.

C. Insulate duct access panels and doors to achieve same fire rating as duct in accordance with its UL listing.

3.16 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

1. Flat Acrylic Finish: [Two] finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

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

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

3.17 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent inspecting agency to perform field inspections and prepare inspection reports.

B. Perform the following field tests and inspections and prepare test reports:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to [one] location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to [one] location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

3. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to [three] locations of straight pipe, [three] locations of threaded fittings, [three] locations of welded fittings, [two] locations of threaded strainers, [two] locations of welded strainers, [three] locations of threaded valves, and [three] locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements. Remove defective Work.

D. Install new insulation and jackets to replace insulation and jackets removed for inspection. Repeat inspection procedures after new materials are installed.

3.18 DUCT INSULATION, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor and outdoor ductwork and plenums as scheduled.

2. All duct mounted components shall be externally insulated the same R value as connecting ductwork. This includes but is not limited to the following.

a. Duct mounted coils, including coils mounted to VAV boxes. Insulation shall cover u-bends and piping header.

b. Duct mounted sound attenuators.

c. Duct mounted dampers.

B. Items Not Insulated:

1. Exposed supply air distribution systems with architectural significance where specifically noted on plans.

2. Fibrous-glass ducts.

3. Metal ducts with duct liner where thickness is increased to comply with energy code and ASHRAE/IESNA 90.1.

a. Use of duct liner is limited to only those locations duct liner is specified or indicated.

4. Factory-insulated flexible ducts.

5. Factory-insulated plenums and casings.

6. Flexible connectors.

7. Vibration-control devices.

8. Factory-insulated access panels and doors.

9. Fire dampers where not permitted by UL listing.

10. Return air ductwork in ceiling spaces utilized as return air plenums.

C. Insulation thickness and associated thermal conductivity shall meet installed R value scheduled. For mineral fiber blanket insulation, installed R value shall be based on the insulation being compressed 25%.

D. Provide the following factory applied insulation jacketing:

1. Mineral fiber blanket:

a. Exposed applications: PSK

b. Concealed applications: FSK

2. Mineral fiber board:

   a. Exposed applications: ASJ

   b. Concealed applications: FSK

END OF SECTION 230700

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 -GENERAL

1.01 RELATED DOCUMENTS

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

B. OPR, BoD, and documentation prepared by Owner and Architect contains requirements that apply to this Section.

1.02 SUMMARY

A. This Section includes requirements for commissioning the HVAC system and its subsystems and equipment. This Section supplements the general requirements specified in Division 01 Section "General Commissioning Requirements."

B. Related Sections include the following:

1. Section 019113 "General Commissioning Requirements" for general requirements for commissioning processes that apply to this Section.

2. Section 26 0800 “Commissioning of Electrical Systems” for electrical systems commissioning requirements.

1.03 DEFINITIONS

A. Architect: Includes Architect identified in the Contract for Construction between Owner and Contractor, plus consultant/design professionals responsible for design of HVAC, electrical, communications, controls for HVAC systems, and other related systems.

B. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

C. BoD: Basis of Design.

D. CxA: Commissioning Authority.

E. OPR: Owner`s Project Requirements.

F. Systems, Subsystems, and Equipment: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, and equipment.

G. TAB: Testing, Adjusting, and Balancing.

1.04 CONTRACTOR`S RESPONSIBILITIES

A. The following responsibilities are in addition to those specified in Division 01 Section "General Commissioning Requirements."

B. Contractor:

1. Perform commissioning tests at the direction of the CxA as defined in the Commissioning Plan.

2. Attend Construction phase controls coordination meeting.

3. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

4. Provide information requested by the CxA for final commissioning documentation.

5. Provide training to Owner's personnel on system operations, preventive maintenance, sequence of operations, and function on systems.

6. Attend TAB review & coordination meeting for TAB Work.

7. Certify that TAB Work is complete.

C. Mechanical Contractor:

1. Attend TAB verification testing.

2. Provide measuring instruments and logging devices to record test data, and data acquisition equipment to record data for the complete range of testing for the required test period.

D. HVAC Instrumentation and Control Contractor: With the CxA, review control designs for compliance with the OPR and BoD, controllability with respect to actual equipment to be installed, and recommend adjustments to control designs and sequence of operation descriptions.

E. TAB Contractor:

1. Contract Documents Review: With the CxA, review the Contract Documents before developing TAB procedures.

a. Verify the following:
1) Accessibility of equipment and components required for TAB Work.
2) Adequate number and placement of duct balancing dampers to allow proper balancing while minimizing sound levels in occupied spaces.
3) Adequate number and placement of balancing valves to allow proper balancing and recording of water flow.
4) Adequate number and placement of test ports and test instrumentation to allow reading and compilation of system and equipment performance data needed to conduct both TAB and commissioning testing.
5) Air and water flow rates have been specified and compared to central equipment output capacities.

b. Identify discontinuities and omissions in the Contract Documents.

c. This review of the Contract Documents by the TAB Subcontractor satisfies requirements for a design review report as specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

2. Additional Responsibilities: Participate in tests specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls" and

F. Electrical Contractor:

1. With the Mechanical Contractor, coordinate installations and connections between and among electrical and HVAC systems, subsystems, and equipment.

1.05 COMMISSIONING DOCUMENTATION

A. The following are in addition to documentation specified in Division 01 Section "General Commissioning Requirements."

B. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.

2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.

3. Process and schedule for completing construction checklists and manufacturer’s prestart and startup checklists for HVAC&R systems, assemblies, equipment and components to be verified and tested.

4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.

5. Certificate of readiness certifying that HVAC&R systems, subsystems equipment and associated controls are ready for testing.

6. Test and inspection reports and certificates.

7. Corrective action documents.

8. Verification of testing, adjusting, and balancing reports.

C. Test Checklists: CxA shall develop test checklists for HVAC systems, subsystems, and equipment, including interfaces and interlocks with other systems. CxA shall prepare separate checklists for each mode of operation and provide space to indicate whether the mode under test responded as required. Contractors shall complete test checklists. In addition to the requirements specified in Division 01 Section "General Commissioning Requirements," checklists shall include, but not be limited to, the following:

1. Calibration of sensors and sensor function.

2. Testing conditions under which test was conducted, including (as applicable) ambient conditions, set points, override conditions, and status and operating conditions that impact the results of test.

3. Control sequences for HVAC systems.

4. Strength of control signal for each set point at specified conditions.

5. Responses to control signals at specified conditions.

6. Sequence of response(s) to control signals at specified conditions.

7. Electrical demand or power input at specified conditions.

8. Power quality and related measurements.

9. Expected performance of systems, subsystems, and equipment at each step of test.

10. Narrative description of observed performance of systems, subsystems, and equipment. Notation to indicate whether the observed performance at each step meets the expected results.

11. Interaction of auxiliary equipment.

12. Issues log.

1.06 SUBMITTALS

A. The following submittals are in addition to those specified in Division 01 Section "General Commissioning Requirements."

B. Testing Procedures: CxA shall submit detailed testing plan, procedures, and checklists for each series of tests. Submittals shall include samples of data reporting sheets that will be part of the reports.

C. Certificate of Readiness: CxA shall compile certificates of readiness from the appropriate Contractor certifying that systems, subsystems, equipment, and associated controls are ready for testing.

D. Certificate of Completion of Installation, Prestart, and Startup: CxA shall certify that installation, prestart, and startup activities have been completed.

E. Certified Pipe Cleaning and Flushing Report: Contractors shall certify that pipe cleaning, flushing, hydrostatic testing, and chemical treating have been completed. CxA shall Verify reports.

F. Test and Inspection Reports: CxA shall compile and submit test and inspection reports and certificates, and shall include them in systems manual and commissioning report.

G. Corrective Action Documents: CxA shall submit corrective action documents.

H. Certified TAB Reports: CxA shall submit verified, certified TAB reports.

PART 2 -PRODUCTS (NOT USED)

PART 3 -EXECUTION

3.01 TESTING PREPARATION

A. Prerequisites for Testing: (Completed by Contractor)

1. Certify that HVAC systems, subsystems, and equipment have been completed, calibrated, and started; are operating according to the OPR, BoD, and Contract Documents; and that Certificates of Readiness are signed and submitted.

2. Certify that HVAC instrumentation and control systems have been completed and calibrated; are operating according to the OPR, BoD, and Contract Documents; and that pretest set points have been recorded.

3. Certify that TAB procedures have been completed, and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.

4. Test systems and intersystem performance after approval of test checklists for systems, subsystems, and equipment.

5. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shut down, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

6. Verify each operating cycle after it has been running for a specified period and is operating in a steady-state condition.

7. Inspect and verify the position of each device and interlock identified on checklists. Sign off each item as acceptable, or failed. Repeat this test for each operating cycle that applies to system being tested.

8. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

9. Annotate checklist or data sheet when a deficiency is observed.

10. Verify equipment interface with monitoring and control system and TAB criteria; include the following:

    a. Supply and return flow rates for VAV and constant volume systems in each operational mode.

    b. Operation of terminal units in both heating and cooling cycles.

    c. Minimum outdoor-air intake in each operational mode and at minimum and maximum airflows.

    d. Building pressurization.

    e. Total exhaust airflow and total outdoor-air intake.

    f. Operation of indoor-air-quality monitoring systems.

11. Verify proper responses of monitoring and control system controllers and sensors to include the following:

    a. For each controller or sensor, record the indicated monitoring and control system reading and the test instrument reading. If initial test indicates that the test reading is outside of the control range of the installed device, check calibration of the installed device and adjust as required. Retest malfunctioning devices and record results on checklist or data sheet.

    b. Report deficiencies and prepare an issues log entry.

12. Verify that HVAC equipment field quality-control testing has been completed and approved. CxA shall direct, witness, and document field quality-control tests, inspections, and startup specified in individual Division 23 Sections.

B. Testing Instrumentation: Install measuring instruments and logging devices to record test data for the required test period. Instrumentation shall monitor and record full range of operating conditions and shall allow for calculation of total capacity of system for each mode of operation. For individual room cooling tests, provide temporary heaters to impose a cooling load indicated in BoD. Operational modes include the following:

1. Occupied and unoccupied.

2. Warm up and cool down.

3. Economizer cycle.

4. Emergency power supply.

5. Life-safety and safety systems.

6. Smoke control.

7. Fire safety.

3.02 TAB VERIFICATION

A. Prior to performance of testing and balancing work, provide TAB plan at the pre TAB meeting with the Contractor, HVAC Contractor, and CxA.

B. Prior to performance of testing and balancing work, provide copies of sample reports, forms, checklists, and certificates to the CxA.

C. TAB Contractor shall coordinate with CxA for work required in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" TAB Contractor shall copy CxA with required reports, sample forms, checklists, and certificates.

D. The Contractor, HVAC Contractor, and CxA shall witness TAB Work.

E. TAB Preparation:

1. TAB Contractor shall provide CxA with data required for "Pre-Field TAB Engineering Reports" specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

    a. CxA shall use this data to certify that prestart and startup activities have been completed for systems, subsystems, and equipment installation.

F. Ductwork Air Leakage Testing:

1. Architect will identify, for HVAC Contractor and CxA, portions of duct systems to have ductwork air leakage testing. Ductwork air leakage testing shall be performed according to Division 23 Section "Metal Ducts," and shall be witnessed by the CxA.

2. On approval of preliminary ductwork air leakage testing report, the CxA shall coordinate verification testing of ductwork air leakage testing. Verification testing shall include random retests of portions of duct section tests, reported in preliminary ductwork air leakage testing report. The HVAC Contractor shall perform tests using the same instrumentation (by model and serial number) as for original testing; the CxA shall witness verification testing.

G. Verification of Final TAB Report:

1. Provide technicians, instrumentation, and tools to verify testing & balancing of HVAC & Plumbing systems at the direction of CxA.

2. CxA shall select 20 percent of report for field verification.

3. CxA shall notify TAB Contractor 10 days in advance of the date of field verification; however, notice shall not include data points to be verified. The TAB Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.

4. Failure of an item is defined as follows:

a. For all readings other than sound, a deviation of more than 10 percent.
1) For sound pressure readings, a deviation of 3 dB. (Note: Variations in background noise must be considered.)

5. Failure of more than 10 percent of selected items shall result in rejection of final TAB report.

H. If deficiencies are identified during verification testing, CxA shall notify the HVAC Contractor, Construction Manager and Architect, and shall take action to remedy the deficiency. Architect shall review final tabulated checklists and data sheets to determine if verification is complete and that system is operating according to the Contract Documents.

I. CxA shall certify that TAB Work has been successfully completed.

3.03 TESTING

A. Test systems and intersystem performance after test checklists for systems, subsystems, and equipment have been approved.

B. Perform tests using design conditions whenever possible.

1. Simulate conditions by imposing an artificial load when it is not practical to test under design conditions and when written approval for simulated conditions is received from CxA. Before simulating conditions, calibrate testing instruments. Set and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

2. Alter set points when simulating conditions is not practical and when directed by CxA.

3. Alter sensor values with a signal generator when design or simulating conditions and altering set points are not practical. Do not use sensor to act as signal generator to simulate conditions or override values.

C. Scope of HVAC Contractor Testing:

1. Testing scope shall include entire HVAC installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. It shall include measuring capacities and effectiveness of operational and control functions.

2. Test all operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. Detailed Testing Procedures: CxA, with HVAC Contractor, TAB Contractor, and HVAC Instrumentation and Control Contractor, shall prepare detailed testing plans, procedures, and checklists for HVAC systems, subsystems, and equipment.

E. Heating Water Testing and Acceptance Procedures: Testing requirements are specified in Division 23 boiler Sections. CxA shall review and comment on submittals, test data, and shall compile information for inclusion in systems manual.

F. HVAC Instrumentation and Control System Testing:

1. Field testing plans and testing requirements are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operation for HVAC Controls" The CxA, HVAC Contractor, and the HVAC Instrumentation and Control Contractor shall collaborate to prepare testing plans.

2. CxA shall convene a meeting of appropriate entities to review test report of HVAC instrumentation and control systems.

G. Pipe cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Division 23 piping Sections. HVAC Contractor shall prepare pipe system cleaning, flushing, and hydrostatic testing. CxA shall review and comment on plan and final reports. CxA shall certify that pipe cleaning, flushing, hydrostatic tests, and chemical treatment have been completed. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed Drawings for each pipe sector showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.

2. Description of equipment for flushing operations.

3. Minimum flushing water velocity.

4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

H. Heat-Generation System Testing: HVAC Contractor shall prepare a testing plan to verify performance of equipment. Plan shall include the following:

I. HVAC Distribution System Testing: HVAC Contractor shall prepare a testing plan to verify performance of air, and hydronic distribution systems; special exhaust; and other distribution systems. Include HVAC terminal equipment and unitary equipment. Plan shall include the following:

1. Sequence of testing and testing procedures for each item of equipment and section of pipe to be tested, identified by identification marker. Markers shall be keyed to Drawings showing the physical location of each item of equipment and pipe test section. Drawings shall be formatted to allow each item of equipment and section of piping to be physically located and identified when referred to in the system testing plan.

2. Tracking checklist for managing and ensuring that all pipe sections have been tested.

J. Deferred Testing:

1. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, the deficiency shall be documented and reported to Owner. Deficiencies shall be resolved and corrected by appropriate parties and test rescheduled.

2. If the testing plan indicates specific seasonal testing, appropriate initial performance tests shall be completed and documented and additional tests scheduled.

END OF SECTION 230800

SECTION 230900 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

B. Commissioning:

1. An independent third-party Commissioning Agent will document completion of the Mechanical/HVAC Systems for the project. The Division 23 Mechanical/HVAC Contractor is a member of the Commissioning Team and will facilitate completion of the Commissioning process. Refer to section 01 91 13 “General Commissioning Requirements” for the project Commissioning requirements and roles and responsibilities for each member of the Commissioning Team.

1.02 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Related Sections include the following:

1. Section 23 05 00 “Common Work Results for Mechanical”

1.03 DESCRIPTION OF WORK

A. The Instrumentation and Control System shall be a digital, distributed microprocessor-based system with a pneumatic and electronic interface, where required. The Control System for this project will be referred to as a Building Automation System (BAS).

B. The Control System Contractor shall provide a complete system using new, existing and relocated control devices to operate as specified and indicated on drawings. The contractor shall inspect the existing conditions prior to submitting a proposal. The existing temperature control system control devices, dampers, operators, wiring, conduit, air piping, valves, etc. not being modified and which are no longer utilized, shall be removed, and not abandoned in place.

1. All temperature control devices to be removed shall be returned to the Owner in good condition.

C. The Control Contractor will be responsible for all; installation, programming, commissioning, testing and performance verification.

D. The Controls Contractor will be responsible for providing all devices required for a complete operating control system.

E. Total quantity and type of control points shall consist of specifications, drawings and as required to complete the sequence of operation as specified. Additional points shall be provided as required to meet all sequence of operation functions, safeties and data base. The drawings and Specifications are not intended to show all details necessary to make the system complete and operable so as to perform all functions and operate according to the specified sequences.

F. The Control Contractor shall be responsible for all phases of software design, all equipment, installation and warranty for the BAS.

G. The Contractor shall leave operable existing controls in operation until the BAS is tested and proven operative. At that point, and with concurrence from the Owner and the Engineer, the Contractor shall be responsible for removing existing controls that are no longer necessary. Start-up of the BAS system, and any installation work that requires the interruption of the normal operation of any piece of equipment, shall be scheduled with the Owner. If the interruption of the normal operation of any piece of equipment during normal working hours is unacceptable to the Owner, then it shall be scheduled during after hours (night or weekend).

H. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner or Architect/Engineer in writing. Unless approved otherwise, all products (including firmware revisions) used in this installation shall have been used in at least twelve (12) projects prior to this installation. The previous sites may be located anywhere in the U.S.A. This requirement is not intended to restrict the Contractor to the use of any outdated equipment. Therefore, all products used in this installation shall also be currently under manufacture and have available, for at least ten years after completion of the contract, a complete line of spare parts. If the above requirements are mutually exclusive, the Contractor shall include a specific statement to this effect in the Bid.

I. Provide electrical work as required, complying with requirements of Division 26 sections including, but not limited to raceways, wires, cables, electrical identification, supporting devices and electrical connections for equipment. Work includes, but is not limited to, the following:

1. Interlock and control wiring between field-installed controls, indicating devices and unit control panels.

2. The Contractor shall be responsible for all additional electrical and other costs involved to accommodate the temperature control system panel, motors and electrical devices requiring power which differs from the power requirements shown on the electrical drawings.

3. Refer to Division 20 sections for mechanical/electrical coordination.

J. Coordinate with other contractors & identify location requirements for all necessary control devices which are provided under this section and may be installed by others. Including, but not limited to, the following:

1. Automatic control valves.

2. Flow switches.

3. Modulating dampers.

4. Required wells for insertion thermostats and/or temperature sensing wells.

5. Pressure Sensors.

1.04 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

1.05 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.

2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.

3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.

4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.

5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.

6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.

7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

a. Water Temperature: Plus or minus 1 deg F.

b. Water Flow: Plus or minus 5 percent of full scale.

c. Water Pressure: Plus or minus 2 percent of full scale.

d. Space Temperature: Plus or minus 1 deg F.

e. Ducted Air Temperature: Plus or minus 1 deg F.

f. Outside Air Temperature: Plus or minus 2 deg F.

g. Dew Point Temperature: Plus or minus 3 deg F.

h. Temperature Differential: Plus or minus 0.25 deg F.

i. Relative Humidity: Plus or minus 5 percent.

j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.

k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.

l. Airflow (Terminal): Plus or minus 10 percent of full scale.

m. Air Pressure (Space): Plus or minus 0.01-inch wg.

n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.

o. Carbon Monoxide: Plus or minus 5 percent of reading.

p. Carbon Dioxide: Plus or minus 50 ppm.

q. Electrical: Plus or minus 5 percent of reading.

1.06 SEQUENCE OF OPERATION

A. Refer to sequences of control on drawings.

1.07 SUBMITTALS

A. Submit in accordance with Division 1, Division 20 and the following submittal requirements.

B. Product Data: Include manufacturer's technical literature for each control device. Indicate:

1. Dimensions.

2. Capacities.

3. Performance characteristics.

4. Electrical characteristics.

5. Finishes for materials.

6. Commissioning, installation and startup instructions.

7. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

8. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

9. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.

2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.

a. Label each control device with setpoint or adjustable range of control. Provide a bill of materials with manufacturer's part number.

3. Wiring Diagrams: Power, signal, and control wiring.

a. Indicate all required point to point electrical wiring. Clearly differentiate between portions of wiring that are existing and portions to be field-installed.

4. Details of control panel faces, including controls, instruments, and labeling.

5. Written description of sequence of operation.

6. Schedule of dampers including size, leakage, and flow characteristics.

7. Schedule of valves including flow characteristics.

8. Schedule of wells and taps.

9. DDC System Hardware:

a. Wiring diagrams for control units with termination numbers.

b. Schematic diagrams and floor plans for field sensors and control hardware.

c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

10. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations. Provide a detailed listing of all software program code written for each system

11. Controlled Systems:

a. Schematic diagrams of each controlled system with, control points labeled, controlled equipment and control elements graphically shown, with wiring.

b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.

c. Written description of sequence of operation including schematic diagram.

d. Provide a point list with database input information to include a point name, address, base and span, action and other required information

12. Provide a detailed test plan and procedure for each HVAC system and for each type of terminal unit control including valves. The test plans shall fully define reporting methods, procedure, equipment utilized, milestones for the tests, identifying the simulation programs, and personnel. The test procedures shall be developed from the test plans and shall consist of instructions for test execution and evaluation. A test report form shall be developed for each point and sequence of operation. Commissioning procedures shall be provided for each HVAC system and for each type of terminal unit control system. If the control devices do not have auto-tuning, the procedure shall include setpoint, prop. band, integral, derivative, mode constraints input, output settings, tuning procedures., etc.

D. Submit manufacturer's installation instructions.

E. Submittal data and shop drawings shall be prepared and submitted in the following formats:

1. All drawings prepared for the project shall be developed using the AutoCAD CADD program (most current version) or Visio. Any other format must be approved by the Engineer.

2. All submittals data shall be the same size for any group of information and shall be bound - i.e. three screw and post binder or similar. All the information shall be indexed and tabbed with reference to the specific section of these specifications.

3. The format for different groups of submittal information are as follows:

a. Control drawings, building plans (including complete floor plans), schematics and system configurations shall be CADD prepared drawing, bound and indexed. Drawings that cannot represent the total information on an individual ANSI size B (11" x 17") drawing, i.e. a building plan, shall be noted with appropriate match lines, cross references and key plans.

b. Technical data, sequence of operations, material list, point lists, program listings, I/O schedules, operator's and programmer's manuals, etc. shall be type written, original product data sheets or CADD prepared drawings, ANSI size A or ANSI size B.

4. Upon completion of the project and acceptance of systems the contractor shall provide to the Owner one set of hard copy as-built shop drawings and diskettes.

F. Shop drawings shall include riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typicals will be allowed where appropriate.

G. When the Architect/Engineer requires, the Contractor will resubmit with the corrected or additional submittal data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully reviewed.

H. Contractor agrees that shop drawing submittals processed by the Architect/Engineer are not change orders, that the purpose of shop drawing submittals by the Contractor is to demonstrate to the Architect/Engineer that the Contractor understands the design concept, that he demonstrates his understanding by indicating which equipment and material he intends to furnish and install, and by detailing the fabrication and installation methods he intends to use.

I. Contractor further agrees that if deviations, discrepancies, or conflicts between shop drawing submittals and the contract documents in the form of design drawings and specifications are discovered either prior to or after shop drawing submittals are processed by the Architect/Engineer, the design drawings and specifications shall control and shall be followed. If alternates do not meet these requirements, it shall be this Contractor's responsibility to remove them and install material originally specified, at no cost to the Owner.

J. Samples for Verification: For each color required, of each type of thermostat or sensor cover.

1.08 INFORMATIONAL SUBMITTALS

A. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

B. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with LonWorks.

C. Qualification Data: For Installer and manufacturer.

D. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

E. Field quality-control test reports.

1.09 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.

2. Interconnection wiring diagrams with identified and numbered system components and devices.

3. Keyboard illustrations and step-by-step procedures indexed for each operator function.

4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

5. Calibration records and list of set points.

B. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.

2. Program Software Backup: On a magnetic media or compact disc, complete with data files.

3. Device address list.

4. Printout of software application and graphic screens.

5. Software license required by and installed for DDC workstations and control systems.

1.10 MAINTENANCE MATERIAL SUBMITTALS

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. Replacement Materials: One replacement diaphragm or relay mechanism for each unique valve motor, controller, thermostat and positioning relay.

2. Maintenance Materials: One thermostat adjusting key(s).

3. Maintenance Materials: One pneumatic thermostat test kit.

1.11 QUALITY ASSURANCE

A. Only those manufacturers specified are allowed to bid temperature controls. All bidders shall make available, upon the Owner's request, open book unit pricing of all materials and labor.

B. Bidders must have installed and completed at least two (2) direct digital temperature control jobs of similar design, size and scope using the same equipment as specified.

C. Bidders must have a local office in the area of the project site.

D. Bidders must have capabilities of doing component level repairs on all systems, including electronic systems.

E. Installer Qualifications: Automatic control system manufacturer's authorized representative, who is trained, approved and regularly employed by the Temperature Control Contractor for installation of system components required for this project. Firms regularly engaged in installation and commissioning and servicing of digital control equipment, of types and sizes required, whose firm has been in business in similar service for not less than 5 years.

F. No Field Devices shall be multiplexed to a single I/O point unless specified. Each control or sensing point shall be terminated at a unique location on the BAS panel, Slave or Dedicated Controller and be associated with a unique software point on the BAS.

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

H. Comply with ASHRAE 135 for DDC system components.

I. Codes and Standards:

1. All equipment and the installation shall comply with the requirements of all applicable local and national codes including but not limited to the currently enforced edition of the International Building Code, International Fire Code, and all applicable codes of the National Fire Protection Association including the National Electrical Code.

2. Electrical Standards: Provide electrical products, which have been tested, listed and labeled by UL and comply with NEMA standards.

3. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for electric control systems.

4. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

J. All bidders must have a minimum of one person dedicated to software generation. This person shall be located in an office local to the project site.

K. The equipment and software proposed by the supplier shall be currently in manufacture. No custom products shall be allowed unless required by the Specification. All products shall be supported by the manufacturer for a minimum of 5 years including spare parts, board repairs and software revisions.

L. The Temperature Control Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others work.

M. It will be the responsibility of this Contractor to work in cooperation with the Owner and with all other contractors and employees rendering such assistance and so arrange his work such that the entire project will be delivered complete in the best possible condition and in the shortest time.

1.12 PROPRIETARY INFORMATION:

A. Project Documentation: All custom software, programs, code, databases, graphic files and drawings (whether hard copy or CADD based files) prepared for this system shall be the exclusive property of the Owner and shall not be reproduced or distributed without prior written permission from the Owner.

B. The use or reference to Owner any of its subsidiaries or any of the facility automation projects shall not be used by the Manufacturer or Contractor in any promotional media, including advertisements, sale brochures, annual reports and client references or endorsements, without prior written permission from the Owner. The Owner reserves the right to restrict or refuse access to any or all of its facilities.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. Provide factory shipping cartons for each piece of equipment, and control device. Maintain cartons through shipping, storage and handling as required to prevent any equipment damage, and to eliminate all dirt and moisture from equipment. Store all equipment and materials inside and protected from weather.

C. System Software: Update to latest version of software at Project completion.

1.14 COORDINATION

A. The controls contractor is responsible for costs/effort required to support the recalibration and rebalancing of existing air terminal boxes to new min/max airflows by the Test and Balance (TAB) contractor.

B. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

C. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

D. Coordinate equipment with Section 23 33 00 Air Duct Accessories to achieve monitoring capability of the fire/smoke dampers.

PART 2 PRODUCTS

2.01 CONTROL SYSTEM

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

1. Johnson Controls, Inc.; Controls Group.

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.02 GENERAL PRODUCTS DESCRIPTION:

A. The Building Automation System (BAS) shall be capable of integrating multiple building function including equipment supervision and control, alarm management, energy management, and historical data collection and archiving. All products and materials installed shall be suitable for the intended application requirements including but not limited to:

1. Accuracy
2. Rangeability
3. Temperature and pressure ranges
4. Shut-off pressures
5. Differential pressures
6. Repeatability
7. Materials of construction suitable with the environment and/or media in which they are in contact with
8. Code compliance
9. Velocities.

B. The BAS shall consist of the following:

1. Standalone DDC panels
2. Standalone application specific controllers (ASCs)
3. High Speed Communication Network (LAN) by Owner.

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, standalone DDC panels, and operator devices.

D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

E. Standalone DDC panels shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC panel or combination of panels on the network without dependence upon a central processing device. Standalone DDC panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

F. Shared points will not be allowed except for outside air temperature, outside air pressure, outside air relative humidity and inside building pressure.

G. BAS shall allow third party software to operate on personal computer workstation without any degradation to the controls operating normally. Third party software will not be allowed on the ADX server/main building server.

2.03 NETWORKING/COMMUNICATIONS:

A. The expansion of the BAS shall utilize networking/communications compatible with BAS infrastructure.

B. Local Area Network

1. Workstation/DDC Panel Support: Operator workstations and DDC panels shall directly reside on a local area network such that communications may be executed between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.

2. Dynamic Data Access: All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.

a. Access to system data shall not be restricted by the hardware configuration of the BAS. The hardware configuration of the BAS network shall be totally transparent to the user when accessing data or developing control programs.

3. General Network Design: Network design shall include the following provisions:

a. High speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. The minimum baud rate shall be 1 Megabaud.

b. Support of any combination of controllers and operator workstations directly connected to the local area network. A minimum of 50 devices shall be supported on a single local area network.

c. Detection and accommodation of single or multiple failures of either workstations, DDC panels, or the network media. The network shall include provisions for automatically reconfiguring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.

d. Message and alarm buffering to prevent information from being lost.

e. Error detection, correction, and retransmission to guarantee data integrity.

f. Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.

g. Commonly available, multiple sourced, networking components and protocols shall be used to allow the BAS to coexist with other networking applications such as office automation. BACNET, MAP, ETHERNET, IBM Token Ring and ARCNET are acceptable technologies.

h. Use of industry standard IEEE 802.x protocol. Communications must be of a deterministic nature to assure calculable performance under worst-case network loading.

i. Synchronization of the realtime clocks in all DDC panels shall be provided.

2.04 STANDALONE DDC PANELS:

A. General: Standalone DDC panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each standalone DDC panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification and the attached point list.

B. Memory: Each DDC panel shall have sufficient memory to support its own operating system and databases including:

1. Control Processes

2. Energy Management Applications

3. Alarm Management

4. Historical/Trend Data for all points

5. Maintenance Support Applications

6. Custom Processes

7. Operator I/O

8. Dial-Up Communications

9. Manual Override Monitoring

C. Point Types: Each DDC panel shall support the following types of point inputs and outputs:

1. Digital Inputs for status/alarm contacts

2. Digital Outputs for on/off equipment control

3. Analog Inputs for temperature, pressure, humidity, flow and position measurements

4. Analog Outputs for valve and damper position control, and capacity control of primary equipment

5. Pulse inputs for pulsed contact monitoring

D. Expandability:

1. The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, field controllers, sensors and actuators.

2. The system architecture shall support a minimum capacity of 20% for all types of DDC panels, and all point types included in the initial installation.

E. Wireless Bluetooth Technology: Standalone DDC panels shall have wireless Bluetooth technology for simultaneous operation of multiple operator I/O devices such as industry standard printers, laptop workstations, etc.

F. Hardware Override Monitoring: DDC panels shall monitor the status or position of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited. DDC panels shall also collect override activity information for daily and monthly reports.

G. Local Status Display Indicator Lamps: The DDC panel shall provide local status indication for each binary input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

H. Integrated On-Line Diagnostics: Each DDC panel shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all subsidiary equipment. The DDC panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each DDC panel, and shall not require the connection of an operator I/O device.

I. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with the latest IEEE Standard 587.

1. Provide ISLATROL active tracking filters or equal, which provides both high and low voltage transients, non-linear characteristics, capable of instantaneously responding to spikes or transients without degradation to the filter or its performance. Power protection device shall be UL listed and have reliability in excess of 100,000 hours of mean time between failures.

2. Signal wiring shall not be installed in same conduit as high voltage wiring.

J. Power Fail Restart:

1. In the event of the loss of power, there shall be an orderly shutdown of all standalone DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

2. Upon restoration of power, the DDC panel shall automatically resume full operation without manual intervention.

3. Should DDC panel memory be lost for any reason, the user shall have the capability of reloading the DDC panel via the local area network or via the local RS-232C port.

2.05 SYSTEM SOFTWARE FEATURES:

A. General

1. All necessary software to form a complete operating system as described in this specification shall be provided.

2. The software programs specified in this section shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher level computer for execution.

B. Control Software Description

1. Pre-Tested Control Algorithms: The DDC panels shall have the ability to perform the following pre-tested control algorithms.

    a. Two Position Control

    b. Proportional Control

    c. Proportional plus Integral Control

    d. Proportional, Integral, plus Derivative Control

    e. Automatic Control Loop Tuning

2. Equipment Cycling Protection; Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.

3. Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

4. Power Fail Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.

C. Energy Management Applications: DDC panels shall have the ability to perform any or all of the following energy management routines.

1. Time of Day Scheduling

2. Calendar Based Scheduling

3. Holiday Scheduling

4. Temporary Schedule Overrides

5. Night Setback Control

6. Enthalpy Switchover (Economizer)

7. Peak Demand Limiting

8. Temperature Compensated Load Rolling

9. Fan Speed/CFM Control

10. Heating/Cooling Interlock

D. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the Execution portion of this specification.

E. Custom Process Programming Capability: DDC panels shall be able to execute custom, job- specific processes defined by the user, to automatically perform calculations and special control routines.

1. Process Inputs and Variables: It shall be possible to use any of the following in a custom process:

a. Any system-measured point data or status

b. Any calculated data

c. Any results from other processes

d. User-Defined Constants

e. Arithmetic functions (+, -, *, /, square root, exp, etc.)

f. Boolean logic operators (and, or, exclusive or, etc.)

g. On-delay/Off-delay/One-shot timers.

2. Process Triggers: Custom processes may be triggered based on any combination of the following:

a. Time interval

b. Time of day

c. Date other processes

d. Time programming

e. Events (e.g., point alarms)

3. Dynamic Data Access:

a. single process shall be able to incorporate measured or calculated data from any and all other DDC panels on the local area network.

b. In addition, a single process shall be able to issue commands to points in any and all other DDC panels on the local area network.

4. Advisory/Message Generation: Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device, buffer the information in a follow-up file, or cause the execution of a dial-up connection to a remote device such as a printer or pager.

5. Custom Process Documentation: The custom control programming feature shall beself-documenting. All interrelationships defined by this feature shall be documented via graphical flowcharts and English language descriptors.

F. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. These alarms shall be added in a manner to match the existing alarm management system. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network.

1. Point Change Report Description: All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.

2. Prioritization: The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided. Each DDC panel shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

3. The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.

4. Report Routing: Alarm reports, messages, and files will be directed to a user-defined list of operator devices, or PCs used for archiving alarm information. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.

5. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 65-character alarm message to more fully describe the alarm condition or direct operator response.

6. Each standalone DDC panel shall be capable of storing a library of a least 250 Alarm

7. Messages. Each message may be assignable to any number of points in the panel.

8. Auto-Dial Alarm Management: In Dial-up applications, only critical alarms shall initiate a call to a remote operator device. In all other cases, call activity shall be minimized by time-stamping and saving reports until an operator scheduled time, a manual request, or until the buffer space is full. The alarm buffer must store a minimum of 50 alarms.

G. Historical Data and Trend Analysis: A variety of Historical Data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways.

1. Continuous Point Histories: Standalone DDC panels shall store Point History Files for all analog and binary inputs and outputs.

2. The Point History routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all points shall be store for the past 24 hours to allow the user to immediately analyze equipment performance and all problem related events for the past day. Point History files for binary input or output points and analog output points shall include a continuous record of the last ten status changes or commands for each point.

3. Control Loop Performance Trends: Standalone DDC panels shall also provide high resolution sampling capability with an operator-adjustable resolution of 10-300 seconds in one second increments for verification of control loop performance.

4. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting operator- specified performance data over extended periods of time. Sample intervals of one minute to two hours, in one-minute intervals, shall be provided. Each standalone DDC panel shall have a dedicated buffer for trend data, and shall be capable of storing a minimum of 500 data samples.

5. Data Storage and Archiving: Trend data shall be stored at the Standalone DDC panels, and uploaded to hard disk storage when archival is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. All trend data shall be available in disk file form for use in 3rd Party person computer applications.

H. Runtime Totalization: Standalone DDC panels shall automatically accumulate and store runtime hours for binary input and output points as specified in the Execution portion of this specification.

1. The Totalization routine shall have a sampling resolution of one minute or less.

2. The user shall have the ability to define a warning limit for Runtime Totalization.

3. Unique, user-specified messages shall be generated when the limit is reached.

I. Analog/Pulse Totalization: Standalone DDC panels shall automatically sample, calculate, and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g. KWH, gallons, KBTU, tons, etc.).

2. The Totalization routine shall have a sampling resolution of one minute or less.

3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

J. Event Totalization: Standalone DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.

1. The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.

2. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

2.06 INTEGRATION FOR BUILDING SYSTEMS:

A. The project will include a fully integrated direct digital building automation and control system (BAS). BAS system installation and all BAS integration will be performed by a single capable contractor. All control components and all integrated and interfaced building systems exchanging data with the BAS as detailed below in the interoperability section will be monitored via a common Graphical User Interface. The Graphical User Interface will be web- based, enabling building operators to securely retrieve and acknowledge alarms and perform full featured operation, programming and monitoring functions via a common web browser from any computer accessing the facility-wide Ethernet TCP/IP LAN/WAN. The BAS will support accessibility both locally via a direct physical connection to the facility-wide LAN/WAN and remotely via a secure Internet or Virtual Private Network (VPN) connection to the facility-wide LAN/WAN. The full operational capabilities of the user interface will be identical for each workstation or laptop accessing the BAS regardless of the computer's physical location ordata connection method. The interface will have full command and control capabilities over all DDC control equipment as well as the integrated/interfaced building systems comprising the complete BAS architecture.

B. Interoperability

1. A significant amount of interoperability between building systems will be provided. Throughout the BAS, data transmission and exchange will be accomplished via IT and BAS industry standard open communication protocols. To accommodate flexibility and future expandability, the BAS will intrinsically support, without the addition of any supplemental hardware or software, the BACnet and LonTalk® industry standard open communication protocols. The scope of building systems incorporated and their level of interoperability are as follows:

    a. Integrated building systems shall connect to the BAS providing coordinated bi- directional control via real-time data exchange using a common communications protocol. Integration shall extend to the operator's workstation software, which shall support user interaction with all building system components. The following building systems shall be fully integrated and all points available through each system's microprocessor panel shall be monitored:
        1) Johnson Controls (Building Automation)
        2) Fireworks Systems (Fire Monitoring Systems)
        3) Leviton Lighting Control System
        4) Oracle Maintenance Management System
        5) Powerex (Medical Vacuum)

2.07 APPLICATION OF SPECIFIC CONTROLLERS - HVAC APPLICATIONS:

A. Each Standalone DDC Controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).

B. Each ASC shall operate as a Standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Points shall not be shared between controllers.

C. Each ASC shall have sufficient memory to support its own operating system and data base including:

    1. Control Processes

    2. Energy Management Applications

    3. Operator I/O (Portable Service Terminal)

D. The operator interface to any ASC point data or programs shall be through any network- resident PC workstation, or any PC or portable operator's terminal connected to any DDC panel in the network.

E. Application Specific Controllers shall directly support the temporary use of a portable service terminal. The capabilities of the portable service terminal shall include, but not be limited to, the following:

    1. Display temperatures

    2. Display status

    3. Display setpoints

    4. Display control parameters

    5. Override binary output control

6. Override analog setpoints

7. Modification of gain and offset constants

F. Power Fail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller.

2.08 AHU CONTROLLERS:

A. AHU Controllers shall support, but not be limited to, the following configurations of systems to address current requirements as described in the Execution portion of this specification, and for future expansion.

1. Large Air Handling Units

a. Mixed Air-Single Path

b. Mixed Air-Dual Path

c. 100% Single Path

d. 100% Dual Path

B. AHU Controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally standalone fashion.

C. AHU Controllers shall have a library of control routines and program logic to perform the sequence operation as specified in the Execution portion of this specification.

D. Occupancy-Based Standby/Comfort Mode Control: Each AHU Controller shall have a provision for occupancy sensing overrides. Based upon the contract status of either a manual wall switch or an occupancy sensing device, the AHU Controller shall automatically select either Standby or Comfort mode to minimize the heating and cooling requirements while satisfying comfort conditions.

E. Continuous Zone Temperature Histories: Each AHU Controller shall automatically and continuously maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

F. Alarm Management: Each AHU Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

2.09 OPERATOR INTERFACE:

A. General: The intent is for any new operator interface to match existing.

B. Basic Interface Description:

1. Command Entry/Menu Selection Process: Operator Workstation interface softwareshall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software.

2. The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

3. Graphical and Text-Based Displays: At the option of the user, Operator Workstations shall provide consistent graphical or text-based displays of all system point and applications data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all workstations.

4. Multiple, Concurrent Displays: The Operator Interface shall provide the ability to simultaneously view several different types of system displays in overlapping windows to speed building analysis. For example, the interface shall provide the ability to simultaneously display a graphic depicting an air handling unit, while displaying the trend graph of several associated space temperatures to allow the user to analyze the system performance. If the interface is unable to display several different types of displays at the same time, the BAS Contractor shall provide at least two operator stations.

5. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display, and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password.

    a. Passwords shall be exactly the same for all operator devices, including portable or panel-mounted network terminals. Any additions or changes made to password definition shall automatically cause passwords at all DDC panels on a network to be updated and downloaded to minimize the task of maintaining system security. Users shall not be required to update passwords for DDC panels individually.

    b. A minimum of five levels of access shall be supported:
        1) Level 1 = Data Access and Display
        2) Level 2 = Level 1 + Operator Overrides
        3) Level 3 = level 2 + Database Modification
        4) Level 4 = Level 3 + Database Generation
        5) Level 5 = Level 4 + Password Add/Modification

    c. A minimum of 50 passwords shall be supported at each DDC panel.

    d. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device, including portable or panel mounted devices, and shall be limited to only those items defined for the access level of the password used to log-on.

    e. User-definable, automatic log-off timers from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

6. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:

    a. Start-up or shutdown selected equipment

    b. Adjust setpoints

    c. Add/Modify/Delete time programming

    d. Enable/Disable process execution

e. Lock/Unlock alarm reporting for each point

f. Enable/Disable Totalization for each point

g. Enable/Disable Trending for each point

h. Override PID loop setpoints

i. Enter temporary override schedules

j. Define Holiday Schedules

k. Change time/date

l. Enter/Modify analog alarm limits

m. Enter/Modify analog warning limits

n. View limits

o. Enable/Disable demand limiting for each meter

p. Enable/Disable duty cycle for each load.

7. Logs and Summaries:

a. Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

b. Reports shall be generated automatically or manually, and directed to either CRT displays, printers, or disk files. As a minimum, the system shall allow the user to easily obtain the following types of reports:
1) A general listing of all points in the network
2) List of all points currently in alarm
3) List of all off-line points
4) List all points currently in override status
5) List of all disabled points
6) List all points currently locked out
7) List of all items defined in "Follow-Up" file
8) List all weekly Schedules
9) List all Holiday Programming
10) List of limits and deadbands

C. Dynamic Color Graphic Displays: Color graphic floor plan displays, and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems, and hot water boiler systems, shall be provided as specified in the Execution portion of this specification to optimize system performance analysis and speed alarm recognition.

1. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.

2. Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.

3. Windowing: The windowing environment of the PC Operator Workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

4. Graphics Definition Package: Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.

   a. The BAS Contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (i.e. fans, cooling coils, filters, dampers, etc.), complete mechanical systems (i.e. constant volume- terminal reheat, VAV, etc.) and electrical symbols.

   b. The graphic development package shall use a mouse or similar pointing devicein conjunction with a drawings program to allow the user to perform the following:
      1) Define symbols
      2) Position and size symbols
      3) Define background screens
      4) Define connecting lines and curves
      5) Locate, orient, and size descriptive text
      6) Define and display colors for all elements
      7) Establish correlation between symbols or text and associated system points or other displays.

   c. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout, or any other logical grouping of points which aid the operator in the analysis of the facility.
      1) To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC panels, including application specific controllers used for DDC unitary or VAV terminal unit control.

D. System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the Operator. System definition and modification procedures shall not interface with normal system operation and control.

   1. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:

      a. Add/Delete/Modify Standalone DDC Panels

      b. Add/Delete/Modify Operator Workstations

      c. Add/Delete/Modify Application Specific Controllers

      d. Add/Delete/Modify points of any type, and all associated point parameters, and tuning constants

      e. Add/Delete/Modify alarm reporting definition for each point.

      f. Add/Delete/Modify control loops

      g. Add/Delete/Modify energy management applications

h. Add/Delete/Modify time and calendar-based programming

i. Add/Delete/Modify Totalization for every point

j. Add/Delete/Modify Historical Data Trending for every point

k. Add/Delete/Modify custom control processes

l. Add/Delete/Modify any and all graphic displays, symbols, and cross-references to point data

m. Add/Delete/Modify dial-up telecommunication definition

n. Add/Delete/Modify all operator passwords

o. Add/Delete/Modify Alarm Messages

2. Programming Description: Definition of operator device characteristics, DDC panels, individual points, applications and control sequences shall be performed through fill-in- the-blank templates and graphical programming approach.

a. Graphical programming shall allow the user to define the software configuration of DDC control logic for HVAC system control sequences, fan interlocks, pump interlocks, PID control loops, and other control relationships through the creation of graphical logic flow diagrams.

b. Graphical Programming: Control sequences are created by using a mouse input device to draw interconnecting (comparisons and mathematical calculations), and outputs of a control sequence. As a minimum, graphic symbols shall be used to represent:
   1) Process Inputs, such as temperature, humidity, or pressure values, status, time, date, or any other measured or calculated system data.
   2) Mathematical Process Operators, such as addition, subtraction, multiplication, or greater than, equal to, less than, etc.
   3) Logical Process Operators such as AND, OR, Exclusive OR, NOT, etc.
   4) Time Delays
   5) Process Control Outputs such as start/stop control points, analog adjust points, etc.
   6) Process Calculation Outputs
   7) Text file Outputs and Advisories

c. Network-Wide Strategy Development: Inputs and outputs for any process shall not be restricted to a single DDC panel, but shall be able to allow the development of all other DDC panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).

d. Sequencing, Testing, and Simulation: A software tool shall be provided, which allows a user to simulate control sequence execution to test strategies before they are actually applied to mechanical systems. Users shall be able to enter hypothetical input data, and verify desired control response and calculation results via graphical displays and hardcopy printouts.

3. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hardcopy printouts of all configuration and application data. Control process and DDC control loop documentation shall be provided in logical, graphical flow diagram format to allow control sequences to be easily interpreted and modified at any time in the future.

4. Database Save/Restore/Back-Up: Back-up copies of all standalone DDC panel databases shall be stored in at least one personal computer operator workstation.

5. Continuous supervision of the integrity of all DDC panel databases shall be provided. In the event that any DDC panel on the network experiences a loss of its data base for any reason, the system shall automatically download a new copy of the respective database to restore proper operation. Database back-up/Download shall occur over the local area network without operator intervention. Users shall also have the ability to manually execute downloads of any or all portions of a DDC panel's database.

2.10 MATERIALS AND EQUIPMENT:

A. General: The Contractor shall provide control products in the sizes and capacities indicated.

B. The existing control system shall remain and be reused as is. Additional controllers, sensors, and devices which are required to make a complete control system shall be the responsibility of the controls contractor.

C. Dampers:

1. Shall be constructed of a minimum of 13 gauge galvanized steel frame, 1/16" extruded aluminum air foil blades, zinc plated steel concealed in frame linkage, zinc plated steel blade pin, oil impregnated bronze bearings, self compensating stainless steel side seals, neoprene blade seals. Leakage rates shall not exceed 7 cfm/ft2 at 4" w.c. static pressure differential for a 24" x 24" damper. Provide extended shaft for proper and adequate actuator connection and operation. Damper blades shall not exceed 6" in height.

2. Damper blade operation shall be as follows:

APPLICATION	OPERATION
Modulating Air Volume Control	Opposed Blade
Mixing Plenum	Parallel Blade
Isolation/Shut-off Service	Parallel Blade

3. Select dampers to fail in normally open or closed positions as follows:

a. Air Handlers:
   1) Return Air: N.O.
   2) Exhaust Air: N.C.
   3) Minimum Outside Air: N.O.
   4) Outside Air (Economizer): N.C.

b. VAV's: Last position

c. Relief Dampers: Last position

D. Automatic Control Valves:

1. Control valves shall have equal percentage plugs. Ball valves may use characterization disks.

2. Control Valve Construction:

a. Small Valves 1/2" through 1": Valves shall be constructed with a cast brass body and screwed ends. Trim shall consist of a removable cage providing valve plug guiding throughout the entire travel range. An alloy stem with brass trim shall be provided. Bonnet, cage and the stem and plug assembly shall be removable for servicing. Body rating shall be 400 psi at 150 deg. F.

b. Valves - 1/2" through 2": Valves shall be constructed with a cast brass body and screwed ends. For some applications where reviewed with the engineer, valves may be selected by the control manufacturer to have either bronze or cast iron bodies with screwed or flanged ends.

3. Control Valve Operators/Actuators:

a. All automatic control valves shall be fully proportioning with modulating plugs for equal percentage of linear flow characteristics and shall be provided with actuators of sufficient power for the duty intended. Valve body and actuator election shall be sufficient to handle system pressure which will be encountered on the project.

b. Where required by the sequence of operation, valves shall be capable of being sequenced either with other valves or other pneumatically actuate devices. Where such sequencing is required the actual spring range, when adjusted for spring shift, shall be such that no overlapping occurs. In the event that spring shift can cause an overlap, a pilot positioning operator shall be furnished.

c. Actuator shall be spring return type.

4. Temperature control contractor and manufacturer shall size control valves for proper control characteristics for each application.

5. Water control valves shall be sized for a pressure drop between 4 to 6 psig at full flow condition.

6. Select valves to fail in normally open or closed position as follows:

a. Terminal Heating Devices:
   1) Offices, Patient Care, Hospital, Public Areas.
   2) Terminal boxes (VAV/CV): Fail in Last Position

b. All humidifier Valves: NC

c. Or as dictated by life safety, freeze protection, humidity, fire or temperature protection.

2.11 INPUTS/OUTPUTS:

A. General: The following section shall be used as a guide for identifying minimum performance requirements. The intent is for the contractor to install devices to match existing.

B. All input accuracies required by this section shall be end-to-end (from sensing point to BAS display). End-to-end accuracy includes all errors due to the sensor, transmitter, wiring and BAS signal measurement and A/D conversion.

C. Thermistors or solid state sensors shall be provided for temperature sensing applications except where accuracies or ranges required cannot be met by these devices, Nickel RTD's shall be used. The sensors shall be powered by the BAS panel or Dedicated Controller. The solid state sensors shall be accurate to within ±1.0deg F. over the following ranges and meet the following requirements:

1. Room Type Instruments: 50deg F to 100deg F. For room space applications: Sensor shall be surface recessed mounted in a plastic aluminum/stainless cover with an insulated baseplate & vandelproof screws.

2. Each thermostat shall have the following features:

a. Exposed/Concealed setpoint adjustment dial with temperature graduation indication.

b. LCD Display.

c. All/Public area thermostats shall be provided with a plastic vented, lockable security cover.

3. Duct & Plenum Applications: -30deg F. to 240deg F. Supply, return, exhaust or mixed air averaging type, which shall have an extended element of sufficient length to cover the entire duct cross-section with a minimum of three passes. If a single averaging thermistor of sufficient length to meet the preceding are not available then two or more sensors and AIs shall be used and averaged in software.

4. Water Temperature Applications: 30deg F to 230deg F.

D. Where RTD's are required, they shall be 1000-ohm nickel type. They shall be accurate to within ±1.0deg F over the range of 32deg F to 600deg F.

E. Where thermocouples are required, they shall be type J and be supplied with a 4-20 mA DC transmitter. They shall be accurate to within ±2.0deg F over the range of 32deg F to 1300deg F.

F. Provide matched temperature sensors for applications which require both inlet and outlet temperatures of any device.

G. Thermowells shall be monel, brass or copper for use in copper water lines; and 300 series stainless steel for all other applications.

H. Outdoor Air Temperature & Humidity Transmitter:

1. Provide relative humidity and temperature probe with membrane filters and UVstabilized solar radiation shield. Probe shall have a temperature measuring range of -40deg F. to +120deg F. with an accuracy of ±.54deg F at 68deg F. and relative humidity measuring range of 0 to 100% RH with an accuracy of 2% 0 to 90% RH with a repeatability better than 1% RH per year. RH and temperature probe shall be capable of a continuous temperature operating range of -40deg F. to +120deg F. Provide necessary transmitter for output signals.

2. Provide 1 spare set of protective filters for each transmitter.

I. Humidity Transmitter:

1. Transmitters shall measure relative humidity from 0-100% RH with repeatable accuracy of ±2% RH. Long range RH stability shall be better than 1% RH/year. Duct mounting enclosure shall be cast aluminum, NEMA 4. Instruments shall be temperature compensated over entire range of operation. Sensor shall utilize the registered HUMICAP H-sensor. Sensor filter shall be membrane type, 18.5 mm. Provide 4-20 mA output signal to building automation control system.

2. Wall Mounted Humidity Transmitter: Transmitter shall measure relative humidity from 0 to 100% RH, ±2% accuracy, wall mounted ABS plastic box, with a long range RH stability better than 1% RH/year and temperature compensated over the entire range. Sensor shall utilize the registered HUMICAP H-sensor. Sensor filter shall be membrane type 18.5 mm and a 4-20 mA output signal.

    a. Provide 1 spare set of filters for each transmitter.

J. Humidity and temperature calibrator kit:

1. Provide Viasala HMK41 Kit for single point calibration of air temperature and humidity transmitters. Kit shall include:

    a. HMI41 Sensor.

    b. HMP46 Probe.

    c. I.S.T. Certificate.

    d. 1911622 Calibration Cable.

    e. Carrying Case.

K. Pressure Sensors, Transmitters and Differential Switches:

1. Pump/Liquid (wet) differential pressure switches shall be as manufactured by Dwyer with neoprene diaphragm, stainless steel internal parts, NEMA 4 housing.

2. Air Differential Pressure Transmitters shall be the Veris PX series (as required) with an accuracy of ±1% of range (including nonlinearity and hysteresis), solid state circuitry, no moving parts, capacitance principle capable of sensing positive, negative and differential pressures. Transmitter shall have 4-20 mA output signal and be powered by the control system or dedicated controller and capable of withstanding momentary overpressure of 8 times the pressure range.

3. Differential air pressure switches for filter or proof of airflow status shall be DwyerSeries 1910, with automatic reset, SPDT or Cleveland.

4. Hi-static pressure safety switches shall be Dwyer series 1900 MR, with manual reset, snap switch, SPDT, with repetitive accuracy within 3%.

5. Water/Liquid/Steam/Refrigerant Pressure Transmitter: Kele & Associates Model SA, stainless pressure transmitter with 4-20 mA output signal, watertight enclosure with stainless steel bulkhead fitting, accuracy of ±1% full scale, temperature compensated, 300 series stainless steel wetted parts.

    a. Provide Model 47S pressure snubber for applications where the transmitter is subjected to fluid hammer, pressure surge or pulsation.

b. Provide Model PT steam syphon pigtail steam applications and where the fluid temperature is higher than the maximum operating temperature rating of the transmitter.

6. Air and Vacuum Pressure Transmitter: Kele & Associates Model P100GTE, solid state, 4-20 mA signal with a full scale accuracy of 1%.

L. Output Devices:

1. Control Relays: Control relay contacts shall be rated for the application, with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage. Provide with LED to indicate status.

2. Analog output transducers shall be of positioning type with position feedback and control internal to the transducer. As an option, position feedback may also be input to the BAS.

3. Analog output transducers shall meet the following requirements:

a. 4-20 mA DC output.

b. Two-pipe electromechanical design or microprocessor-based design.

c. 3-15 psi output range adjustable to a 0-20 psi range minimum.

d. Linearity, repeatability and hysteresis no greater than 2% of full scale.

e. Air capacity of 1000 SCIM minimum.

f. Air consumption of no more than 100 SCIM.

g. Pressure gauges shall be installed on the branch and supply lines.

h. Acceptable transducers are the Bellofram T1000, Fairchild T5700, Johnson

i. N6810, Mamac EP-310 or an equivalent.

4. Electronic analog output transducers shall output a signal to match the controlled device. The Contractor shall be responsible for verifying the required signals for all controlled devices. Transducers shall be completely solid-state with no mechanical parts.

5. Time Delay Relays: Time delay relay contacts shall be rated for the application with a minimum of 2 sets of Form C contacts enclosed is a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Relays shall be equipped with coil transient suppression, devices to limit transients to 150% of rated coil voltage. Delayed contact openings or closing shall be adjustable from 1 to 60 seconds with a minimum accuracy of ±2% of setting.

6. Latching Relays: Latching Relay contacts shall be rated for the application with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage.

2.12 GAUGES:

A. General: Provide air pressure gauges for indication of supply and control air pressure at each branch for all control valve sizes 1" and larger, as well as all control dampers, all controllers, relays and EP and PE switches.

B. Air pressure gauges shall be a minimum of 1-1/2" diameter, resistant to effects of shock, pulsation and vibration, with a full scale accuracy of ±2.5%.

C. Round receiver gauges for continuous indication of analog values shall be 4" dial face instruments. Gauges shall be calibrated in appropriate units for the variable being measured and shall operate through their full range on a change in air pressure from 3 to 15 psi. Accuracy shall be plus or minus 1/2% of full scale.

2.13 POSITIONERS:

A. Positive positioning relays shall be provided on valve actuators and damper operators when required to provide sufficient power, sequencing and repeatability.

B. Provide for smooth gradual operation over operating span adjustment of 0 to 15 psi and start point adjustment of 3 to 10 psi.

2.14 CUMULATORS, SWITCHES AND MISCELLANEOUS ITEMS:

A. Provide all cumulators, switches and other miscellaneous items as may be required for the successful operation of the temperature regulation systems specified herein and/or shown on Drawings.

B. Provide suitable indicating plates with all switches.

C. Pressure/Electric switches shall be micro switch type. Range shall be 0 - 20 psi with electrical rating of 10 amperes minimum for 115V/1/60.

2.15 POWER MONITORING:

A. General: Provide current switches, current transducers, voltage transducers, current transformers as required to meet the specified sequence of operation and indicated below.

B. Current Operated Switches: AC current switch, Neilsen - Kuljian Model PD50AC, or PD75, solid state, 5 year warranty, three selectable ranges for optimum adjustability and resolution. Provide external current transformer where required.

C. Current Transducers: AC current to DC current output, ±.5% accuracy, 4-20 mA output signal, Kele and Associates Model 4CMA. Provide external current transformer where required.

D. application, ±1/2% accuracy, 4-20 mA DC output.

2.16 TEMPERATURE CONTROL CABINETS:

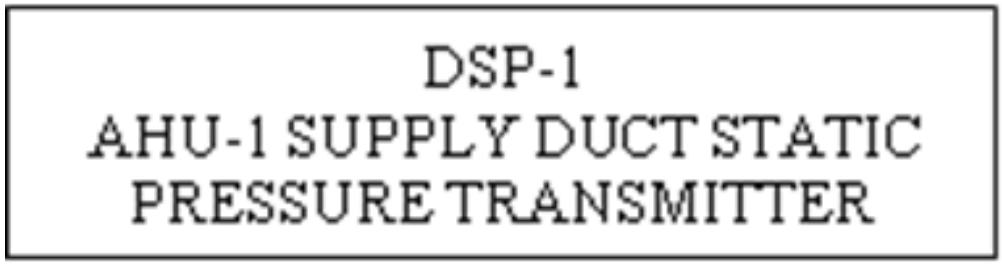
A. General: All controllers and field interface devices shall be installed in control panel cabinet/enclosure as described below.

B. Cabinets shall be UL listed, 14 gauge furniture grade steel, finished with baked enamel painted finish inside and out, cabinet doors shall have piano hinge and standard key cylinder locking latch.

C. Control panels located outdoors shall be NEMA 4X.

D. All devices installed on the control cabinet shall be labeled with a fixed mounted, color contrasted, engraved laminated plastic tags, including describing the function of the device, similar to the following example:

ΔP Transmitter Device Label:



E. All electrical devices within the panel shall be prewired to terminal strips with all inter-device wiring within the panel completed prior to installation of the system.

F. Mount control panels adjacent to associated equipment on vibration free walls or free standing steel angle supports or "Unistrut" support stand.

2.17 VARIABLE FREQUENCY DRIVES:

A. Variable frequency drives shall be arranged so that it can be operated in an open circuit mode, disconnected from the motors, for start-up adjustments and trouble shooting.

B. Automatic operation shall be from a 4-20 milliamp signal follower, which shall follow a transducer signal. The signal follower shall contain the following design features.

1. Shall accept a transducer output signal and condition it to produce a speed reference signal for the invertor.

2. Minimum speed adjustment (Zero to Maximum RPM).

C. Wire all safeties to operate both in hand and auto positions as well as drive and by-pass sections.

D. Provide communication interface necessary to forward VFD computer communication information to and from the BAS/VFD through BACNET. Also see Section 23 05 05.

2.18 HIGH & LOW TEMPERATURE LIMIT CONTROL DEVICES:

A. Provide PENN A70 series or equal, DPST, manual reset, two isolated sets of contacts.

B. Control responds to temperature along any one foot of entire element.

C. Vapor charged sensing element shall be calibrated for altitude of project site.

D. Provide multiple limit control devices as required to provide complete and full coverage of the entire coil face area and/or duct cross section area.

2.19 ELECTRICAL MATERIALS:

A. All wiring installed in inaccessible areas shall be in conduit. Wiring in accessible areas may be in conduit or cable tray. See Division 26 for conduit installation requirements. Where wiring is exposed in plenum locations (i.e. open cable tray, wiring shall be plenum rated.) See Division 27 for cable tray installation requirements.

B. Conduit and Conductors: Types as indicated in Division 26 sized per Division 26 except for low-voltage twisted pair or single jacketed cable (3/4" minimum). All low voltage conductors shall be stranded 22 gauge copper minimum; twisted pair.

C. Fittings per Division 26: Bushings or nylon insulated throats are not required for jacketed cables.

D. All J-boxes shall be identified and labeled per Division 26.

E. All conductors and cables shall be labeled per Division 26.

F. Conduit and box supports shall be per Division 26.

G. Junction boxes shall be of types and sizes as indicated in Division 26.

H. Conduits shall not exceed 40% maximum fill for single conductor and jacketed cables.

I. Fiber Optic Cable:

1. Acceptable fiber optic cable shall include the following sizes; 50/125, 62.5/125 or100/140. Only glass fiber is acceptable, no plastic.

2. Fiber optic cable shall only be installed and terminated by an experienced contractor.

3. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

J. Coaxial Cable:

1. Coaxial cable shall conform to RG62 or RG59 rating.

2. Provide plenum rated coaxial cable when running in return air plenums.

K. All temperature control panels & controllers shall be provided with fuse protection on both incoming power load supply (primary side) and on low voltage side of control transformer (secondary side).

L. Provide lightning arresters Kele & Associates Model 392-SVSR2 or equal, at all points where communication cables exit or enter the building.

M. All communication cabling shall be shielded type.

2.20 POINTS

A. Provide any and all points for the systems to function in accordance with the sequences or as described or implied elsewhere within the specifications or on the drawings.

2.21 END SWITCHES:

A. All end switches shall be NEMA rated contacts, NEMA 4X enclosure if required, either SPDT, DPDT DPST as required to meet the sequence of operation, complete the points list and necessary interlocks or safeties control wiring. End switches shall be as manufactured by Cutler-Hammer, Allen-Bradley, or Kele.

B. All end switches shall be designed and configured to provide positive indication of a control device (i.e. damper or valve) position for the service intended.

2.22 DDC EQUIPMENT

A. Operator Workstation: Existing front-end operator station shall be used.

B. Diagnostic Terminal Unit: Portable notebook-style, PC-based microcomputer terminal capable of accessing system data by connecting to system network with minimum configuration as follows:

1. System: With one integrated USB 2.0 port, integrated Intel Pro 10/100 (Ethernet), integrated audio, bios, and hardware monitoring.

2. Processor: Core i9, 4 GHz.

3. Random-Access Memory: 128 MB.

4. Graphics: Video adapter, minimum 1024 x 768 pixels, 64-MB video memory.

5. Monitor: 17 inches, LCD color.

6. Keyboard: QWERTY 105 keys in ergonomic shape.

7. Hard-Disk Drive: 800 MB.

8. CD-ROM Read/Write Drive: 48x24x48.

9. Pointing Device: Touch pad or other internal device.

C. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.

2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.

b. Discrete/digital, analog, and pulse I/O.

c. Monitoring, controlling, or addressing data points.

d. Software applications, scheduling, and alarm processing.

e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:

a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.

b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.

c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.

d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.

e. Remote communications.

f. Maintenance management.

g. Units of Measure: Inch-pound and SI (metric).

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

5. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

6. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

D. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.

2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.

b. Discrete/digital, analog, and pulse I/O.

c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

4. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

5. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

E. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.

2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.

3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.

4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.

5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.

6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.

7. Universal I/Os: Provide software selectable binary or analog outputs.

F. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.

2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.

3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

G. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.

2. Maximum response time of 10 nanoseconds.

3. Minimum transverse-mode noise attenuation of 65 dB.

4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.23 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.

2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.

3. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.

4. LonWorks Compliance: Communicate using EIA/CEA 709.1 datalink/physical layer protocol using LonTalk protocol.

5. Enclosure: Dustproof rated for operation at 32 to 120 deg F.

6. Enclosure: Waterproof rated for operation at 40 to 150 deg F.

2.24 ALARM PANELS

A. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch- thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. Provide common keying for all panels.

B. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.

1. Alarm Condition: Indicating light flashes and horn sounds.

2. Acknowledge Switch: Horn is silent and indicating light is steady.

3. Second Alarm: Horn sounds and indicating light is steady.

4. Alarm Condition Cleared: System is reset and indicating light is extinguished.

5. Contacts in alarm panel allow remote monitoring by independent alarm company.

C. Refrigerator, Freezer, Cooler Temperature Sensors

1. For use in refrigerators, freezers and coolers to monitor the temperature of the contents instead or the air temperature.

D. Acceptable Manufacturers:

1. Kele ACI A/ - Thermal Vial Temperature Sensor and Transmitter

E. Materials and Construction:

1. Glycol filled vial/bottle with mounting bracket.

2. 1000 OHM platinum RTD sensor. Accuracy +/- 1.5% of span.

3. Operating Range: -58 to 120 □F.

4. Transmitter supply voltage: 18.5 to 32 VDC.

5. Signal output: 4-20 mA

2.25 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:

1. Manufacturers:

a. BEC Controls Corporation.

b. Ebtron, Inc.

c. Heat-Timer Corporation.

d. T.M. Instruments Inc.

e. MAMAC Systems, Inc.

f. RDF Corporation.

2. Accuracy: Plus or minus 0.5 deg F at calibration point.

3. Wire: Twisted, shielded-pair cable.

4. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.

5. Averaging Elements in Ducts: 36 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft.

6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.

7. Room Sensor Cover Construction: Manufacturer's standard locking covers.

a. Set-Point Adjustment: Concealed.

b. Set-Point Indication: Concealed.

c. Thermometer: Concealed.

d. Color: Coordinate with Architect.

e. Orientation: Vertical.

8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

C. RTDs and Transmitters:

1. Manufacturers:

a. BEC Controls Corporation.

b. MAMAC Systems, Inc.

c. RDF Corporation.

2. Accuracy: Plus or minus 0.2 percent at calibration point.

3. Wire: Twisted, shielded-pair cable.

4. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.

5. Averaging Elements in Ducts: 18 inches long, rigid; use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as required.

6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.

7. Room Sensor Cover Construction: Manufacturer's standard locking covers.

a. Set-Point Adjustment: Concealed.

b. Set-Point Indication: Concealed.

c. Thermometer: Concealed.

d. Color: Coordinate with Architect.

e. Orientation: Vertical.

8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

D. Humidity Sensors: Bulk polymer sensor element.

1. Manufacturers:

a. BEC Controls Corporation.

b. General Eastern Instruments.

c. MAMAC Systems, Inc.

d. ROTRONIC Instrument Corp.

e. TCS/Basys Controls.

f. Vaisala.

2. Accuracy: 2 percent full range with linear output.

3. Room Sensor Range: 20 to 80 percent relative humidity.

4. Room Sensor Cover Construction: Manufacturer's standard locking covers.

   a. Set-Point Adjustment: Concealed.

   b. Set-Point Indication: Concealed.

   c. Thermometer: Concealed.

   d. Color: Coordinate with Architect.

   e. Orientation: Vertical.

5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.

6. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of 32 to 120 deg F.

7. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

E. Pressure Transmitters/Transducers:

1. Manufacturers:

   a. BEC Controls Corporation.

   b. General Eastern Instruments.

   c. MAMAC Systems, Inc.

   d. ROTRONIC Instrument Corp.

   e. TCS/Basys Controls.

   f. Vaisala.

2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.

   a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.

   b. Output: 4 to 20 mA.

   c. Building Static-Pressure Range: 0- to 0.25-inch wg.

   d. Duct Static-Pressure Range: 0- to 5-inch wg.

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.

4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.

5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.

6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

F. Room Sensor Cover Construction: Manufacturer's standard locking covers.

1. Set-Point Adjustment: Concealed.

2. Set-Point Indication: Concealed.

3. Thermometer: Concealed.

4. Color: Coordinate with Architect.

5. Orientation: Vertical.

G. Room sensor accessories include the following:

1. Insulating Bases: For sensors located on exterior walls.

2. Guards: Locking; heavy-duty, transparent plastic; mounted on separate base.

3. Adjusting Key: As required for calibration and cover screws.

2.26 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

H. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

1. Manufacturers:

    a. BEC Controls Corporation.

    b. T.M. Instruments Inc.

2.27 GAS DETECTION EQUIPMENT

A. Manufacturers:

1. W. Technologies.

2. CEA Instruments, Inc.

3. Ebtron, Inc.

4. Gems Sensors Inc.

5. Greystone Energy Systems Inc.

6. Honeywell International Inc.; Home & Building Control.

7. INTEC Controls, Inc.

8. T.M. Instruments Inc.

9. MSA Canada Inc.

10. QEL/Quatrosense Environmental Limited.

11. Sauter Controls Corporation.

12. Sensidyne, Inc.

13. TSI Incorporated.

14. Vaisala.

15. Vulcain Inc.

B. Carbon Monoxide Detectors: Single or multichannel, dual-level detectors using solid-state plug-in sensors with a 3-year minimum life; suitable over a temperature range of 32 to 104 deg F; with 2 factory-calibrated alarm levels at 50 and 100 ppm.

C. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.

D. Oxygen Sensor and Transmitter: Single detectors using solid-state zircon cell sensing; suitable over a temperature range of minus 32 to plus 1100 deg F and calibrated for 0 to 5 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.

E. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.

2.28 FLOW MEASURING STATIONS

A. Duct Airflow Station: Combination of air straightener and multiport, self-averaging pitot tube station.

1. Manufacturers:

a. Air Monitor Corporation.

b. Wetmaster Co., Ltd.

2. Casing: Galvanized-steel frame.

3. Flow Straightener: Aluminum honeycomb, 3/4-inch parallel cell, 3 inches deep.

4. Sensing Manifold: Copper manifold with bullet-nosed static pressure sensors positioned on equal area basis.

2.29 THERMOSTATS

A. Manufacturers:

1. Erie Controls.

2. Danfoss Inc.; Air-Conditioning and Refrigeration Div.

3. Heat-Timer Corporation.

4. Sauter Controls Corporation.

5. tekmar Control Systems, Inc.

6. Theben AG - Lumilite Control Technology, Inc.

B. Electric, solid-state, microcomputer-based room thermostat with remote sensor.

1. Automatic switching from heating to cooling.

2. Preferential rate control to minimize overshoot and deviation from set point.

3. Set up for four separate temperatures per day.

4. Instant override of set point for continuous or timed period from 1 hour to 31 days.

5. Short-cycle protection.

6. Programming based on every day of week.

7. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.

8. Battery replacement without program loss.

9. Thermostat display features include the following:

a. Time of day.

b. Actual room temperature.

c. Programmed temperature.

d. Programmed time.

e. Duration of timed override.

f. Day of week.

g. System mode indications include "heating," "off," "fan auto," and "fan on."

C. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

D. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.

2. Selector Switch: Integral, manual on-off-auto.

E. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in water lines with separate wells of same material as bulb.

2. Bulbs in air ducts with flanges and shields.

3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.

4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.

5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.

6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

F. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

G. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.

H. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.

1. Bulb Length: Minimum 20 feet.

2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

I. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.

1. Bulb Length: Minimum 20 feet.

2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

2.30 HUMIDISTATS

A. Manufacturers:

1. MAMAC Systems, Inc.

2. ROTRONIC Instrument Corp.

B. Duct-Mounting Humidistats: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.

2.31 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.

4. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.

5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.

6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Manufacturers:

a. Belimo Aircontrols (USA), Inc.

2. Valves: Size for torque required for valve close off at maximum pump differential pressure.

3. Dampers: Size for running torque calculated as follows:

   a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.

   b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.

   c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.

   d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.

   e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.

   f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

4. Coupling: V-bolt and V-shaped, toothed cradle.

5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.

6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.

7. Power Requirements (Two-Position Spring Return): 24-V ac.

8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.

9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.

10. Temperature Rating: Minus 22 to plus 122 deg F.

11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.

12. Run Time: 12 seconds open, 5 seconds closed.

2.32 CONTROL VALVES

A. Manufacturers:

1. Danfoss Inc.; Air Conditioning & Refrigeration Div.

2. Erie Controls.

3. Hayward Industrial Products, Inc.

4. Magnatrol Valve Corporation.

5. Neles-Jamesbury.

6. Parker Hannifin Corporation; Skinner Valve Division.

B. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

C. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.

2. Thermostatic Operator: Liquid-filled integral sensor with integral adjustable dial.

2.33 DAMPERS

A. Manufacturers:

1. Air Balance Inc.

2. Don Park Inc.; Autodamp Div.

3. TAMCO (T. A. Morrison & Co. Inc.).

4. United Enertech Corp.

5. Vent Products Company, Inc.

B. Dampers: AMCA-rated, parallel-blade design; 0.108-inch- minimum thick, galvanized-steel or 0.125-inch- minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.

1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.

2. Operating Temperature Range: From minus 40 to plus 200 deg F.

3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.

4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

2.34 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Section 27 15 00 "Communications Horizontal Cabling."

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that emergency power supply is available to control units and operator workstation.

B. Verify that duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.02 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. The Contractor shall install all equipment, control air piping/tubing, conduit and wiring parallel to building lines.

E. Install guards on thermostats in the following locations:

1. Entrances.

2. Public areas.

3. Where indicated.

F. Install automatic dampers according to Section 23 33 00 "Air Duct Accessories."

G. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

H. Install labels and nameplates to identify control components according to Section 23 05 53 "Mechanical Identification".

I. All automatic control valves, control dampers, wells, and similar control devices furnished by the Temperature Control Contractor shall be installed under his supervision by the Mechanical Contractor.

J. Install current sensors for fans controlled by VFDs on the load side of the VFD.

K. Install duct volume-control dampers according to Section 23 31 13 "Metal Ducts" and Section 23 31 16 "Nonmetal Ducts."

L. Install electronic and fiber-optic cables according to Section 27 15 00 "Communications Horizontal Cabling."

3.03 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Horizontal runs of conduit, trays, tubing or wiring shall be hung from structural members using new supports, or where feasible, utilizing existing temperature control conduit and piping. The Contractor shall verify adequacy of existing systems and warrant these systems as if they were new. Single runs of conduit, tubing or wire shall be by clevis ring and all thread rod. Multiple runs shall be by "Trapeze" or "Unistrut" supports. "Plumber's Strap" shall not be allowed. Maximum distance between supports shall be per the NEC. Existing supports shall only be used upon written concurrence by the Architect, Engineer or Owner.

B. All vertical runs of conduit or tubing shall be through new core drills. Existing core drills may be used if approved by the Owner. The installation shall be supported above each floor penetration using clamps to "Unistrut".

C. All communication wire that enters or leaves a building structure shall be installed with lightning protection per NEC.

D. All wire terminations shall be with compression type round hole spade lugs under a pan head screw landing; Stay-Kon or equivalent. All wire splices shall be with compression type insulated splice connectors or properly sized "wire-nut" connectors. Hand twisted, soldered and/or taped terminations or splices are not acceptable.

E. Where tubing, wiring or conduit penetrates floors or walls, sleeves with bushings shall be provided for tubing and wires. The conduit or sleeve opening shall be sealed with fire proof packing so the smoke and fire rating of the wall or floor is maintained.

F. Under no circumstances shall wire, tubing, tray, J-boxes or any BAS equipment be run in, mounted on, or suspended from any of the telephone system's equipment, cable trays or support structure (Grey Iron).

G. All the material installed under this contract must be mounted on, or supported from the building structure or supports furnished by this Contractor.

H. Control Wiring:

1. Run wiring in metallic conduit, tubing or raceways. Exceptions are as follows:

   a. NEC Class 2 low voltage wiring where not exposed to view such as above suspended ceilings, in shafts, etc., may be run in cable (when approved by code authority). Run cable in owner approved race-ways or cable supports

   b. Wiring enclosed in temperature control panels.

2. Where conduit is used, provide steel fittings.

3. Low Voltage Conductors: 18 gauge minimum, except 19 gauge may be used for home runs to central panels and 22 gauge minimum for resistance or thermistor sensing element connections.

4. Wire control interlocks and control panels, except one 120V power circuit to each temperature control panel shown on drawings and schedules shall be provided under Division 26. Coordinate with Electrical Contractor.

5. All wiring shall comply with the requirements of local and national electrical codes.

6. Do not interlock alarms with starter switching to bypass alarm when equipment is manually disconnected.

7. Variable frequency drives shall be arranged so that it can be operated in an open circuit mode, disconnected from the motors, for start-up adjustments and trouble shooting.

8. All costs of controls, wiring conduit and associated labor shall be included in the temperature control bid. The control wiring shall be installed under the supervision of this Contractor.

9. Install exposed cable in raceway.

10. Install concealed cable in conduit.

11. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.

12. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

13. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

14. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

I. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

J. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.04 ENCLOSURES:

A. The tubing and wiring within all enclosures shall be run in plastic trays. Tubing and wiring within BAS panels may be run using adhesive-backed tie wraps.

B. All plastic tubing shall be connected to enclosures through conduit. All copper tubing shall be connected to enclosures through bulkhead fittings.

C. Mount all enclosures, including those which house BAS Panels, Slaves and Field Device Panels, so that the top of the enclosure does not exceed six feet, six inches (6'-6"); and the center of any keypad/LCD combination does not exceed five foot, six inches (5'-6") from the floor or is less than four feet zero inches (4'-0") from the floor.

D. Field Device Panels contain related Field Devices such as relays, control power (24V) transformers, output transducers, etc., that are outboard of the BAS Panels or Dedicated Controllers. Each Field Device Panel shall be mounted within an enclosure.

3.05 INSTALLATION PRACTICES:

A. The Contractor shall install and calibrate all Field Devices, sensors and transducers necessary for the complete operation of the I/O points described herein.

B. Sensors shall be removable without shutting down the system in which they are installed unless safety concerns are an issue requiring a lockout our tag-out.

C. All immersion sensors shall be installed in new, welded thermowells supplied by the Contractor. Existing thermowells may be reused with concurrence from the Owner. Coordinate any required shutdown with Owner.

D. Thermistor wire leads shall be permanently terminated at panels or controllers with wire clamps.

E. Where none exist, furnish and coordinate with mechanical contractor the installation of pressure/temperature gauges adjacent to each immersion type sensor.

F. Sensors shall be installed with the use of a wet or hot tap without draining the system if required.

3.06 IDENTIFICATION:

A. All control air piping/tubing, J-boxes, conduit and wiring shall be labeled.

B. Electrical devices, wiring, conduit and J-boxes shall be labeled and identified as required by Division 16.

1. As a minimum regardless of Division 26 requirements, all temperature control J-box covers shall be painted blue.

C. Identification shall be provided for all enclosures, panels, junction boxes, controllers or Field Devices. Except for enclosures, provide Brady labels. The lettering shall be white on a black background with minimum 1/4-inch high letters.

1. All new devices will be tagged. Color code to differentiate between new devices.

D. Thoroughly clean the surface to which the label shall be applied with a solvent before applying the identification.

E. The plan code designation shown on all shop drawing identification shall be consistent with the contract documents.

F. All I/O Field Devices that are not mounted within Field Device Panel enclosures shall be identified with engraved plastic laminated nameplates or Brady labels installed so that they are visible from ground level.

G. The identification shall show the designation used on the record documents and identify the function such as "mixed air temperature sensor" and "fan status DP switch".

H. Calibration settings shall be marked with paint or indelible ink.

3.07 LOCATIONS:

A. All sensing devices and locations shall be located by the Contractor as shown on the submittal shop drawings with final review by the Engineer.

B. Wall mount space sensors shall be mounted five (5) feet above finished floor. Pendant mount space sensors shall be mounted eight (8) feet above finished floor.

C. Enclosures housing Field Devices shall be located, as much as possible, immediately adjacent horizontally to the BAS panels or Slaves which are being interfaced to.

3.08 VALVES, WELLS, FLOW SWITCHES AND AUTOMATIC CONTROL DAMPERS:

A. The Controls Contractor shall have his control equipment on the project site when required and give the Owner 24 hours written notice when systems must be shut down for installation.

3.09 SENSORS:

A. Temperature controls trades shall verify all wall mounted sensor locations with the Architect/ Engineer/Owner in order to avoid interference with wall mounted and space furnishings.

1. Where interferences require moving the temperature sensor more than two feet, consult with the Architect/Engineer for relocation.

2. Do not install wall mounted sensors in decorative, tile or stone walls without specific direction from the Architect or Engineer.

B. Wall mounted temperature sensors shall be mounted in metal wall boxes as specified in, and installed per Division 26. Provide insulation around box where adjacent temperature fluctuations may affect sensor performance.

C. Provide ¾" minimum size conduit from wall box to above accessible ceiling.

D. Check and verify location of thermostats and other exposed control sensors with plans and room details before installation. Locate thermostats 60" above finished floor except for in corridors/hallways which should be 84" above finished floor.

3.10 EQUIPMENT PROTECTION AND COORDINATION:

A. Where existing walls are penetrated with conduit or piping, provide a fire stop assembly which meets or exceeds the original rating of the assembly. Refer to Division 23.

B. A detailed Method of Procedure (MOP) stating the steps to be taken, time schedule and impacted systems for the service interruption shall be submitted to the Architect for approval prior to beginning work. Refer to Division 1 and Division 23 for requirements.

3.11 CLEANUP:

A. At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned and all other areas shall be cleaned around equipment provided under this contract. Clean the exposed surfaces of tubing, hangers, and other exposed metal of all grease, plaster, dust, or other foreign materials.

B. Upon final completion of work in an area, vacuum and/or damp wipe all finished room surfaces and furnishings. Use extreme care in cleaning around telephone switching and computer equipment and under no circumstances shall water or solvents be used around this equipment.

C. At the completion of the work and at the end of each work day, remove from the building, the premises, and surrounding streets, etc., all rubbish and debris resulting from the operations and leave all equipment spaces absolutely clean and ready for use.

3.12 SOFTWARE, DATABASE AND GRAPHICS:

A. Software Installation: The Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this section. This includes any operating system software or other third party software necessary for successful operation of the system.

B. Database Configuration: The Contractor will provide all labor to configure those portions of the database that are required by the points list and sequence of operation.

C. Color Graphics: Unless otherwise directed by the Owner, the Contractor will provide color graphic displays for all systems which are specified with a sequence of operation, depicted in the mechanical drawings for each system and floor plan. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the Owner.

3.13 TEMPERATURE CONTROL DRAWINGS:

A. Upon completion of project and after record drawings of the temperature controls have been prepared and reviewed, the Contractor shall provide one (1) complete set of temperature controls drawings.

3.14 START UP AND TESTING:

A. Prior to Beneficial Use of the BAS, the contractor shall perform virtual testing of the software and the Contractor shall supply to Architect/Engineer two (2) debugged printouts of all software entered into the BAS. Also supply all users programming and engineering manuals required to interpret the software. Included in the printouts, though not limited to, shall be the following:

1. Point data base.

2. All custom control programs written in the BAS control language.

3. All parameters required for proper operation of BAS control and utility firmware such as start-stop routines, etc.

4. Printouts or plotted detailed copies of the complete interactive system graphics.

B. The software printout shall be fully documented for ease of interpretation by the Architect/Engineer and Owner, without assistance from the Contractor. English language descriptions shall be either integrated with or attached to the BAS printout. Specifically, the following shall be documented:

1. All point (I/O and virtual) names.

2. All BAS Programming Language commands, functions, syntax, operators, and reserved variables.

3. Use of all BAS firmware.

4. The intended actions, decisions, and calculations of each line or logical group of lines in the custom control program(s). Sequences of operation are not acceptable for use in this documentation requirement.

5. Complete descriptions of and theories explaining all software and firmware algorithms. The algorithms to be described include, but are not limited to, PID, optimum start/stop, demand limiting, etc.

C. Documentation that was supplied as part of the submittals need not be submitted at this time.

D. Upon review of software, a point-to-point test of the BAS installation shall commence. The Contractor shall provide two men equipped with two-way communication and shall test actual field operation of each control and sensing point. This procedure shall occur during off hour periods. The purpose is to test the calibration, response, and action of every point. Any test equipment required to prove the proper operation of the BAS shall be provided by and operated by the Contractor. The Engineer and/Owner will be present to oversee, observe, and review the test. Demonstrate compliance that system functions per the Sequence of Operation.

1. Upon review of the point-to-point demonstration, the Contractor shall start up the BAS by putting all controlled equipment in automatic and enabling software. Contractor shall commence final software and overall BAS hardware/software debugging.

2. The point-to-point demonstration shall include any existing BAS equipment if it affects the operation of the equipment included under this contract.

3. As a minimum, existing conditions shall be maintained during system changeover.

E. Final acceptance of the BAS is contingent upon a hardware/software system test. All groups of points that yield a system of control shall be tested for compliance with the sequences of operation. Included in the test, but not limited to, shall be:

1. BAS loop response for devices that do not have the autotuning feature. The Contractor shall supply a trend data output in graphical form showing the step response of each BAS loop. The test shall show the loop's response to a change in set point which represents a change in the actuator position of at least 25% of its full range. The sampling rate of the trend shall be from one to three minutes depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that does not yield temperature control of + 0.2deg F or humidity control of + 3% RH shall require further tuning by the Contractor.

2. Interlocks and other sequences.

3. BAS control under HVAC equipment failure.

4. HVAC operation under BAS equipment failure.

5. Battery backup.

6. BAS control under power failure/restart.

7. Reset schedules.

8. BAS alarm reporting capability.

F. A detailed test report as defined under Submittals shall be provided indicating its completion and proper system operation.

G. The BAS will not be accepted as meeting the requirements of Beneficial Use until all tests described in this section have been performed to the satisfaction of both the Architect/Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor shall be exempt from the Beneficial Use requirements if requested in writing by the Contractor and concurred by the Owner and Architect/Engineer. Such tests shall be performed as part of the BAS warranty.

1. A typed written document stating that the system has been fully checked out on a point by point basis shall be submitted to the Architect/Engineer. All documentation associated with the check out shall be included.

3.15 PROJECT RECORD DOCUMENTS:

A. The Contractor shall be responsible for updating all existing Project Record Documents associated with the Scope of Work outlined in the Drawings and Specifications.

B. Prior to final completion of the installation, prepare a complete set of record drawings on a clear and legible set of ANSI size 'B' (11" x 17") prints. The content, format and procedure of the submittal shall be as described by the General Conditions.

C. Provide one set of control drawings for the Facility Control Room, locate as directed by the Engineer.

D. Prior to final completion of the installation, prepare three (3) operation and maintenance manuals. The information is to be inserted in the existing operation and maintenance manuals or provided in a tabbed and indexed, 3 ring binder. The information shall include:

1. Operator's manual with step-by-step procedures for logging on/off, interrogating the system, producing reports, acknowledging alarms, overriding computer control, and changing firmware parameters.

2. Programmer's manual with complete description of the custom control language and associated editor, including sample written programs. Provide complete sets of all programming forms, applications memorandums, and addenda to the programmer's manual. All software or firmware algorithms shall be completely described and documented.

3. Maintenance, Installation, and Engineering manual(s) that clearly explains how to debug hardware problems, how to repair or replace hardware, preventive maintenance guidelines and schedules, calibration procedures, and how to engineer and install new points, panels, and Operator Interfaces.

4. Documentation of all software including software parameters that will need updating by the Owner such as, though not limited to, holiday, seasonal and start/stop schedules, comfort and duty cycling schedules.

5. All programs, code, databases, graphic files, CADD drawings and symbol libraries generated for operation of the system shall be included as a part of the system documentation. This information shall be submitted both in hard copy bound format and digital media format.

6. Input/output schedules, data sheets, and all other items required under Submittals.

7. Describe all regular maintenance that will need to be performed on the BAS hardware. List replacement parts with part numbers.

8. Complete original issue documentation and software diskettes for all third party software furnished and installed as a part of the system or required for the operation of the system including text editors, control language program and compiler, database managers, graphics and CADD packages, operating systems and communications software.

9. Complete original issue documentation, installation and operational manuals and supporting software for all third party hardware furnished and installed as a part of the system or required for the operation of the system including remote terminals, user's computer workstation, monitors, graphics and memory boards, printers and modems.

10. During the warranty period, all copies of the drawings and manuals shall be updated to include all hardware and software changes. A final update at 1 year shall be provided to the Owner.

E. All of the above documentation shall record both the equipment installed under this contract and the exact termination to all other existing control or BAS equipment.

F. The record drawings shall document the complete existing control system. This includes all mechanical equipment in work area which has automatic control.

3.16 WARRANTY:

A. The Warranty period shall begin on the date of beneficial use completion as authorized by the Architect/Engineer and Owner in writing. Beneficial use shall not occur before the Contractor has performed the tests required. With these requirements met, beneficial use shall not occur until, in the opinion of the Architect/Engineer, the BAS is sufficiently complete to be utilized for the purposes for which it is intended.

1. There shall be a warranty start date after each of the three main phases of the Project is complete – East Addition, West Addition, Remodel.

B. The BAS system shall be guaranteed to be free from defects in material and workmanship and in software design and operation for a period of the warranty after completion of the contract. The Contractor shall provide the necessary skills, labor, and parts to assure the proper operation of, and to provide all required current and preventive maintenance. This warranty shall become effective starting the date of Beneficial Use completion.

1. The hardware warranty shall include all equipment which has been purchased by the Contractor. The existing hardware is not subject to the warranty requirements.

2. All software work completed by the Contractor, associated with existing hardware, is subject to the warranty requirements outlined herein.

3. The Contractor shall respond to all calls during the warranty period for all problems or questions experienced in the operation of the installed equipment and shall take steps to correct any deficiencies that may exist.

4. The response time to any problems shall be four (4) hours maximum 24 hours per day, 7 days per week. Corrective action, temporary or permanent shall be made within one business day.

C. The Contractor shall perform an on-site or remote internet inspection of the operation of the system 3 months after each phase is completed. They shall report to the Owner in writing after each inspection, define any problems with the system and its operation, and define the procedure which will be taken to correct the problem. Contractor shall comment on the possible resolution of any problems that are out of the scope of their Contract.

1. Any problems shall be corrected as required by the warranty requirements.

D. The system shall be polled via the internet inspection for any alarm signals or "abnormal off" messages. Upon receiving such a message, the Contractor shall take indicated corrective action.

E. The Contractor shall maintain a backup of all BAS software installed in the system. The backup shall be updated monthly or whenever a change to the software is made. A reload of backup software into the system shall be performed by the Contractor immediately upon notification by the Owner. The reload shall be free of charge unless it is due to a power failure of a duration longer than the battery backup.

F. The Contractor shall optimize all control software to assure acceptable operating and space conditions, and peak energy efficiency.

G. At the end of the warranty period, the Contractor shall supply updated copies of the latest versions of all Project Record Documentation. This includes final updated drawings, software documentation and magnetic media backups that include all changes that have been made to the system during the warranty period.

3.17 TRAINING:

A. The Contractor shall provide 20 hours of training for the building operators with no limit to the number of attendees. The training sessions shall be broken into no more than (10) 2-hour sessions. The training session shall be made available to the Owner prior to the end of the warranty period but after final completion of the contract. The session shall be given at the Owner's facility. Scheduling shall be approved by the Owner. The training shall focus on general design, operation, and maintenance procedures of the products installed, though not necessarily the specific system designed, and shall cover:

1. Hardware configuration including PC boards, switches, communication and point wiring, and location and installation of all sensors and control devices.

2. Hardware maintenance, calibration, troubleshooting, diagnostics, and repair instructions.

3. Operation of man-machine interface including logging on/off, interrogating the system, producing reports, acknowledging alarms, overriding computer control, and changing firmware/software parameters.

4. Programming the BAS using the editor and the design of custom control software.

5. Recovery procedures from both BAS and HVAC failures.

3.18 THE INSTRUCTOR FOR THE ABOVE SESSION SHALL BE AN EMPLOYEE OF THE CONTRACTOR, WHO IS QUALIFIED TO PROVIDE CUSTOMER TRAINING AND APPLICATIONS SUPPORT.

3.19 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.

2. Test and adjust controls and safeties.

3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

4. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

5. Test each point through its full operating range to verify that safety and operating control set points are as required.

6. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.

7. Test each system for compliance with sequence of operation.

8. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.

2. Check instruments for proper location and accessibility.

3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.

4. Check instrument tubing for proper fittings, slope, material, and support.

5. Check installation of air supply for each instrument.

6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.

7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.

8. Check temperature instruments and material and length of sensing elements.

9. Check control valves. Verify that they are in correct direction.

10. Check DDC system as follows:

a. Verify that DDC controller power supply is from emergency power supply, if applicable.

b. Verify that wires at control panels are tagged with their service designation and approved tagging system.

c. Verify that spare I/O capacity has been provided.

d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.20 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.

2. Make three-point calibration test for both linearity and accuracy for each analog instrument.

3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

4. Control System Inputs and Outputs:

a. Check analog inputs at 0, 50, and 100 percent of span.

b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.

c. Check digital inputs using jumper wire.

d. Check digital outputs using ohmmeter to test for contact making or breaking.

e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.

b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.

b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.

b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.

9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.

10. Provide diagnostic and test instruments for calibration and adjustment of system.

11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions.

3.21 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Section 01 79 00 "Demonstration and Training."

END OF SECTION 230900

SECTION 232923 - VARIABLE FREQUENCY CONTROLLERS FOR HVAC

PART 1 -GENERAL

1.01 SUMMARY

A. Section includes separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

B. See Division 26 Section "Motor-Control Centers" for VFCs installed in motor-control centers.

1.02 DEFINITIONS

A. BAS: Building automation system.

B. CE: Conformite Europeene (European Compliance).

C. CPT: Control power transformer.

D. EMI: Electromagnetic interference.

E. IGBT: Insulated-gate bipolar transistor.

F. LAN: Local area network.

G. LED: Light-emitting diode.

H. MCP: Motor-circuit protector.

I. NC: Normally closed.

J. NO: Normally open.

K. OCPD: Overcurrent protective device.

L. PID: Control action, proportional plus integral plus derivative.

M. PWM: Pulse-width modulated.

N. RFI: Radio-frequency interference.

O. VFC: Variable-frequency motor controller.

1.03 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

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

1.04 SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

B. LEED Submittals:

1. Product Data for Credit EA 5: For continuous metering equipment for energy consumption.

C. Shop Drawings: For each VFC indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings.

2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

D. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

E. Seismic Qualification Certificates: For VFCs, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

F. Product certificates.

G. Source quality-control reports.

H. Field quality-control reports.

I. Operation and maintenance data.

1.05 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. IEEE Compliance: Fabricate and test VFC according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical."

1.06 WARRANTY

A. Special Warranty: Manufacturer`s standard form in which manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 -PRODUCTS

2.01 MANUFACTURED UNITS

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

1. ABB.

2. Baldor Electric Company.

3. Danfoss Inc.; Danfoss Drives Div.

4. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

5. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

6. Rockwell Automation, Inc.; Allen-Bradley Brand.

7. Siemens Energy & Automation, Inc.

8. Square D; a brand of Schneider Electric.

9. Toshiba International Corporation.

10. Yaskawa Electric America, Inc; Drives Division.

B. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

C. Application: Constant torque and variable torque.

D. VFC Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."

2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."

3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

E. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

F. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

G. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.

2. Input AC Voltage Unbalance: Not exceeding 3 percent.

3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.

4. Minimum Efficiency: 96 percent at 60 Hz, full load.

5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.

6. Minimum Short-Circuit Current (Withstand) Rating: 10 kA.

7. Ambient Temperature Rating: Not less than 14 deg F and not exceeding 104 deg F.

8. Ambient Storage Temperature Rating: Not less than minus 4 deg F and not exceeding 140 deg F

9. Humidity Rating: Less than 95 percent (noncondensing).

10. Altitude Rating: Not exceeding 3300 feet.

11. Vibration Withstand: Comply with IEC 60068-2-6.

12. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

13. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.

14. Speed Regulation: Plus or minus 5 percent.

15. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.

16. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

H. Inverter Logic: Microprocessor based, 16 bit, isolated from all power circuits.

I. Isolated Control Interface: Allows VFCs to follow remote-control electrical signal over a minimum 40:1 speed range.

J. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.

2. Maximum Speed: 80 to 100 percent of maximum rpm.

3. Acceleration: 0.1 to 999.9 seconds.

4. Deceleration: 0.1 to 999.9 seconds.

5. Current Limit: 30 to minimum of 150 percent of maximum rating.

K. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.

2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.

3. Under- and overvoltage trips.

4. Inverter overcurrent trips.

5. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.

6. Critical frequency rejection, with three selectable, adjustable deadbands.

7. Instantaneous line-to-line and line-to-ground overcurrent trips.

8. Loss-of-phase protection.

9. Reverse-phase protection.

10. Short-circuit protection.

11. Motor overtemperature fault.

L. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

M. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

N. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

O. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

P. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

Q. Integral Input Disconnecting Means and OCPD: NEMA AB 1, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of VFC input current rating.

2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.

2.02 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.

2. Run.

3. Overvoltage.

4. Line fault.

5. Overcurrent.

6. External fault.

B. Panel-Mounted Operator Station: Manufacturer`s standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.

2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Running log of total power versus time.

2. Total run time.

3. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).

2. Motor speed (rpm).

3. Motor status (running, stop, fault).

4. Motor current (amperes).

5. Motor torque (percent).

6. Fault or alarming status (code).

7. PID feedback signal (percent).

8. DC-link voltage (V dc).

9. Set point frequency (Hz).

10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

a. A minimum of two programmable analog inputs: 0- to 10-V dc.

b. A minimum of six multifunction programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:

a. 0- to 10-V dc.

b. 4- to 20-mA dc.

c. Potentiometer using up/down digital inputs.

d. Fixed frequencies using digital inputs.

e. Insert signal input.

3. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc), which can be configured for any of the following:

a. Output frequency (Hz).

b. Output current (load).

c. DC-link voltage (V dc).

d. Motor torque (percent).

e. Motor speed (rpm).

f. Set point frequency (Hz).

g. Insert indication.

4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

a. Motor running.

b. Set point speed reached.

c. Fault and warning indication (overtemperature or overcurrent).

d. PID high- or low-speed limits reached.

e. Insert indication.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

1. Number of Loops: One.

G. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms and energy usage. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC`s nonvolatile memory.

1. Network Communications Ports: Ethernet and RS-422/485.

2. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet; protocols accessible via the communications ports.

2.03 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Insert requirements.

B. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

2.04 BYPASS SYSTEMS

A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

B. Bypass Mode: Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor and retransfer shall only be allowed with the motor at zero speed.

C. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.

D. Bypass Controller: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

1. Bypass Contactor: Load-break, IEC-rated contactor.

2. Output Isolating Contactor: Non-load-break, IEC-rated contactor.

3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

E. Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.

1. Bypass Contactor: Load-break, IEC-rated contactor.

2. Input and Output Isolating Contactors: Non-load-break, IEC-rated contactors.

3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

F. Bypass Contactor Configuration: Full-voltage (across-the-line) type.

1. NORMAL/BYPASS selector switch.

2. HAND/OFF/AUTO selector switch.

3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.

4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer`s standard matching control power or line voltage.

b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

a. CPT Spare Capacity: 50 VA.

6. Overload Relays: NEMA ICS 2.

2.05 OPTIONAL FEATURES

A. Damper control circuit with end of travel feedback capability.

B. Firefighter`s Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station, this password-protected input:

1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).

2. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.

3. Forces VFC to transfer to Bypass Mode and operate motor at full speed.

4. Causes display of Override Mode on the VFC display.

5. Reset VFC to normal operation on removal of override signal automatically.

C. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

D. Insert optional feature.

2.06 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.

2. Outdoor Locations: Type 3R.

3. Kitchen Areas: Type 4X, stainless steel.

4. Other Wet or Damp Indoor Locations: Type 4.

5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.07 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oil-tight type.

B. Push Buttons: Covered types; maintained.

1. Pilot Lights: Incandescent types; Insert color(s); push to test.

a. Selector Switches: Rotary type.

C. NC bypass contactor auxiliary contact(s).

D. Control Relays: Auxiliary and adjustable pneumatic time-delay relays.

E. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

F. Supplemental Analog Meters:

1. Elapsed time meter.

2. Kilowatt meter.

3. Kilowatt-hour meter.

G. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

H. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

I. Cooling Fan and Exhaust System: For NEMA 250, Type 1; UL 508 component recognized: Supply fan, with composite intake and exhaust grilles and filters; 120-V ac; obtained from integral CPT.

2.08 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2 .

1. Test each VFC while connected to its specified motor.

2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 -EXECUTION

3.01 INSTALLATION

A. Wall-Mounting Controllers: Install VFCs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical."

B. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

1. Curbs and roof penetrations are specified in Division 07 Section "Roof Accessories."

2. Structural-steel channels are specified in Division 26 Section "Hangers and Supports for Electrical."

C. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in each fusible-switch VFC.

F. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."

G. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

I. Comply with NECA 1.

3.02 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Electrical Identification."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each VFC with engraved nameplate.

3. Label each enclosure-mounted control and pilot device.

3.03 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Division 26 Section "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.

2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.04 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.

2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.

3. Test continuity of each circuit.

4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect before starting the motor(s).

5. Test each motor for proper phase rotation.

6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. VFCs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.05 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.

D. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner`s maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 232923

SECTION 233113 - METAL DUCTS

PART 1 -GENERAL

1.01 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.

2. Single-wall round ducts and fittings.

3. Sheet metal materials.

4. Sealants and gaskets.

5. Hangers and supports.

1.02 PERFORMANCE REQUIREMENTS

A. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible".

1.03 SUBMITTALS

A. Informational Submittals

1. Shop Drawings:

a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.

b. Factory- and shop-fabricated ducts and fittings.

c. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.

d. Elevation of top of ducts.

e. Dimensions of main duct runs from building grid lines.

f. Fittings.

g. Reinforcement and spacing.

h. Seam and joint construction.

i. Penetrations through fire-rated and other partitions.

j. Equipment installation based on equipment being used on Project.

k. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.

l. Hangers and supports, including methods for duct and building attachment[<>] and vibration isolation.

2. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

a. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.

b. Suspended ceiling components.

c. Structural members to which duct will be attached.

d. Size and location of initial access modules for acoustical tile.

e. Penetrations of smoke barriers and fire-rated construction.

f. Items penetrating finished ceiling including the following:
1) Lighting fixtures.
2) Air outlets and inlets.
3) Speakers.
4) Sprinklers.
5) Access panels.
6) Perimeter moldings.

B. Close Outs

1. Field quality-control reports.

1.04 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.

2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 -PRODUCTS

2.01 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible."

2.02 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.

2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible."

2.03 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.

2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

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

2.04 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.

2. Solids Content: Minimum 65 percent.

3. Shore A Hardness: Minimum 20.

4. Water resistant.

5. Mold and mildew resistant.

6. VOC: Maximum 75 g/L (less water).

7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.

8. Service: Indoor or outdoor.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.

2. Type: S.

3. Grade: NS.

4. Class: 25.

5. Use: O.

6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

E. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.

2.05 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Strap and Rod Sizes: Comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

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

F. Trapeze and Riser Supports:

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

PART 3 -EXECUTION

3.01 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

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

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

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA`s "Duct Cleanliness for New Construction Guidelines."

3.02 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible."

3.03 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.

2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

C. Hanger Spacing: Comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports. Trim threaded rods to no more than 1” overrun.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum interval of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

G. Insulated Duct:

1. Attach spacers to duct.

a. Duct Operating Above Ambient Air Temperature: Hangers and supports may project through insulation.

b. Duct Operating Below Ambient Air Temperature: Use thermal-hanger shield insert. Provide protection saddle shield insert, minimum 4 inch, 180 degrees for round duct and a minimum of 4” turn up on rectangular duct.

c. Insert Material: Length of at least as long as protective shield.

d. Thermal Hanger Shields: Install with insulation same thickness as duct insulation.

3.04 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 23 Section "Duct Accessories."

B. Comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.05 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.06 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA`s "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.

2. Test representative duct sections totaling no less than 25 percent of total installed duct area for each system.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

4. Test for leaks before applying external insulation.

5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.

6. Give seven days` advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.

2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.07 DUCT CLEANING

A. The following shall be used if new ductwork fails duct system cleanliness tests.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section " Duct Accessories" for access panels and doors.

2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.

3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.

2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).

2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.

3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.

4. Coils and related components.

5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.

6. Supply-air ducts, dampers, actuators, and turning vanes.

7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.

3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.

4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

6. Provide drainage and cleanup for wash-down procedures.

7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer`s written instructions after removal of surface deposits and debris.

3.08 START UP

A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.09 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Supply Ducts:

a. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
1) Pressure Class: Positive 2-inch wg.
2) Minimum SMACNA Seal Class: A.
3) SMACNA Leakage Class for Rectangular: 12.
4) SMACNA Leakage Class for Round and Flat Oval: 6.

b. Ducts Connected to Variable-Air-Volume Air-Handling Units:
1) Pressure Class: 125% of scheduled total static capability of fan or AHU.
2) Minimum SMACNA Seal Class: A.
3) SMACNA Leakage Class for Rectangular: 6.
4) SMACNA Leakage Class for Round and Flat Oval: 3.

c. Ducts Connected to Equipment Not Listed Above:
1) Pressure Class: Positive 4-inch wg.
2) Minimum SMACNA Seal Class: A.
3) SMACNA Leakage Class for Rectangular: 6.
4) SMACNA Leakage Class for Round and Flat Oval: 3.

2. Return Ducts:

a. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
1) Pressure Class: Positive or negative 2-inch wg.
2) Minimum SMACNA Seal Class: A.

3) SMACNA Leakage Class for Rectangular: 12.
4) SMACNA Leakage Class for Round and Flat Oval: 6.

b. Ducts Connected to Air-Handling Units:
1) Pressure Class: 125% of scheduled total static capability of fan or AHU.
2) Minimum SMACNA Seal Class: A.
3) SMACNA Leakage Class for Rectangular: 6.
4) SMACNA Leakage Class for Round and Flat Oval: 3.

c. Ducts Connected to Equipment Not Listed Above:
1) Pressure Class: Positive 4-inch wg.
2) Minimum SMACNA Seal Class: A.
3) SMACNA Leakage Class for Rectangular: 6.
4) SMACNA Leakage Class for Round and Flat Oval: 3.

3. Exhaust Ducts:

a. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
1) Pressure Class: 125% of scheduled total static capability of fan.
2) Minimum SMACNA Seal Class: A.
3) SMACNA Leakage Class for Rectangular: 12.
4) SMACNA Leakage Class for Round and Flat Oval: 6.

b. Ducts Connected to Equipment Not Listed Above:
1) Pressure Class: Scheduled total static capability of fan.
2) Minimum SMACNA Seal Class: A.
3) SMACNA Leakage Class for Rectangular: 12.
4) SMACNA Leakage Class for Round and Flat Oval: 6.

4. Intermediate Reinforcement:

a. Exposed to Airstream: Match duct material.

b. Not Exposed to Airstream: Match duct material.

B. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm or Lower:
1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm:
1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm or Higher:
1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Round Duct: Comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

    a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
        1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
        2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
        3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

    b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.

    c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or welded.

C. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connections."

    a. Rectangular Main to Rectangular Branch: 45-degree entry.

    b. Rectangular Main to Round Branch: Conical spin in.

2. Round and Flat Oval: Comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

    a. Velocity 1500 fpm or Lower: Conical tap.

    b. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - DUCT ACCESSORIES

PART 1 -GENERAL

1.01 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Fire dampers.
4. Combination fire and smoke dampers.
5. Remote damper operators.
6. Duct-mounted access doors.
7. Flexible connectors.
8. Flexible ducts.
9. Duct accessory hardware.

1.02 SUBMITTALS

A. Action Submittals

1. Product Data: For each of the following:

a. Fire Dampers, Smoke Dampers, Combination Fir and Smoke Dampers

B. Informational Submittals

1. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

a. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
1) Special fittings.
2) Manual volume damper installations.
3) Control damper installations.
4) Fire-damper, smoke-damper, combination fire- and smoke-damper, and ceiling installations, including sleeves; and duct-mounted access doors and remote damper operators.
5) Duct security bars.
6) Wiring Diagrams: For power, signal, and control wiring.

2. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

C. Close Outs

1. Source quality-control reports.

2. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.03 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with AMCA 500-D testing for damper rating.

PART 2 -PRODUCTS

2.01 MATERIALS

A. Comply with SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60.

2. Exposed-Surface Finish: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316 to match duct system material, and having a finish matching that of the associated ductwork.

D. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.

E. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

F. Reinforcement Shapes and Plates: ASTM A36 galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie Rods: ASTM A36 galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.02 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by air moving equipment manufacturer or one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.

2. Greenheck Fan Corporation.

3. Nailor Industries Inc.

4. NCA Manufacturing, Inc.

5. Pottorff; a division of PCI Industries, Inc.

6. Ruskin Company.

B. Description: Gravity balanced parallel blade.

C. Ratings:

1. Leakage:

a. Dampers shall have a maximum leakage of 10 cfm @ 1 in. wg. Tested in accordance with AMCA standard 500-D.

2. Differential Pressure:

a. Dampers shall have a maximum differential pressure rating of 10 in. wg.

3. Velocity:

a. Dampers shall have a maximum velocity rating of 3500 fpm.

D. Construction:

1. Extruded aluminum frame with multiple single-piece blades, maximum 6-inch width, extruded aluminum with sealed edges, extruded vinyl or neoprene, mechanically locked blade seals, aluminum axels with synthetic sleeve bearings.

E. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.

2. Adjustable tension spring return.

3. Counterweights and spring-assist kits for vertical airflow installations.

4. 90-degree stops.

2.03 MANUAL VOLUME DAMPERS

A. Standard, Manual Volume Dampers:

1. Standard leakage rating, with linkage outside airstream.

2. Suitable for horizontal or vertical applications.

3. Frames:

a. Material and construction shall match that of the duct system. Fabricate in accordance with SMACNA Duct Construction Standards, and as indicated.

4. Blades and Blade Axles:

   a. Material and construction shall match that of the duct system. Fabricate in accordance with SMACNA Duct Construction Standards, and as indicated.

   b. Multiple or single blade. Single blades shall be limited to 12” in height/diameter.

   c. Parallel- or opposed-blade design.

   d. Stiffen damper blades for stability.

5. Bearings:

   a. Molded synthetic.

   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

B. Damper Hardware:

1. Provide locking quadrant regulators on single and multi-blade dampers.

2. On insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

2.04 FIRE DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.

2. Arrow United Industries; a division of Mestek, Inc.

3. Greenheck Fan Corporation.

4. McGill AirFlow LLC.

5. METALAIRE, Inc.

6. Nailor Industries Inc.

7. NCA Manufacturing, Inc.

8. Pottorff; a division of PCI Industries, Inc.

9. Prefco; Perfect Air Control, Inc.

10. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

1. Where dampers are located in aluminum or stainless steel duct, provide stainless steel dampers.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.052 or 0.138 inch thick, as indicated, and of length to suit application.

a. Where dampers are located in aluminum or stainless steel duct, provide stainless steel dampers.

2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. 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.

1. Where dampers are located in aluminum or stainless steel duct, provide stainless steel dampers.

I. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.05 COMBINATION FIRE AND SMOKE DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.

2. Arrow United Industries; a division of Mestek, Inc.

3. Greenheck Fan Corporation.

4. McGill AirFlow LLC.

5. METALAIRE, Inc.

6. Nailor Industries Inc.

7. NCA Manufacturing, Inc.

8. Pottorff; a division of PCI Industries, Inc.

9. Prefco; Perfect Air Control, Inc.

10. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

1. Where dampers are located in aluminum or stainless steel duct, provide stainless steel dampers.

F. Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated.

G. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

1. Where dampers are located in aluminum or stainless steel duct, provide stainless steel dampers.

H. Leakage: Class I.

I. Rated pressure and velocity to exceed design airflow conditions.

J. Mounting Sleeve: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application.

1. Where dampers are located in aluminum or stainless steel duct, provide stainless steel dampers.

K. Damper Motors: two-position action.

L. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 22 Section "Common Motor Requirements for Mechanical."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.

5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.

6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.

7. Electrical Connection: 115 V, single phase, 60 Hz.

M. Accessories:

1. Auxiliary switches for signaling.

2. Momentary test switch, damper mounted.

2.06 REMOTE DAMPER OPERATORS

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

1. Pottorff; a division of PCI Industries, Inc.

2. Ventfabrics, Inc.

3. Young Regulator Company.

B. Description: Cable system designed for remote manual damper adjustment.

C. Tubing: Brass.

D. Cable: Stainless steel.

2.07 DUCT-MOUNTED ACCESS DOORS

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

1. American Warming and Ventilating; a division of Mestek, Inc.

2. Ductmate Industries, Inc.

3. Flexmaster U.S.A., Inc.

4. Greenheck Fan Corporation.

5. McGill AirFlow LLC.

6. Nailor Industries Inc.

7. Pottorff; a division of PCI Industries, Inc.

8. Ventfabrics, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."

1. Door:

a. Double wall, rectangular.

b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.

c. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.

d. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.

b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.

c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.

d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.

2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.

3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.

4. Factory set at 10-inch wg.

5. Doors close when pressures are within set-point range.

6. Hinge: Continuous piano.

7. Latches: Cam.

8. Seal: Neoprene or foam rubber.

9. Insulation Fill: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.08 FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.

2. Duro Dyne Inc.

3. Ventfabrics, Inc.

4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3 inches wide attached to 2 strips of 3-inch-wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 30 oz./sq. yd..

2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.

3. Service Temperature: Minus 40 to plus 200 deg F.

F. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.

2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.09 FLEXIBLE DUCTS

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

1. Flexmaster U.S.A., Inc.

2. McGill AirFlow LLC.

3. Thermaflex.

4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Noninsulated, Flexible Duct: UL 181, Class 1, multiple layer of aluminum laminate supported by helically wound spring steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.

2. Maximum Air Velocity: 4000 fpm.

3. Temperature Range: Minus 20 to plus 210 deg F.

C. Insulated, Flexible Duct: UL 181, Class 1, multiple layer of aluminum laminate supported by helically wound spring steel wire, insulated; with vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.

2. Maximum Air Velocity: 4000 fpm.

3. Temperature Range: Minus 20 to plus 210 deg F.

4. Insulation R-value: Comply with ASHRAE/IESNA 90.1

D. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

2.10 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 -EXECUTION

3.01 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA`s "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated. Gravity backdraft dampers are acceptable for fans operating below 300 cfm.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.

2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire, smoke and combination fire and smoke dampers according to UL listing.

H. Connect ducts to duct silencers with flexible duct connectors.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.

2. Upstream and downstream from duct filters.

3. At outdoor-air intakes and mixed-air plenums.

4. At drain pans and seals.

5. Downstream from control dampers, backdraft dampers, and equipment.

6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.

J. Install access doors with swing against duct static pressure.

K. Access Door Minimum Sizes:

1. Hand Access: 24 by 24 inches. Where duct is less than 24 inches, use largest size allowable.

2. Head and Hand Access: 18 by 16 inches.

3. Head and Shoulders Access: 21 by 16 inches.

4. Body Access: 25 by 16 inches.

5. Body plus Ladder Access: 25 by 17 inches.

L. Label access doors according to Division 22 Section "Mechanical Identification" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

O. Connect terminal units to supply ducts directly.

P. Connect diffusers to ducts directly or with maximum 48-inch lengths of flexible duct banded in place. Do not use flexible ducts to change directions.

Q. Connect flexible ducts to metal ducts with draw bands.

R. Install duct test holes where required for testing and balancing purposes.

S. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.02 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.

2. Inspect locations of access doors and verify that purpose of access door can be performed.

3. Inspect turning vanes for proper and secure installation.

4. Inspect turning vanes for blockage and remove any debris prior to startup.

5. Operate remote damper operators to verify full range of movement of operator and damper.

6. Fire, Smoke and Combination Fire and Smoke Dampers

    a. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.

    b. Full unobstructed access to the fire or combination fire/smoke damper shall be verified and corrected as required.

    c. If the damper is equipped with a fusible link, the link shall be removed for testing to ensure full closure and lock-in place if so equipped.

    d. The operational test of the damper shall verify that there is no damper interference due to rusted, bent, misaligned, or damaged frame or blades, or defective hinges or other moving parts.

    e. The damper frame shall not be penetrated by any foreign objects that would affect fire damper operations.

    f. The damper shall not be blocked from closure in any way.

    g. The fusible link shall be reinstalled after testing is complete.
        1) If the link is damaged or painted, it shall be replaced with a link of the same size, temperature, and load rating.

    h. All inspections and testing shall be documented indicating the location of the fire damper or combination fire/smoke damper, date of inspection, name of inspector, and deficiencies discovered.
        1) The documentation shall have a space to indicate when and how the deficiencies were corrected.

    i. All documentation shall be maintained and made available for review by the AHJ.

    j. Maintenance.
        1) Reports of changes in airflow or noise from the duct system shall be investigated to verify that they are not related to damper operation.
        2) All exposed moving parts of the damper shall be dry lubricated as required by the manufacturer.
        3) If the damper is not operable, repairs shall begin without delay.
        4) Following any repairs, the damper shall be tested for operation.
        5) All maintenance shall be documented.

    k. Provide an 11-month test.

B. All tests shall be completed in a safe manner by personnel wearing personal protective equipment.

END OF SECTION 233300

SECTION 233443 - FANS

PART 1 -GENERAL

1.01 SUMMARY

A. Section Includes:

1. Plenum fans.

2. Domed roof, upblast roof, and sidewall exhaust fans.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Submit the following product data for each unit:

a. Static pressure, airflow (CFM), speed (RPM), system curve, outlet velocity, and fan tag for each fan.

b. Certified fan curves showing fan performance with the system operating points identified on curves. Surge, or “Do not operate” line, indicated on fan curve.

c. Performance curves published by the fan manufacturer and based on tests in accordance with AMCA 210. Curves drawn with the fan flow rate plotted against fan total pressure and fan brake horsepower per AMCA 210.

d. Bearing sizing and life calculations for each similar size and type of fan.

e. Sound power levels for each size and type of fan. Sound levels provided for all 8 octave bands for discharge of fan, inlet to fan, and radiated noise through casing.

f. Dimensional data for each size and type of fan, including operating and maintenance clearances.

g. Details of vibration isolation bases including selections for vibration isolation springs.

h. Motor ratings, electrical characteristics, and motor accessories. Include wiring diagrams for power, signal, and control wiring.

i. Roof curbs.

j. Fan speed controller.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or BIM model, drawn to scale and coordinated with all building trades.

B. Seismic Qualification Data: For fans, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.05 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

1. Motors and electrical accessories: Comply with NEMA 1.

B. Fan Sound Ratings: Comply with AMCA 311 and label fans with the AMCA-Certified Ratings Seal. Sound ratings to comply with AMCA 301. Factory test fans according to AMCA 300.

C. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. Test fans for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.

D. Operating Limits: Classify fans according to AMCA 99.

E. Test high-plume induction type fans and certify to provide specified primary and secondary air volumes. Provide certified reports.

F. Base fan performance ratings on actual project site elevation.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Provide protection to ensure that the interior and exterior of each fan is completely protected from dirt or weather during shipping. Cover all openings with sealed sheet metal or plastic.

B. Lift and support units with manufacturer’s designated lifting and support points.

1.07 WARRANTY

A. Provide a complete parts and labor warranty for a minimum of one year from the date of Substantial Completion.

1.08 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section “Roof Accessories”.

PART 2 -PRODUCTS

2.01 MANUFACTURERS

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

1. Centrifugal:

a. Loren Cook Co.

b. Acme.

c. Twin City Fan.

d. Aerovent.

e. Greenheck.

f. Trane.

g. PennBarry.

2. Vane-Axial and Tube-Axial:

a. Howden Buffalo, Inc.

b. Woods.

c. Trane.

d. Greenheck.

e. Cook.

2.02 PERFORMANCE REQUIREMENTS

A. Capacities and Characteristics: As scheduled on the drawings.

2.03 GENERAL CONSTRUCTION - ALL FANS

A. Variable sheaves for motors 7.5 HP and under and fixed sheaves for motors 10 HP and over. Size variable sheaves at midpoint of specified operating conditions to allow field adjustment up or down during balancing procedures. Provide one (1) additional fixed sheave set for final balancing.

B. Selection and ratings based on tests made in accordance with AMCA 210.

C. AMCA licensed and bear the AMCA seal for both sound and performance levels.

D. Minimum Class I construction with proper UL label.

E. Specified fan RPM, outlet velocity, and tip speed are the maximum acceptable. Motor horsepower, CFM, and static pressure are the minimum acceptable.

F. Fasteners corrosion resistant type.

G. Fan housing of suitable thickness and bracing required for stable and rigid construction, with no deflection, and to prevent vibration and pulsation.

H. Fans having duct-connected inlets provided with a flanged inlet and/or outlet collar matching companion flange.

I. OSHA belt guards on all belt driven fans.

J. Spark-proof Type A, B, or C (AMCA 99-0401) as required by application.

K. Weatherproof housing for exterior fan with ventilation grilles to cover motor and drive assembly.

L. Special construction fans, such as spark-proof, explosion-proof, or specially coated fans as required by application.

M. Birdscreen on fans exposed to the exterior environment.

N. Fan shaft of solid high carbon steel, accurately turned, ground and polished, and ring gauged for accuracy.

1. Shafts dial indicator inspected for straightness after the keys are cut.

2. Fan shaft coated with rust inhibitive coating.

O. Fan wheel assembly or propeller assembly statically and dynamically balanced prior to fan assembly.

P. The entire rotating assembly designed so the first critical speed is minimum 25% over the maximum fan class speed.

Q. Fan Shaft Bearings:

1. Bolted on a rigid welded steel framework integral with the housing.

2. Designed and individually tested specifically for use in air handling applications.

3. Sized for a minimum L-10 life of 200,000 hours at the maximum fan class operating speed and horsepower. Selection to account for all operating conditions including belt pull. Bearings selected in accordance with standards set forth by the American Bearing Manufacturers Association (ABMA).

4. Grease lubricated self-aligning ball or roller type. Provide tapered roller bearings for vertical applications.

5. Housings to be solid cast iron, pillow block or flange mount type. Provide split pillow block bearings where required by the application speed.

6. Stamped bearing housings permitted on fans of 1/4 HP or less.

7. Bearings of type that can be re-lubricated, and equipped with grease fittings.

R. Where fan bearings are not easily accessible or are installed in a hazardous exhaust airstream, provide clear plastic grease leads, properly secured to avoid damage or fatigue, routed to an accessible location.

S. Fan Drive:

1. Multiple V-belt type sized for 1.65 times the fan motor horsepower. Sheaves fixed or adjustable based on fan motor horsepower. Fan sheave shall have a tapered lock, split and keyed hub. Spacing on equipment and motor pulleys to align. For fans 1/2 HP and larger, quantity of belts such that if any one belt fails, remaining belts to allow fan to continue functioning as designed. Multiple belts provided as a matched set.

2. OSHA approved type fan drive guards provided with provision for RPM measurement at both motor and fan without removing the guard.

3. Fan belts oil resistant 24,000-hour non-static belts.

T. Provide thrust arrestors to limit movement of the fan upon start-up.

U. For pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at factory.

2.04 PAINTING

A. Each fan component shall be thoroughly cleaned, degreased, and deburred.

B. Prior to assembly, prime coat all non-galvanized ferrous metal parts with zinc rich primer (minimum 70 percent zinc), total dry film thickness of not less than 1.3 mils.

C. For interior units, finish paint all non-galvanized ferrous metal parts with alkyd enamel paint.

1. Low-luster interior enamel; total dry film thickness of not less than 2.6 mils.

D. For exterior units, finish paint all non-galvanized ferrous metal parts with alkyd enamel paint.

1. Semi-gloss exterior enamel; total dry film thickness of not less than 2.6 mils.

E. Aluminum and stainless steel parts do not require painting.

F. Special coatings for corrosive exhaust systems specified in the specific exhaust fan specifications.

2.05 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 23 Section “Common Motor Requirements for Mechanical”.

B. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

C. Motor Enclosure: Open drip-proof, totally enclosed, fan-cooled or explosion-proof as required per fan per application.

2.06 CENTRIFUGAL FANS

A. Domed Roof, Up Blast Roof, and Sidewall Exhaust Fans

1. General:

a. Housing constructed of heavy gauge spun aluminum with a rigid internal support structure.

b. Fan wheel backward inclined.

c. Drive frame assembly constructed of heavy gauge steel.

d. Fresh air for motor cooling shall be drawn into the motor through a tube free of contaminants or through a space between the fan shroud and the motor cover.

e. Fan drives sized for 1.5 times the motor horsepower. Pulleys cast type, keyed and securely attached to the wheel and motor shafts.

f. Motor pulleys adjustable for final balancing.

g. Provide factory-installed disconnect switch, wired from the fan motor to a junction box installed within the motor compartment. Provide a conduit chase through the base to the motor compartment.

h. Belt tensioner for quick belt service.

2. Roof-mounted up blast exhaust fans to have a leak proof housing constructed with a one-piece windband with an integral rolled bead, and shall be joined to the curb-cap with a continuously welded seam.

3. Sidewall mounted exhaust fans to have a leak proof housing constructed with a one-piece windband with an integral rolled bead. Provide a mounting plate that will be attached and sealed to the wall prior to installing fan.

4. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

5. Bird Screens: Removable 1/2-inch mesh, aluminum or brass wire.

6. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

7. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

a. Configuration: Built-in cant and mounting flange.

b. Overall Height: 12 inches.

c. Sound Curb: Curb with sound-absorbing insulation matrix.

d. Pitch Mounting: Manufacture curb for roof slope.

e. Metal Liner: Galvanized steel.

2.07 PLENUM FANS

A. Single width non-overloading centrifugal type, mounted on rigidly built and braced all welded fan pedestals made of structural steel, mounted to square, flat mounting plates, and equipped with lifting lugs.

B. Wheel matched to inlet cone to provide precise running tolerances and maximum operating performance and efficiency.

C. Fan wheel with a completely enclosing protective cage with a removable section large enough to service the fan or drive easily. Cages across the fan plenum access door are not acceptable.

D. Lubrication lines with Zerk fittings, extended to the exterior of the protective fan cage.

E. Removable fan inlet screen.

PART 3 -EXECUTION

3.01 INSTALLATION

A. Lift and support units with manufacturer`s designated lifting or supporting points.

B. Install fans in accordance with details, approved submittals, and the fan manufacturer's installation requirements and recommendations. Ensure fans are installed to allow easy accessibility for service or removal of fan components.

C. Provide and install supplemental steel, supports, isolators and hangers necessary to hang or mount fans. Coordinate final location and placement of intermediate steel and ductwork connections in field.

1. Install suspended fans with supports attached to structural members.

D. Install any associated motors, drives, or other components that have been shipped loose.

E. Install flexible inlet and discharge couplings to prevent vibration transmission to ductwork.

F. Inlet and discharge ductwork shall have a minimum straight run of two (2) fan diameters upstream and downstream of the fan.

G. Prior to final acceptance, thoroughly clean fan of all grease, dirt, and dust, etc. Apply touch-up paint or touch-up coating after final cleaning to repair any damage to the finish.

H. Install units with clearances for service and maintenance.

I. Label fans according to requirements specified in Division 22 Section “Mechanical Identification”.

3.02 DUCTWORK AND PIPING CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section “Duct Accessories”.

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.03 ELECTRICAL CONNECTIONS

A. Connect wiring according to Division 26 Section “Low-Voltage Electrical Power Conductors and Cables”.

B. Ground equipment according to Division 26 Section “Grounding and Bonding for Electrical Systems”.

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.04 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Division 26 Section “Control-Voltage Electrical Power Cables”.

3.05 FIELD QUALITY CONTROL

A. Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections prior to fan operation:

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices, and that connections to ducts and electrical components are complete.

3. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

4. Verify that cleaning and adjusting are complete.

5. Inspect fan scroll for debris or water.

6. Remove guards. Align and adjust belt tension, verify that fan wheel and motor rotate freely, and that bearing operation is smooth. Re-install belt guards.

7. Adjust damper linkages for proper damper operation.

8. Verify lubrication of bearings and other moving parts. Use proper bearing venting procedures, in particular at motor bearings. Use only grease type specifically recommended by fan manufacturer. Do not over-grease. Fill extended grease lines if not already filled, using manufacturer recommended grease and proper venting procedures.

9. Verify proper motor and fan rotation.

10. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.06 ADJUSTING

A. Comply with requirements in Division 23 Section “Testing, Adjusting, and Balancing for HVAC” for testing, adjusting, and balancing procedures.

B. Replace fan and motor pulleys as required to achieve design airflow.

3.07 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner`s maintenance personnel to adjust, operate, and maintain fans.

END OF SECTION 233443

SECTION 233600 - AIR TERMINAL UNITS

PART 1 -GENERAL

1.01 SUMMARY

A. Section Includes:

1. Shutoff, single-duct air terminal units.

1.02 ACTION SUBMITTALS

A. Product Data: For each type, including construction, rated capacities, furnished specialties, sound-power ratings, and accessories.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

B. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. Manufacturer standard operating and maintenance manual for each type.

2. Performance curves, including heating coils.

3. Instructions for resetting minimum and maximum air volumes.

4. Instructions for adjusting software set points.

PART 2 -PRODUCTS

2.01 VARIABLE VOLUME, SINGLE-DUCT AIR TERMINAL UNITS

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

1. Enviro-Tec.

2. Krueger.

3. Price Industries.

4. Titus.

5. Trane; a business of American Standard Companies.

6. Tuttle & Bailey.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: Minimum 22 gauge, single wall.

1. Liner: 1 inch thick fiber-free foam, ASHRAE 62.1, UL-181 and ASTM E 84 25/50 compliant.

a. Cover liner with nonporous foil.

2. Air Inlet: Oval, round or rectangular collar connection.

3. Air Outlet: S-slip and drive connections.

4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.

D. Volume Damper: Low leakage galvanized steel with peripheral gasket and self-lubricating bearings.

E. Airflow Sensor: Multi-point flow sensor to maintain control accuracy independent of field conditions.

F. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

1. Access door interlocked disconnect switch.

2. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)

3. Nickel chrome 80/20 heating elements.

4. Airflow switch for proof of airflow.

5. Fuses in terminal box for overcurrent protection (for coils more than 48 A).

6. Magnetic contactor for each step of control (for three-phase coils).

G. Direct Digital Controls: Unitary controller and actuator specified in Division 23 Section “HVAC Instrumentation and Controls”.

2.02 SOURCE QUALITY CONTROL

A. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 -EXECUTION

3.01 INSTALLATION

A. Install air terminal units according to NFPA 90A, “Standard for the Installation of Air Conditioning and Ventilating Systems”.

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Provide insulated access panels with quarter turn sash latches on bottom of all air terminals for access to coil and airflow sensor.

D. Unit shall be installed with rigid inlet connection with minimum five duct diameter inlet straight length.

E. Install electric units with minimum five duct lengths after coil.

F. Provide 42 inch clearance around disconnect for units with electric heat.

3.02 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA`s “HVAC Duct Construction Standards - Metal and Flexible, Chapter 4, “Hangers and Supports” and Division 23 Section “Metal Ducts”.

3.03 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.

B. Connect ducts to air terminal units according to Division 23 Section “Metal Ducts”.

3.04 IDENTIFICATION

A. Label each air terminal unit. Comply with requirements in Division 22 Section “Mechanical Identification” for equipment labels and warning signs and labels.

3.05 FIELD QUALITY CONTROL

A. Perform the following tests and inspections.

1. After installing air terminal units, test for compliance with requirements.

2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Air terminal unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.06 DEMONSTRATION

A. Train Owner`s maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 -GENERAL

1.01 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

1.02 ACTION SUBMITTALS

A. Product Data: For each product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data.

PART 2 -PRODUCTS

2.01 MANUFACTURERS

A. Except where titles below introduce lists, the following requirements apply to product selection:

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

a. Krueger.

b. METALAIRE; a division of Metal Industries Inc.

c. Nailor.

d. Price Industries.

e. Titus.

f. Tuttle & Bailey.

2.02 GENERAL REQUIREMENTS

A. The following requirements shall apply to all grilles, registers and diffusers. Where conflicting requirements are indicated for specific titles below, those requirements shall supersede the general requirements.

1. Devices shall be specifically designed for variable-air-volume flows.

2. Material: As scheduled.

3. Finish: As scheduled.

4. Face Style: As scheduled.

5. Face Size: As scheduled.

6. Mounting: Verify ceiling frame and panel style and dimension with reflected ceiling plan, room finish schedule and material type.

7. Pattern: Adjustable.

8. Accessories: As scheduled.

2.03 LAMINAR FLOW DIFFUSERS AND CEILING FRAMING SYSTEMS

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

1. Precision Air Products.

2. Titus.

3. Flanders.

4. AAF.

5. Price.

6. Krueger.

7. Tuttle & Bailey.

B. Description:

1. Diffuser shall provide non-aspirating vertical air distribution.

2. Integrated ceiling framing system to include laminar flow diffusers, fill-in blank panels and ceiling grid with gasketing to support all components within the system.

3. Finish: Antimicrobial white.

C. HEPA-filtered Diffusers with Room-side Replaceable HEPA Filters:

1. ASHRAE Group E non-aspirating laminar flow type in accordance with ASHRAE 170 for operating rooms.

2. Upper (pressure) chamber constructed of 0.063 inch aluminum, all mating surfaces continuously welded and internally sealed. Upper chamber to form a knife edge seal with filter gel.

3. Top inlet collar with internal air balancing mechanism, room-side adjustable. Integral or external dampers (opposed blade or butterfly) are not allowed.

4. HEPA filters held firmly in place by clip assemblies with stainless steel filter clips, nuts, and bolts.

5. Diffuser frame assembly constructed of extruded aluminum with mitered, continuously welded and internally sealed corners. The frame assembly shall align with the upper chamber's knife edge to form a dual knife edge seal with the filter's gel to form an air-tight seal.

6. Perforated faceplate shall be 0.050 inch aluminum and perforations to be nominal 16% open area. Provide vinyl coated stainless steel cable safety retainers. The faceplate shall be installed in an extruded aluminum mounting frame with mitered back-welded corners.

7. Manufacturer to insulate the assembly with 1-1/2 inch duct wrap foil-faced insulation.

8. One diffuser per room shall include a red LED indicator light, factory mounted in corner of faceplate. Light shall be connected to factory preset pressure switch. Coordinate 24 volt power supply with project Electrical Contractor.

9. Provide factory installed ports in diffuser plenum of one diffuser per room to accept pressure monitoring tubing; one above and one below the filter. Ports shall be accessible in the field for connection by the Controls Contractor.

10. Dedicated aerosol port and dispersion manifold to allow field testing.

D. HEPA Filters:

1. Individually tested IEST-RP-CC001 Type J test meeting minimum efficiency of 99.99% on 0.3 micron size particles.

2. Media: Pleated to 53mm pack thickness.

3. Pressure drop shall not exceed 0-.45 inches w.g. at filter face velocity of 100 fpm. All material shall meet UL900 class.

4. Filter frame: Integral channel filled with cleanroom grade, non-flowing urethane gel.

2.04 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, Method of Testing for Rating the Performance of Air Outlets and Inlets.

PART 3 -EXECUTION

3.01 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.02 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb according to manufacturer's written instructions and coordination drawings.

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 panel. Where architectural features or other items conflict with installation, notify Architect/Engineer for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of manual dampers, fire and smoke dampers.

D. All return grilles in plenums shall be installed with 24x24x12 or 24x12x12 back pan matching return grille dimensions unless detailed otherwise in documents. Back pan shall be painted black.

3.03 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

3.04 CLEANING

A. Inspect exposed finish of diffusers, registers, and grilles after installation. Clean exposed surfaces and replace diffusers, registers, and grilles having damaged finishes.

END OF SECTION 233713

SECTION 237416 - PACKAGED ROOFTOP AIR-CONDITIONING UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Packaged, large-capacity, rooftop air-conditioning units.

1.02 RELATED REQUIREMENTS

A. Section 230548 - Vibration and Seismic Controls for HVAC.

B. Section 230900 Direct Digital Controls (DDC) for HVAC: Control components, time clocks.

C. Section 260583 - Wiring Connections: Installation and wiring of thermostats and other control components; wiring from unit terminal strip to remote panel.

D. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

A. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; 2023.

B. AHRI 270 - Sound Performance Rating of Outdoor Unitary Equipment; 2015, with Addendum (2016).

C. AMCA 611 - Certified Ratings Program - Product Rating Manual for Airflow Measurement Stations; 2015.

D. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

E. ASHRAE Std 135 - A Data Communication Protocol for Building Automation and Control Networks; 2020, with Errata (2023).

F. IEEE 802.11 - IEEE Standard for Information Technology--Telecommunications and Information Exchange between Systems - Local and Metropolitan Area Networks--Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications; 2020 (Corrigendum 2022).

G. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2020.

H. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.

1.04 SUBMITTALS

A. Product Data: Provide capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.

B. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.

C. Shop Drawings: Indicate capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.

D. Manufacturer's Instructions: Indicate assembly, support details, connection requirements, and include start-up instructions.

E. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect units from physical damage by storing off site until roof mounting curbs are in place and ready for immediate installation of units.

PART 2 PRODUCTS

2.01 PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

A. Manufacturers:

1. Klimor

2. Johnson Controls International.

3. Trane.

B. Casing

1. Modular construction. Posts made from anodized aluminum profiles with thermal break. 2" thick double walls with thermal break. Insulation shall be R=13. Designed for outdoor use.

C. Fans

1. All units shall be equipped with direct driven plenum Fans, with air foil backward-curved impellers with 5-7 blades made of steel; the impellers are installed directly on the motor shafts. All power and sound ratings have been tested & rated according to applicable AMCA Standards & Publications. All Fan Assemblies are belt-less, AMCA Arrangement 4.

2. Bearings shall be rated for L10 = 150,000 hours.

3. Single point power connection with manual disconnect.

a. Single power supply connection for each fan section. Built in short circuit protection (circuit breakers) and main switch. Enclosure class: NEMA 4

D. Filters

1. Pre-filter shall be MERV 8

2. Final filter shall be MERV 14

E. Dampers

1. Provide external motorized opposed blade dampers. Dampers shall have aluminum blades with rubber gaskets on the edges. Dampers shall comly with AMCA 500 standard, class 1.

F. Drain Pan

1. Drain pan shall be stainless steel construction. Triple sloped toward condesnsate drainage point. 1" NPT threaded connection point

G. Roof Curb

1. Roof mounting curb: 14 inches high, galvanized steel, channel frame with gaskets, nailer strips.

H. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 50.

I. Disconnect Switch: Factory mount disconnect switch in control panel.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that roof is ready to receive work and opening dimensions are as required by manufacturer.

B. Verify that proper power supply is available.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NFPA 90A.

C. Mount units on factory built roof mounting curb providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.

3.03 SYSTEM STARTUP

A. Prepare and start equipment. Adjust for proper operation.

3.04 CLOSEOUT ACTIVITIES

A. Demonstrate proper operation of equipment to Owner's designated representative.

3.05 MAINTENANCE

A. See Section 017000 - Execution and Closeout Requirements for additional requirements relating to maintenance service.

B. Provide service and maintenance of packaged rooftop units for one year from Date of Substantial Completion.

C. Provide routine maintenance service with a two-month interval as maximum time period between calls.

D. Include maintenance items as outlined in manufacturer's operating and maintenance data, including minimum of six filter replacements, minimum of one fan belt replacement, and controls check-out, adjustments, and recalibration.

E. After each service call, submit copy of service call work order or report that includes description of work performed.

END OF SECTION 237416

SECTION 238126.13 - SMALL-CAPACITY SPLIT-SYSTEM AIR CONDITIONERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Air cooled condensing units.

B. Indoor air handling (fan and coil) units for ductless systems.

C. Controls.

1.02 RELATED REQUIREMENTS

A. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections and installation and wiring of thermostats and other controls components.

1.03 REFERENCE STANDARDS

A. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; 2023.

B. ASHRAE Std 23 - Methods for Performance Testing Positive Displacement Refrigerant Compressors and Compressor Units; 2022.

C. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.

D. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems; 2024.

E. UL 207 - Standard for Refrigerant-Containing Components and Accessories, Nonelectrical; Current Edition, Including All Revisions.

1.04 SUBMITTALS

A. See Section 013000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.

C. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.

D. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.

E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.

F. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.05 WARRANTY

A. See Section 017800 - Closeout Submittals, for additional warranty requirements.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Mitsubishi

B. Samsung.

C. Trane Inc

2.02 SYSTEM DESIGN

A. Split-System Heating and Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.

1. Provide refrigerant lines internal to units and between indoor and outdoor units, factory cleaned, dried, pressurized and sealed, with insulated suction line.

B. Performance Requirements: See Drawings for additional requirements.

C. Electrical Characteristics:

1. ____ kW.

2. ____ volts, single phase, 60 Hz.

3. ____ amperes maximum fuse size.

4. Disconnect Switch: Factory mount disconnect switch on equipment under provisions of Section 260583.

2.03 INDOOR AIR HANDLING UNITS FOR DUCTLESS SYSTEMS

A. Manufacturers:

1. Mitsubishi.

2. Sansung.

3. Trane Inc.

B. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, evaporator coil, and controls; wired for single power connection with control transformer.

C. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.

1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207.

2. Manufacturer: System manufacturer.

2.04 OUTDOOR UNITS

A. Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.

1. Construction and Ratings: In accordance with AHRI 210/240 with testing in accordance with ASHRAE Std 23 and UL 207.

B. Accessories: Filter drier, high-pressure switch (manual reset), low pressure switch (automatic reset), service valves and gauge ports, thermometer well (in liquid line).

1. Provide thermostatic expansion valves.

C. Operating Controls:

1. Control by room thermostat to maintain room temperature setting.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with NFPA 90A and NFPA 90B.

END OF SECTION 238126.13

SECTION 238413.13 - HEATED-PAN HUMIDIFIERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pan humidifier.

1.02 RELATED REQUIREMENTS

A. Section 221005 - Plumbing Piping.

B. Section 230913 - Instrumentation and Control Devices for HVAC: Humidistats.

C. Section 232113 - Hydronic Piping.

D. Section 233100 - HVAC Ducts and Casings.

E. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

A. AHRI 610 (I-P) - Standard for Performance Rating of Central System Humidifiers for Residential Applications; 2014.

1.04 SUBMITTALS

A. See Section 013000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide catalog data indicating rated capacity, dimensions, duct and service connections, electric nameplate data and wiring diagrams.

C. Shop Drawings: Indicate rough-in dimensions, duct and service connections, electric nameplate data and wiring diagrams.

D. Manufacturer's Instructions: Indicate assembly and installation instructions.

E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.

F. Warranty: Submit manufacturer warranty and ensure forms have been completed in name of Owner and registered with manufacturer.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.06 WARRANTY

A. See Section 017800 - Closeout Submittals, for additional warranty requirements.

B. Provide five year manufacturer warranty for for entire unit.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Armstrong International Inc; Humidiclean Series HC-6000 Humidifier: www.armstronginternational.com/#sle.

B. Dri-Steem Corporation; _____: www.dristeem.com/#sle.

C. Substitutions: See Section 016000 - Product Requirements.

2.02 MANUFACTURED UNITS

A. Units: AHRI 610 (I-P); evaporative pan with stand, cabinet enclosure, heating coil, humidistat, pre-wired except for humidistat, for use with heating hot water.

2.03 COMPONENTS

A. Pan, Cover, Screws and Bolts: Stainless steel with duct collar.

B. Overflow and Drainage Fittings: Copper or Brass.

C. Float Valve Mechanism: Stainless steel or brass with 1/4 inch (8 mm) fill connection.

D. Coil: 7/8 inch (22 mm) OD copper.

E. Coil: Shielded electric immersion heating element with safety cut-out switch (set at 225 degrees F (107 degrees C)) to disconnect electric heating element on low water level in pan; ____ kW, ____ volts, single phase, 60 Hz.

F. Floor Stand: Extruded aluminum.

G. Cabinet Enclosure: Galvanized sheet metal with baked enamel finish.

H. Flush Cycle: Timers allow one to four flushes per day of three to 120 minutes duration by shutting off power to heating element and opening drain valve.

I. Disconnect Switch: Factory mount disconnect switch in control panel.

2.04 ACCESSORIES

A. Humidistats: Refer to Section 230913.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Connect unit to hot water supply. Provide gate valve and solenoid valve on heating water supply line, and globe valve on heating water return line. Refer to Section 232113.

C. Pipe overflow and valved manual drain to floor drain.

D. Install piping with unions or flanges for easy removal of pan for servicing.

E. Connect units to ducts. Keep duct runs minimum length and slope back to humidifier. Refer to Section 233100.

END OF SECTION 238413.13

SECTION 238413 - HUMIDIFIERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Humidifier Units.

1.02 RELATED REQUIREMENTS

A. Section 230719 - HVAC Piping Insulation.

B. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

A. AHRI 610 (I-P) - Standard for Performance Rating of Central System Humidifiers for Residential Applications; 2014.

1.04 SUBMITTALS

A. See Section 013000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide catalog sheets indicating general assembly, dimensions, weights, materials, and certified performance ratings.

C. Shop Drawings: Indicate general assembly, dimensions, weights, and materials.

D. Operation Data: Include assembly instructions, float adjustment, bleed rates, and electrical requirements.

E. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.06 WARRANTY

A. See Section 017800 - Closeout Submittals, for additional warranty requirements.

B. Provide five year manufacturer warranty for units.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Carel.

B. Approved equal.

2.02 MANUFACTURED UNITS

A. Units: AHRI 610 (I-P); factory assembled consisting of casing, tank, filters, spray pumps, water and drain connections.

2.03 CASING

A. Assembly: Galvanized steel, minimum 0.0635 inch (1.6 mm) thick, reinforced and braced with galvanized steel angles and corrosion resistant cap screws.

2.04 DRAIN TANK

A. Tank: Welded black steel 4 inches (100 mm) deep, 0.1345 inch (3.4 mm) thick, finished inside and out with zinc chromate, iron oxide phenolic resin paint and coated inside with asphalt coating.

2.05 FILTERS

A. Filters: Two rows of neoprene coated filter mats in removable frames.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Connect unit to water supply. Provide gate valve on water supply line. Provide 3/4 inch (20 mm) hose bibb accessible from interior.

C. Pipe drain and overflow to nearest floor drain.

END OF SECTION 238413