

SECTION 22 05 11
COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section shall apply to all sections of Division 22.
- B. Definitions:
 - 1. Exposed: Piping and equipment exposed to view in finished rooms.
- C. Abbreviations/Acronyms:
 - 1. ABS: Acrylonitrile Butadiene Styrene
 - 2. AISI: American Iron and Steel Institute
 - 3. AWG: American Wire Gauge
 - 3. BACnet: Building Automation and Control Network
 - 4. CDA: Copper Development Association
 - 5. CO: Carbon Monoxide
 - 6. COR: Contracting Officer's Representative
 - 7. CPVC: Chlorinated Polyvinyl Chloride
 - 8. CR: Chloroprene
 - 9. CWP: Cold Working Pressure
 - 10. db(A): Decibels (A weighted)
 - 11. DDC: Direct Digital Control
 - 12. DISS: Diameter Index Safety System
 - 13. DWV: Drainage, Waste and Vent
 - 14. ECC: Engineering Control Center
 - 15. EPDM: Ethylene Propylene Diene Monomer
 - 16. EPT: Ethylene Propylene Terpolymer
 - 17. ETO: Ethylene Oxide
 - 18. FAR: Federal Acquisition Regulations
 - 19. FD: Floor Drain
 - 20. FG: Fiberglass
 - 21. FNPT: Female National Pipe Thread
 - 22. FPM: Fluoroelastomer Polymer
 - 23. HDPE: High Density Polyethylene
 - 24. HOA: Hands-Off-Automatic
 - 25. HP: Horsepower
 - 26. ID: Inside Diameter

- 27. MAWP: Maximum Allowable Working Pressure
- 28. NPTF: National Pipe Thread Female
- 29. NPS: Nominal Pipe Size
- 30. NPT: National Pipe Thread
- 31. OD: Outside Diameter
- 32. OSD: Open Sight Drain
- 33. OS&Y: Outside Stem and Yoke
- 34. PP: Polypropylene
- 35. PTFE: Polytetrafluoroethylene
- 36. PVC: Polyvinyl Chloride
- 37. PVDF: Polyvinylidene Fluoride
- 38. RTRP: Reinforced Thermosetting Resin Pipe
- 39. SPS: Sterile Processing Services
- 40. SUS: Saybolt Universal Second
- 41. SWP: Steam Working Pressure
- 42. TFE: Tetrafluoroethylene
- 43. THHN: Thermoplastic High-Heat Resistant Nylon Coated Wire
- 44. THWN: Thermoplastic Heat & Water Resistant Nylon Coated Wire
- 45. USDA: U.S. Department of Agriculture
- 46. VAC: Voltage in Alternating Current
- 47. WOG: Water, Oil, Gas

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- D. Section 03 30 00, CAST-IN-PLACE CONCRETE: Concrete and Grout.
- E. Section 05 36 00, COMPOSITE METAL DECKING: Building Components for Attachment of Hangers.
- F. Section 05 50 00, METAL FABRICATIONS.
- G. Section 07 84 00, FIRESTOPPING.
- H. Section 07 92 00, JOINT SEALANTS.
- I. Section 09 91 00, PAINTING.
- J. Section 22 07 11, PLUMBING INSULATION.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below shall form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. American Society for Testing and Materials (ASTM):

- A36/A36M-2012Standard Specification for Carbon Structural Steel
- A575-96(R2013)e1Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
- E84-2013aStandard Test Method for Surface Burning Characteristics of Building Materials
- E119-2012aStandard Test Methods for Fire Tests of Building Construction and Materials
- F1760-01(R2011)Standard Specification for Coextruded Poly(Vinyl Chloride) (PVC) Non-Pressure Plastic Pipe Having Reprocessed-Recycled Content

C. International Code Council, (ICC):

- IBC-2012International Building Code
- IPC-2012International Plumbing Code

D. Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry, Inc:

- SP-58-2009Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application and Installation
- SP-69-2003Pipe Hangers and Supports - Selection and Application

E. National Fire Protection Association (NFPA):

- 51B-2014Standard for Fire Prevention During Welding, Cutting and Other Hot Work
- 54-2012National Fuel Gas Code
- 70-2011National Electrical Code (NEC)

F. NSF International (NSF):

- 5-2012Water Heaters, Hot Water Supply Boilers, and Heat Recovery Equipment
- 14-2012Plastic Piping System Components and Related Materials
- 61-2012Drinking Water System Components - Health Effects
- 372-2011Drinking Water System Components - Lead Content

G. Department of Veterans Affairs (VA):

PG-18-10Plumbing Design Manual

PG-18-13-2011Barrier Free Design Guide

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 05 11, COMMON WORK RESULTS FOR PLUMBING", with applicable paragraph identification.
- C. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements and will fit the space available.
- D. If equipment is submitted which differs in arrangement from that shown, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.
- E. Prior to submitting shop drawings for approval, contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.
- F. Manufacturer's Literature and Data: Manufacturer's literature shall be submitted under the pertinent section rather than under this section.
 - 2. Equipment and materials identification.
 - 3. Firestopping materials.
 - 5. Wall, floor, and ceiling plates.
- G. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient installation. Final review and approvals will be made only by groups.

H. Coordination Drawings: Complete consolidated and coordinated layout drawings shall be submitted for all new systems, and for existing systems that are in the same areas. The drawings shall include plan views, elevations and sections of all systems and shall be on a scale of not less than 1:32 (3/8 inch equal to one foot). Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings shall clearly show the proposed location and adequate clearance for all equipment, controls, piping, pumps, valves and other items. All valves, trap primer valves, water hammer arrestors, strainers, and equipment requiring service shall be provided with an access door sized for the complete removal of plumbing device, component, or equipment. Equipment foundations shall not be installed until equipment or piping layout drawings have been approved. Detailed layout drawings shall be provided for all piping systems. In addition, details of the following shall be provided.

1. Mechanical equipment rooms.
2. Interstitial space.
3. Hangers, inserts, supports, and bracing.
4. Pipe sleeves.
5. Equipment penetrations of floors, walls, ceilings, or roofs.

I. Maintenance Data and Operating Instructions:

1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment. Include complete list indicating all components of the systems with diagrams of the internal wiring for each item of equipment.

1.5 QUALITY ASSURANCE

A. Products Criteria:

1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture, supply and servicing of the specified products for at least 5 years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least 5 years.

2. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.
 3. The products and execution of work specified in Division 22 shall conform to the referenced codes and standards as required by the specifications. Local codes and amendments enforced by the local code official shall be enforced, if required by local authorities such as the natural gas supplier. If the local codes are more stringent, then the local code shall apply. Any conflicts shall be brought to the attention of the Contracting Officers Representative (COR).
 4. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.
 5. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.
 6. Asbestos products or equipment or materials containing asbestos shall not be used.
- B. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the COR prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.
- C. Execution (Installation, Construction) Quality:
1. All items shall be applied and installed in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract documents shall be referred to the COR for resolution. Printed copies or electronic files of manufacturer's installation instructions shall be provided to the COR at least 10 working days prior to commencing installation of any item.

2. All items that require access, such as for operating, cleaning, servicing, maintenance, and calibration, shall be easily and safely accessible by persons standing at floor level, or standing on permanent platforms, without the use of portable ladders. Examples of these items include, but are not limited to: all types of valves, filters and strainers, transmitters, and control devices. Prior to commencing installation work, refer conflicts between this requirement and contract documents to COR for resolution.
 3. Complete layout drawings shall be required by Paragraph, SUBMITTALS. Construction work shall not start on any system until the layout drawings have been approved by VA.
 4. Installer Qualifications: Installer shall be licensed and shall provide evidence of the successful completion of at least five projects of equal or greater size and complexity. Provide tradesmen skilled in the appropriate trade.
 5. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or additional time to the Government.
- D. Guaranty: Warranty of Construction, FAR clause 52.246-21.
- E. Plumbing Systems: IPC, International Plumbing Code. Unless otherwise required herein, perform plumbing work in accordance with the latest version of the IPC. For IPC codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall". Reference to the "code official" or "owner" shall be interpreted to mean the COR.
- F. Cleanliness of Piping and Equipment Systems:
1. Care shall be exercised in the storage and handling of equipment and piping material to be incorporated in the work. Debris arising from cutting, threading and welding of piping shall be removed.
 2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.
 3. The interior of all tanks shall be cleaned prior to delivery and beneficial use by the Government. All piping shall be tested in accordance with the specifications and the International Plumbing Code (IPC). All filters, strainers, fixture faucets shall be flushed of debris prior to final acceptance.

4. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.6 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage.
2. Damaged equipment shall be replaced with an identical unit as determined and directed by the COR. Such replacement shall be at no additional cost or additional time to the Government.
3. Interiors of new equipment and piping systems shall be protected against entry of foreign matter. Both inside and outside shall be cleaned before painting or placing equipment in operation.
4. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.

1.7 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

- C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them on Auto-Cad version 2011 or newer provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.
- D. Certification documentation shall be provided prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and a certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 MATERIALS FOR VARIOUS SERVICES

- A. Plastic pipe, fittings and solvent cement shall meet NSF 14 and shall bear the NSF seal "NSF-PW". Polypropylene pipe and fittings shall comply with NSF 14 and NSF 61. Solder or flux containing lead shall not be used with copper pipe.
- B. Material or equipment containing a weighted average of greater than 0.25 percent lead shall not be used in any potable water system intended for human consumption, and shall be certified in accordance with NSF 61 or NSF 372.
- C. In-line devices such as water meters, building valves, check valves, stops, valves, fittings, tanks and backflow preventers shall comply with NSF 61 and NSF 372.
- D. End point devices such as drinking fountains, lavatory faucets, kitchen and bar faucets, ice makers supply stops, and end-point control valves used to dispense drinking water must meet requirements of NSF 61 and NSF 372.

2.2 FACTORY-ASSEMBLED PRODUCTS

- A. Standardization of components shall be maximized to reduce spare part requirements.
- B. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for final assembled unit.

1. All components of an assembled unit need not be products of same manufacturer.
 2. Constituent parts that are alike shall be products of a single manufacturer.
 3. Components shall be compatible with each other and with the total assembly for intended service.
 4. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly at no additional cost or time to the Government.
- C. Components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.
- D. Major items of equipment, which serve the same function, shall be the same make and model.

2.3 COMPATIBILITY OF RELATED EQUIPMENT

- A. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a complete and fully operational system that conforms to contract requirements.

2.4 SAFETY GUARDS

- A. Pump shafts and couplings shall be fully guarded by a sheet steel guard, covering coupling and shaft but not bearings. Material shall be minimum 16-gage sheet steel; ends shall be braked and drilled and attached to pump base with minimum of four 8 mm (1/4 inch) bolts. Reinforce guard as necessary to prevent side play forcing guard onto couplings.
- B. All Equipment shall have moving parts protected from personal injury.

2.5 LIFTING ATTACHMENTS

- A. Equipment shall be provided with suitable lifting attachments to enable equipment to be lifted in its normal position. Lifting attachments shall withstand any handling conditions that might be encountered, without bending or distortion of shape, such as rapid lowering and braking of load.

2.6 PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

- A. Type Numbers Specified: For materials, design, manufacture, selection, application, and installation refer to MSS SP-58. For selection and application refer to MSS SP-69. Refer to Section 05 50 00, METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting.
- B. For Attachment to Concrete Construction:
 - 1. Concrete insert: Type 18, MSS SP-58.
 - 2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 100 mm (4 inches) thick when approved by the COR for each job condition.
 - 3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 100 mm (4 inches) thick when approved by the COR for each job condition.
- C. For Attachment to Steel Construction: MSS SP-58.
 - 1. Welded attachment: Type 22.
 - 2. Beam clamps: Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 23 mm (7/8 inch) outside diameter.
- D. Hanger Rods: Hot-rolled steel, ASTM A36/A36M or ASTM A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 40 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.
- E. Multiple (Trapeze) Hangers: Galvanized, cold formed, lipped steel channel horizontal member, not less than 43 mm by 43 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (No. 12 gage), designed to accept special spring held, hardened steel nuts.
 - 1. Allowable hanger load: Manufacturers rating less 91kg (200 pounds).
 - 2. Guide individual pipes on the horizontal member of every other trapeze hanger with 8 mm (1/4 inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 15 mm (1/2 inch) galvanized steel bands, or insulated calcium silicate shield for insulated piping at each hanger.
- F. Pipe Hangers and Supports: (MSS SP-58), use hangers sized to encircle insulation on insulated piping. Refer to Section 22 07 11, PLUMBING INSULATION for insulation thickness. To protect insulation, provide

Type 39 saddles for roller type supports or insulated calcium silicate shields. Provide Type 40 insulation shield or insulated calcium silicate shield at all other types of supports and hangers including those for insulated piping.

1. General Types (MSS SP-58):

- a. Standard clevis hanger: Type 1; provide locknut.
- b. Riser clamps: Type 8.
- c. Wall brackets: Types 31, 32 or 33.
- d. Roller supports: Type 41, 43, 44 and 46.
- e. Saddle support: Type 36, 37 or 38.
- f. Turnbuckle: Types 13 or 15.
- g. U-bolt clamp: Type 24.
- h. Copper Tube:
 - 1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, copper-coated, plastic coated or taped with isolation tape to prevent electrolysis.
 - 2) For vertical runs use epoxy painted, copper-coated or plastic coated riser clamps.
 - 3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.
 - 4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.
- i. Supports for plastic or glass piping: As recommended by the pipe manufacturer with black rubber tape extending one inch beyond steel support or clamp.

2. Plumbing Piping (Other Than General Types):

- a. Horizontal piping: Type 1, 5, 7, 9, and 10.
- b. Chrome plated piping: Chrome plated supports.
- c. Hangers and supports in pipe chase: Prefabricated system ABS self-extinguishing material, not subject to electrolytic action, to hold piping, prevent vibration and compensate for all static and operational conditions.
- d. Blocking, stays and bracing: Angle iron or preformed metal channel shapes, 1.3 mm (18 gage) minimum.

G. Pre-insulated Calcium Silicate Shields:

1. Provide 360 degree water resistant high density 965 kPa (140 psig) compressive strength calcium silicate shields encased in galvanized metal.
2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
3. Shield thickness shall match the pipe insulation.
4. The type of shield is selected by the temperature of the pipe, the load it must carry, and the type of support it will be used with.
 - a. Shields for supporting cold water shall have insulation that extends a minimum of 25 mm (1 inch) past the sheet metal.
 - b. The insulated calcium silicate shield shall support the maximum allowable water filled span as indicated in MSS SP-69. To support the load, the shields shall have one or more of the following features: structural inserts 4138 kPa (600 psig) compressive strength, an extra bottom metal shield, or formed structural steel (ASTM A36/A36M) wear plates welded to the bottom sheet metal jacket.
5. Shields may be used on steel clevis hanger type supports, trapeze hangers, roller supports or flat surfaces.

H. Seismic Restraint of Piping: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

2.7 PIPE PENETRATIONS

- A. Pipe penetration sleeves shall be installed for all pipe other than rectangular blocked out floor openings for risers in mechanical bays.
- B. Pipe penetration sleeve materials shall comply with all firestopping requirements for each penetration.
- C. To prevent accidental liquid spills from passing to a lower level, provide the following:
 1. For sleeves: Extend sleeve 50 mm (2 inch) above finished floor and provide sealant for watertight joint.
 2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
 3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.
- D. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges, with structural engineer prior

approval. Any deviation from these requirements must receive prior approval of COR.

- E. Sheet metal, plastic, or moisture resistant fiber sleeves shall be provided for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.
- F. Cast iron or zinc coated pipe sleeves shall be provided for pipe passing through exterior walls below grade. The space between the sleeve and pipe shall be made watertight with a modular or link rubber seal. The link seal shall be applied at both ends of the sleeve.
- G. Galvanized steel or an alternate black iron pipe with asphalt coating sleeves shall be for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. A galvanized steel sleeve shall be provided for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, sleeves shall be connected with a floor plate.
- H. Brass Pipe Sleeves shall be provided for pipe passing through quarry tile, terrazzo or ceramic tile floors. The sleeve shall be connected with a floor plate.
- I. Sleeve clearance through floors, walls, partitions, and beam flanges shall be 25 mm (1 inch) greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation plus 25 mm (1 inch) in diameter. Interior openings shall be caulked tight with firestopping material and sealant to prevent the spread of fire, smoke, water and gases.
- J. Sealant and Adhesives: Shall be as specified in Section 07 92 00, JOINT SEALANTS. Bio-based materials shall be utilized when possible.
- K. Pipe passing through roof shall be installed through a 4.9 kg per square meter copper flashing with an integral skirt or flange. Skirt or flange shall extend not less than 200 mm (8 inches) from the pipe and set in a solid coating of bituminous cement. Extend flashing a minimum of 250 mm (10 inches) up the pipe. Pipe passing through a waterproofing membrane shall be provided with a clamping flange. The annular space between the sleeve and pipe shall be sealed watertight.

2.8 TOOLS AND LUBRICANTS

- A. Furnish, and turn over to the COR, special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.
- B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.
- C. Tool Containers: metal, permanently identified for intended service and mounted, or located, where directed by the COR.
- D. Lubricants: A minimum of 0.95 L (1 quart) of oil, and 0.45 kg (1 pound) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application. Bio-based materials shall be utilized when possible.

2.9 WALL, FLOOR AND CEILING PLATES

- A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.
- B. Thickness: Not less than 2.4 mm (3/32 inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025 inch) for up to 75 mm (3 inch) pipe, 0.89 mm (0.035 inch) for larger pipe.
- C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Wall plates shall be used where insulation ends on exposed water supply pipe drop from overhead. A watertight joint shall be provided in spaces where brass or steel pipe sleeves are specified.

2.10 ASBESTOS

- A. Materials containing asbestos are not permitted.

PART 3 - EXECUTION**3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING**

- A. Location of piping, sleeves, inserts, hangers, and equipment, access provisions shall be coordinated with the work of all trades. Piping, sleeves, inserts, hangers, and equipment shall be located clear of windows, doors, openings, light outlets, and other services and utilities. Equipment layout drawings shall be prepared to coordinate

proper location and personnel access of all facilities. The drawings shall be submitted for review.

- B. Manufacturer's published recommendations shall be followed for installation methods not otherwise specified.
- C. Operating Personnel Access and Observation Provisions: All equipment and systems shall be arranged to provide clear view and easy access, without use of portable ladders, for maintenance, testing and operation of all devices including, but not limited to: all equipment items, valves, backflow preventers, filters, strainers, transmitters, sensors, meters and control devices. All gages and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Maintenance and operating space and access provisions that are shown on the drawings shall not be changed nor reduced.
- D. Structural systems necessary for pipe and equipment support shall be coordinated to permit proper installation.
- E. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.
- F. Cutting Holes:
 - 1. Holes shall be located to avoid interference with structural members such as beams or grade beams. Holes shall be laid out in advance and drilling done only after approval by COR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to COR for approval.
 - 2. Waterproof membrane shall not be penetrated. Pipe floor penetration block outs shall be provided outside the extents of the waterproof membrane.
 - 3. Holes through concrete and masonry shall be cut by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by COR where working area space is limited.
- G. Interconnection of Pneumatic Instrumentation and Controls: Generally, pneumatic interconnections are not shown but must be provided.
- H. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.

I. Protection and Cleaning:

1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the COR. Damaged or defective items in the opinion of the COR, shall be replaced at no additional cost or time to the Government.
2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Pipe openings, equipment, and plumbing fixtures shall be tightly covered against dirt or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.

J. Concrete and Grout: Concrete and shrink compensating grout 25 MPa (3000 psig) minimum, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE, shall be used for all pad or floor mounted equipment.

K. Gages, thermometers, valves and other devices shall be installed with due regard for ease in reading or operating and maintaining said devices. Thermometers and gages shall be located and positioned to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.

L. Interconnection of Electrical Instrumentation and Controls: Electrical interconnection is generally not shown but shall be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, alarms, instruments and computer workstations. Comply with NFPA 70.

M. Many plumbing systems interface with the HVAC control system. See the HVAC control points list and Section 23 09 23, DIRECT DIGITAL CONTROL SYSTEM FOR HVAC.

N. Work in Existing Building:

1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00 00, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).

2. As specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will cause the least interfere with normal operation of the facility.
- O. Work in Animal Research Areas: Seal all pipe penetrations with silicone sealant to prevent entrance of insects.
- P. Work in bathrooms, restrooms, housekeeping closets: All pipe penetrations behind escutcheons shall be sealed with plumbers putty.
- Q. Switchgear Drip Protection: Every effort shall be made to eliminate the installation of pipe above data equipment, and electrical and telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints. Drain valve shall be provided in low point of casement pipe.
- R. Inaccessible Equipment:
 1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost or additional time to the Government.
 2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as electrical conduit, motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

3.2 TEMPORARY PIPING AND EQUIPMENT

- A. Continuity of operation of existing facilities may require temporary installation or relocation of equipment and piping. Temporary equipment or pipe installation or relocation shall be provided to maintain continuity of operation of existing facilities.
- B. The Contractor shall provide all required facilities in accordance with the requirements of phased construction and maintenance of service. All piping and equipment shall be properly supported, sloped to drain, operate without excessive stress, and shall be insulated where injury can occur to personnel by contact with operating facilities. The requirements of paragraph 3.1 shall apply.

- C. Temporary facilities and piping shall be completely removed back to the nearest active distribution branch or main pipe line and any openings in structures sealed. Dead legs are not allowed in potable water systems. Necessary blind flanges and caps shall be provided to seal open piping remaining in service.

3.3 RIGGING

- A. Openings in building structures shall be planned to accommodate design scheme.
- B. Alternative methods of equipment delivery may be offered and will be considered by Government under specified restrictions of phasing and service requirements as well as structural integrity of the building.
- C. All openings in the building shall be closed when not required for rigging operations to maintain proper environment in the facility for Government operation and maintenance of service.
- D. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility.
- E. Contractor shall check all clearances, weight limitations and shall provide a rigging plan designed by a Registered Professional Engineer. All modifications to structures, including reinforcement thereof, shall be at Contractor's cost, time and responsibility.
- F. Rigging plan and methods shall be referred to COR for evaluation prior to actual work.

3.4 PIPE AND EQUIPMENT SUPPORTS

- A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Holes shall be drilled or burned in structural steel ONLY with the prior written approval of the COR.
- B. The use of chain pipe supports, wire or strap hangers; wood for blocking, stays and bracing, or hangers suspended from piping above shall not be permitted. Rusty products shall be replaced.

- C. Hanger rods shall be used that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. A minimum of 15 mm (1/2 inch) clearance between pipe or piping covering and adjacent work shall be provided.
- D. For horizontal and vertical plumbing pipe supports, refer to the International Plumbing Code (IPC) and these specifications.
- E. Overhead Supports:
 - 1. The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.
 - 2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.
 - 3. Tubing and capillary systems shall be supported in channel troughs.
- F. Floor Supports:
 - 1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Concrete bases and structural systems shall be anchored and doweled to resist forces under operating and seismic conditions (if applicable) without excessive displacement or structural failure.
 - 2. Bases and supports shall not be located and installed until equipment mounted thereon has been approved. Bases shall be sized to match equipment mounted thereon plus 50 mm (2 inch) excess on all edges. Structural drawings shall be reviewed for additional requirements. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top, and shall be suitable for painting.
 - 3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a grout material to permit alignment and realignment.

3.6 PLUMBING SYSTEMS DEMOLITION

- A. Rigging access, other than indicated on the drawings, shall be provided after approval for structural integrity by the COR. Such access shall be provided without additional cost or time to the Government. Where work is in an operating plant, approved protection from dust and debris shall be provided at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.
- B. In an operating plant, cleanliness and safety shall be maintained. The plant shall be kept in an operating condition. Government personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and plant operation. Work shall be confined to the immediate area concerned; maintain cleanliness and wet down demolished materials to eliminate dust. Dust and debris shall not be permitted to accumulate in the area to the detriment of plant operation. All flame cutting shall be performed to maintain the fire safety integrity of this plant. Adequate fire extinguishing facilities shall be available at all times. All work shall be performed in accordance with recognized fire protection standards including NFPA 51B. Inspections will be made by personnel of the VA Medical Center, and the Contractor shall follow all directives of the COR with regard to rigging, safety, fire safety, and maintenance of operations.
- C. Unless specified otherwise, all piping, wiring, conduit, and other devices associated with the equipment not re-used in the new work shall be completely removed from Government property per Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT. This includes all concrete equipment pads, pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. All openings shall be sealed after removal of equipment, pipes, ducts, and other penetrations in roof, walls, floors, in an approved manner and in accordance with plans and specifications where specifically covered. Structural integrity of the building system shall be maintained. Reference shall also be made to the drawings and specifications of the other disciplines in the project for additional facilities to be demolished or handled.

- D. All valves including gate, globe, ball, butterfly and check, all pressure gages and thermometers with wells shall remain Government property and shall be removed and delivered to COR and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these plans and specifications. Such material shall be removed from Government property expeditiously and shall not be allowed to accumulate. Coordinate with the COR and Infection Control.

3.7 CLEANING AND PAINTING

- A. Prior to final inspection and acceptance of the plant and facilities for beneficial use by the Government, the plant facilities, equipment and systems shall be thoroughly cleaned and painted. Refer to Section 09 91 00, PAINTING.
- B. In addition, the following special conditions apply:
1. Cleaning shall be thorough. Solvents, cleaning materials and methods recommended by the manufacturers shall be used for the specific tasks. All rust shall be removed prior to painting and from surfaces to remain unpainted. Scratches, scuffs, and abrasions shall be repaired prior to applying prime and finish coats.
 2. The following Material and Equipment shall NOT be painted:
 - a. Motors, controllers, control switches, and safety switches.
 - b. Control and interlock devices.
 - c. Regulators.
 - d. Pressure reducing valves.
 - e. Control valves and thermostatic elements.
 - f. Lubrication devices and grease fittings.
 - g. Copper, brass, aluminum, stainless steel and bronze surfaces.
 - h. Valve stems and rotating shafts.
 - i. Pressure gages and thermometers.
 - j. Glass.
 - k. Name plates.
 3. Control and instrument panels shall be cleaned and damaged surfaces repaired. Touch-up painting shall be made with matching paint type and color obtained from manufacturer or computer matched.

4. Pumps, motors, steel and cast iron bases, and coupling guards shall be cleaned, and shall be touched-up with the same paint type and color as utilized by the pump manufacturer.
5. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats per Section 09 91 00, Painting.
6. The final result shall be a smooth, even-colored, even-textured factory finish on all items. The entire piece of equipment shall be repainted, if necessary, to achieve this. Lead based paints shall not be used.

3.8 IDENTIFICATION SIGNS

- A. Pipe Identification: Refer to Section 09 91 00, PAINTING.

3.9 STARTUP AND TEMPORARY OPERATION

- A. Startup of equipment shall be performed as described in the equipment specifications. Vibration within specified tolerance shall be verified prior to extended operation. Temporary use of equipment is specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.

3.10 OPERATING AND PERFORMANCE TESTS

- A. Prior to the final inspection, all required tests shall be performed as specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TESTS and submit the test reports and records to the COR.
- B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost to the Government.
- C. When completion of certain work or systems occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then conduct such performance tests and finalize control settings during the first actual seasonal use of the respective systems following completion of work. Rescheduling of these tests shall be requested in writing to COR for approval.

3.11 OPERATION AND MAINTENANCE MANUALS

- A. All new and temporary equipment and all elements of each assembly shall be included.
- B. Data sheet on each device listing model, size, capacity, pressure, speed, horsepower, impeller size, and other information shall be included.

- C. Manufacturer's installation, maintenance, repair, and operation instructions for each device shall be included. Assembly drawings and parts lists shall also be included. A summary of operating precautions and reasons for precautions shall be included in the Operations and Maintenance Manual.
- D. Lubrication instructions, type and quantity of lubricant shall be included.
- E. Schematic diagrams and wiring diagrams of all control systems corrected to include all field modifications shall be included.
- F. Set points of all interlock devices shall be listed.
- G. Trouble-shooting guide for the control system troubleshooting shall be inserted into the Operations and Maintenance Manual.
- H. The control system sequence of operation corrected with submittal review comments shall be inserted into the Operations and Maintenance Manual.
- I. Emergency procedures for shutdown and startup of equipment and systems.

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SECTION 22 05 23
GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL**1.1 DESCRIPTION**

- A. This section describes the requirements for general-duty valves for domestic water and sewer systems.
- B. A complete listing of all acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES.
- C. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
 - 1070-2004Performance Requirements for Water Temperature Limiting Devices
- B. American Society for Testing and Materials (ASTM):
 - A276-2013aStandard Specification for Stainless Steel Bars and Shapes
 - B62-2009Standard Specification for Composition Bronze or Ounce Metal Castings
 - B584-2013Standard Specification for Copper Alloy Sand Castings for General Applications
- C. International Code Council (ICC):
 - IPC-2012International Plumbing Code
- D. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):
 - SP-25-2008Standard Marking Systems for Valves, Fittings, Flanges and Unions
 - SP-80-2013Bronze Gate, Globe, Angle, and Check Valves
 - SP-110-2010Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

E. National Environmental Balancing Bureau (NEBB):

7th Edition 2005 Procedural Standards for Testing, Adjusting,
Balancing of Environmental Systems

F. NSF International (NSF):

61-2012Drinking Water System Components - Health
Effects

372-2011Drinking Water System Components - Lead Content

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING", with applicable paragraph identification.
- C. Manufacturer's Literature and Data Including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
1. Ball Valves.
 2. Gate Valves.
 4. Balancing Valves.
 5. Check Valves.
 6. Globe Valves.
- D. Test and Balance reports for balancing valves.
- E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replaceable parts:
1. Include complete list indicating all components of the systems.
 2. Include complete diagrams of the internal wiring for each item of equipment.
 3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Valves shall be prepared for shipping as follows:
1. Protect internal parts against rust and corrosion.
 2. Protect threads, flange faces, grooves, and weld ends.
 3. Set angle, gate, and globe valves closed to prevent rattling.

4. Set ball and plug valves open to minimize exposure of functional surfaces.
 5. Set butterfly valves closed or slightly open.
 6. Block check valves in either closed or open position.
- B. Valves shall be prepared for storage as follows:
1. Maintain valve end protection.
 2. Store valves indoors and maintain at higher than ambient dew point temperature.

PART 2 - PRODUCTS

2.1 VALVES, GENERAL

- A. Asbestos packing and gaskets are prohibited.
- B. Bronze valves shall be made with dezincification resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc shall not be permitted.
- C. Valves in insulated piping shall have 50 mm or DN50 (2 inch) stem extensions and extended handles of non-thermal conductive material that allows operating the valve without breaking the vapor seal or disturbing the insulation. Memory stops shall be fully adjustable after insulation is applied.
- D. All valves used to supply potable water shall meet the requirements of NSF 61 and NSF 372.

2.2 SHUT-OFF VALVES

- A. Cold, Hot and Re-circulating Hot Water:
 1. 50 mm or DN50 (2 inches) and smaller: Ball, MSS SP-110, Ball valve shall be full port three piece or two piece with a union design with adjustable stem package. Threaded stem designs are not allowed. The ball valve shall have a SWP rating of 1035 kPa (150 psig) and a CWP rating of 4138 kPa (600 psig). The body material shall be Bronze ASTM B584, Alloy C844. The ends shall be non-lead solder.

2. Less than 100 mm DN100 (4 inches): Butterfly shall have an iron body with EPDM seal and aluminum bronze disc. The butterfly valve shall meet MSS SP-67, type I standard. The butterfly valve shall have a SWP rating of 1380 kPa (200 psig). The valve design shall be lug type suitable for bidirectional dead-end service at rated pressure. The body material shall meet ASTM A536, ductile iron.

2.3 BALANCING VALVES

- A. Hot Water Re-circulating, 75 mm or DN75 (3 inches) and smaller manual balancing valve shall be of bronze body, brass ball construction with glass and carbon filled TFE seat rings and designed for positive shutoff. The manual balancing valve shall have differential pressure read-out ports across the valve seat area. The read out ports shall be fitting with internal EPT inserts and check valves. The valve body shall have 8 mm or DN8 NPT (1/4 inch NPT) tapped drain and purge port. The valves shall have memory stops that allow the valve to close for service and then reopened to set point without disturbing the balance position. All valves shall have calibrated nameplates to assure specific valve settings.

2.4 CHECK VALVES

- A. 75 mm or DN75 (3 inches) and smaller shall be Class 125, bronze swing check valves with non-metallic disc suitable for type of service. The check valve shall meet MSS SP-80 Type 4 standard. The check valve shall have a CWP rating of 1380 kPa (200 psig). The check valve shall have a Y pattern horizontal body design with bronze body material conforming to ASTM B62, solder joints, and PTFE or TFE disc.

2.5 GLOBE VALVES

- A. 75 mm or DN75 (3 inches) or smaller: Class 150, bronze globe valve with non-metallic disc. The globe valve shall meet MSS SP-80, Type 2 standard. The globe valve shall have a CWP rating of 2070 kPa (300 psig). The valve material shall be bronze with integral seal and union ring bonnet conforming to ASTM B62 with solder ends, copper-silicon bronze stem, PTFE or TFE disc, and malleable iron hand wheel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Valve interior shall be examined for cleanliness, freedom from foreign matter, and corrosion. Special packing materials shall be removed, such as blocks, used to prevent disc movement during shipping and handling.

- B. Valves shall be operated in positions from fully open to fully closed. Guides and seats shall be examined and made accessible by such operations.
- C. Threads on valve and mating pipe shall be examined for form and cleanliness.
- D. Mating flange faces shall be examined for conditions that might cause leakage. Bolting shall be checked for proper size, length, and material. Gaskets shall be verified for proper size and that its material composition is suitable for service and free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.2 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. Valves shall be located for easy access and shall be provide with separate support. Valves shall be accessible with access doors when installed inside partitions or above hard ceilings.
- C. Valves shall be installed in horizontal piping with stem at or above center of pipe.
- D. Valves shall be installed in a position to allow full stem movement.
- E. Check valves shall be installed for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level and on top of valve.
- F. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no cost to the Government.

3.3 ADJUSTING

- A. Valve packing shall be adjusted or replaced after piping systems have been tested and put into service but before final adjusting and balancing. Valves shall be replaced if persistent leaking occurs.
- B. Set field-adjustable flow set points of balancing valves and record data. Ensure recorded data represents actual measured or observed conditions. Permanently mark settings of valves and other adjustment devices allowing settings to be restored. Set and lock memory stops. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

C. Testing and adjusting of balancing valves shall be performed by an independent NEBB Accredited Test and Balance Contractor. A final settings and flow report shall be submitted to the VA Contracting Officer's Representative (COR).

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SECTION 22 07 11
PLUMBING INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Field applied insulation for thermal efficiency and condensation control for
 - 1. Plumbing piping and equipment.
- B. Definitions
 - 1. ASJ: All service jacket, white finish facing or jacket.
 - 2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.
 - 3. Cold: Equipment or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.
 - 4. Concealed: Piping above ceilings and in chases, interstitial space, and pipe spaces.
 - 5. Exposed: Piping and equipment exposed to view in finished areas including mechanical equipment rooms or exposed to outdoor weather. Shafts, chases and interstitial spaces are not considered finished areas.
 - 6. FSK: Foil-scrim-kraft facing.
 - 7. Hot: Plumbing equipment or piping handling media above 41 degrees C (105 degrees F).
 - 8. Density: kg/m^3 - kilograms per cubic meter (Pcf - pounds per cubic foot).
 - 9. Thermal conductance: Heat flow rate through materials.
 - a. Flat surface: Watts per square meter (BTU per hour per square foot).
 - b. Pipe or Cylinder: Watts per square meter (BTU per hour per linear foot).
 - 10. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).

11. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.
12. R: Pump recirculation.
13. CW: Cold water.
14. SW: Soft water.
15. HW: Hot water.
16. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Mineral fiber and bond breaker behind sealant.
- B. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: General mechanical requirements and items, which are common to more than one section of Division 22.
- C. Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING: Hot and cold water piping.

1.3 QUALITY ASSURANCE

- A. Refer to article QUALITY ASSURANCE, in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- B. Criteria:
 1. Comply with NFPA 90A, particularly paragraphs 4.3.3.1 through 4.3.3.6, 4.3.10.2.6, and 5.4.6.4, parts of which are quoted as follows:

4.3.3.1 Pipe insulation and coverings, vapor retarder facings, adhesives, fasteners, tapes, unless otherwise provided for in 4.3.3.1.12 or 4.3.3.1.2, shall have, in the form in which they are used, a maximum flame spread index of 25 without evidence of continued progressive combustion and a maximum smoke developed index of 50 when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*.

4.3.3.1.1 Where these products are to be applied with adhesives, they shall be tested with such adhesives applied, or the adhesives used shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when in the final dry state. (See 4.2.4.2.)

4.3.3.3 Pipe insulation and coverings shall not flame, glow, smolder, or smoke when tested in accordance with a similar test for pipe covering, ASTM C 411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation, at the temperature to which they are exposed in service.

4.3.3.3.1 In no case shall the test temperature be below 121°C (250°F).

4.3.10.2.6.3 Nonferrous fire sprinkler piping shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with UL 1887, Standard for Safety Fire Test of Plastic Sprinkler Pipe for Visible Flame and Smoke Characteristics.

4.3.10.2.6.7 Smoke detectors shall not be required to meet the provisions of this section.

2. Test methods: ASTM E84, UL 723, or NFPA 255.
3. Specified k factors are at 24 degrees C (75 degrees F) mean temperature unless stated otherwise. Where optional thermal insulation material is used, select thickness to provide thermal conductance no greater than that for the specified material. For pipe, use insulation manufacturer's published heat flow tables. For domestic hot water supply and return, run out insulation and condensation control insulation, no thickness adjustment need be made.
4. All materials shall be compatible and suitable for service temperature, and shall not contribute to corrosion or otherwise attack surface to which applied in either the wet or dry state.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Shop Drawings:
 1. All information, clearly presented, shall be included to determine compliance with drawings and specifications and ASTM, federal and military specifications.
 - a. Insulation materials: Specify each type used and state surface burning characteristics.
 - b. Insulation facings and jackets: Each type used.

- c. Insulation accessory materials: Each type used.
- d. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation.
- e. Make reference to applicable specification paragraph numbers for coordination.

1.5 STORAGE AND HANDLING OF MATERIAL

Store materials in clean and dry environment, pipe covering jackets shall be clean and unmarred. Place adhesives in original containers. Maintain ambient temperatures and conditions as required by printed instructions of manufacturers of adhesives, mastics and finishing cements.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. Federal Specifications (Fed. Spec.):
 - L-P-535E (2)-91Plastic Sheet (Sheeting): Plastic Strip; Poly (Vinyl Chloride) and Poly (Vinyl Chloride - Vinyl Acetate), Rigid.
- C. Military Specifications (Mil. Spec.):
 - MIL-A-3316C (2)-90Adhesives, Fire-Resistant, Thermal Insulation
 - MIL-A-24179A (1)-87Adhesive, Flexible Unicellular-Plastic Thermal Insulation
 - MIL-C-19565C (1)-88Coating Compounds, Thermal Insulation, Fire-and Water-Resistant, Vapor-Barrier
 - MIL-C-20079H-87Cloth, Glass; Tape, Textile Glass; and Thread, Glass and Wire-Reinforced Glass
- D. American Society for Testing and Materials (ASTM):
 - A167-04Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
 - B209-07Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
 - C411-05Standard test method for Hot-Surface Performance of High-Temperature Thermal Insulation

C449-07	.....Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
C533-09	.....Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
C534-08	.....Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
C547-07	.....Standard Specification for Mineral Fiber pipe Insulation
C552-07	.....Standard Specification for Cellular Glass Thermal Insulation
C553-08	.....Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
C585-09	.....Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System) R (1998)
C612-10	.....Standard Specification for Mineral Fiber Block and Board Thermal Insulation
C1126-10	.....Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation
C1136-10	.....Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
D1668-97a (2006)	.....Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing
E84-10	.....Standard Test Method for Surface Burning Characteristics of Building Materials
E119-09C	.....Standard Test Method for Fire Tests of Building Construction and Materials
E136-09 b	.....Standard Test Methods for Behavior of Materials in a Vertical Tube Furnace at 750 degrees C (1380 F)

E. National Fire Protection Association (NFPA):

- 101-09Life Safety Code
- 251-06Standard methods of Tests of Fire Endurance of
Building Construction Materials
- 255-06Standard Method of tests of Surface Burning
Characteristics of Building Materials

F. Underwriters Laboratories, Inc (UL):

- 723UL Standard for Safety Test for Surface Burning
Characteristics of Building Materials with
Revision of 08/03

G. Manufacturer's Standardization Society of the Valve and Fitting
Industry (MSS):

- SP58-2002Pipe Hangers and Supports Materials, Design,
and Manufacture

PART 2 - PRODUCTS**2.1 MINERAL FIBER OR FIBER GLASS**

- A. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation),
Class 1, $k = 0.037$ (0.26) at 24 degrees C (75 degrees F), for use at
temperatures up to 230 degrees C (450 degrees F) with an all service
vapor retarder jacket with polyvinyl chloride premolded fitting
covering.

2.2 FLEXIBLE ELASTOMERIC CELLULAR THERMAL

- ASTM C177, C518, $k = 0.039$ (0.27) at 24 degrees C (75 degrees F), flame
spread not over 25, smoke developed not over 50, for temperatures from
minus 4 degrees C (40 degrees F) to 93 degrees C (200 degrees F). No
jacket required.

2.3 CALCIUM SILICATE

- A. Preformed pipe Insulation: ASTM C533, Type I and Type II with indicator
denoting asbestos-free material.
- B. Premolded Pipe Fitting Insulation: ASTM C533, Type I and Type II with
indicator denoting asbestos-free material.
- C. Equipment Insulation: ASTM C533, Type I and Type II
- D. Characteristics:

Insulation Characteristics		
ITEMS	TYPE I	TYPE II
Temperature, maximum degrees C (degrees F)	649 (1200)	927 (1700)
Density (dry), Kg/m ³ (lb/ ft ³)	232 (14.5)	288 (18)
Thermal conductivity: Min W/ m K (Btu in/h ft ² degrees F)@ mean temperature of 93 degrees C (200 degrees F)	0.059 (0.41)	0.078 (0.540)
Surface burning characteristics: Flame spread Index, Maximum	0	0
Smoke Density index, Maximum	0	0

2.4 INSULATION FACINGS AND JACKETS

- A. Vapor Retarder, higher strength with low water permeance ≤ 0.02 or less perm rating, Beach puncture 50 units for insulation facing on pipe insulation jackets. Facings and jackets shall be all service type (ASJ) or PVDC Vapor Retarder jacketing.
- B. ASJ jacket shall be white kraft bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 75mm (3 inch) butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.
- C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK) or PVDC vapor retarder jacketing type for concealed ductwork and equipment.
- D. Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be polyvinyl chloride (PVC) conforming to Fed Spec L-P-335, composition A, Type II Grade GU, and Type III, minimum thickness 0.7 mm (0.03 inches). Provide color matching vapor retarder pressure sensitive tape.

2.5 PIPE COVERING PROTECTION SADDLES

- A. Cold pipe support: Premolded pipe insulation 180 degrees (half-shells) on bottom half of pipe at supports. Material shall be cellular glass or high density Polyisocyanurate insulation of the same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m³ (3.0 pcf).

Nominal Pipe Size and Accessories Material (Insert Blocks)	
Nominal Pipe Size mm (inches)	Insert Blocks mm (inches)
Up through 125 (5)	150 (6) long
150 (6)	150 (6) long
200 (8), 250 (10), 300 (12)	225 (9) long
350 (14), 400 (16)	300 (12) long
450 through 600 (18 through 24)	350 (14) long

- B. Warm or hot pipe supports: Premolded pipe insulation (180 degree half-shells) on bottom half of pipe at supports. Material shall be high density Polyisocyanurate (for temperatures up to 149 degrees C [300 degrees F]), cellular glass or calcium silicate. Insulation at supports shall have same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m³ (3.0 pcf).

2.6 ADHESIVE, MASTIC, CEMENT

- A. Mil. Spec. MIL-A-3316, Class 1: Jacket and lap adhesive and protective finish coating for insulation.
- B. Mil. Spec. MIL-A-3316, Class 2: Adhesive for laps and for adhering insulation to metal surfaces.
- C. Mil. Spec. MIL-C-19565, Type I or Type II: Vapor barrier compound for indoor use.
- D. Other: Insulation manufacturers' published recommendations.

2.7 MECHANICAL FASTENERS

- A. Pins, anchors: Welded pins, or metal or nylon anchors with galvanized steel or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.
- B. Staples: Outward clinching galvanized steel
- C. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy.

- D. Bands: 13 mm (1/2 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

2.8 REINFORCEMENT AND FINISHES

- A. Tape for Flexible Elastomeric Cellular Insulation: As recommended by the insulation manufacturer.
- B. PVC fitting cover: Fed. Spec L-P-535, Composition A, 11-86 Type II, Grade GU, with Form B Mineral Fiber insert, for media temperature 4 degrees C (40 degrees F) to 121 degrees C (250 degrees F). Below 4 degrees C (40 degrees F) and above 121 degrees C (250 degrees F). Provide double layer insert. Provide color matching vapor barrier pressure sensitive tape.

2.9 FIRESTOPPING MATERIAL

Other than pipe insulation, refer to Section 07 84 00 FIRESTOPPING.

2.10 FLAME AND SMOKE

Unless shown otherwise all assembled systems shall meet flame spread 25 and smoke developed 50 rating as developed under ASTM, NFPA and UL standards and specifications. See paragraph 1.3 "Quality Assurance".

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Required pressure tests of piping joints and connections shall be completed and the work approved by the Resident Engineer for application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.
- B. Except for specific exceptions, insulate all specified equipment, and piping (pipe, fittings, valves, accessories). Insulate each pipe individually. Do not use scrap pieces of insulation where a full length section will fit.
- C. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 16 degrees C (60 degrees F) and below. Lap and seal vapor barrier over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 150 mm (6 inches).

- D. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.
- E. Construct insulation on parts of equipment such as cold water pumps and heat exchangers that must be opened periodically for maintenance or repair, so insulation can be removed and replaced without damage. Install insulation with bolted 1 mm thick (20 gage) galvanized steel or aluminum covers as complete units, or in sections, with all necessary supports, and split to coincide with flange/split of the equipment.
- F. Insulation on hot piping and equipment shall be terminated square at items not to be insulated, access openings and nameplates. Cover all exposed raw insulation with white sealer or jacket material.
- G. Protect all insulations outside of buildings with aluminum jacket using lock joint or other approved system for a continuous weather tight system. Access doors and other items requiring maintenance or access shall be removable and sealable.
- H. Plumbing work not to be insulated:
 - 1. Piping and valves of fire protection system.
 - 2. Chromium plated brass piping.
 - 3. Water piping in contact with earth.
 - 4. Small horizontal cold water branch runs in partitions to individual fixtures may be without insulation for maximum distance of 900 mm (3 feet).
 - 5. Distilled water piping.
- I. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.
- J. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights.
Use of polyurethane spray-foam to fill a PVC elbow jacket is prohibited on cold applications.
- K. Firestop Pipe insulation:
 - 1. Provide firestopping insulation at fire and smoke barriers through penetrations. Fire stopping insulation shall be UL listed as defines in Section 07 84 00, FIRESTOPPING.

2. Pipe penetrations requiring fire stop insulation including, but not limited to the following:
 - a. Pipe risers through floors
 - b. Pipe chase walls and floors
 - c. Smoke partitions
 - d. Fire partitions
- L. Freeze protection of above grade outdoor piping (over heat tracing tape): 20 mm (0.75) thick insulation, for all pipe sizes 75 mm (3 inches) and smaller and 25 mm (1 inch) thick insulation for larger pipes. Provide metal jackets for all pipes. Provide for cold water make-up where indicated on the drawings as described in Section 23 21 13, HYDRONIC PIPING (electrical heat tracing systems).
- M. Molded Mineral Fiber Pipe and Tubing Covering:
 1. Fit insulation to pipe, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.
 2. Contractor's options for fitting, flange and valve insulation:
 - a. Insulating and finishing cement for sizes less than 100 mm (4 inches) operating at surface temperature of 16 degrees C (61 degrees F) or more.
 - b. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts. Provide two insert layers for pipe temperatures below 4 degrees C (40 degrees F), or above 121 degrees C (250 degrees F). Secure first layer of insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.
 - c. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place. For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 16 degrees C (60 degrees F) or less, vapor seal with a layer of glass

fitting tape imbedded between two 2 mm (1/16 inch) coats of vapor barrier mastic.

- d. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 50 mm (2 inches).

- 3. Nominal thickness in millimeters and inches specified in the schedule at the end of this section.

N. Flexible Elastomeric Cellular Thermal Insulation:

- 1. Apply insulation and fabricate fittings in accordance with the manufacturer's installation instructions and finish with two coats of weather resistant finish as recommended by the insulation manufacturer.
- 2. Pipe and tubing insulation:
 - a. Use proper size material. Do not stretch or strain insulation.
 - b. To avoid undue compression of insulation, provide cork stoppers or wood inserts at supports as recommended by the insulation manufacturer. Insulation shields are specified under Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
 - c. Where possible, slip insulation over the pipe or tubing prior to connection, and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed. Make changes from mineral fiber insulation in a straight run of pipe, not at a fitting. Seal joint with tape.
- 3. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.
- 4. Pipe insulation: nominal thickness in millimeters (inches as specified in the schedule at the end of this section).

O. Calcium Silicate:

1. Minimum thickness in millimeter (inches) specified below for piping other than in boiler plant.

Nominal Thickness Of Calcium Silicate Insulation (Non-Boiler Plant)				
Nominal Pipe Size Millimeters (Inches)	Thru 25 (1)	32 to 75 (1-1/4 to 3)	100-200 (4 to 6)	Over 200 (6)
93-260 degrees C (200- 500 degrees F) (HPS, HPR)	100 (4)	125 (5)	150 (6)	150 (6)

2. MRI Quench Vent Insulation: Type I, class D, 150 mm (6 inch) nominal thickness.

3.3 PIPE INSULATION SCHEDULE

Provide insulation for piping systems as scheduled below:

Insulation Thickness Millimeters (Inches)					
		Nominal Pipe Size Millimeters (Inches)			
Operating Temperature Range/Service	Insulation Material	Less than 25 (1)	25 - 32 (1 - 1¼)	38 - 75 (1½ - 3)	100 (4) and Above
4-60 degrees C (40- 140 degrees F) (Domestic Hot and Cold Water Supply and Return)	Mineral Fiber (Above ground piping only)	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
38-60 degrees C (40- 140 degrees F) (Domestic Hot and Cold Water Supply and Return)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	38 (1.5)	38 (1.5)	----	----

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SECTION 22 13 00
FACILITY SANITARY AND VENT PIPING

PART 1 - GENERAL**1.1 DESCRIPTION**

- A. This section pertains to sanitary sewer and vent systems, including piping, equipment and all necessary accessories as designated in this section.
- B. A complete listing of all acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 07 84 00, FIRESTOPPING: Penetrations in rated enclosures.
- D. Section 07 92 00, JOINT SEALANTS: Sealant products.
- E. Section 09 91 00, PAINTING: Preparation and finish painting and identification of piping systems.
- F. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: Pipe Hangers and Supports, Materials Identification.
- G. Section 22 07 11, PLUMBING INSULATION.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
 - A13.1-2007Scheme for the Identification of Piping Systems
 - A112.36.2M-1991(R 2012) Cleanouts
 - A112.6.3-2001 (R2007) ..Standard for Floor and Trench Drains
 - B1.20.1-2013Pipe Threads, General Purpose (Inch)
 - B16.1-2010Gray Iron Pipe Flanges and Flanged Fittings
 - B16.4-2011Standard for Grey Iron Threaded Fittings
 - Classes 125 and 250
 - B16.15-2013Cast Copper Alloy Threaded Fittings, Classes
 - 125 and 250
 - B16.18-2012Cast Copper Alloy Solder Joint Pressure Fittings
 - B16.21-2011Nonmetallic Flat Gaskets for Pipe Flanges

- B16.22-2013Wrought Copper and Copper Alloy Solder-Joint
Pressure Fittings
- B16.23-2011Cast Copper Alloy Solder Joint Drainage
Fittings: DWV
- B16.24-2001 (R2006)Cast Copper Alloy Pipe Flanges and Flanged
Fittings
- B16.29-2012Wrought Copper and Wrought Copper Alloy Solder-
Joint Drainage Fittings: DWV
- B16.39-2009Malleable Iron Threaded Pipe Unions Classes
150, 250, and 300
- B18.2.1-2012Square, Hex, Heavy Hex, and Askew Head Bolts
and Hex, Heavy Hex, Hex Flange, Lobed Head, and
Lag Screws (Inch Series)
- C. American Society of Sanitary Engineers (ASSE):
- 1001-2008Performance Requirements for Atmospheric Type
Vacuum Breakers
- 1018-2001Performance Requirements for Trap Seal Primer
Valves - Potable Water Supplied
- 1044-2001Performance Requirements for Trap Seal Primer
Devices - Drainage Types and Electronic Design
Types
- 1079-2012Performance Requirements for Dielectric Pipe
Unions
- D. American Society for Testing and Materials (ASTM):
- A53/A53M-2012Standard Specification for Pipe, Steel, Black
And Hot-Dipped, Zinc-coated, Welded and
Seamless
- A74-2013aStandard Specification for Cast Iron Soil Pipe
and Fittings
- A888-2013aStandard Specification for Hubless Cast Iron
Soil Pipe and Fittings for Sanitary and Storm
Drain, Waste, and Vent Piping Applications
- B32-2008Standard Specification for Solder Metal
- B43-2009Standard Specification for Seamless Red Brass
Pipe, Standard Sizes
- B75-2011Standard Specification for Seamless Copper Tube

B88-2009	.....Standard Specification for Seamless Copper Water Tube
B306-2013	.....Standard Specification for Copper Drainage Tube (DWV)
B584-2013	.....Standard Specification for Copper Alloy Sand Castings for General Applications
B687-1999 (R 2011)	.....Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples
B813-2010	.....Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
B828-2002 (R 2010)	.....Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
C564-2012	.....Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
D1785-2012	.....Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
D2321-2011	.....Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
D2564-2012	.....Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
D2665-2012	.....Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
D2855-1996 (R 2010)	.....Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
D5926-2011	.....Standard Specification for Poly(Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems
F402-2005 (R 2012)	.....Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings

- F477-2010Standard Specification for Elastomeric Seals
(Gaskets) for Joining Plastic Pipe
- F1545-1997 (R 2009)Standard Specification for Plastic-Lined
Ferrous Metal Pipe, Fittings, and Flanges
- E. Cast Iron Soil Pipe Institute (CISPI):
- 2006Cast Iron Soil Pipe and Fittings Handbook
- 301-2012Standard Specification for Hubless Cast Iron
Soil Pipe and Fittings for Sanitary and Storm
Drain, Waste, and Vent Piping Applications
- 310-2012Specification for Coupling for Use in
Connection with Hubless Cast Iron Soil Pipe and
Fittings for Sanitary and Storm Drain, Waste,
and Vent Piping Applications
- F. Copper Development Association, Inc. (CDA):
- A4015Copper Tube Handbook
- G. International Code Council (ICC):
- IPC-2012International Plumbing Code
- H. Manufacturers Standardization Society (MSS):
- SP-123-2013Non-Ferrous Threaded and Solder-Joint Unions
for Use With Copper Water Tube
- I. National Fire Protection Association (NFPA):
- 70-2011National Electrical Code (NEC)
- J. Plumbing and Drainage Institute (PDI):
- WH-201 (R 2010)Water Hammer Arrestors Standard
- K. Underwriters' Laboratories, Inc. (UL):
- 508-99 (R2013)Standard For Industrial Control Equipment

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 13 00, FACILITY SANITARY AND VENT PIPING", with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. Piping.
2. Penetration Sleeves.
3. Pipe Fittings.
4. Traps.
5. Exposed Piping and Fittings.

1.5 AS-BUILT DOCUMENTATION

- A. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them on Auto-Cad version provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.
- B. Certification documentation shall be provided prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and a certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 SANITARY WASTE, DRAIN, AND VENT PIPING

- A. Cast iron waste, drain, and vent pipe and fittings.
 1. Cast iron waste, drain, and vent pipe and fittings shall be used for the following applications:
 - a. Pipe buried in or in contact with earth.
 - b. Sanitary pipe extensions to a distance of approximately 1500 mm (5 feet) outside of the building.
 - c. Interior waste and vent piping above grade.
 2. Cast iron Pipe shall be bell and spigot or hubless (plain end or no-hub or hubless).
 3. The material for all pipe and fittings shall be cast iron soil pipe and fittings and shall conform to the requirements of CISPI 301, ASTM A888, or ASTM A74.
 4. Cast iron pipe and fittings shall be made from a minimum of 95 percent post-consumer recycled material.

5. Joints for hubless pipe and fittings shall conform to the manufacturer's installation instructions. Couplings for hubless joints shall conform to CISPI 310. Joints for hub and spigot pipe shall be installed with compression gaskets conforming to the requirements of ASTM C564.

2.2 EXPOSED WASTE PIPING

- A. Chrome plated brass piping of full iron pipe size shall be used in finished rooms for exposed waste piping connecting fixtures, casework, cabinets, equipment and reagent racks when not concealed by apron including those furnished by the Government or specified in other sections.
 1. The Pipe shall meet ASTM B43, regular weight.
 2. The Fittings shall conform to ASME B16.15.
 3. Nipples shall conform to ASTM B687, Chromium-plated.
 4. Unions shall be brass or bronze with chrome finish. Unions 65 mm (2-1/2 inches) and larger shall be flange type with approved gaskets.
- B. In unfinished Rooms such as mechanical Rooms and Kitchens, Chrome-plated brass piping is not required. The pipe materials specified under the paragraph "Sanitary Waste, Drain, and Vent Piping" can be used. The sanitary pipe in unfinished rooms shall be painted as specified in Section 09 91 00, PAINTING.

2.3 SPECIALTY PIPE FITTINGS

- A. Transition pipe couplings shall join piping with small differences in outside diameters or different materials. End connections shall be of the same size and compatible with the pipes being joined. The transition coupling shall be elastomeric, sleeve type reducing or transition pattern and include shear and corrosion resistant metal, tension band and tightening mechanism on each end. The transition coupling sleeve coupling shall be of the following material:
 1. For cast iron soil pipes, the sleeve material shall be rubber conforming to ASTM C564.
 2. For dissimilar pipes, the sleeve material shall be PVC conforming to ASTM D5926, or other material compatible with the pipe materials being joined.

- B. The dielectric fittings shall conform to ASSE 1079 with a pressure rating of 861 kPa (125 psig) at a minimum temperature of 82 degrees C (180 degrees F). The end connection shall be solder joint copper alloy and threaded ferrous.
- C. Dielectric flange insulating kits shall be of non-conducting materials for field assembly of companion flanges with a pressure rating of 1035 kPa (150 psig). The gasket shall be neoprene or phenolic. The bolt sleeves shall be phenolic or polyethylene. The washers shall be phenolic with steel backing washers.
- D. The di-electric nipples shall be electroplated steel nipple complying with ASTM F1545 with a pressure rating of 2070 kPa (300 psig) at 107 degrees C (225 degrees F). The end connection shall be male threaded. The lining shall be inert and noncorrosive propylene.

2.4 CLEANOUTS

- A. Cleanouts shall be the same size as the pipe, up to 100 mm (4 inches); and not less than 100 mm (4 inches) for larger pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. Minimum clearance of 600 mm (24 inches) shall be provided for clearing a clogged sanitary line.
- B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside calk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 50 mm (2 inches). When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In the carpeted areas, carpet cleanout markers shall be provided. Two way cleanouts shall be provided where indicated on drawings and at every building exit. The loading classification for cleanouts in sidewalk areas or subject to vehicular traffic shall be heavy duty type.

- C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 600 mm (24 inches) above the floor. If there are no fixtures installed on the lowest floor, the cleanout shall be installed at the base of the stack. The cleanouts shall be extended to the wall access cover.

Cleanout shall consist of sanitary tees. Nickel-bronze square frame and stainless steel cover with minimum opening of 150 by 150 mm (6 by 6 inches) shall be furnished at each wall cleanout. Where the piping is concealed, a fixture trap or a fixture with integral trap, readily removable without disturbing concealed pipe, shall be accepted as a cleanout equivalent providing the opening to be used as a cleanout opening is the size required.

- D. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/hubless cast iron ferrule. Plain end (hubless) piping in interstitial space or above ceiling may use plain end (hubless) blind plug and clamp.

2.5 TRAPS

- A. Traps shall be provided on all sanitary branch waste connections from fixtures or equipment not provided with traps. Exposed brass shall be polished brass chromium plated with nipple and set screw escutcheons. Concealed traps may be rough cast brass or same material as the piping they are connected to. Slip joints are not permitted on sewer side of trap. Traps shall correspond to fittings on cast iron soil pipe or steel pipe respectively, and size shall be as required by connected service or fixture.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

- A. The pipe installation shall comply with the requirements of the International Plumbing Code (IPC) and these specifications.
- B. Branch piping shall be installed for waste from the respective piping systems and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.
- C. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe shall be reamed to full size after cutting.
- D. All pipe runs shall be laid out to avoid interference with other work.
- E. The piping shall be installed above accessible ceilings where possible.

- F. The piping shall be installed to permit valve servicing or operation.
- G. The piping shall be installed free of sags and bends.
- H. Seismic restraint shall be installed where required by code.
- I. Changes in direction for soil and waste drainage and vent piping shall be made using appropriate branches, bends and long sweep bends.
Sanitary tees and short sweep quarter bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and eighth bend fittings shall be used if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- J. Buried soil and waste drainage and vent piping shall be laid beginning at the low point of each system. Piping shall be installed true to grades and alignment indicated with unbroken continuity of invert. Hub ends shall be placed upstream. Required gaskets shall be installed according to manufacturer's written instruction for use of lubricants, cements, and other installation requirements.
- K. Cast iron piping shall be installed according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings"
- L. Aboveground copper tubing shall be installed according to Copper Development Association's (CDA) "Copper Tube Handbook".
- M. Aboveground PVC piping shall be installed according to ASTM D2665. Underground PVC piping shall be installed according to ASTM D2321.
- N. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no cost to the Government.

3.2 JOINT CONSTRUCTION

- A. Hub and spigot, cast iron piping with gasket joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Hub and spigot, cast iron piping with calked joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.

- C. Hubless or No-hub, cast iron piping shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless piping coupling joints.
- D. For threaded joints, thread pipe with tapered pipe threads according to ASME B1.20.1. The threads shall be cut full and clean using sharp disc cutters. Threaded pipe ends shall be reamed to remove burrs and restored to full pipe inside diameter. Pipe fittings and valves shall be joined as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service.
 - 2. Pipe sections with damaged threads shall be replaced with new sections of pipe.

3.3 SPECIALTY PIPE FITTINGS

- A. Transition coupling shall be installed at pipe joints with small differences in pipe outside diameters.
- B. Dielectric fittings shall be installed at connections of dissimilar metal piping and tubing.

3.4 PIPE HANGERS, SUPPORTS AND ACCESSORIES

- A. All piping shall be supported according to the International Plumbing Code (IPC), Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, and these specifications. Where conflicts arise between these the code and Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING the most restrictive or the requirement that specifies supports with highest loading or shortest spacing shall apply.
- B. Hangers, supports, rods, inserts and accessories used for pipe supports shall be painted according to Section 09 91 00, PAINTING. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.
- C. Horizontal piping and tubing shall be supported within 300 mm (12 inches) of each fitting or coupling.
- D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:
 - 1. 40 mm or DN40 to 50 mm or DN50 (NPS 1-1/2 inch to NPS 2 inch): 1500 mm (60 inches) with 10 mm (3/8 inch) rod.
 - 2. 75 mm or DN75 (NPS 3 inch): 1500 mm (60 inches) with 15 mm (1/2 inch) rod.

3. 100 mm or DN100 to 125 mm or DN125 (NPS 4 inch to NPS 5 inch): 1500 mm (60 inches) with 18 mm (5/8 inch) rod.
 4. 150 mm or DN150 to 200 mm or DN200 (NPS 6 inch to NPS 8 inch): 1500 mm (60 inches) with 20 mm (3/4 inch) rod.
 5. 250 mm or DN250 to 300 mm or DN300 (NPS 10 inch to NPS 12 inch): 1500 mm (60 inch) with 23 mm (7/8 inch) rod.
- E. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 4.6 m (15 feet).
- F. In addition to the requirements in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, Floor, Wall and Ceiling Plates, Supports, Hangers shall have the following characteristics:
1. Solid or split unplated cast iron.
 2. All plates shall be provided with set screws.
 3. Height adjustable clevis type pipe hangers.
 4. Adjustable floor rests and base flanges shall be steel.
 5. Hanger rods shall be low carbon steel, fully threaded or threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
 6. Riser clamps shall be malleable iron or steel.
 7. Rollers shall be cast iron.
 8. See Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, for requirements on insulated pipe protective shields at hanger supports.
- G. Miscellaneous materials shall be provided as specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6.1 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. All necessary auxiliary steel shall be provided to provide that support.
- H. Cast escutcheon with set screw shall be provided at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

I. Penetrations:

1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, a fire stop shall be installed that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING. Clearances between raceways and openings shall be completely filled and sealed with the fire stopping materials.
2. Water proofing: At floor penetrations, clearances shall be completely sealed around the pipe and make watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS.

J. Exhaust vents shall be extended separately through roof. Sanitary vents shall not connect to exhaust vents.

3.5 TESTS

- A. Sanitary waste and drain systems shall be tested either in its entirety or in sections.
- B. Waste System tests shall be conducted before trenches are backfilled or fixtures are connected. A water test or air test shall be conducted, as directed.
 1. If entire system is tested for a water test, tightly close all openings in pipes except highest opening, and fill system with water to point of overflow. If the waste system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 3 m (10 foot) head of water. In testing successive sections, test at least upper 3 m (10 feet) of next preceding section so that each joint or pipe except upper most 3 m (10 feet) of system has been submitted to a test of at least a 3 m (10 foot) head of water. Water shall be kept in the system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
 2. For an air test, an air pressure of 34 kPa (5 psig) gage shall be maintained for at least 15 minutes without leakage. A force pump and mercury column gage shall be used for the air test.
 3. After installing all fixtures and equipment, open water supply so that all p-traps can be observed. For 15 minutes of operation, all p-traps shall be inspected for leaks and any leaks found shall be corrected.

4. Final Tests: Either one of the following tests may be used.
 - a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke under pressure of .25 kPa (1 inch of water) with a smoke machine. Chemical smoke is prohibited.
 - b. Peppermint Test: Introduce 60 ml (2 ounces) of peppermint into each line or stack.

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**SECTION 22 40 00
PLUMBING FIXTURES****PART 1 - GENERAL****1.1 DESCRIPTION**

- A. Plumbing fixtures, associated trim and fittings necessary to make a complete installation from wall or floor connections to rough piping, and certain accessories.

1.2 RELATED WORK

- A. Sealing between fixtures and other finish surfaces: Section 07 92 00, JOINT SEALANTS.
- B. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.3 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Submit plumbing fixture information in an assembled brochure, showing cuts and full detailed description of each fixture.

1.4 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American National Standard Institute (ANSI):
The American Society of Mechanical Engineers (ASME):
A112.6.1M-02 (R2008).....Floor Affixed Supports for Off-the-Floor
Plumbing Fixtures for Public Use
A112.19.2M-03.....Vitreous China Plumbing Fixtures
- C. American Society for Testing and Materials (ASTM):
A276-2010Stainless and Heat-Resisting Steel Bars and
Shapes
WW-P-541-E/GENPlumbing Fixtures with Amendment 1
- D. National Association of Architectural Metal Manufacturers (NAAMM):
NAAMM AMP 500-505
Metal Finishes Manual (1988)
- E. NSF International (NSF)
NSF/ANSI 14 (2013).....Plastics Piping System Components and Related
Materials
NSF/ANSI 61 (2012).....Drinking Water System Components - Health
Effects
NSF/ANSI 372 (2011).....Drinking Water System Components - Lead Content
- F. American with Disabilities Act (A.D.A) Section 4-19.4 Exposed Pipes and
Surfaces

G. Environmental Protection Agency EPA PL 93-523 1974; A 1999) Safe Drinking Water Act.

H. International Building Code, ICC IPC 2012.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Material or equipment containing a weighted average of greater than 0.25 percent lead shall not be used in any potable water system intended for human consumption, and shall be certified in accordance with NSF/ANSI 61 or NSF 372. Endpoint devices used to dispense water for drinking must meet the requirements of NSF/ANSI 61, Section 9.
- B. Plastic pipe, fittings, and solvent cement shall meet NSF/ANSI 14 and shall be NSF listed for the service intended.

2.2 STAINLESS STEEL

- A. Corrosion-resistant Steel (CRS):
 - 1. Plate, Sheet and Strip: CRS flat products shall conform to chemical composition requirements of any 300 series steel specified in ASTM A276.
 - 2. Finish: Exposed surfaces shall have standard polish (ground and polished) equal to NAAMM finish Number 4.
- B. Die-cast zinc alloy products are prohibited.

2.3 STOPS

- A. Provide lock-shield loose key or screw driver pattern angle stops, straight stops or stops integral with faucet, with each compression type faucet whether specifically called for or not, including sinks in wood and metal casework, laboratory furniture and pharmacy furniture. Locate stops centrally above or below fixture in accessible location.
- B. Furnish keys for lock shield stops to Resident Engineer.
- C. Supply from stops not integral with faucet shall be chrome plated copper flexible tubing or flexible stainless steel with inner core of non-toxic polymer.
- D. Supply pipe from wall to valve stop shall be rigid threaded IPS copper alloy pipe, i.e. red brass pipe nipple, chrome plated where exposed.

2.4 ESCUTCHEONS

Heavy type, chrome plated, with set screws. Provide for piping serving plumbing fixtures and at each wall, ceiling and floor penetrations in exposed finished locations and within cabinets and millwork.

2.5 LAMINAR FLOW CONTROL DEVICE

- A. Smooth, bright stainless steel or satin finish, chrome plated metal laminar flow device shall provide non-aeration, clear, coherent laminar flow that will not splash in basin. Device shall also have a flow control restrictor and have vandal resistant housing.

B. Flow Control Restrictor:

1. Capable of restricting flow from 95 ml/s to 110 ml/s (1.5 gpm to 1.7 gpm) for lavatories; 125 ml/s to 140 ml/s (2.0 gpm to 2.2 gpm) for sinks P-505 through P-520, P-524 and P-528; and 170 ml/s to 190 ml/s (2.75 gpm to 3.0 gpm) for dietary food preparation and rinse sinks or as specified.
2. Compensates for pressure fluctuation maintaining flow rate specified above within 10 percent between 170 kPa and 550 kPa (25 psi and 80 psi).
3. Operates by expansion and contraction, eliminates mineral/sediment build-up with self-cleaning action, and is capable of easy manual cleaning.

2.6 CARRIERS

- A. ASME/ANSI A112.6.1M, with adjustable gasket faceplate chair carriers for wall hung closets with auxiliary anchor foot assembly, hanger rod support feet, and rear anchor tie down.
- B. ASME/ANSI A112.6.1M, lavatory, chair carrier for thin wall construction All lavatory chair carriers shall be capable of supporting the lavatory with a 250-pound vertical load applied at the front of the fixture.
- C. Where water closets, lavatories or sinks are installed back-to-back and carriers are specified, provide one carrier to serve both fixtures in lieu of individual carriers. The drainage fitting of the back to back carrier shall be so constructed that it prevents the discharge from one fixture from flowing into the opposite fixture.

2.7 LAVATORIES

- A. Dimensions for lavatories are specified, Length by width (distance from wall) and depth.
- B. Brass components in contact with water shall contain no more than 3 percent lead content by dry weight.
- C. **(L-1)** Lavatory. Straight back, approximately 521 mm by 464 mm (20.5 inches by 18.25 inches) and a (4 inches) apron, first quality white vitreous china. ASME A112.19.2 for Vitreous China Fixtures. Punching for faucet on (8 inches) centers. Concealed arm support. Set with rim above finished floor per architectural. Basis of design: American Standard 0356.015 Lucerne or approved equal.
 1. Faucet: Solid POLISHED CHROME and cast brass construction, vandal resistant, heavy-duty individual wrist blade handles, gooseneck. 8" Centers. 5-1/4" Rigid / Swing Gooseneck Spout. 2.2 GPM (8.3 L/min). 4" Vandal Proof Wristblade Handles. Ceramic 1/4 Turn Operating Cartridge. 1/2" NPSM Supply Inlets and Coupling Nut for 3/8" or 1/2" Flexible riser. Wrist Blade Lever Handle Control ASME/ANSI

- A112.18.1. Provide laminar flow control device (no aerators), and vandal proof screws. Basis of Design: Faucet: Chicago Faucets 786-E29XKABCP.
2. Drain: Cast or wrought brass with flat grid strainer offset tailpiece, chrome plated. Provide cover per A.D.A 4-19.4.
 3. Stops: Angle type, see paragraph 2.2 Stops. Provide cover per A.D.A 4-19.4.
 4. Trap: Cast copper alloy, 38 mm by 32 mm (1 1/2 inches by 1 1/4 inches) P-trap. Adjustable with connected elbow and 1.4 mm thick (17 gauge) tubing extensions to wall. Exposed metal trap surface and connection hardware shall be chrome plated with a smooth bright finish. Set trap perpendicular to wall. Provide cover per A.D.A 4-19.4.

2.8 SINKS AND MOP SINKS

- A. Dimensions for sinks and mop sinks are specified, length by width (distance from wall) and depth.
- B. **(KS-1)** Sink (CRS, Single Compartment, Counter Top ASME/ANSI A112.19.2M,) self-rimming, approximately 31 by 22 inches with single compartment inside dimensions approximately 28 inches by 16 inches by 6 1/2 inches deep. Shall be minimum of 1.3 mm thick (18 gauge) Stainless Steel CRS. Corners and edges shall be well rounded. Full undercoat spray sides and bottom. sink compliant to ADA and ANSI/ICC A117.1 accessibility requirements when installed according to the requirements of ADA. Basis of design: Elkay model LRAD312265 or approved equal.
1. Faucet: Solid polished chrome and cast brass construction, vandal resistant, heavy-duty individual wrist blade handles, gooseneck. 8" Centers. 5-1/4" Rigid / Swing Gooseneck Spout. 2.2 GPM (8.3 L/min). 4" Vandal Proof Wristblade Handles. Ceramic 1/4 Turn Operating Cartridge. 1/2" NPSM Supply Inlets and Coupling Nut for 3/8" or 1/2" Flexible riser. Wrist Blade Lever Handle Control ASME/ANSI A112.18.1. Provide laminar flow control device(no aerators), and vandal proof screws. Basis of Design: Chicago Faucets 786-E29XKABCP.
 2. Drain: Drain plug with cup strainer, stainless steel. Elkay LK99. Rinsing basket LKWRB2816SS.
 3. Trap: Cast copper alloy 38 mm (1 1/2 inches) P-trap with cleanout plug. Provide wall connection and escutcheon.
 4. Provide cover for drain, stops and trap per A.D.A 4-19.4.
- C. **(SS-1)** Service 'MOP' Sink (Corner, Floor Mounted) stain resistant molded stone, 24 inches by 24 inches by 10. Provide stainless steel CRS bumper guard. Basis of Design: Fiat MSB 2424 or approved equal.

1. Faucet: Solid brass construction, Chrome plated service faucet with vacuum breaker, integral stops, adjustable wall brace, pail hook and 3/4" hose thread on spout. Body inlets 8" center to center, four arm handles. Valves contain renewable hub, renewable seats, swivel discs, encased washers and brass washer screws. Commercial red brass alloy casting-rough finish. Spout shall have a pail hook, 19 mm (3/4 inch) hose coupling threads, vacuum breaker, and top brace to wall. Chrome Plated with Wall Brace, Vacuum Breaker and Pail Hook, 8 Inch Centers. Basis of Design: Fiat 830-AA or approved equal.
2. Drain: Seventy six millimeter (3 inches) cast brass drain. 3" Quick Drain Connector: Neoprene connecting gasket suitable for attaching extra heavy cast iron soil pipe and Schedule 40 steel pipe to the drain body. Basis of Design: Fiat QDC-3XH or approved equal.
3. Trap: P-trap, drain through floor.

2.9 WATER CLOSETS

A. (WC-1) Water Closet.

Wall Hung, ASME A112.19.2-2008. Elongated bowl, siphon jet, wall outlet, top inlet spud. 1" I.P.S. angle stop with back-flow prevention and vandal-resistant cap. Top of seat shall be 450 mm (18 inches) above finished floor. Basis of Design: American Standard 2856.016 AFWall Millennium 1.6 gpf.

1. Seat: Institutional/Industrial, solid plastic, extra heavy duty, chemical resistant, posture contoured body open front design less cover for elongated bowls, integrally molded bumpers, concealed check hinge with stainless steel post. Color shall be white. Ever-Clean anti-microbial. American Standard 5905.110 or approved equal.
2. Fittings and Accessories: Gaskets-neoprene; bolts with chrome plated cap nuts and washers and carrier.
3. Flush valve: 1.6 gpf/6.0 lpf. Large chloramines resistant diaphragm, semi-red brass body, hydraulic flush valve, adjustable tailpiece, high pressure vacuum breaker, elbow flush connection, spud coupling for 40 mm (1-1/2 inches) top spud, and cast set screw wall and spud flanges. Sweat Solder Adapter with Cover Tube & Cast Wall Flange with Set screw. Synthetic Rubber Diaphragm with Dual Filtered Fixed Bypass. 1" I.P.S. Screwdriver Stop with free spinning vandal resistant stop cap. Spud Coupling and Flange for 1 1/2" Top Spud. Non-Hold-Open Handle, Fixed Metering Bypass and No External Volume Adjustment to Ensure Water Conservation. Valve shall be in compliance to the applicable sections of ASE 1037. Low Zinc Brass Castings for Dezincification Resistance. ADA Compliant Metal

Oscillating Non-Hold-Open Handle. Basis of Design: Sloan Royal 111-1.6.

B. (WC-2) Water Closet

Floor Mounted, ASME A112.19.2-2008/CSA B45.1-08 for Vitreous China Fixtures) elongated bowl. Rear outlet. Siphon jet. Rim height shall be 16.5 inches above finished floor accessible application. Basis of Design: American Standard Priolo FloWise 3695.001.

1. Seat: Institutional/Industrial, solid plastic, extra heavy duty, chemical resistant, posture contoured body open front design less cover for elongated bowls, integrally molded bumpers, concealed check hinge with stainless steel post. Color shall be white. Ever-Clean anti-microbial. American Standard 5905.110 or approved equal.
2. Fittings and Accessories: Floor flange fittings-cast iron; Gasket-wax; bolts with chromium plated cap nuts and washers.
3. Flush valve: 1.6 gpf/6.0 lpf. Large chloramines resistant diaphragm, semi-red brass body, hydraulic flush valve, adjustable tailpiece, high pressure vacuum breaker, elbow flush connection, spud coupling for 40 mm (1-1/2 inches) top spud, and cast set screw wall and spud flanges. Sweat Solder Adapter with Cover Tube & Cast Wall Flange with Set screw. Synthetic Rubber Diaphragm with Dual Filtered Fixed Bypass. 1" I.P.S. Screwdriver Stop with free spinning vandal resistant stop cap. Spud Coupling and Flange for 1½" Top Spud. Non-Hold-Open Handle, Fixed Metering Bypass and No External Volume Adjustment to Ensure Water Conservation. Valve shall be in compliance to the applicable sections of ASE 1037. Low Zinc Brass Castings for Dezincification Resistance. ADA Compliant Metal Oscillating Non-Hold-Open Handle. Basis of Design: Sloan Royal 111-1.6.

2.10 ELECTRIC WATER COOLERS - DISPENSER, DRINKING WATER

- A. Standard rating conditions: 10 degrees C (50 degrees F) water with 27 degrees C (80 degrees F) inlet water temperature and 32 degrees C (90 degrees F) ambient air temperature.
- B. **(EWC-1)** Electric Water Cooler (Mechanically Cooled, Wall Hung, Self-contained, Wheelchair) bubbler style, 30 l/h (8 gph) lead free. Units shall have pushbar activation. Provide with bottle filling station. Bottle filler shall include an electronic sensor for touchless activation with auto 20-second shut-off timer. Bottle filler shall provide 1.1 gpm flow rate with laminar flow to minimize splashing. Shall include integrated silver ion anti-microbial protection in key areas. Unit shall meet ADA guidelines. Unit shall be lead-free design which is certified to NSF/ANSI 61 and 372 and meets Federal and State

low-lead requirements. Unit shall be certified to UL399 and CAN/CSA 22.2 No. 120. Provide with flexi-guard bubbler. Cooler panel finish: Stainless Steel. Basis of Design: Elkay EZS8WSSK.

- C. **(EWC-2)** Electric Water Cooler: Mechanically cooled, self-contained, wheel chair, bubbler style fully exposed dual height stainless steel 8 gph. Units shall have pushbar activation. Provide with bottle filling station. Bottle filler shall include an electronic sensor for touchless activation with auto 20-second shut-off timer. Bottle filler shall provide 1.1 gpm flow rate with laminar flow to minimize splashing. Shall include integrated silver ion anti-microbial protection in key areas. Unit shall meet ADA guidelines. Unit shall be lead-free design which is certified to NSF/ANSI 61 and 372 and meets Federal and State low-lead requirements. Unit shall be certified to UL399 and CAN/CSA 22.2 No. 120. Provide with flexi-guard bubblers. Cooler panel finish: Stainless Steel. Basis of Design: Elkay EZSTL8WSSK.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Fixture Setting: Opening between fixture and floor and wall finish shall be sealed as specified under Section 07 92 00, JOINT SEALANTS.
- B. Supports and Fastening: Secure all fixtures, equipment and trimmings to partitions, walls and related finish surfaces. Exposed heads of bolts and nuts in finished rooms shall be hexagonal, polished chrome plated brass with rounded tops.
- C. Through Bolts: For free standing marble and metal stud partitions refer to Section 10 21 13, TOILET COMPARTMENTS.
- D. Toggle Bolts: For hollow masonry units, finished or unfinished.
- E. Expansion Bolts: For brick or concrete or other solid masonry. Shall be 6 mm (1/4 inch) diameter bolts, and to extend at least 76 mm (3 inches) into masonry and be fitted with loose tubing or sleeves extending into masonry. Wood plugs, fiber plugs, lead or other soft metal shields are prohibited.
- F. Tightly cover and protect fixtures and equipment against dirt, water and chemical or mechanical injury.
- G. Do not use aerators on lavatories and sinks.

3.2 CLEANING

At completion of all work, fixtures, exposed materials and equipment shall be thoroughly cleaned.

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**SECTION 23 05 11
COMMON WORK RESULTS FOR HVAC****PART 1 - GENERAL****1.1 DESCRIPTION**

- A. The requirements of this Section apply to all sections of Division 23.
- B. Definitions:
 - 1. Exposed: Piping, ductwork, and equipment exposed to view in finished rooms.
 - 2. Option or optional: Contractor's choice of an alternate material or method.
 - 3. RE: Resident Engineer
 - 4. COTR: Contracting Officer's Technical Representative.

1.2 RELATED WORK

- A. Section 00 72 00, GENERAL CONDITIONS
- B. Section 01 00 00, GENERAL REQUIREMENTS
- C. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES
- D. Section 05 50 00, METAL FABRICATIONS
- E. Section 07 84 00, FIRESTOPPING
- F. Section 07 92 00, JOINT SEALANTS
- G. Section 09 91 00, PAINTING
- H. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION
- I. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC
- J. Section 23 07 11, HVAC, PLUMBING, and Boiler Plant Insulation
- K. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- L. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC
- M. Section 23 21 13, HYDRONIC PIPING
- N. Section 23 31 00, HVAC DUCTS and CASINGS
- O. Section 23 36 00, AIR TERMINAL UNITS
- P. Section 23 37 00, AIR OUTLETS and INLETS
- Q. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS

1.3 QUALITY ASSURANCE

- A. Mechanical, electrical and associated systems shall be safe, reliable, efficient, durable, easily and safely operable and maintainable, easily and safely accessible, and in compliance with applicable codes as specified. The systems shall be comprised of high quality institutional-class and industrial-class products of manufacturers that are experienced specialists in the required product lines. All construction

firms and personnel shall be experienced and qualified specialists in industrial and institutional HVAC

B. Flow Rate Tolerance for HVAC Equipment: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

C. Equipment Vibration Tolerance:

1. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT. Equipment shall be factory-balanced to this tolerance and re-balanced on site, as necessary.
2. After HVAC air balance work is completed and permanent drive sheaves are in place, perform field mechanical balancing and adjustments required to meet the specified vibration tolerance.

D. Products Criteria:

1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years (or longer as specified elsewhere). The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other specification sections for any exceptions and/or additional requirements.
2. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.
3. Conform to codes and standards as required by the specifications. Conform to local codes, if required by local authorities such as the natural gas supplier, if the local codes are more stringent than those specified. Refer any conflicts to the Resident Engineer.
4. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.
5. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.
6. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.

7. Asbestos products or equipment or materials containing asbestos shall not be used.

E. Equipment Service Organizations:

1. HVAC: Products and systems shall be supported by service organizations that maintain a complete inventory of repair parts and are located within 50 miles to the site.

F. Execution (Installation, Construction) Quality:

1. Apply and install all items in accordance with manufacturer's written instructions. Refer conflicts between the manufacturer's instructions and the contract drawings and specifications to the Resident Engineer for resolution. Provide written hard copies or computer files of manufacturer's installation instructions to the Resident Engineer at least two weeks prior to commencing installation of any item. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations is a cause for rejection of the material.
2. Provide complete layout drawings required by Paragraph, SUBMITTALS. Do not commence construction work on any system until the layout drawings have been approved.

- G. Upon request by Government, provide lists of previous installations for selected items of equipment. Include contact persons who will serve as references, with telephone numbers and e-mail addresses.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, and with requirements in the individual specification sections.
- B. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements.
- C. If equipment is submitted which differs in arrangement from that shown, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.
- D. Prior to submitting shop drawings for approval, contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.

- E. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient.
- F. Layout Drawings:
1. Submit complete consolidated and coordinated layout drawings for all new systems, and for existing systems that are in the same areas. Refer to Section 00 72 00, GENERAL CONDITIONS, Article, SUBCONTRACTS AND WORK COORDINATION.
 2. The drawings shall include plan views, elevations and sections of all systems and shall be on a scale of not less than 1:32 (3/8-inch equal to one foot). Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings shall clearly show locations and adequate clearance for all equipment, piping, valves, control panels and other items. Show the access means for all items requiring access for operations and maintenance. Provide detailed layout drawings of all piping and duct systems.
 3. Do not install equipment foundations, equipment or piping until layout drawings have been approved.
 4. In addition, for HVAC systems, provide details of the following:
 - a. Mechanical equipment rooms.
 - b. Interstitial space.
 - c. Hangers, inserts, supports, and bracing.
 - d. Pipe sleeves.
 - e. Duct or equipment penetrations of floors, walls, ceilings, or roofs.
- G. Manufacturer's Literature and Data: Submit under the pertinent section rather than under this section.
1. Submit belt drive with the driven equipment. Submit selection data for specific drives when requested by the Resident Engineer.
 2. Submit electric motor data and variable speed drive data with the driven equipment.
 3. Equipment and materials identification.
 4. Fire-stopping materials.
 5. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.
 6. Wall, floor, and ceiling plates.

H. HVAC Maintenance Data and Operating Instructions:

1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.
2. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.

I. Provide copies of approved HVAC equipment submittals to the Testing, Adjusting and Balancing Subcontractor.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning, Heating and Refrigeration Institute (AHRI):
430-2009.....Central Station Air-Handling Units
- C. American National Standard Institute (ANSI):
B31.1-2007.....Power Piping
- D. Rubber Manufacturers Association (ANSI/RMA):
IP-20-2007.....Specifications for Drives Using Classical
V-Belts and Sheaves
IP-21-2009.....Specifications for Drives Using Double-V
(Hexagonal) Belts
IP-22-2007.....Specifications for Drives Using Narrow V-Belts
and Sheaves
- E. Air Movement and Control Association (AMCA):
410-96.....Recommended Safety Practices for Air Moving
Devices
- F. American Society of Mechanical Engineers (ASME):
Boiler and Pressure Vessel Code (BPVC):
Section I-2007.....Power Boilers
Section IX-2007.....Welding and Brazing Qualifications
Code for Pressure Piping:
B31.1-2007.....Power Piping
- G. American Society for Testing and Materials (ASTM):
A36/A36M-08.....Standard Specification for Carbon Structural
Steel
A575-96(2007).....Standard Specification for Steel Bars, Carbon,
Merchant Quality, M-Grades

- E84-10.....Standard Test Method for Surface Burning
Characteristics of Building Materials
- E119-09c.....Standard Test Methods for Fire Tests of Building
Construction and Materials
- H. Manufacturers Standardization Society (MSS) of the Valve and Fittings
Industry, Inc:
- SP-58-2009.....Pipe Hangers and Supports-Materials, Design and
Manufacture, Selection, Application, and
Installation
- SP 69-2003.....Pipe Hangers and Supports-Selection and
Application
- SP 127-2001.....Bracing for Piping Systems, Seismic - Wind -
Dynamic, Design, Selection, Application
- I. National Electrical Manufacturers Association (NEMA):
- MG-1-2009.....Motors and Generators
- J. National Fire Protection Association (NFPA):
- 31-06.....Standard for Installation of Oil-Burning
Equipment
- 54-09.....National Fuel Gas Code
- 70-08.....National Electrical Code
- 85-07.....Boiler and Combustion Systems Hazards Code
- 90A-09.....Standard for the Installation of Air
Conditioning and Ventilating Systems
- 101-09.....Life Safety Code

1.6 DELIVERY, STORAGE AND HANDLING

- A. Protection of Equipment:
1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage.
 2. Place damaged equipment in first class, new operating condition; or, replace same as determined and directed by the Resident Engineer. Such repair or replacement shall be at no additional cost to the Government.
 3. Protect interiors of new equipment and piping systems against entry of foreign matter. Clean both inside and outside before painting or placing equipment in operation.

4. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.

B. Cleanliness of Piping and Equipment Systems:

1. Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.
2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.
3. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.7 JOB CONDITIONS - WORK IN EXISTING BUILDING

- A. Building Operation: Government employees will be continuously operating and managing all facilities, including temporary facilities, that serve the medical center.
- B. Maintenance of Service: Schedule all work to permit continuous service as required by the medical center.
- C. Steam and Condensate Service Interruptions: Limited steam and condensate service interruptions, as required for interconnections of new and existing systems, will be permitted by the Resident Engineer during periods when the demands are not critical to the operation of the medical center. These non-critical periods are limited to between 8 pm and 5 am in the appropriate off-season (if applicable). Provide at least one week advance notice to the Resident Engineer.
- D. Phasing of Work: Comply with all requirements shown on drawings or specified.
- E. Building Working Environment: Maintain the architectural and structural integrity of the building and the working environment at all times. Maintain the interior of building at 18 degrees C (65 degrees F) minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. No storm water or ground water leakage permitted. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA.

- F. Acceptance of Work for Government Operation: As new facilities are made available for operation and these facilities are of beneficial use to the Government, inspections will be made and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After correction of deficiencies as necessary for beneficial use, the Contracting Officer will process necessary acceptance and the equipment will then be under the control and operation of Government personnel.

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

- A. Provide maximum standardization of components to reduce spare part requirements.
- B. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for final assembled unit.
 - 1. All components of an assembled unit need not be products of same manufacturer.
 - 2. Constituent parts that are alike shall be products of a single manufacturer.
 - 3. Components shall be compatible with each other and with the total assembly for intended service.
 - 4. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.
- C. Components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.
- D. Major items of equipment, which serve the same function, must be the same make and model. Exceptions will be permitted if performance requirements cannot be met.

2.2 COMPATIBILITY OF RELATED EQUIPMENT

Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a complete and fully operational plant that conforms to contract requirements.

2.3 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Use symbols, nomenclature and equipment numbers specified, shown on the drawings and shown in the maintenance manuals. Identification for piping is specified in Section 09 91 00, PAINTING.
- B. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 48 mm (3/16-inch) high of brass with black-filled letters, or rigid black plastic with white letters specified in Section 09 91 00, PAINTING permanently fastened to the equipment. Identify unit components such as coils, filters, fans, etc.
- C. Control Items: Label all temperature and humidity sensors, controllers and control dampers. Identify and label each item as they appear on the control diagrams.
- D. Valve Tags and Lists:
 - 1. Valve tags: Engraved black filled numbers and letters not less than 13 mm (1/2-inch) high for number designation, and not less than 6.4 mm (1/4-inch) for service designation on 19 gage 38 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.
 - 2. Valve lists: Typed or printed plastic coated card(s), sized 216 mm (8-1/2 inches) by 280 mm (11 inches) showing tag number, valve function and area of control, for each service or system. Punch sheets for a 3-ring notebook.
 - 3. Provide detailed plan for each floor of the building indicating the location and valve number for each valve. Identify location of each valve with a color coded thumb tack in ceiling.

2.4 FIRESTOPPING

Section 07 84 00, FIRESTOPPING specifies an effective barrier against the spread of fire, smoke and gases where penetrations occur for piping and ductwork. Refer to Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION, for firestop pipe and duct insulation.

2.5 GALVANIZED REPAIR COMPOUND

Mil. Spec. DOD-P-21035B, paint form.

2.6 HVAC PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

- A. Supports for Roof Mounted Items:
 - 1. Equipment: Equipment rails shall be galvanized steel, minimum 1.3 mm (18 gauge), with integral baseplate, continuous welded corner seams, factory installed 50 mm by 100 mm (2 by 4) treated wood nailer, 1.3 mm (18 gauge) galvanized steel counter flashing cap with screws, built-in cant strip, (except for gypsum or tectum deck), minimum

- height 280 mm (11 inches). For surface insulated roof deck, provide raised cant strip to start at the upper surface of the insulation.
2. Pipe/duct pedestals: Provide a galvanized Unistrut channel welded to U-shaped mounting brackets which are secured to side of rail with galvanized lag bolts.
- B. Pipe Supports: Comply with MSS SP-58. Type Numbers specified refer to this standard. For selection and application comply with MSS SP-69. Refer to Section 05 50 00, METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting requirements.
- C. Attachment to Concrete Building Construction:
1. Concrete insert: MSS SP-58, Type 18.
 2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 102 mm (four inches) thick when approved by the Resident Engineer for each job condition.
 3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 102 mm (four inches) thick when approved by the Resident Engineer for each job condition.
- D. Attachment to Steel Building Construction:
1. Welded attachment: MSS SP-58, Type 22.
 2. Beam clamps: MSS SP-58, Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 23mm (7/8-inch) outside diameter.
- E. Attachment to Metal Pan or Deck: As required for materials specified in Section 05 31 00, STEEL DECKING and Section 05 36 00, COMPOSITE METAL DECKING.
- F. Attachment to existing structure: Support from existing floor/roof frame.
- G. Hanger Rods: Hot-rolled steel, ASTM A36 or A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 38 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.
- H. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (No. 12 gage), designed to accept special spring held, hardened steel nuts. Not permitted for steam supply and condensate piping.
1. Allowable hanger load: Manufacturers rating less 91kg (200 pounds).

2. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4-inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 13mm (1/2-inch) galvanized steel bands, or preinsulated calcium silicate shield for insulated piping at each hanger.

I. Supports for Piping Systems:

1. Select hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or preinsulated calcium silicate shields. Provide Type 40 insulation shield or preinsulated calcium silicate shield at all other types of supports and hangers including those for preinsulated piping.
2. Piping Systems except High and Medium Pressure Steam (MSS SP-58):
 - a. Standard clevis hanger: Type 1; provide locknut.
 - b. Riser clamps: Type 8.
 - c. Wall brackets: Types 31, 32 or 33.
 - d. Roller supports: Type 41, 43, 44 and 46.
 - e. Saddle support: Type 36, 37 or 38.
 - f. Turnbuckle: Types 13 or 15. Preinsulate.
 - g. U-bolt clamp: Type 24.
 - h. Copper Tube:
 - 1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with non adhesive isolation tape to prevent electrolysis.
 - 2) For vertical runs use epoxy painted or plastic coated riser clamps.
 - 3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.
 - 4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.
 - i. Supports for plastic or glass piping: As recommended by the pipe manufacturer with black rubber tape extending one inch beyond steel support or clamp.

J. Pre-insulated Calcium Silicate Shields:

1. Provide 360 degree water resistant high density 965 kPa (140 psi) compressive strength calcium silicate shields encased in galvanized metal.

2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
3. Shield thickness shall match the pipe insulation.
4. The type of shield is selected by the temperature of the pipe, the load it must carry, and the type of support it will be used with.
 - a. Shields for supporting chilled or cold water shall have insulation that extends a minimum of 1 inch past the sheet metal. Provide for an adequate vapor barrier in chilled lines.
 - b. The pre-insulated calcium silicate shield shall support the maximum allowable water filled span as indicated in MSS-SP 69. To support the load, the shields may have one or more of the following features: structural inserts 4138 kPa (600 psi) compressive strength, an extra bottom metal shield, or formed structural steel (ASTM A36) wear plates welded to the bottom sheet metal jacket.
5. Shields may be used on steel clevis hanger type supports, roller supports or flat surfaces.

2.7 PIPE PENETRATIONS

- A. Install sleeves during construction for other than blocked out floor openings for risers in mechanical bays.
- B. To prevent accidental liquid spills from passing to a lower level, provide the following:
 1. For sleeves: Extend sleeve 25 mm (one inch) above finished floor and provide sealant for watertight joint.
 2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
 3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.
- C. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of Resident Engineer.
- D. Sheet Metal, Plastic, or Moisture-resistant Fiber Sleeves: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.
- E. Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.

- F. Galvanized Steel or an alternate Black Iron Pipe with asphalt coating
Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, connect sleeve with floor plate.
- G. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.
- H. Sleeves are not required for wall hydrants for fire department connections or in drywall construction.
- I. Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.
- J. Sealant and Adhesives: Shall be as specified in Section 07 92 00, JOINT SEALANTS.

2.8 DUCT PENETRATIONS

- A. Provide curbs for roof mounted piping, ductwork and equipment. Curbs shall be 18 inches high with continuously welded seams, built-in cant strip, interior baffle with acoustic insulation, curb bottom, hinged curb adapter.
- B. Provide firestopping for openings through fire and smoke barriers, maintaining minimum required rating of floor, ceiling or wall assembly. See section 07 84 00, FIRESTOPPING.

2.9 SPECIAL TOOLS AND LUBRICANTS

- A. Furnish, and turn over to the Resident Engineer, tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.

2.10 WALL, FLOOR AND CEILING PLATES

- A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.
- B. Thickness: Not less than 2.4 mm (3/32-inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025-inch) for up to 80 mm (3-inch pipe), 0.89 mm (0.035-inch) for larger pipe.

- C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

2.11 ASBESTOS

Materials containing asbestos are not permitted.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

- A. Coordinate location of piping, sleeves, inserts, hangers, ductwork and equipment. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Prepare equipment layout drawings to coordinate proper location and personnel access of all facilities. Submit the drawings for review as required by Part 1. Follow manufacturer's published recommendations for installation methods not otherwise specified.
- B. Operating Personnel Access and Observation Provisions: Select and arrange all equipment and systems to provide clear view and easy access, without use of portable ladders, for maintenance and operation of all devices including, but not limited to: all equipment items, valves, filters, strainers, transmitters, sensors, control devices. All gages and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Do not reduce or change maintenance and operating space and access provisions that are shown on the drawings.
- C. Equipment and Piping Support: Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations to permit proper installation.
- D. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.
- E. Cutting Holes:
1. Cut holes through concrete and masonry by rotary core drill.
Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by Resident Engineer where working area space is limited.
 2. Locate holes to avoid interference with structural members such as beams or grade beams. Holes shall be laid out in advance and drilling done only after approval by Resident Engineer. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to Resident Engineer for approval.
 3. Do not penetrate membrane waterproofing.

- F. Interconnection of Instrumentation or Control Devices: Generally, electrical and pneumatic interconnections are not shown but must be provided.
- G. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.
- H. Electrical and Pneumatic Interconnection of Controls and Instruments: This generally not shown but must be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments and computer workstations. Comply with NFPA-70.
- I. Protection and Cleaning:
1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the Resident Engineer. Damaged or defective items in the opinion of the Resident Engineer, shall be replaced.
 2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and equipment against dirt, water chemical, or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.
- J. Install gages, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gages to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.
- K. Work in Existing Building:
1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00 00, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).
 2. As specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will least interfere with normal operation of the facility.

3. Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills, will be permitted only with approval of the Resident Engineer. Locate openings that will least effect structural slabs, columns, ribs or beams. Refer to the Resident Engineer for determination of proper design for openings through structural sections and opening layouts approval, prior to cutting or drilling into structure. After Resident Engineer's approval, carefully cut opening through construction no larger than absolutely necessary for the required installation.
- L. Switchgear/Electrical Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints. Installation of piping, ductwork, leak protection apparatus or other installations foreign to the electrical installation shall be located in the space equal to the width and depth of the equipment and extending from to a height of 1.8 m (6 ft.) above the equipment of to ceiling structure, whichever is lower (NFPA 70).
- M. Inaccessible Equipment:
 1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost to the Government.
 2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders.

3.2 TEMPORARY PIPING AND EQUIPMENT

- A. Continuity of operation of existing facilities will generally require temporary installation or relocation of equipment and piping.
- B. The Contractor shall provide all required facilities in accordance with the requirements of phased construction and maintenance of service. All piping and equipment shall be properly supported, sloped to drain, operate without excessive stress, and shall be insulated where injury can occur to personnel by contact with operating facilities. The requirements of Paragraph 3.1 apply.
- C. Temporary facilities and piping shall be completely removed and any openings in structures sealed. Provide necessary blind flanges and caps to seal open piping remaining in service.

3.3 PIPE AND EQUIPMENT SUPPORTS

- A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Drill or burn holes in structural steel only with the prior approval of the Resident Engineer.
- B. Use of chain, wire or strap hangers; wood for blocking, stays and bracing; or, hangers suspended from piping above will not be permitted. Replace or thoroughly clean rusty products and paint with zinc primer.
- C. Use hanger rods that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 15 mm (1/2-inch) clearance between pipe or piping covering and adjacent work.
- D. HVAC Horizontal Pipe Support Spacing: Refer to MSS SP-69. Provide additional supports at valves, strainers, in-line pumps and other heavy components. Provide a support within one foot of each elbow.
- E. HVAC Vertical Pipe Supports:
 - 1. Up to 150 mm (6-inch pipe), 9 m (30 feet) long, bolt riser clamps to the pipe below couplings, or welded to the pipe and rests supports securely on the building structure.
 - 2. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.
- F. Overhead Supports:
 - 1. The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.
 - 2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.
 - 3. Tubing and capillary systems shall be supported in channel troughs.
 - 4. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a granular material to permit alignment and realignment.
 - 5. For seismic anchoring, refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.4 MECHANICAL DEMOLITION

- A. Rigging access, other than indicated on the drawings, shall be provided by the Contractor after approval for structural integrity by the Resident Engineer. Such access shall be provided without additional cost or time to the Government. Where work is in an operating plant, provide approved protection from dust and debris at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.
- B. In an operating facility, maintain the operation, cleanliness and safety. Government personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and plant operation. Confine the work to the immediate area concerned; maintain cleanliness and wet down demolished materials to eliminate dust. Do not permit debris to accumulate in the area to the detriment of plant operation. Perform all flame cutting to maintain the fire safety integrity of this plant. Adequate fire extinguishing facilities shall be available at all times. Perform all work in accordance with recognized fire protection standards. Inspection will be made by personnel of the VA Medical Center, and Contractor shall follow all directives of the RE or COTR with regard to rigging, safety, fire safety, and maintenance of operations.
- C. Completely remove all piping, wiring, conduit, and other devices associated with the equipment not to be re-used in the new work. This includes all pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. Seal all openings, after removal of equipment, pipes, ducts, and other penetrations in roof, walls, floors, in an approved manner and in accordance with plans and specifications where specifically covered. Structural integrity of the building system shall be maintained. Reference shall also be made to the drawings and specifications of the other disciplines in the project for additional facilities to be demolished or handled.
- D. All valves including gate, globe, ball, butterfly and check, all pressure gages and thermometers with wells shall remain Government property and shall be removed and delivered to Resident Engineer and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these plans and specifications. Such material shall be removed from Government property expeditiously and shall not be allowed to accumulate.

3.5 CLEANING AND PAINTING

- A. Prior to final inspection and acceptance of the plant and facilities for beneficial use by the Government, the plant facilities, equipment and systems shall be thoroughly cleaned and painted. Refer to Section 09 91 00, PAINTING.
- B. In addition, the following special conditions apply:
 - 1. Cleaning shall be thorough. Use solvents, cleaning materials and methods recommended by the manufacturers for the specific tasks. Remove all rust prior to painting and from surfaces to remain unpainted. Repair scratches, scuffs, and abrasions prior to applying prime and finish coats.
 - 2. Material And Equipment Not To Be Painted Includes:
 - a. Motors, controllers, control switches, and safety switches.
 - b. Control and interlock devices.
 - c. Regulators.
 - d. Pressure reducing valves.
 - e. Control valves and thermostatic elements.
 - f. Lubrication devices and grease fittings.
 - g. Copper, brass, aluminum, stainless steel and bronze surfaces.
 - h. Valve stems and rotating shafts.
 - i. Pressure gauges and thermometers.
 - j. Glass.
 - k. Name plates.
 - 3. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.
 - 4. Pumps, motors, steel and cast iron bases, and coupling guards shall be cleaned, and shall be touched-up with the same color as utilized by the pump manufacturer
 - 5. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats.
 - 6. Paint shall withstand the following temperatures without peeling or discoloration:
 - a. Condensate and feedwater -- 38 degrees C (100 degrees F) on insulation jacket surface and 120 degrees C (250 degrees F) on metal pipe surface.
 - b. Steam -- 52 degrees C (125 degrees F) on insulation jacket surface and 190 degrees C (375 degrees F) on metal pipe surface.

7. Final result shall be smooth, even-colored, even-textured factory finish on all items. Completely repaint the entire piece of equipment if necessary to achieve this.

3.6 IDENTIFICATION SIGNS

- A. Provide laminated plastic signs, with engraved lettering not less than 5 mm (3/16-inch) high, designating functions, for all equipment, switches, motor controllers, relays, meters, control devices, including automatic control valves. Nomenclature and identification symbols shall correspond to that used in maintenance manual, and in diagrams specified elsewhere. Attach by chain, adhesive, or screws.
- B. Factory Built Equipment: Metal plate, securely attached, with name and address of manufacturer, serial number, model number, size, performance.
- C. Pipe Identification: Refer to Section 09 91 00, PAINTING.

3.7 MOTOR AND DRIVE ALIGNMENT

- A. Belt Drive: Set driving and driven shafts parallel and align so that the corresponding grooves are in the same plane.
- B. Direct-connect Drive: Securely mount motor in accurate alignment so that shafts are free from both angular and parallel misalignment when both motor and driven machine are operating at normal temperatures.

3.8 STARTUP AND TEMPORARY OPERATION

Start up equipment as described in equipment specifications. Verify that vibration is within specified tolerance prior to extended operation. Temporary use of equipment is specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.

3.9 OPERATING AND PERFORMANCE TESTS

- A. Prior to the final inspection, perform required tests as specified in Section 01 00 00, GENERAL REQUIREMENTS and submit the test reports and records to the Resident Engineer.
- B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost to the Government.
- C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then make performance tests for heating systems and for cooling systems respectively during first actual seasonal use of respective systems following completion of work.

- - - E N D - - -

SECTION 23 05 12
GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT

PART 1 - GENERAL**1.1 DESCRIPTION:**

This section specifies the furnishing, installation and connection of motors for HVAC and steam generation equipment.

1.2 RELATED WORK:

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA and SAMPLES.
- B. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- E. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- G. Section 26 24 19, MOTOR-CONTROL CENTERS.
- F. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.
- G. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS

1.3 SUBMITTALS:

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA and SAMPLES, and Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Provide documentation to demonstrate compliance with drawings and specifications.
 - 2. Include electrical ratings, efficiency, bearing data, power factor, frame size, dimensions, mounting details, materials, horsepower, voltage, phase, speed (RPM), enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.
- C. Manuals:
 - 1. Submit simultaneously with the shop drawings, companion copies of complete installation, maintenance and operating manuals, including technical data sheets and application data.
- D. Certification: Two weeks prior to final inspection, unless otherwise noted, submit four copies of the following certification to the Resident Engineer:
 - 1. Certification that the motors have been applied, installed, adjusted, lubricated, and tested according to manufacturer published recommendations.

- E. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

SPEC WRITER NOTES:

Designer shall review current published standards references listed below applicable to this specification.

1.4 APPLICABLE PUBLICATIONS:

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. National Electrical Manufacturers Association (NEMA):
MG 1-2006 Rev. 1 2009 .Motors and Generators
MG 2-2001 Rev. 1 2007 ..Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators
- C. National Fire Protection Association (NFPA):
70-2008National Electrical Code (NEC)
- D. Institute of Electrical and Electronics Engineers (IEEE):
112-04Standard Test Procedure for Polyphase Induction Motors and Generators
- E. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
90.1-2007Energy Standard for Buildings Except Low-Rise Residential Buildings

PART 2 - PRODUCTS

2.1 MOTORS:

- A. For alternating current, fractional and integral horsepower motors, NEMA Publications MG 1 and MG 2 shall apply.
- B. All material and equipment furnished and installation methods shall conform to the requirements of Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS; and Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide premium efficiency type motors as scheduled. Unless otherwise specified for a particular application, use electric motors with the following requirements.

- C. Single-phase Motors: Motors for centrifugal fans and pumps may be split phase or permanent split capacitor (PSC) type. Provide capacitor-start type for hard starting applications.
- able down to 20% of full speed and 85% efficient at all speeds.//
- D. Poly-phase Motors: NEMA Design B, Squirrel cage, induction type.
1. Two Speed Motors: Each two-speed motor shall have two separate windings. Provide a time- delay (20 seconds minimum) relay for switching from high to low speed.
- E. Voltage ratings shall be as follows:
1. Single phase:
- a. Motors connected to 120-volt systems: 115 volts.
- b. Motors connected to 208-volt systems: 200 volts.
- c. Motors connected to 240 volt or 480 volt systems: 230/460 volts, dual connection.
2. Three phase:
- a. Motors connected to 208-volt systems: 200 volts.
- b. Motors, less than 74.6 kW (100 HP), connected to 240 volt or 480 volt systems: 208-230/460 volts, dual connection.
- c. Motors, 74.6 kW (100 HP) or larger, connected to 240-volt systems: 230 volts.
- d. Motors, 74.6 kW (100 HP) or larger, connected to 480-volt systems: 460 volts.
- e. Motors connected to high voltage systems (Over 600V): Shall conform to NEMA Standards for connection to the nominal system voltage shown on the drawings.
- F. Number of phases shall be as follows:
1. Motors, less than 373 W (1/2 HP): Single phase.
2. Motors, 373 W (1/2 HP) and larger: 3 phase.
3. Exceptions:
- a. Hermetically sealed motors.
- b. Motors for equipment assemblies, less than 746 W (one HP), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.
- G. Motors shall be designed for operating the connected loads continuously in a 40°C (104°F) environment, where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation. If the motors exceed 40°C (104°F), the motors shall be rated for the actual ambient temperatures.

SPEC WRITER NOTES:

Indicate motor enclosures on equipment scheduled on the drawings.

- H. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting and running torque.
- I. Motor Enclosures:
1. Shall be the NEMA types as specified and/or shown on the drawings.
 2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types, which are most suitable for the environmental conditions where the motors are being installed. Enclosure requirements for certain conditions are as follows:
 - a. Motors located outdoors, indoors in wet or high humidity locations, or in unfiltered airstreams shall be totally enclosed type.
 - b. Where motors are located in an NEC 511classified area, provide TEFC explosion proof motor enclosures.
 - c. Where motors are located in a corrosive environment, provide TEFC enclosures with corrosion resistant finish.
 3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.
- J. Special Requirements:
1. Where motor power requirements of equipment furnished deviate from power shown on plans, provide electrical service designed under the requirements of NFPA 70 without additional time or cost to the Government.
 2. Assemblies of motors, starters, controls and interlocks on factory assembled and wired devices shall be in accordance with the requirements of this specification.
 3. Wire and cable materials specified in the electrical division of the specifications shall be modified as follows:
 - a. Wiring material located where temperatures can exceed 71 degrees C (160 degrees F) shall be stranded copper with Teflon FEP insulation with jacket. This includes wiring on the boilers.
 - b. Other wiring at boilers and to control panels shall be NFPA 70 designation THWN.
 - c. Provide shielded conductors or wiring in separate conduits for all instrumentation and control systems where recommended by manufacturer of equipment.

4. Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.
5. Motors utilized with variable frequency drives shall be rated "inverter-duty" per NEMA Standard, MG1, Part 31.4.4.2. Provide motor shaft grounding apparatus that will protect bearings from damage from stray currents.
- K. Additional requirements for specific motors, as indicated in the other sections listed in Article 1.2, shall also apply.
- L. Energy-Efficient Motors (Motor Efficiencies): All permanently wired polyphase motors of 746 Watts (1 HP) or more shall meet the minimum full-load efficiencies as indicated in the following table. Motors of 746 Watts or more with open, drip-proof or totally enclosed fan-cooled enclosures shall be NEMA premium efficiency type, unless otherwise indicated. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section. Motors not specified as "premium efficiency" shall comply with the Energy Policy Act of 2005 (EPACT).

Minimum Premium Efficiencies Open Drip-Proof				Minimum Premium Efficiencies Totally Enclosed Fan-Cooled			
Rating kW (HP)	1200 RPM	1800 RPM	3600 RPM	Rating kW (HP)	1200 RPM	1800 RPM	3600 RPM
0.746 (1)	82.5%	85.5%	77.0%	0.746 (1)	82.5%	85.5%	77.0%
1.12 (1.5)	86.5%	86.5%	84.0%	1.12 (1.5)	87.5%	86.5%	84.0%
1.49 (2)	87.5%	86.5%	85.5%	1.49 (2)	88.5%	86.5%	85.5%
2.24 (3)	88.5%	89.5%	85.5%	2.24 (3)	89.5%	89.5%	86.5%
3.73 (5)	89.5%	89.5%	86.5%	3.73 (5)	89.5%	89.5%	88.5%
5.60 (7.5)	90.2%	91.0%	88.5%	5.60 (7.5)	91.0%	91.7%	89.5%
7.46 (10)	91.7%	91.7%	89.5%	7.46 (10)	91.0%	91.7%	90.2%
11.2 (15)	91.7%	93.0%	90.2%	11.2 (15)	91.7%	92.4%	91.0%
14.9 (20)	92.4%	93.0%	91.0%	14.9 (20)	91.7%	93.0%	91.0%
18.7 (25)	93.0%	93.6%	91.7%	18.7 (25)	93.0%	93.6%	91.7%
22.4 (30)	93.6%	94.1%	91.7%	22.4 (30)	93.0%	93.6%	91.7%
29.8 (40)	94.1%	94.1%	92.4%	29.8 (40)	94.1%	94.1%	92.4%
37.3 (50)	94.1%	94.5%	93.0%	37.3 (50)	94.1%	94.5%	93.0%

44.8 (60)	94.5%	95.0%	93.6%	44.8 (60)	94.5%	95.0%	93.6%
56.9 (75)	94.5%	95.0%	93.6%	56.9 (75)	94.5%	95.4%	93.6%
74.6 (100)	95.0%	95.4%	93.6%	74.6 (100)	95.0%	95.4%	94.1%
93.3 (125)	95.0%	95.4%	94.1%	93.3 (125)	95.0%	95.4%	95.0%
112 (150)	95.4%	95.8%	94.1%	112 (150)	95.8%	95.8%	95.0%
149.2 (200)	95.4%	95.8%	95.0%	149.2 (200)	95.8%	96.2%	95.4%

M. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at 1200 RPM, 1800 RPM and 3600 RPM.

PART 3 - EXECUTION

3.1 INSTALLATION:

Install motors in accordance with manufacturer's recommendations, the NEC, NEMA, as shown on the drawings and/or as required by other sections of these specifications.

3.2 FIELD TESTS

- A. Perform an electric insulation resistance Test using a megohmmeter on all motors after installation, before start-up. All shall test free from grounds.
- B. Perform Load test in accordance with ANSI/IEEE 112, Test Method B, to determine freedom from electrical or mechanical defects and compliance with performance data.
- C. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame, to be determined at the time of final inspection.
- D. All test data shall be compiled into a report form for each motor and provided to the contracting officer or their representative.

3.3 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of all equipment. Coordinate the startup and contractor testing schedules with Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.4 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.5 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 05 41
NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

Noise criteria, vibration tolerance and vibration isolation for HVAC and plumbing work.

1.2 RELATED WORK

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA and SAMPLES.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- C. Section 23 31 00, HVAC DUCTS and CASINGS.
- D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- E. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS

1.3 QUALITY ASSURANCE

- A. Refer to article, QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
 - 1. For equipment which has no sound power ratings scheduled on the plans, the contractor shall select equipment such that the foregoing noise criteria, local ordinance noise levels, and OSHA requirements are not exceeded. Selection procedure shall be in accordance with ASHRAE Fundamentals Handbook, Chapter 7, Sound and Vibration.
 - 3. An allowance, not to exceed 5db, may be added to the measured value to compensate for the variation of the room attenuating effect between room test condition prior to occupancy and design condition after occupancy which may include the addition of sound absorbing material, such as, furniture. This allowance may not be taken after occupancy. The room attenuating effect is defined as the difference between sound power level emitted to room and sound pressure level in room.
 - 4. In absence of specified measurement requirements, measure equipment noise levels three feet from equipment and at an elevation of maximum noise generation.
- 1. Equipment:
 - a. All mechanical equipment not supported with isolators external to the unit shall be securely anchored to the structure. Such mechanical equipment shall be properly supported to resist a

horizontal force of 50 percent of the weight of the equipment furnished.

- b. Piping: Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- 3. Ductwork: Refer to specification Section 23 31 00, HVAC DUCTS AND CASINGS.
- D. Allowable Vibration Tolerances for Rotating, Non-reciprocating Equipment: Not to exceed a self-excited vibration maximum velocity of 5 mm per second (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions or measured at equipment mounting feet if bearings are concealed. Measurements for internally isolated fans and motors may be made at the mounting feet.

1.4 SUBMITTALS

- A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Vibration isolators:
 - a. Floor mountings
 - b. Hangers
 - c. Snubbers
 - d. Thrust restraints
 - 2. Bases.
 - 3. Acoustical enclosures.
- C. Isolator manufacturer shall furnish with submittal load calculations for selection of isolators, including supplemental bases, based on lowest operating speed of equipment supported.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):
 - 2009Fundamentals Handbook, Chapter 7, Sound and Vibration
- C. American Society for Testing and Materials (ASTM):
 - A123/A123M-09Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

- A307-07bStandard Specification for Carbon Steel Bolts
and Studs, 60,000 PSI Tensile Strength
- D2240-05(2010)Standard Test Method for Rubber Property -
Durometer Hardness
- D. Manufacturers Standardization (MSS):
- SP-58-2009Pipe Hangers and Supports-Materials, Design and
Manufacture
- E. Occupational Safety and Health Administration (OSHA):
- 29 CFR 1910.95Occupational Noise Exposure
- F. American Society of Civil Engineers (ASCE):
- ASCE 7-10Minimum Design Loads for Buildings and Other
Structures.
- G. American National Standards Institute / Sheet Metal and Air
Conditioning Contractor's National Association (ANSI/SMACNA):
- 001-2008Seismic Restraint Manual: Guidelines for
Mechanical Systems, 3rd Edition.
- H. International Code Council (ICC):
- 2009 IBCInternational Building Code.
- I. Department of Veterans Affairs (VA):
- H-18-8 2010Seismic Design Requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Type of isolator, base, and minimum static deflection shall be as required for each specific equipment application as recommended by isolator or equipment manufacturer but subject to minimum requirements indicated herein and in the schedule on the drawings.
- B. Elastometric Isolators shall comply with ASTM D2240 and be oil resistant neoprene with a maximum stiffness of 60 durometer and have a straight-line deflection curve.
- C. Exposure to weather: Isolator housings to be either hot dipped galvanized or powder coated to ASTM B117 salt spray testing standards. Springs to be powder coated or electro galvanized. All hardware to be electro galvanized. In addition provide limit stops to resist wind velocity. Velocity pressure established by wind shall be calculated in accordance with section 1609 of the International Building Code. A minimum wind velocity of 75 mph shall be employed.
- D. Uniform Loading: Select and locate isolators to produce uniform loading and deflection even when equipment weight is not evenly distributed.

- E. Color code isolators by type and size for easy identification of capacity.

2.2 SEISMIC RESTRAINT REQUIREMENTS FOR EQUIPMENTS

- A. Bolt pad mounted equipment, without vibration isolators, to the floor or other support using ASTM A307 standard bolting material.
- B. Floor mounted equipment, with vibration Isolators: Type SS. Where Type N isolators are used provide channel frame base horizontal restraints bolted to the floor, or other support, on all sides of the equipment. Size and material required for the base shall be as recommended by the isolator manufacturer.
- C. On all sides of suspended equipment, provide bracing for rigid supports and provide restraints for resiliently supported equipment.

2.3 VIBRATION ISOLATORS

- A. Floor Mountings:
 - 1. Double Deflection Neoprene (Type N): Shall include neoprene covered steel support plated (top and bottom), friction pads, and necessary bolt holes.
 - 2. Pads (Type D), Washers (Type W), and Bushings (Type L): Pads shall be natural rubber or neoprene waffle, neoprene and steel waffle, or reinforced duck and neoprene. Washers and bushings shall be reinforced duck and neoprene. Washers and bushings shall be reinforced duck and neoprene. Size pads for a maximum load of 345 kPa (50 pounds per square inch).
 - 3. Seismic Pad (Type DS): Pads shall be natural rubber / neoprene waffle with steel top plate and drilled for an anchor bolt. Washers and bushings shall be reinforced duck and neoprene. Size pads for a maximum load of 345 kPa (50 pounds per square inch).
- C. Snubbers: Each spring mounted base shall have a minimum of four all-directional or eight two directional (two per side) seismic snubbers that are double acting. Elastomeric materials shall be shock absorbent neoprene bridge quality bearing pads, maximum 60 durometer, replaceable and have a minimum thickness of 6 mm (1/4 inch). Air gap between hard and resilient material shall be not less than 3 mm (1/8 inch) nor more than 6 mm (1/4 inch). Restraints shall be capable of withstanding design load without permanent deformation.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Vibration Isolation:

1. No metal-to-metal contact will be permitted between fixed and floating parts.
 2. Connections to Equipment: Allow for deflections equal to or greater than equipment deflections. Electrical, drain, piping connections, and other items made to rotating or reciprocating equipment (pumps, compressors, etc.) which rests on vibration isolators, shall be isolated from building structure for first three hangers or supports with a deflection equal to that used on the corresponding equipment.
 3. Common Foundation: Mount each electric motor on same foundation as driven machine. Hold driving motor and driven machine in positive rigid alignment with provision for adjusting motor alignment and belt tension. Bases shall be level throughout length and width. Provide shims to facilitate pipe connections, leveling, and bolting.
 4. Provide heat shields where elastomers are subject to temperatures over 38 degrees C (100 degrees F).
 5. Extend bases for pipe elbow supports at discharge and suction connections at pumps. Pipe elbow supports shall not short circuit pump vibration to structure.
 6. Non-rotating equipment such as heat exchangers and convertors shall be mounted on isolation units having the same static deflection as the isolation hangers or support of the pipe connected to the equipment.
- B. Inspection and Adjustments: Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls. Adjust, repair, or replace isolators as required to reduce vibration and noise transmissions to specified levels.

3.2 ADJUSTING

- A. Adjust vibration isolators after piping systems are filled and equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4inch (6-mm) movement during start and stop.
- D. Adjust active height of spring isolators.
- E. Adjust snubbers according to manufacturer's recommendations.
- F. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

- G. Torque anchor bolts according to equipment manufacturer's recommendations to resist seismic forces.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL**1.1 DESCRIPTION**

- A. Testing, adjusting, and balancing (TAB) of heating, ventilating and air conditioning (HVAC) systems. TAB includes the following:
1. Planning systematic TAB procedures.
 2. Design Review Report.
 3. Systems Inspection report.
 4. Systems Readiness Report.
 5. Balancing air and water distribution systems; adjustment of total system to provide design performance; and testing performance of equipment and automatic controls.
 6. Recording and reporting results.
 7. System Readiness Report.
- B. Definitions:
1. Basic TAB used in this Section: Chapter 37, "Testing, Adjusting and Balancing" of 2007 ASHRAE Handbook, "HVAC Applications".
 2. TAB: Testing, Adjusting and Balancing; the process of checking and adjusting HVAC systems to meet design objectives.
 3. AABC: Associated Air Balance Council.
 4. NEBB: National Environmental Balancing Bureau.
 5. Hydronic Systems: Includes heating hot water.
 6. Air Systems: Includes all outside air, supply air, return air, exhaust air and relief air systems.
 7. Flow rate tolerance: The allowable percentage variation, minus to plus, of actual flowrate from values (design) in the contract documents.

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- C. Section 23 09 23, Direct-Digital Control System for HVAC.
- D. Section 23 21 13, Hydronic Piping.
- E. Section 23 37 00, Air Outlets and Inlets.
- F. Section 23 36 00, Air Terminal Units
- G. Section 23 31 00, HVAC Ducts and Casings.

H. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS

1.3 QUALITY ASSURANCE

- A. Refer to Articles, Quality Assurance and Submittals, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Qualifications:
1. TAB Agency: The TAB agency shall be a subcontractor of the General Contractor and shall report to and be paid by the General Contractor.
 2. The TAB agency shall be either a certified member of AABC or certified by the NEBB to perform TAB service for HVAC, water balancing and vibrations and sound testing of equipment. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the agency loses subject certification during this period, the General Contractor shall immediately notify the Resident Engineer and submit another TAB firm for approval. Any agency that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any work related to the TAB. All work performed in this Section and in other related Sections by the TAB agency shall be considered invalid if the TAB agency loses its certification prior to Contract completion, and the successor agency's review shows unsatisfactory work performed by the predecessor agency.
 3. TAB Specialist: The TAB specialist shall be either a member of AABC or an experienced technician of the Agency certified by NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the General Contractor shall immediately notify the Resident Engineer and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB specialist shall be considered invalid if the TAB Specialist

- loses its certification prior to Contract completion and must be performed by an approved successor.
4. TAB Specialist shall be identified by the General Contractor within 60 days after the notice to proceed. The TAB specialist will be coordinating, scheduling and reporting all TAB work and related activities and will provide necessary information as required by the Resident Engineer. The responsibilities would specifically include:
 - a. Shall directly supervise all TAB work.
 - b. Shall sign the TAB reports that bear the seal of the TAB standard. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC or NEBB.
 - c. Would follow all TAB work through its satisfactory completion.
 - d. Shall provide final markings of settings of all HVAC adjustment devices.
 - e. Permanently mark location of duct test ports.
 5. All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of 3 projects comparable in size and complexity to this project. Qualifications must be certified by the TAB agency in writing. The lead technician shall be certified by AABC or NEBB
- C. Test Equipment Criteria: The instrumentation shall meet the accuracy/calibration requirements established by AABC National Standards or by NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems and instrument manufacturer. Provide calibration history of the instruments to be used for test and balance purpose.
- D. Tab Criteria:
1. One or more of the applicable AABC, NEBB or SMACNA publications, supplemented by ASHRAE Handbook "HVAC Applications" Chapter 36, and requirements stated herein shall be the basis for planning, procedures, and reports.
 2. Flow rate tolerance: Following tolerances are allowed. For tolerances not mentioned herein follow ASHRAE Handbook "HVAC Applications", Chapter 36, as a guideline. Air Filter resistance during tests, artificially imposed if necessary, shall be at least 100 percent of manufacturer recommended change over pressure drop values for pre-filters and after-filters.

- a. Air terminal units (maximum values): Minus 2 percent to plus 10 percent.
- b. Individual room air outlets and inlets, and air flow rates not mentioned above: Minus 5 percent to plus 10 percent except if the air to a space is 100 CFM or less the tolerance would be minus 5 to plus 5 percent.
- c. Hot water coils: Minus 5 percent to plus 5 percent.
3. Systems shall be adjusted for energy efficient operation as described in PART 3.
4. Typical TAB procedures and results shall be demonstrated to the Resident Engineer for one air distribution system (including all fans, three terminal units, three rooms randomly selected by the Resident Engineer):
 - a. When field TAB work begins.
 - b. During each partial final inspection and the final inspection for the project if requested by VA.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Submit names and qualifications of TAB agency and TAB specialists within 60 days after the notice to proceed. Submit information on three recently completed projects and a list of proposed test equipment.
- C. For use by the Resident Engineer staff, submit one complete set of applicable AABC or NEBB publications that will be the basis of TAB work.
- D. Submit Following for Review and Approval:
 1. Design Review Report within 90 days for conventional design projects.
 2. Systems inspection report on equipment and installation for conformance with design.
 3. Duct Air Leakage Test Report.
 4. Systems Readiness Report.
 5. Intermediate and Final TAB reports covering flow balance and adjustments, performance tests, vibration tests and sound tests.
 6. Include in final reports uncorrected installation deficiencies noted during TAB and applicable explanatory comments on test results that differ from design requirements.

- E. Prior to request for Final or Partial Final inspection, submit completed Test and Balance report for the area.

1.5 APPLICABLE PUBLICATIONS

- A. The following publications form a part of this specification to the extent indicated by the reference thereto. In text the publications are referenced to by the acronym of the organization.
- B. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):
2007HVAC Applications ASHRAE Handbook, Chapter 37, Testing, Adjusting, and Balancing and Chapter 47, Sound and Vibration Control
- C. Associated Air Balance Council (AABC):
2002AABC National Standards for Total System Balance
- D. National Environmental Balancing Bureau (NEBB):
7th Edition 2005Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems
2nd Edition 2006Procedural Standards for the Measurement of Sound and Vibration
3rd Edition 2009Procedural Standards for Whole Building Systems Commissioning of New Construction
- E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
3rd Edition 2002HVAC SYSTEMS Testing, Adjusting and Balancing

PART 2 - PRODUCTS

2.1 PLUGS

Provide plastic plugs to seal holes drilled in ductwork for test purposes.

2.2 INSULATION REPAIR MATERIAL

See Section 23 07 11, HVAC and BOILER PLANT INSULATION Provide for repair of insulation removed or damaged for TAB work.

PART 3 - EXECUTION

3.1 GENERAL

- A. Refer to TAB Criteria in Article, Quality Assurance.
- B. Obtain applicable contract documents and copies of approved submittals for HVAC equipment and automatic control systems.

3.2 DESIGN REVIEW REPORT

The TAB Specialist shall review the Contract Plans and specifications and advise the Resident Engineer of any design deficiencies that would prevent the HVAC systems from effectively operating in accordance with the sequence of operation specified or prevent the effective and accurate TAB of the system. The TAB Specialist shall provide a report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

3.3 SYSTEMS INSPECTION REPORT

- A. Inspect equipment and installation for conformance with design.
- B. The inspection and report is to be done after air distribution equipment is on site and duct installation has begun, but well in advance of performance testing and balancing work. The purpose of the inspection is to identify and report deviations from design and ensure that systems will be ready for TAB at the appropriate time.
- C. Reports: Follow check list format developed by AABC, NEBB or SMACNA, supplemented by narrative comments, with emphasis on air handling units and fans. Check for conformance with submittals. Verify that diffuser and register sizes are correct. Check air terminal unit installation including their duct sizes and routing.

3.4 SYSTEM READINESS REPORT

- A. The TAB Contractor shall measure existing air and water flow rates associated with existing systems utilized to serve renovated areas as indicated on drawings. Submit report of findings to resident engineer.
- B. Inspect each System to ensure that it is complete including installation and operation of controls. Submit report to RE in standard format and forms prepared and or approved by the Commissioning Agent.
- C. Verify that all items such as ductwork piping, ports, terminals, connectors, etc., that is required for TAB are installed. Provide a report to the Resident Engineer.
- D. TAB Contractor shall perform testing and provide a system readiness report for air volumes of ducts and diffusers served by EXISTING systems in the following rooms: BV-110, BV-111, BV-111A, BV-112, BV-113 & BV-114.

3.5 TAB REPORTS

- A. Submit an intermediate report for 50 percent of systems and equipment tested and balanced to establish satisfactory test results.
- B. The TAB contractor shall provide raw data immediately in writing to the Resident Engineer if there is a problem in achieving intended results before submitting a formal report.
- C. If over 20 percent of readings in the intermediate report fall outside the acceptable range, the TAB report shall be considered invalid and all contract TAB work shall be repeated and re-submitted for approval at no additional cost to the owner.
- D. Do not proceed with the remaining systems until intermediate report is approved by the Resident Engineer.

3.6 TAB PROCEDURES

- A. Tab shall be performed in accordance with the requirement of the Standard under which TAB agency is certified by either AABC or NEBB.
- B. General: During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.
- C. Coordinate TAB procedures with existing systems and any phased construction completion requirements for the project. Provide TAB reports for pre construction air flow rate.
- D. Allow time in construction schedule as directed by COTR and contract documents for TAB and submission of all reports for an organized and timely correction of deficiencies.
- E. Air Balance and Equipment Test: Include air handling units, fans, terminal units, fan coil units, room diffusers/outlets/inlets.
 - 1. Test and balance systems in all specified modes of operation, including variable volume, economizer, and fire emergency modes. Verify that dampers and other controls function properly.
 - 2. Variable air volume (VAV) systems:
 - a. Coordinate TAB, including system volumetric controls, with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
 - b. Section 23 36 00, AIR TERMINAL UNITS, specifies that maximum and minimum flow rates for air terminal units (ATU) be factory set.

Check and readjust ATU flow rates if necessary. Balance air distribution from ATU on full cooling maximum scheduled cubic meters per minute (cubic feet per minute). Reset room thermostats and check ATU operation from maximum to minimum cooling, to the heating mode, and back to cooling. Record and report the heating coil leaving air temperature when the ATU is in the maximum heating mode. Record and report outdoor air flow rates under all operating conditions (The test shall demonstrate that the minimum outdoor air ventilation rate shall remain constant under all operating conditions).

- c. Adjust operating pressure control setpoint to maintain the design flow to each space with the lowest setpoint.
 5. Record final measurements for air handling equipment performance data sheets.
 3. Record air pressure drop for air handling units, across all components including fan section, filter sections, cooling coils, heating coils, attenuator section, and discharge plenum. Record TSP across complete unit.
 4. Adjust and record air volume of outdoor air, return air and relief air at air handler and return fan.
 5. Adjust return fan speed and air volume to new values as scheduled. Provide new sheaves and belts as required to achieve scheduled performance. Record air volumes and pressures at return fan.
 6. Adjust exhaust fan fan speed and air volume to new values as scheduled. Provide new sheaves and belts as required to achieve scheduled performance. Record air volumes and pressures at fan.
- F. Water Balance and Equipment Test: Include circulating pumps, convertors, coils, coolers and condensers:
1. Adjust flow rates for equipment. Set coils and evaporator to values on equipment submittals, if different from values on contract drawings.
 2. Record final measurements for hydronic equipment on performance data sheets. Include entering and leaving water temperatures for heating and cooling coils, and for convertors. Include entering and leaving air temperatures (DB/WB for cooling coils) at cooling coils and

reheat coils. Make air and water temperature measurements at the same time.

3.7 MARKING OF SETTINGS

Following approval of Tab final Report, the setting of all HVAC adjustment devices including valves, splitters and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored if disturbed at any time. Style and colors used for markings shall be coordinated with the Resident Engineer.

3.8 IDENTIFICATION OF TEST PORTS

The TAB Specialist shall permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leaks and maintain integrity of vapor barrier.

3.9 PHASING

- A. Phased Projects: Testing and Balancing Work to follow project with areas shall be completed per the project phasing. Upon completion of the project all areas shall have been tested and balanced per the contract documents.
- B. Existing Areas: Systems that serve areas outside of the project scope shall not be adversely affected. Measure existing parameters where shown to document system capacity.

3.10 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of all equipment. Coordinate the startup and contractor testing schedules with Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.11 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

- - E N D - - -

SECTION 23 07 11
HVAC AND BOILER PLANT INSULATION**PART 1 - GENERAL****1.1 DESCRIPTION**

- A. Field applied insulation for thermal efficiency and condensation control for
 - 1. HVAC piping, ductwork and equipment.
- B. Definitions
 - 1. ASJ: All service jacket, white finish facing or jacket.
 - 2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.
 - 3. Cold: Equipment, ductwork or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.
 - 4. Concealed: Ductwork and piping above ceilings and in chases, interstitial space, and pipe spaces.
 - 5. Exposed: Piping, ductwork, and equipment exposed to view in finished areas including mechanical and electrical equipment rooms or exposed to outdoor weather. Attics and crawl spaces where air handling units are located are considered to be mechanical rooms. Shafts, chases, interstitial spaces, unfinished attics, crawl spaces and pipe basements are not considered finished areas.
 - 6. FSK: Foil-scrim-kraft facing.
 - 7. Hot: HVAC Ductwork handling air at design temperature above 16 degrees C (60 degrees F); HVAC equipment or piping handling media above 41 degrees C (105 degrees F and piping media and equipment 32 to 230 degrees C (90 to 450 degrees F).
 - 8. Density: kg/m^3 - kilograms per cubic meter (Pcf - pounds per cubic foot).
 - 9. Runouts: Branch pipe connections up to 25-mm (one-inch) nominal size to fan coil units or reheat coils for terminal units.
 - 10. Thermal conductance: Heat flow rate through materials.
 - a. Flat surface: Watt per square meter (BTU per hour per square foot).
 - b. Pipe or Cylinder: Watt per square meter (BTU per hour per linear foot).

11. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).
12. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.
13. HWH: Hot water heating supply.
14. HWHR: Hot water heating return.
15. GH: Hot glycol-water heating supply.
16. GHR: Hot glycol-water heating return.
17. CW: Cold water.
18. SW: Soft water.
19. HW: Hot water.
20. CH: Chilled water supply.
21. CHR: Chilled water return.
22. GC: Chilled glycol-water supply.
23. GCR: Chilled glycol-water return.
24. RS: Refrigerant suction.
25. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.

1.3 QUALITY ASSURANCE

- A. Refer to article QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Criteria:
 1. Comply with NFPA 90A, particularly paragraphs 4.3.3.1 through 4.3.3.6, 4.3.10.2.6, and 5.4.6.4, parts of which are quoted as follows:

4.3.3.1 Pipe insulation and coverings, duct coverings, duct linings, vapor retarder facings, adhesives, fasteners, tapes, and supplementary materials added to air ducts, plenums, panels, and duct silencers used in duct systems, unless otherwise provided for in 4.3.3.1.1 or 4.3.3.1.2., shall have, in the form in which they are used, a maximum flame spread index of 25 without evidence of continued progressive combustion and a maximum smoke developed index of 50 when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*.

4.3.3.1.1 Where these products are to be applied with adhesives, they shall be tested with such adhesives applied, or the adhesives used shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when in the final dry state. (See 4.2.4.2.)

4.3.3.1.2 The flame spread and smoke developed index requirements of 4.3.3.1.1 shall not apply to air duct weatherproof coverings where they are located entirely outside of a building, do not penetrate a wall or roof, and do not create an exposure hazard.

4.3.3.2 Closure systems for use with rigid and flexible air ducts tested in accordance with UL 181, Standard for Safety Factory-Made Air Ducts and Air Connectors, shall have been tested, listed, and used in accordance with the conditions of their listings, in accordance with one of the following:

(1) UL 181A, Standard for Safety Closure Systems for Use with Rigid Air Ducts and Air Connectors

(2) UL 181B, Standard for Safety Closure Systems for Use with Flexible Air Ducts and Air Connectors

4.3.3.3 Air duct, panel, and plenum coverings and linings, and pipe insulation and coverings shall not flame, glow, smolder, or smoke when tested in accordance with a similar test for pipe covering, ASTM C 411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation, at the temperature to which they are exposed in service.

4.3.3.3.1 In no case shall the test temperature be below 121°C (250°F).

4.3.3.4 Air duct coverings shall not extend through walls or floors that are required to be fire stopped or required to have a fire resistance rating, unless such coverings meet the requirements of 5.4.6.4.

4.3.3.5* Air duct linings shall be interrupted at fire dampers to prevent interference with the operation of devices.

4.3.3.6 Air duct coverings shall not be installed so as to conceal or prevent the use of any service opening.

4.3.10.2.6 Materials exposed to the airflow shall be noncombustible or limited combustible and have a maximum smoke developed index of 50 or comply with the following.

4.3.10.2.6.1 Electrical wires and cables and optical fiber cables shall be listed as noncombustible or limited combustible and have a maximum smoke developed index of 50 or shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with NFPA 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

4.3.10.2.6.4 Optical-fiber and communication raceways shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with UL 2024, Standard for Safety Optical-Fiber Cable Raceway.

4.3.10.2.6.6 Supplementary materials for air distribution systems shall be permitted when complying with the provisions of 4.3.3.

5.4.6.4 Where air ducts pass through walls, floors, or partitions that are required to have a fire resistance rating and where fire dampers are not required, the opening in the construction around the air duct shall be as follows:

(1) Not exceeding a 25.4 mm (1 in.) average clearance on all sides

(2) Filled solid with an approved material capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste when subjected to the time-temperature fire conditions required for fire barrier penetration as specified in NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*

2. Test methods: ASTM E84, UL 723, or NFPA 255.

3. Specified k factors are at 24 degrees C (75 degrees F) mean temperature unless stated otherwise. Where optional thermal insulation material is used, select thickness to provide thermal conductance no greater than that for the specified material. For pipe, use insulation manufacturer's published heat flow tables. For domestic hot water supply and return, run out insulation and condensation control insulation, no thickness adjustment need be made.

4. All materials shall be compatible and suitable for service temperature, and shall not contribute to corrosion or otherwise attack surface to which applied in either the wet or dry state.

C. Every package or standard container of insulation or accessories delivered to the job site for use must have a manufacturer's stamp or label giving the name of the manufacturer and description of the material.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Shop Drawings:
 - 1. All information, clearly presented, shall be included to determine compliance with drawings and specifications and ASTM, federal and military specifications.
 - a. Insulation materials: Specify each type used and state surface burning characteristics.
 - b. Insulation facings and jackets: Each type used. Make it clear that white finish will be furnished for exposed ductwork, casings and equipment.
 - c. Insulation accessory materials: Each type used.
 - d. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation.
 - e. Make reference to applicable specification paragraph numbers for coordination.

1.5 STORAGE AND HANDLING OF MATERIAL

Store materials in clean and dry environment, pipe covering jackets shall be clean and unmarred. Place adhesives in original containers. Maintain ambient temperatures and conditions as required by printed instructions of manufacturers of adhesives, mastics and finishing cements.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. Federal Specifications (Fed. Spec.):
 - L-P-535E (2)- 99Plastic Sheet (Sheeting): Plastic Strip; Poly (Vinyl Chloride) and Poly (Vinyl Chloride - Vinyl Acetate), Rigid.
- C. Military Specifications (Mil. Spec.):
 - MIL-A-3316C (2)-90Adhesives, Fire-Resistant, Thermal Insulation
 - MIL-A-24179A (1)-87Adhesive, Flexible Unicellular-Plastic Thermal Insulation
 - MIL-C-19565C (1)-88Coating Compounds, Thermal Insulation, Fire-and Water-Resistant, Vapor-Barrier

- MIL-C-20079H-87Cloth, Glass; Tape, Textile Glass; and Thread,
Glass and Wire-Reinforced Glass
- D. American Society for Testing and Materials (ASTM):
- A167-99(2004)Standard Specification for Stainless and
Heat-Resisting Chromium-Nickel Steel Plate,
Sheet, and Strip
- B209-07Standard Specification for Aluminum and
Aluminum-Alloy Sheet and Plate
- C411-05Standard test method for Hot-Surface
Performance of High-Temperature Thermal
Insulation
- C449-07Standard Specification for Mineral Fiber
Hydraulic-Setting Thermal Insulating and
Finishing Cement
- C533-09Standard Specification for Calcium Silicate
Block and Pipe Thermal Insulation
- C534-08Standard Specification for Preformed Flexible
Elastomeric Cellular Thermal Insulation in
Sheet and Tubular Form
- C547-07Standard Specification for Mineral Fiber pipe
Insulation
- C552-07Standard Specification for Cellular Glass
Thermal Insulation
- C553-08Standard Specification for Mineral Fiber
Blanket Thermal Insulation for Commercial and
Industrial Applications
- C585-09Standard Practice for Inner and Outer Diameters
of Rigid Thermal Insulation for Nominal Sizes
of Pipe and Tubing (NPS System) R (1998)
- C612-10Standard Specification for Mineral Fiber Block
and Board Thermal Insulation
- C1126-04Standard Specification for Faced or Unfaced
Rigid Cellular Phenolic Thermal Insulation
- C1136-10Standard Specification for Flexible, Low
Permeance Vapor Retarders for Thermal
Insulation

- D1668-97a (2006)Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing
- E84-10Standard Test Method for Surface Burning Characteristics of Building Materials
- E119-09cStandard Test Method for Fire Tests of Building Construction and Materials
- E. National Fire Protection Association (NFPA):
- 90A-09Standard for the Installation of Air Conditioning and Ventilating Systems
- 96-08Standards for Ventilation Control and Fire Protection of Commercial Cooking Operations
- 101-09Life Safety Code
- 251-06Standard methods of Tests of Fire Endurance of Building Construction Materials
- 255-06Standard Method of tests of Surface Burning Characteristics of Building Materials
- F. Underwriters Laboratories, Inc (UL):
- 723UL Standard for Safety Test for Surface Burning Characteristics of Building Materials with Revision of 09/08
- G. Manufacturer's Standardization Society of the Valve and Fitting Industry (MSS):
- SP58-2009Pipe Hangers and Supports Materials, Design, and Manufacture

PART 2 - PRODUCTS

2.1 MINERAL FIBER OR FIBER GLASS

- A. ASTM C612 (Board, Block), Class 1 or 2, density 48 kg/m³ (3 pcf), k = 0.037 (0.26) at 24 degrees C (75 degrees F), external insulation for temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.
- B. ASTM C553 (Blanket, Flexible) Type I, Class B-3, Density 16 kg/m³ (1 pcf), k = 0.045 (0.31) at 24 degrees C (75 degrees F), for use at temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.

- C. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, $k = 0.037$ (0.26) at 24 degrees C (75 degrees F), for use at temperatures up to 230 degrees C (450 degrees F) with an all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.

2.2 RIGID CELLULAR PHENOLIC FOAM

- A. Preformed (molded) pipe insulation, ASTM C1126, type III, grade 1, $k = 0.021$ (0.15) at 10 degrees C (50 degrees F), for use at temperatures up to 121 degrees C (250 degrees F) with all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.
- B. Equipment and Duct Insulation, ASTM C 1126, type II, grade 1, $k = 0.021$ (0.15) at 10 degrees C (50 degrees F), for use at temperatures up to 121 degrees C (250 degrees F) with rigid cellular phenolic insulation and covering, and all service vapor retarder jacket.

2.3 CELLULAR GLASS CLOSED-CELL

- A. Comply with Standard ASTM C177, C518, density 120 kg/m³ (7.5 pcf) nominal, $k = 0.033$ (0.29) at 24 degrees C (75 degrees F).
- B. Pipe insulation for use at temperatures up to 200 degrees C (400 degrees F) with all service vapor retarder jacket.

2.4 FLEXIBLE ELASTOMERIC CELLULAR THERMAL

ASTM C177, C518, $k = 0.039$ (0.27) at 24 degrees C (75 degrees F), flame spread not over 25, smoke developed not over 50, for temperatures from minus 4 degrees C (40 degrees F) to 93 degrees C (200 degrees F). No jacket required.

2.5 CALCIUM SILICATE

- A. Preformed pipe Insulation: ASTM C533, Type I and Type II with indicator denoting asbestos-free material.
- B. Premolded Pipe Fitting Insulation: ASTM C533, Type I and Type II with indicator denoting asbestos-free material.
- C. Equipment Insulation: ASTM C533, Type I and Type II

D. Characteristics:

Insulation Characteristics		
ITEMS	TYPE I	TYPE II
Temperature, maximum degrees C (degrees F)	649 (1200)	927 (1700)
Density (dry), Kg/m ³ (lb/ ft ³)	232 (14.5)	288 (18)
Thermal conductivity: Min W/ m K (Btu in/h ft ² degrees F)@ mean temperature of 93 degrees C (200 degrees F)	0.059 (0.41)	0.078 (0.540)
Surface burning characteristics: Flame spread Index, Maximum	0	0
Smoke Density index, Maximum	0	0

2.6 INSULATION FACINGS AND JACKETS

- A. Vapor Retarder, higher strength with low water permeance ≤ 0.02 or less perm rating, Beach puncture 50 units for insulation facing on exposed ductwork, casings and equipment, and for pipe insulation jackets. Facings and jackets shall be all service type (ASJ) or PVDC Vapor Retarder jacketing.
- B. ASJ jacket shall be white kraft bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 75 mm (3 inch) butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.
- C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK) or PVDC vapor retarder jacketing type for concealed ductwork and equipment.
- D. Factory composite materials may be used provided that they have been tested and certified by the manufacturer.
- E. Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be polyvinyl chloride

(PVC) conforming to Fed Spec L-P-335, composition A, Type II Grade GU, and Type III, minimum thickness 0.7 mm (0.03 inches). Provide color matching vapor retarder pressure sensitive tape.

Nominal Pipe Size and Accessories Material (Insert Blocks)	
Nominal Pipe Size mm (inches)	Insert Blocks mm (inches)
Up through 125 (5)	150 (6) long
150 (6)	150 (6) long
200 (8), 250 (10), 300 (12)	225 (9) long
350 (14), 400 (16)	300 (12) long
450 through 600 (18 through 24)	350 (14) long

F. Warm or hot pipe supports: Premolded pipe insulation (180 degree half-shells) on bottom half of pipe at supports. Material shall be high density Calcium Sylicate (for temperatures up to 149 degrees C [300 degrees F]), cellular glass or calcium silicate. Insulation at supports shall have same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m³ (3.0 pcf).

2.12 ADHESIVE, MASTIC, CEMENT

- A. Mil. Spec. MIL-A-3316, Class 1: Jacket and lap adhesive and protective finish coating for insulation.
- B. Mil. Spec. MIL-A-3316, Class 2: Adhesive for laps and for adhering insulation to metal surfaces.
- C. Mil. Spec. MIL-A-24179, Type II Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.
- D. Mil. Spec. MIL-C-19565, Type I: Protective finish for outdoor use.
- E. Mil. Spec. MIL-C-19565, Type I or Type II: Vapor barrier compound for indoor use.
- F. ASTM C449: Mineral fiber hydraulic-setting thermal insulating and finishing cement.
- G. Other: Insulation manufacturers' published recommendations.

2.13 MECHANICAL FASTENERS

- A. Pins, anchors: Welded pins, or metal or nylon anchors with galvanized steel-coated or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.
- B. Staples: Outward clinching monel or galvanized steel.

- C. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy.
- D. Bands: 13 mm (0.5 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

2.14 REINFORCEMENT AND FINISHES

- A. Glass fabric, open weave: ASTM D1668, Type III (resin treated) and Type I (asphalt treated).
- B. Glass fiber fitting tape: Mil. Spec MIL-C-20079, Type II, Class 1.
- C. Tape for Flexible Elastomeric Cellular Insulation: As recommended by the insulation manufacturer.
- D. Hexagonal wire netting: 25 mm (one inch) mesh, 0.85 mm thick (22 gage) galvanized steel.
- E. Corner beads: 50 mm (2 inch) by 50 mm (2 inch), 0.55 mm thick (26 gage) galvanized steel; or, 25 mm (1 inch) by 25 mm (1 inch), 0.47 mm thick (28 gage) aluminum angle adhered to 50 mm (2 inch) by 50 mm (2 inch) Kraft paper.
- F. PVC fitting cover: Fed. Spec L-P-535, Composition A, 11-86 Type II, Grade GU, with Form B Mineral Fiber insert, for media temperature 4 degrees C (40 degrees F) to 121 degrees C (250 degrees F). Below 4 degrees C (40 degrees F) and above 121 degrees C (250 degrees F). Provide double layer insert. Provide color matching vapor barrier pressure sensitive tape.

2.15 FIRESTOPPING MATERIAL

Other than pipe and duct insulation, refer to Section 07 84 00
FIRESTOPPING.

2.16 FLAME AND SMOKE

Unless shown otherwise all assembled systems shall meet flame spread 25 and smoke developed 50 rating as developed under ASTM, NFPA and UL standards and specifications. See paragraph 1.3 "Quality Assurance".

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Required pressure tests of duct and piping joints and connections shall be completed and the work approved by the Resident Engineer for application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.
- B. Except for specific exceptions, insulate entire specified equipment, piping (pipe, fittings, valves, accessories), and duct systems.

Insulate each pipe and duct individually. Do not use scrap pieces of insulation where a full length section will fit.

- C. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 16 degrees C (60 degrees F) and below. Lap and seal vapor retarder over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 150 mm (6 inches).
- D. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.
- E. Construct insulation on parts of equipment such as chilled water pumps and heads of chillers, convertors and heat exchangers that must be opened periodically for maintenance or repair, so insulation can be removed and replaced without damage. Install insulation with bolted 1 mm thick (20 gage) galvanized steel or aluminum covers as complete units, or in sections, with all necessary supports, and split to coincide with flange/split of the equipment.
- F. Insulation on hot piping and equipment shall be terminated square at items not to be insulated, access openings and nameplates. Cover all exposed raw insulation with white sealer or jacket material.
- G. Protect all insulations outside of buildings with aluminum jacket using lock joint or other approved system for a continuous weather tight system. Access doors and other items requiring maintenance or access shall be removable and sealable.
- H. HVAC work not to be insulated:
 - 1. Internally insulated ductwork and air handling units.
 - 2. Relief air ducts (Economizer cycle exhaust air).
 - 3. HVAC hot water control valves, hot water unions and balance valves.
 - 4. Hot water drains and vents.
- I. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.

- J. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. The elbow/ fitting insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/ fitting.
- K. Firestop Pipe and Duct insulation:
1. Provide firestopping insulation at fire and smoke barriers through penetrations. Fire stopping insulation shall be UL listed as defines in Section 07 84 00, FIRESTOPPING.
 2. Pipe and duct penetrations requiring fire stop insulation including, but not limited to the following:
 - a. Pipe risers through floors
 - b. Pipe or duct chase walls and floors
 - c. Smoke partitions
 - d. Fire partitions

3.2 INSULATION INSTALLATION

- A. Mineral Fiber Board:
1. Faced board: Apply board on pins spaced not more than 300 mm (12 inches) on center each way, and not less than 75 mm (3 inches) from each edge of board. In addition to pins, apply insulation bonding adhesive to entire underside of horizontal metal surfaces. Butt insulation edges tightly and seal all joints with laps and butt strips. After applying speed clips cut pins off flush and apply vapor seal patches over clips.
 2. Plain board:
 - a. Insulation shall be scored, beveled or mitered to provide tight joints and be secured to equipment with bands spaced 225 mm (9 inches) on center for irregular surfaces or with pins and clips on flat surfaces. Use corner beads to protect edges of insulation.
 - b. For hot equipment: Stretch 25 mm (1 inch) mesh wire, with edges wire laced together, over insulation and finish with insulating and finishing cement applied in one coat, 6 mm (1/4 inch) thick, trowel led to a smooth finish.
 3. Exposed, unlined ductwork and equipment in unfinished areas, mechanical and electrical equipment rooms and attics, interstitial spaces and duct work exposed to outdoor weather:

- a. 50 mm (2 inch) thick insulation faced with ASJ (white all service jacket): Supply air duct unlined air handling units and after filter housing.

B. Flexible Mineral Fiber Blanket:

1. Adhere insulation to metal with 75 mm (3 inch) wide strips of insulation bonding adhesive at 200 mm (8 inches) on center all around duct. Additionally secure insulation to bottom of ducts exceeding 600 mm (24 inches) in width with pins welded or adhered on 450 mm (18 inch) centers. Secure washers on pins. Butt insulation edges and seal joints with laps and butt strips. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations with mastic. Sagging duct insulation will not be acceptable. Install firestop duct insulation where required.
2. Supply air ductwork to be insulated includes main and branch ducts from AHU discharge to room supply outlets, and the bodies of ceiling outlets to prevent condensation. Insulate sound attenuator units, coil casings and damper frames. To prevent condensation insulate trapeze type supports and angle iron hangers for flat oval ducts that are in direct contact with metal duct.
3. Concealed supply air ductwork.
 - a. Above ceilings at a roof level, in attics, and duct work exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with FSK.
 - b. Above ceilings for other than roof level: 40 mm (1 ½ inch) thick insulation faced with FSK.
4. Concealed return air duct:
 - a. In interstitial spaces (where not subject to damage): 40 mm (1-1/2 inch thick insulation faced with FSK.
5. Concealed outside air duct: 40 mm (1-1/2 inch) thick insulation faced with FSK.

C. Molded Mineral Fiber Pipe and Tubing Covering:

1. Fit insulation to pipe or duct, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal

insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.

2. Contractor's options for fitting, flange and valve insulation:

- a. Insulating and finishing cement for sizes less than 100 mm (4 inches) operating at surface temperature of 16 degrees C (61 degrees F) or more.
- b. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts. Provide two insert layers for pipe temperatures below 4 degrees C (40 degrees F), or above 121 degrees C (250 degrees F). Secure first layer of insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.
- c. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place. For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 16 degrees C (60 degrees F) or less, vapor seal with a layer of glass fitting tape imbedded between two 2 mm (1/16 inch) coats of vapor barrier mastic.
- d. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 50 mm (2 inches).

3. Nominal thickness in millimeters and inches specified in the schedule at the end of this section.

E. Cellular Glass Insulation:

1. Pipe and tubing, covering nominal thickness in millimeters and inches as specified in the schedule at the end of this section.

3.8 PIPE INSULATION SCHEDULE

Provide insulation for piping systems as scheduled below:

Insulation Thickness Millimeters (Inches)					
		Nominal Pipe Size Millimeters (Inches)			
Operating Temperature Range/Service	Insulation Material	Less than 25 (1)	25 - 32 (1 - 1¼)	38 - 75 (1½ - 3)	100 (4) and Above
40-60 DEGREES F ED DRAINS	FLEXIBLE ELASTOMERIC	12.5 (1/2)	19 (0.75)	25 (1.0)	-

(40-60 degrees F) (CH, CHS, CHR, GC, GCR)	Mineral Fiber (Above ground piping only)	12.5 (0.5)	25 (1.0)	25 (1.0)	25 (1.0)
38-94 degrees C (100-200 degrees F) (LPR, PC, HWH, HWHR, GH and GHR)	Mineral Fiber (Above ground piping only)	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)

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SECTION 23 08 00**COMMISSIONING OF HVAC SYSTEMS****PART 1 - GENERAL****1.1 DESCRIPTION**

- A. The requirements of this Section apply to all sections of Division 23.
- B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned is specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. A Commissioning Agent (CxA) appointed by the VA will manage the commissioning process.

1.2 RELATED WORK

- A. Section 01 00 00 GENERAL REQUIREMENTS.
- B. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.
- C. Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

1.3 SUMMARY

- A. This Section includes requirements for commissioning the Facility exterior closure, related subsystems and related equipment. This Section supplements the general requirements specified in Section 01 91 00 General Commissioning Requirements.
- B. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

- A. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

- A. Commissioning of a system or systems specified in Division 23 is part of the construction process. Documentation and testing of these systems, as well as training of the VA's Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00 and of Division 23, is required in cooperation with the VA and the Commissioning Agent.

1.6 SUBMITTALS

- A. The commissioning process requires review of selected Submittals that pertain to the systems to be commissioned. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.
- B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

- A. Commissioning of HVAC systems will require inspection of individual elements of the HVAC systems construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00 and the Commissioning plan to schedule HVAC systems inspections as required to support the Commissioning Process.

3.2 PRE-FUNCTIONAL CHECKLISTS

- A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and

resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

- A. Contractor tests as required by other sections of Division 23 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING:

- A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the Resident Engineer. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed. See Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS, for additional details.

3.5 TRAINING OF VA PERSONNEL

- A. Training of the VA operation and maintenance personnel is required in cooperation with the Resident Engineer and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Section 01 91 00. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and Division 23 Sections for additional Contractor training requirements.

----- END -----

SECTION 23 09 23
HVAC CONTROLS**1. Part 1 - General****1.1 Related Documents**

- A. All work of this Division shall be coordinated and provided by the single Building Automation System (BAS) Contractor.
- B. The work of this Division shall be as required by the Specifications, Point Schedules and Drawings.
- C. If the BAS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- D. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- E. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
- F. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- G. Section 23 34 00 HVAC FANS
- H. Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- I. Section 23 82 16, AIR COILS.
- J. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

1.3 DEFINITIONS

- A. Analog: A continuously variable system or value not having discrete levels. Typically exists within a defined range of limiting values.
- B. Binary: A two-state system where an "ON" condition is represented by one discrete signal level and an "OFF" condition is represented by a second discrete signal level.
- C. Building Automation System (BAS): The total integrated system of fully operational and functional elements, including equipment, software, programming, and associated materials, to be provided by this Division BAS Contractor and to be interfaced to the associated work of other related trades.
- D. BAS Contractor: The single Contractor to provide the work of this Division. This Contractor shall be the primary manufacturer, installer, commissioner and ongoing service provider for the BAS work.
- E. Control Sequence: An BAS pre-programmed arrangement of software algorithms, logical computation, target values and limits as required to attain the defined operational control objectives.
- F. Direct Digital Control: The digital algorithms and pre-defined arrangements included in the BAS software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional,

Derivative and Integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.

- G. BAS Network: The total digital on-line real-time interconnected configuration of BAS digital processing units, workstations, panels, sub-panels, controllers, devices and associated elements individually known as network nodes. May exist as one or more fully interfaced and integrated sub-networks, LAN, WAN or the like.
- H. Node: A digitally programmable entity existing on the BAS network.
- I. BAS Integration: The complete functional and operational interconnection and interfacing of all BAS work elements and nodes in compliance with all applicable codes, standards and ordinances so as to provide a single coherent BAS as required by this Division.
- J. Provide: The term "Provide" and its derivatives when used in this Division shall mean to furnish, install in place, connect, calibrate, test, commission, warrant, document and supply the associated required services ready for operation.
- K. PC: IBM-compatible Personal Computer from a recognized major manufacturer
- L. Furnish: The term "Furnish" and its derivatives when used in this Division shall mean supply at the BAS Contractor's cost to the designated third party trade contractor for installation. BAS Contractor shall connect furnished items to the BAS, calibrate, test, commission, warrant and document.
- M. Wiring: The term "Wiring" and its derivatives when used in this Division shall mean provide the BAS wiring and terminations.
- N. Install: The term "Install" and its derivatives when used in this Division shall mean receive at the jobsite and mount.
- O. Protocol: The term "protocol" and its derivatives when used in this Division shall mean a defined set of rules and standards governing the on-line exchange of data between BAS network nodes.
- P. Software: The term "software" and its derivatives when used in this Division shall mean all of programmed digital processor software, preprogrammed firmware and project specific digital process programming and database entries and definitions as generally understood in the BAS industry for real-time, on-line, integrated BAS configurations.
- Q. The use of words in the singular in these Division documents shall not be considered as limiting when other indications in these documents denote that more than one such item is being referenced.
- R. Headings, paragraph numbers, titles, shading, bolding, underscores, clouds and other symbolic interpretation aids included in the Division documents are for general information only and are to assist in the reading and interpretation of these Documents.
- S. 'Division 23', 'Div 23' shall mean the mechanical contractor as governed by other sections of Division 23 specifications, such as hydronic piping installers and HVAC sheet metal installers.

1.4. BAS DESCRIPTION

- A. The BAS ADX primary, backup servers, and the NAEs at the Mpls VAMC reside on the bio-med network. There are dedicated workstations and laptops that have

direct access to the BAS. No attempts to connect JCI laptops or off-the-shelf PCs to any VAMC network should ever be made.

- B. All points of user interface shall be on standard PCs that do not require the purchase of any special software from the BAS manufacturer for use as a building operations terminal. The primary point of interface on these PCs will be a standard Web Browser.
- C. The work of the single BAS Contractor shall be as defined individually and collectively in all Sections of this specification and the associated interfacing work as referenced in the related documents.
- D. The BAS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BAS. Software shall be included, as necessary, to make new BAS components integrate with existing system. At a minimum, this would consist of CCT folder with all the caf files. The NAE point schedule shall also be included directly in the software folder.
- E. Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this Project.
- F. Manage and coordinate the BAS work in a timely manner in consideration of the Project schedules. Coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.
- G. New equipment that will communicate with METASYS shall use BACnet MS/TP communications protocol. BACnet MS/TP allows IP addresses to be shared, rather than using a separate IP address for each piece of equipment.
- H. Access to the bio-med and/or enterprise network requires:
 - 1. NAC(I) Clearance: Contact the COR to initiate the process of obtaining clearance.
 - 2. IT/Cyber Security Training: Contact the COR to initiate the training. The link is <https://www.ees-learning.net/librix/loginhtml.asp?v=librix>.

1.5 QUALITY ASSURANCE

- A. The BAS Contractor shall be the primary manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Building Automation Systems.
- B. The BAS Contractor shall be a recognized national manufacturer, installer and service provider of BAS.
- C. The BAS Contractor shall have a branch facility within a 100-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis.
- D. As evidence and assurance of the contractor's ability to support the Owner's system with service and parts, the contractor must have been in the BAS business for at least the last ten (10) years and have successfully

completed total projects of at least 10 times the value of this contract in each of the preceding five years.

- E. The BAS architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Automation Systems, and shall be the manufacturer's latest standard of design at the time of bid.

1.6 WORK BY OTHERS

- A. The demarcation of work and responsibilities between the BAS Contractor and other related trades shall be as outlined in the BAS RESPONSIBILITY MATRIX

BAS RESPONSIBILITY MATRIX				
WORK	FURNISH	INSTALL	Low Volt. WIRING/TUBE	LINE POWER
BAS low voltage and communication wiring	BAS	BAS	BAS	N/A
VAV box nodes	BAS	23	BAS	26
BAS conduits and raceway	BAS	BAS	BAS	BAS
Automatic dampers EXCEPT INTEGRAL ahu	BAS	23	N/A	N/A
Manual valves	22/23	22/23	N/A	N/A
Automatic CONTROL valves	BAS	22/23	BAS	N/A
VAV boxes	23	23	N/A	N/A
Pipe insertion devices and taps including thermowells, flow and pressure stations.	BAS	22/23	BAS	BAS
BAS Current Switches.	BAS	BAS	BAS	N/A
BAS Control Relays	BAS	BAS	BAS	N/A
Power distribution system monitoring interfaces	26	26	BAS	26
All BAS Nodes, equipment, housings, enclosures and panels.	BAS	BAS	BAS	BAS
Smoke Detectors	28	28	26	26
Fire Dampers	23	23	N/A	N/A
VFDs	26	26	BAS	26

Fire Alarm shutdown relay interlock wiring	26	26	26	26
Fire Alarm smoke control relay interlock wiring	26	26	BAS	26
Fireman's Smoke Control Override Panel	28	28	26	26
Starters, HOA switches	25	26	N/A	26
Control damper actuators	BAS	BAS	BAS	BAS
Smoke Control damper actuators	BAS	BAS	BAS	Pneumatic

1.7 SUBMITTALS - AT A MINIMUM, SUBMIT THE FOLLOWING:

- A. BAS network architecture diagrams including all nodes and interconnections.
- B. Systems schematics, sequences, flow diagrams, and network layout (BAS MS/TP and IP) on CAD floorplans.
- C. Points schedule for each point in the BAS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.
- D. Samples of Graphic Display screen types and associated menus.
- E. Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
- F. Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, and Actuator Type.
- G. Control Valve Schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Design Pressure, and Actuator Type.
- H. Room Schedule including a separate line for each VAV box and/or terminal unit indicating location and address
- I. Details of all BAS interfaces and connections to the work of other trades.
- J. Product data sheets or marked catalog pages including part number, photo and description for all products including software.
- K. Changes made within the current revision of the submittal set shall be clouded or otherwise noted so the modifications are clear.
- L. Layout showing locations of NAEs.
- M. Details of spare capacity.

1.8 RECORD DOCUMENTATION

- A. Operation and Maintenance Manuals -Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BAS provided:
1. Table of contents.
 2. As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
 3. Manufacturers product data sheets or catalog pages for all products including software.
 4. System Operator's manuals.
 5. Archive copy of all site-specific databases and sequences.
 6. BAS network diagrams.
 7. Interfaces to all third-party products and work by other trades.
 8. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets.

1.9 WARRANTY

- A. Provide a one-year labor and material warranty on the BAS.
- B. If within twelve (12) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BAS Contractor at the cost of the BAS Contractor.
- C. Maintain an adequate supply of materials within 100 miles of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during BAS Contractor's normal business hours.

2. PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

- A. The 'Expand Outpatient Mental Health' project shall utilize an existing air handler and return fan. The BAS for these systems is existing. The scope of work includes retrofit of an existing air handler to a new and higher CFM. The scope of work is characterized by:
1. AHU-SW1-09: Project shall utilize the existing unit but replace the cooling coil and the fan section.
 2. BAS shall provide new (170 GPM) 2-way control valve and actuator to control a new 2-bank AHU-09 cooling coil.
 3. The new AHU-SW1-09 fan section shall be an N+1 fan array of four direct drive fans in a new fan wall. There shall be one VFD for each fan. The VFDs shall be provided by Division 26. BAS shall provide control code to control the VFDs serving the fans. Normal operation shall be all 4 fans ramped together to maintain PD set-point. If one fan is out of service, temporary operation shall be to over-run the Hz of three remaining fans. The fan curves and HP of the fans has been selected to allow for up to but not exceed 1.5 times the 60 Hz frequency in order to achieve the same unit airflow with only 3 fans. Other aspects of AHU control such as start/stop

- etc. shall be controlled by existing algorithms. Provide fan status of each fan.
4. Return fan RF-8 shall be retrofit with a new motor and VFD. Provide for Fan tracking and start/stop and status of RF-8. Fan tracking shall employ mathematical algorithm based on coordination of values with engineer and TAB. Controls shall be similar to existing.
 5. BAS shall furnish new AFMS in a new supply air duct in same location as an existing AFMS. BAS shall provide analog transmitter and algorithm for AFMS status and control same as existing.
 6. Provide new controls, and actuators for VAV terminal units. VAV boxes shall have hydronic heating coils. BAS shall provide new actuators. BAS shall furnish new hydronic 2-way control valves for installation by Div 23 fitter. VAV controls shall be provided by BAS and shall be field installed.
 7. Provide recalibration of existing pneumatic VAV terminal units that are re-used.
 8. Furnish new smoke control damper and provide new actuator in Supply air main duct at AHU-9. Smoke control damper shall be furnished by BAS for installation by Div 23.
 9. Provide Bid Alternate as described in other sections and as indicated on plans, including retrofit of existing pneumatic VAV boxes and thermostats, to DDC.
- B. The Building Management System (BAS) shall use an open architecture. To accomplish this effectively, the BAS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.
- C. The Building Management System shall consist of the following:
1. Standalone Network Automation Engine(s)
 2. Field Equipment Controller(s)
 3. Input/Output Module(s)
 4. Local Display Device(s)
 5. Portable Operator's Terminal(s)
 6. Distributed User Interface(s)
 7. Network processing, data storage and communications equipment
 8. Other components required for a complete and working BAS
- D. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.
- E. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.
- E. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

- F. The System shall maintain all settings and overrides through a system reboot.
- G. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.
- H. The System shall comply with (UL) 864 (UUKL) Ninth Edition Smoke Control Listing including the UL 864 Ninth Edition Standard for Control Units and Accessories for Fire Alarm Systems.
 - 1. The System shall comply with the following NFPA Codes and Standards as applicable:
 - 2. NFPA 70 National Electrical Code
 - 3. NFPA 72 National Fire Alarm Code
 - 4. NFPA 101 Life Safety Code
 - 5. NFPA 90A Standard for the Installation of Air-Conditioning and Ventilation Systems
 - 6. NFPA 92B Guide for Smoke Management Systems in Malls, Atria, and Large Areas
 - 7. The System shall comply with the following International Code Council (ICC) Codes:
 - 8. Building Officials and code Administrators International (BOMA) model code
 - 9. International Conference of Building Officials (ICBO) model code
 - 10. Southern Building Code Congress International (SBCCI) regulations
 - 11. Metasys System UL864 UUKL Ninth Edition Smoke Control System Technical Bulletin (LIT-12011252).
- I. Acceptable Manufacturers: Johnson Controls, Metasys Extended Architecture

2.2 BAS ARCHITECTURE

A. Automation Network

- 1. The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels.
- 2. The BAS shall network multiple user interface clients, automation engines, system controllers and application-specific controllers. Provide application and data server(s) as required for systems operation.
- 3. All BAS devices on the automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
- 4. Network Automation Engines (NAE) shall reside on the automation network.

B. Control Network

- 1. Network Automation Engines (NAE) shall provide supervisory control over the control network and shall support all three (3) of the following communication protocols:
 - a. BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9. The NAE shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.

The NAE shall be tested and certified as a BACnet Building Controller (B-BC).

- b. LonWorks enabled devices using the Free Topology Transceiver (FTT-10a).
 - c. The Johnson Controls N2 Field Bus.
2. Control networks shall provide either "Peer-to-Peer," Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.
 3. DDC Controllers shall reside on the control network.
 4. Control network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135.
 5. A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.
 6. The PICS shall be submitted 10 days prior to bidding.

2.3 INTEGRATION

- A. Hardwired: Analog and digital signal values shall be passed from one system to another via hardwired connections.
- B. There will be one separate physical point on each system for each point to be integrated between the systems.
- C. Direct Protocol (Integrator Panel): The BAS system shall include appropriate hardware equipment and software to allow bi-directional data communications between the BAS system and 3rd party manufacturers' control panels. The BAS shall receive, react to, and return information from multiple building systems, including but not limited to the chillers, boilers, variable frequency drives, power monitoring system, and medical gas.
- D. All data required by the application shall be mapped into the Automation Engine's database, and shall be transparent to the operator.
- E. Point inputs and outputs from the third-party controllers shall have real-time interoperability with BAS software features such as: Control Software, Energy Management, Custom Process Programming, Alarm Management, Historical Data and Trend Analysis, Totalization, and Local Area Network Communications.
- F. BACnet Protocol Integration - BACnet: The neutral protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-2003.
- G. A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.

2.4. SITE MANAGEMENT USER INTERFACE APPLICATION COMPONENTS

- A. Operator Interface: An integrated browser based client application shall be used as the user operator interface program.
- B. The System shall employ an event-driven rather than a device polling methodology to dynamically capture and present new data to the user.
- C. All Inputs, Outputs, Setpoints, and all other parameters shall be displayed for operator viewing and modification from the operator interface software.

- D. The user interface software shall provide help menus and instructions for each operation and/or application.
- E. The system shall support customization of the UI configuration and a home page display for each operator.
- F. The system shall support user preferences in the following screen presentations:
 - 1. Alarm
 - 2. Trend
 - 3. Display
 - 4. Applications
- G. All controller software operating parameters shall be displayed for the operator to view/modify from the user interface. These include: setpoints, alarm limits, time delays, PID tuning constants, run-times, point statistics, schedules, and so forth.
- H. The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:
 - 1. User access for selective information retrieval and control command execution
 - 2. Monitoring and reporting
 - 3. Alarm, non-normal, and return to normal condition annunciation
 - 4. Selective operator override and other control actions
 - 5. Information archiving, manipulation, formatting, display and reporting
 - 6. BAS internal performance supervision and diagnostics
 - 7. On-line access to user HELP menus
 - 8. On-line access to current BAS as-built records and documentation
 - 9. Means for the controlled re-programming, re-configuration of BAS operation and for the manipulation of BAS database information in compliance with the prevailing codes, approvals and regulations for individual BAS applications

2.5. NETWORK AUTOMATION ENGINES (NAE)

- A. Network Automation Engine (NAE 55XX)
 - 1. The Network Automation Engine (NAE) shall be a fully user-programmable, supervisory controller. The NAE shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Automation Engines.
 - 2. Automation network - The NAE shall reside on the automation network and shall support a subnet of system controllers.
 - 3. User Interface - Each NAE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.
 - 4. The NAE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NAE.

5. Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.
6. The NAE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.
7. Processor - The NAE shall be microprocessor-based with a minimum word size of 32 bits. The NAE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NAE size and capability shall be sufficient to fully meet the requirements of this Specification.
8. Memory - Each NAE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
9. Hardware Real Time Clock - The NAE shall include an integrated, hardware-based, real-time clock.
10. The NAE shall include troubleshooting LED indicators to identify the following conditions:
 - a. Power - On/Off
 - b. Ethernet Traffic - Ethernet Traffic/No Ethernet Traffic
 - c. Ethernet Connection Speed - 10 Mbps/100 Mbps
 - d. FC Bus A - Normal Communications/No Field Communications
 - e. FC Bus B - Normal Communications/No Field Communications
 - f. Peer Communication - Data Traffic between NAE Devices
 - g. Run - NAE Running/NAE in Startup/NAE Shutting Down/Software Not Running
 - h. Bat Fault - Battery Defective, Data Protection Battery Not Installed
 - i. 24 VAC - 24 VAC Present/Loss Of 24VAC
 - j. Fault - General Fault
 - k. Modem RX - NAE Modem Receiving Data
 - l. Modem TX - NAE Modem Transmitting Data
 - m. Communications Ports - The NAE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.
 - n. Two (2) USB port
 - o. Two (2) URS-232 serial data communication port
 - p. Two (2) RS-485 port
 - q. One (1) Ethernet port
11. Diagnostics - The NAE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Automation Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.
12. Power Failure - In the event of the loss of normal power, The NAE shall continue to operate for a user adjustable period of up to 10 minutes

after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.

13. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
14. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.
15. Certification - The NAE shall be listed by Underwriters Laboratories (UL).
16. Controller network - The NAE shall support the following communication protocols on the controller network:
 - a. The NAE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
 - b. The NAE shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
 - c. The NAE shall be tested and certified as a BACnet Building Controller (B-BC).
 - d. A BACnet Protocol Implementation Conformance Statement shall be provided for the NAE.
 - e. The Conformance Statements shall be submitted 10 days prior to bidding.
 - f. The NAE shall support a minimum of 100 control devices.
 - g. The NAE shall support LonWorks enabled devices using the Free Topology Transceiver FTT10.
 - h. All LonWorks controls devices shall be LonMark certified.
 - i. The NAE shall support a minimum of 255 LonWorks enabled control devices.
 - j. The NAE shall support the Johnson Controls N2 Field Bus.
 - k. The NAE shall support a minimum of 100 N2 control devices.
 - l. The Bus shall conform to Electronic Industry Alliance (EIA) Standard RS-485.
 - m. The Bus shall employ a master/slave protocol where the NAE is the master.
 - n. The Bus shall employ a four (4) level priority system for polling frequency.
 - o. The Bus shall be optically isolated from the NAE.
 - p. The Bus shall support the Metasys Integrator System.

B. Network Integration Engine (NIE 55XX)

1. The Network Integration Engine (NIE) shall be a fully user-programmable, supervisory controller. The NAE shall monitor the network of distributed application-specific controllers on the N1 Network, provide global strategy and direction, and communicate on a peer-to-peer basis with other NAE and NIE controllers.

2. Automation network - The NIE shall reside on the automation network.
3. Metasys N1 Network Integration - The NIE shall connect Metasys N1 based building automation systems to an Internet Protocol (IP) Ethernet network. The Network Integration Engine shall communicate over the automation network on a peer-to-peer basis with NAE and NIE controllers.
4. The NIE shall monitor and control one or more NCM controllers and transfer point data to provide the following features:
 - a. Alarming and alarm limit management
 - b. Point history and Trend data collection
 - c. Totalization of events, run time, and analog rate value
 - d. Event management and Scheduling
 - e. Energy management
 - f. Data sharing
5. In a manner consistent with the Network Automation Engines, the NIE shall record the following user actions on the Metasys N1 network and include them in an audit log.
 - a. Logging on and off
 - b. Commands to equipment
 - c. Parameter changes
 - d. Changes to the system configuration
6. The following capabilities defined in the Metasys N1 network shall remain fully operational until deleted at the M5 Workstation/OWS.
 - a. Totalization
 - b. Scheduling
 - c. Trend collection capabilities
 - d. Event messaging
 - e. Interlocking
 - f. Control Processes
 - g. Optimal Start
7. The NIE shall monitor and control one or more Network Control Modules (NCM) and transfer point data to provide the following features:
 - a. Alarming and alarm limit management
 - b. Point history and Trend data collection
 - c. Totalization of events, run time, and analog rate value
 - d. Event management and Scheduling
 - e. Energy management
 - f. Data sharing
8. In a manner consistent with the NAE, the NIE shall record the following user actions on the Metasys N1 network and include them in an audit log.
 - a. Logging on and off

- b. Commands to equipment
 - c. Parameter changes
 - d. Changes to the system configuration
9. The following capabilities defined in the Metasys N1 network shall remain fully operational until deleted at the M5 Workstation/OWS.
 - a. Totalization
 - b. Scheduling
 - c. Trend collection capabilities
 - d. Event messaging
 - e. Interlocking
 - f. Control Processes
 - g. Optimal Start
 10. User Interface - Each NAE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.
 11. The web based UI software shall be imbedded in the NIE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.
 12. The NIE shall support a minimum of two (2) concurrent users.
 13. The web based user shall have the capability to access all system data through one NIE.
 14. Remote users connected to the network through an Internet Service Provider (ISP) or telephone dial up shall also have total system access through one NIE.
 15. Systems that require the user to address more than one NIE to access all system information are not acceptable.
 16. The NIE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NIE.
 17. Systems that support UI Graphics from a central data base or require the graphics to reside on the user's personal computer are not acceptable.
 18. The NIE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.
 19. Processor - The NIE shall be microprocessor-based with a minimum word size of 32 bits. The NIE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NIE size and capability shall be sufficient to fully meet the requirements of this Specification.
 20. Memory - Each NIE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
 21. Hardware Real Time Clock - The NIE shall include an integrated, hardware-based, real-time clock.

22. The NIE shall include troubleshooting LED indicators to identify the following conditions:
 - a. Power - On/Off
 - b. Ethernet Traffic - Ethernet Traffic/No Ethernet Traffic
 - c. Ethernet Connection Speed - 10 Mbps/100 Mbps
 - d. FC Bus A - Normal Communications/No Field Communications
 - e. FC Bus B - Normal Communications/No Field Communications
 - g. Peer Communication - Data Traffic between Automation Network Devices
 - h. Run - NIE Running/NIE in Startup/NIE Shutting Down/Software Not Running
 - i. Bat Fault - Battery Defective, Data Protection Battery Not Installed
 - j. 24 VAC - 24 VAC Present/Loss Of 24VAC
 - k. Fault - General Fault
 - l. Modem RX - NIE Modem Receiving Data
 - m. Modem TX - NIE Modem Transmitting Data
23. Communications Ports - The NIE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.
 - a. Two (2) USB port
 - b. Two (2) URS-232 serial data communication port
 - c. One (1) Ethernet port
24. Diagnostics - The NIE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The NIE shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.
25. Power Failure - In the event of the loss of normal power, The NIE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.
 - a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
 - b. Upon restoration of normal power and after a minimum off-time delay, the NIE shall automatically resume full operation without manual intervention through a normal soft-start sequence.
26. Certification - The NIE shall be listed by Underwriters Laboratories (UL).

C. Network Integration Engine (NIE 85XX)

1. The Network Integration Engine (NIE) shall be a fully user-programmable, supervisory controller. The NAE shall monitor the network of distributed application-specific controllers on the NI Network, provide global strategy and direction, and communicate on a peer-to-peer basis with other NAE and NIE controllers.

2. Automation network - The NIE shall reside on the automation network.
3. Metasys N1 Network Integration - The NIE shall connect Metasys N1 based building automation systems to an Internet Protocol (IP) Ethernet network. The Network Integration Engine shall communicate over the automation network on a peer-to-peer basis with NAE and NIE controllers.
4. The NIE shall monitor and control one or more NCM controllers and transfer point data to provide the following features:
 - a. Alarming and alarm limit management
 - b. Point history and Trend data collection
 - c. Totalization of events, run time, and analog rate value
 - d. Event management and Scheduling
 - e. Energy management
 - f. Data sharing
5. In a manner consistent with the NAE, the NIE shall record the following user actions on the Metasys N1 network and include them in an audit log.
 - a. Logging on and off
 - b. Commands to equipment
 - c. Parameter changes
 - d. Changes to the system configuration
6. The following capabilities defined in the Metasys N1 network shall remain fully operational until deleted at the M5 Workstation/OWS.
 - a. Totalization
 - b. Scheduling
 - c. Trend collection capabilities
 - d. Event messaging
 - e. Interlocking
 - f. Control Processes
 - g. Optimal Start
7. User Interface - Each NAE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.
8. The web based UI software shall be imbedded in the NIE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.
9. The NIE shall support a minimum of two (2) concurrent users.
10. The web based user shall have the capability to access all system data through one NIE.
11. Remote users connected to the network through an Internet Service Provider (ISP) or telephone dial up shall also have total system access through one NIE.

12. Systems that require the user to address more than one NIE to access all system information are not acceptable.
13. The NIE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NIE.
14. Systems that support UI Graphics from a central data base or require the graphics to reside on the user's personal computer are not acceptable.
15. The NIE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.
16. Processor - The NIE shall be microprocessor-based with a minimum word size of 32 bits. The NIE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NIE size and capability shall be sufficient to fully meet the requirements of this Specification.
17. Memory - Each NIE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
18. Hardware Real Time Clock - The NIE shall include an integrated, hardware-based, real-time clock.
19. Communications Ports - The NIE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.
 - a. Three (3) USB ports
 - b. Two (2) Ethernet ports
 - c. BAS Network Port - 1GB
 - d. Enterprise Network - 100 MB
 - e. One (1) Video Monitor Port
 - f. One (1) 9 pin Serial Port
20. Diagnostics - The NIE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The NIE shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.
21. Power Failure - In the event of the loss of normal power, The NIAE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.
 - a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
 - b. Upon restoration of normal power and after a minimum off-time delay, the NIE shall automatically resume full operation without manual intervention through a normal soft-start sequence.
22. Certification - The NIE shall be listed by Underwriters Laboratories (UL).

2.6 DDC SYSTEM CONTROLLERS

A. Field Equipment Controller (FEC X610)

1. The Field Equipment Controller (FEC) shall be a fully user-programmable, digital controller that communicates via BACnet MS/TP protocol.
2. The FEC shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
3. The FEC shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
4. The FEC shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
5. A BACnet Protocol Implementation Conformance Statement shall be provided for the FEC.
6. The Conformance Statement shall be submitted 10 days prior to bidding.
7. The FEC shall employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.
8. Controllers shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable. The FEC shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
9. The FEC shall include troubleshooting LED indicators to identify the following conditions:
 - a. Power On
 - b. Power Off
 - c. Download or Startup in progress, not ready for normal operation
 - d. No Faults
 - e. Device Fault
 - f. Field Controller Bus - Normal Data Transmission
 - g. Field Controller Bus - No Data Transmission
 - h. Field Controller Bus - No Communication
 - i. Sensor-Actuator Bus - Normal Data Transmission
 - j. Sensor-Actuator Bus - No Data Transmission
 - k. Sensor-Actuator Bus - No Communication
10. The FEC shall accommodate the direct wiring of analog and binary I/O field points.
11. The FEC shall support the following types of inputs and outputs:
12. Universal Inputs - shall be configured to monitor any of the following:
 - a. Analog Input, Voltage Mode
 - b. Analog Input, Current Mode
 - c. Analog Input, Resistive Mode

- d. Binary Input, Dry Contact Maintained Mode
 - e. Binary Input, Pulse Counter Mode
 - f. Binary Inputs - shall be configured to monitor either of the following: Dry Contact Maintained Mode or Pulse Counter Mode
 - g. Analog Outputs - shall be configured to output either of the following: Analog Output, Voltage Mode or Analog Output, current Mode
 - h. Binary Outputs - shall output the following: 24 VAC Triac
 - i. Configurable Outputs - shall be capable of the following: Analog Output, Voltage Mode, Binary Output Mode
13. The FEC shall have the ability to reside on a Field Controller Bus (FC Bus).
- a. The FC Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard protocol SSPC-135, Clause 9.
 - b. The FC Bus shall support communications between the FECs and the NAE.
 - c. The FC Bus shall also support Input/Output Module (IOM) communications with the FEC and with the NAE.
 - d. The FC Bus shall support a minimum of 100 IOMs and FECs in any combination.
 - e. The FC Bus shall operate at a maximum distance of 15,000 Ft. between the FEC and the furthest connected device.
14. The FEC shall have the ability to monitor and control a network of sensors and actuators over a Sensor-Actuator Bus (SA Bus).
- a. The SA Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard Protocol SSPC-135, Clause 9.
 - b. The SA Bus shall support a minimum of 10 devices per trunk.
 - c. The SA Bus shall operate at a maximum distance of 1,200 Ft. between the FEC and the furthest connected device.
15. The FEC shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over the FC Bus or the SA Bus.
16. The FEC shall support, but not be limited to, the following applications:
- a. Chilled water/central plant optimization applications including but not limited to:
 - (1) Selection and sequencing of up to eight chillers of different sizes
 - (2) Selection and sequencing of up to eight (each) primary and secondary chilled water pumps of varying pumping capacities
 - (3) Selection and sequencing of up to eight condenser water pumps
 - (4) Selection and sequencing of cooling towers and bypass valve, including single speed, multi-speed, and vernier control
 - (5) A proven and documented central cooling plant optimization program that incorporates custom equipment efficiency profiles,

without rewriting software code, in order to meet the building load using the least amount of energy as calculated.

- (6) The use of advanced control algorithms that apply equipment specific parameters, including operational limits and efficiency profiles, in order to determine equipment start and runtime preferences
 - (7) Identification of the most efficient equipment combination and automatic control of state and speed of all necessary equipment to balance runtime, optimize timing and sequencing and ensure the efficiency and stability of the central cooling plant
 - (8) Control definition for the chiller plant in a single FEC, as supported by available memory and point Input/Output (I/O), or capable of being split across multiple FECs
- b. Heating central plant applications
 - c. Built-up air handling units for special applications
 - d. Terminal & package units
 - e. Special programs as required for systems control
 - f. The FEC shall support a Local Controller Display (DIS1710) either as an integral part of the FEC or as a remote device communicating over the SA Bus.
 - g. The Display shall use a BACnet Standard SSPC-135, clause 9 Master-Slave/Token-Passing protocol.
 - h. The Display shall allow the user to view monitored points without logging into the system.
 - i. The Display shall allow the user to view and change setpoints, modes of operation, and parameters.
 - j. The Display shall provide password protection with user adjustable password timeout.
 - k. The Display shall be menu driven with separate paths for:
 - (1) Input/Output
 - (2) Parameter/Setpoint
 - (3) Overrides
 - (4) The Display shall use easy-to-read English text messages.
 - (5) The Display shall allow the user to select the points to be shown and in what order.
 - (6) The Display shall support a back lit Liquid Crystal Display (LCD) with adjustable contrast and brightens and automatic backlight brightening during user interaction.
 - (7) The display shall be a minimum of 4 lines and a minimum of 20 characters per line
 - (8) The Display shall have a keypad with no more than 6 keys.
 - (9) The Display shall be panel mountable.

2.7 FIELD DEVICES

A. Input/Output Module (IOM X710)

1. The Input/Output Module (IOM) provides additional inputs and outputs for use in the FEC.
 2. The IOM shall communicate with the FEC over the FC Bus or the SA Bus.
 3. The IOM shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
 4. The IOM shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
 5. The IOM shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
 6. A BACnet Protocol Implementation Conformance Statement shall be provided for the FEC.
 7. The Conformance Statement shall be submitted 10 days prior to bidding.
 8. The IOM shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
 9. The IOM shall have a minimum of 4 points to a maximum of 17 points.
 10. The IOM shall support the following types of inputs and outputs:
 11. Universal Inputs - shall be configured to monitor any of the following:
 - a. Analog Input, Voltage Mode
 - b. Analog Input, Current Mode
 - c. Analog Input, Resistive Mode
 - d. Binary Input, Dry Contact Maintained Mode
 - e. Binary Input, Pulse Counter Mode
 12. Binary Inputs - shall be configured to monitor either of the following:
Dry Contact Maintained Mode or Pulse Counter Mode
 13. Analog Outputs - shall be configured to output either of the following:
Analog Output, Voltage Mode or Analog Output, current Mode
 14. Binary Outputs - shall output the following: 24 VAC Triac
 15. Configurable Outputs - shall be capable of the following: Analog Output, Voltage Mode or Binary Output Mode
 16. The IOM shall include troubleshooting LED indicators to identify the following conditions:
 - a. Power On
 - b. Power Off
 - c. Download or Startup in progress, not ready for normal operation
 - d. No Faults
 - e. Device Fault
 - f. Normal Data Transmission
 - g. No Data Transmission
 - h. No Communication
- B. VAV Modular Assembly (VMA 16X0)

1. The VAV Modular Assembly shall provide both standalone and networked direct digital control of pressure-independent, variable air volume terminal units. It shall address both single and dual duct applications.
2. The VMA shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
3. The VMA shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
4. A BACnet Protocol Implementation Conformance Statement shall be provided for the VMA.
5. The Conformance Statement shall be submitted 10 days prior to bidding.
6. The VAV Modular Assembly shall communicate over the FC Bus using BACnet Standard protocol SSPC-135, Clause 9.
7. The VAV Modular Assembly shall have internal electrical isolation for AC power, DC inputs, and MS/TP communications. An externally mounted isolation transformer shall not be acceptable.
8. The VAV Modular Assembly shall be a configurable digital controller with integral differential pressure transducer and damper actuator. All components shall be connected and mounted as a single assembly that can be removed as one piece.
9. The VAV Modular Assembly shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
10. The integral damper actuator shall be a fast response stepper motor capable of stroking 90 degrees in 30 seconds for quick damper positioning to speed commissioning and troubleshooting tasks.
11. The controller shall determine airflow by dynamic pressure measurement using an integral dead-ended differential pressure transducer. The transducer shall be maintenance-free and shall not require air filters.
12. Each controller shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.
13. The controller shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.
14. Each controller shall continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. In addition, this tuning reduces commissioning costs, and eliminates the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.
15. The controller shall provide the ability to download and upload VMA configuration files, both locally and via the communications network. Controllers shall be able to be loaded individually or as a group using a zone schedule generated spreadsheet of controller parameters.
16. Control setpoint changes initiated over the network shall be written to VMA non-volatile memory to prevent loss of setpoint changes and to provide consistent operation in the event of communication failure.
17. The controller firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.

18. The controller shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.
19. The controller shall interface with balancer tools that allow automatic recalculation of box flow pickup gain ("K" factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow setpoints.
20. Controller performance shall be self-documenting via on-board diagnostics. These diagnostics shall consist of control loop performance measurements executing at each control loop's sample interval, which may be used to continuously monitor and document system performance. The VMA shall calculate exponentially weighted moving averages (EWMA) for each of the following. These metrics shall be available to the end user for efficient management of the VAV terminals.
 - a. Absolute temperature loop error
 - b. Signed temperature loop error
 - c. Absolute airflow loop error
 - d. Signed airflow loop error
 - e. Average damper actuator duty cycle
 - f. The controller shall detect system error conditions to assist in managing the VAV zones. The error conditions shall consist of:
 - (1) Unreliable space temperature sensor
 - (2) Unreliable differential pressure sensor
 - (3) Starved box
 - (4) Actuator stall
 - (5) Insufficient cooling
 - (6) Insufficient heating
21. The controller shall provide a flow test function to view damper position vs. flow in a graphical format. The information would alert the user to check damper position. The VMA would also provide a method to calculate actuator duty cycle as an indicator of damper actuator runtime.
22. The controller shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality), and shall be capable of resetting the box minimum airflow Based on the percent of outdoor air in the primary air stream.
23. The controller shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.
24. Inputs: Analog inputs with user defined ranges shall monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:
 - a. 0-10 VDC Sensors
 - b. 1000ohm RTDs
 - c. NTC Thermistors

- d. Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input "bouncing."
 - e. For noise immunity, the inputs shall be internally isolated from power, communications, and output circuits.
 - f. Provide side loop application for humidity control.
25. Outputs - Analog outputs shall provide the following control outputs:
0-10 VDC
- a. Binary outputs shall provide a SPST Triac output rated for 500mA at 24 VAC.
 - b. For noise immunity, the outputs shall be internally isolated from power, communications, and other output circuits.
26. Application Configuration: The VAV Modular Assembly shall be configured with a software tool that provides a simple Question/Answer format for developing applications and downloading.
27. Sensor Support
- a. The VAV Modular Assembly shall communicate over the Sensor-Actuator Bus (SA Bus) with a Network Sensor.
 - b. The VMA shall support an LCD display room sensor.
 - c. The VMA shall also support standard room sensors as defined by analog input requirements.
 - d. The VMA shall support humidity sensors defined by the AI side loop.

2.8. NETWORK SENSORS (NS-XXX-700X)

- A. The Network Sensors (NS) shall have the ability to monitor the following variables as required by the systems sequence of operations:
 - 1. Zone Temperature
 - 2. Zone Humidity
 - 3. Zone Setpoint
 - 4. Discharge Air Temperature
 - 5. Zone CO2
- B. The NS shall transmit the information back to the controller on the Sensor-Actuator Bus (SA Bus) using BACnet Standard protocol SSPC-135, Clause 9.
- C. The NS shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
 - 1. The NS shall be tested and certified as a BACnet Smart Sensors (B-SS).
 - 2. A BACnet Protocol Implementation Conformance Statement shall be provided for the NS.
 - 3. The Conformance Statement shall be submitted 10 days prior to bidding.
- D. The Network Zone Temperature Sensors shall include the following items:
 - 1. A backlit Liquid Crystal Display (LCD) to indicate the Temperature, Humidity and Setpoint
 - 2. An LED to indicate the status of the Override feature
 - 3. A button to toggle the temperature display between Fahrenheit and Celsius
 - 4. A button to initiate a timed override command

5. Available in either surface mount or wall mount
 6. Available with either screw terminals or phone jack
- E. The Network Discharge Air Sensors shall include the following:
1. 4 inch or 8 inch duct insertion probe
 2. 10 foot pigtail lead
 3. Dip Switches for programmable address selection
 4. Ability to provide an averaging temperature from multiple locations
 5. Ability to provide a selectable temperature from multiple locations
- F. The Network CO2 Zone Sensors shall include the following:
1. Available in either surface mount or wall mount
 2. Available with screw terminals or phone jack

2.9. MANY-TO-ONE WIRELESS ROOM TEMPERATURE SENSOR SYSTEM (WRS-XTX-0000)

- A. The Many-To-One System Receiver (WRS Receiver) shall receive wireless Radio Frequency (RF) signals containing temperature data from multiple Wireless Room Temperature Sensors (WRS Sensors).
- B. The WRS Receiver shall use direct sequence spread spectrum RF technology.
- C. The WRS Receiver shall operate on the 2.4 GHZ ISM Band.
- D. The WRS Receiver shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.
- E. The WRS Receiver shall be FCC compliant to CFR Part 15 subpart B Class A.
- F. The WRS Receiver shall operate as a bidirectional transceiver with the sensors to confirm and synchronize data transmission.
- G. The WRS Receiver shall be capable of communication with WRS Sensors up to a distance of 200 Feet.
- H. The WRS Receiver shall be assembled in a plenum rated plastic housing with flammability rated to UL94-5VB.
- I. The WRS Receiver shall have LED indicators to provide information regarding the following conditions:
1. Power On/Off
 2. Ethernet - Receiver Activity/No Activity
 3. Wireless Normal Mode - Transmission from sensors/No Transmission
 4. Wireless Rapid Transmit Mode - No transmission/ weak signal/Adequate signal/Excellent signal
 5. Ethernet Connection - No connection/10Mbps connection/100Mbps connection
 6. Network Activity - No Network Activity/Half-Duplex Communication/Full-Duplex Communication
- J. The WRS Sensors shall sense and report room temperatures to the WRS Receiver.
1. The WRS Sensors shall use direct sequence spread spectrum RF technology.
 2. The WRS Sensors shall operate on the 2.4 GHZ ISM Band.

3. The WRS Sensors shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.
4. The WRS sensors shall be FCC compliant to CFR Part 15 subpart B Class A.
5. The WRS sensors shall be available with Warmer/Cooler Set Point Adjustment or Set Point Adjustment Scale - 55 to 85° F. COR will direct selection for installation.
6. The WRS sensors shall be assembled in NEMA 1 plastic housings.

2.10 ZFR1800 SERIES WIRELESS FIELD BUS SYSTEM

- A. The ZFR1800 Series System shall employ ZigBee technology to create a wireless mesh network to provide wireless connectivity for Metasys BACnet devices at multiple system levels. This includes communications from FEC and VMA field controllers to sensors and from engines to these field controllers. Wireless devices shall co-exist on the same network with hardwired devices. Hardwired controllers shall be capable of retrofit to wireless devices with no special software.
- B. The ZFR1810 Wireless Field Bus Coordinator shall provide a wireless interface between supported field controllers and an NAE35/45/55 or NCE25 supervisory controller via the BACnet MS/TP field bus. Each wireless mesh network shall be provided with a ZFR1810 Coordinator for initiation and formation of the network.
 1. The ZFR Coordinator shall use direct sequence spread spectrum RF technology.
 2. The ZFR Coordinator shall operate on the 2.4 GHZ ISM Band.
 3. The ZFR Coordinator shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.
 4. The ZFR Coordinator shall be FCC compliant to CFR Part 15 subpart B Class A.
 5. The ZFR Coordinator shall operate as a bidirectional transceiver with the sensors and routers to confirm and synchronize data transmission.
 6. The ZFR Coordinator shall be capable of communication with sensors and routers up to a maximum distance of 250 Feet (line of sight).
 7. The ZFR Coordinator shall be assembled in a plenum rated plastic housing with flammability rated to UL94-5VB.
 8. The ZFR Coordinator shall have LED indicators to provide diagnostic information required for efficient operation and commissioning.
- C. The ZFR1811 Wireless Field Bus Router shall be used with any model Field Equipment Controller (FEC) or VMA1600 series VAV Modular Assembly to provide a wireless interface to supervisory engines, via the ZFR1810 Coordinator, and associated WRZ Wireless Mesh Room Temperature Sensors.
 1. The ZFR1811 Router shall use direct sequence spread spectrum RF technology.
 2. The ZFR1811 Router shall operate on the 2.4 GHZ ISM Band.
 3. The ZFR1811 Router shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.
 4. The ZFR1811 Router shall be FCC compliant to CFR Part 15 subpart B Class A.

5. The ZFR1811 Router shall operate as a bidirectional transceiver with other mesh network devices to ensure network integrity.
 6. The ZFR1811 Router shall be capable of communication with other mesh network devices at a maximum distance of 250 feet (line of sight).
 7. The ZFR1811 Router shall be assembled in a plenum rated plastic housing with flammability rated to UL94-5VB.
 8. The ZFR1811 Router shall provide LED indication for use in commissioning and troubleshooting that can be disabled.
- D. The WRZ-TT Series Wireless Room Temperature Sensors shall sense and transmit room temperatures, room set point, room occupancy notification low battery condition to an associated ZFR1811 Router.
1. The WRZ Sensors shall use direct sequence spread spectrum RF technology.
 2. The WRZ Sensors shall operate on the 2.4 GHZ ISM Band.
 3. The WRZ Sensors shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.
 4. The WRZ sensors shall be FCC compliant to CFR Part 15 subpart B Class A.
 5. The WRZ sensors shall be available with Warmer/Cooler Set Point Adjustment and Set Point Adjustment Scale - 55 to 85° F. COR will direct selection for installation.
- E. Wireless sensors shall be provided with display of room temperature, signal strength, fan mode, occupancy and network status as required by application and indicated on plans or in schedules. The WRZ sensors shall be assembled in NEMA 1 plastic housings.
- F. One-to-One Wireless Room Temperature Sensor System (WRZ)
1. The One-To-One Wireless Receiver (WRS Receiver) shall receive wireless Radio Frequency (RF) signals containing temperature data from multiple Wireless Room Temperature Sensors (WRZ Sensors) and communicate this information to either FEC or VMA controllers via the Sensor/Actuator (SA) Bus.
 2. The WRZ Receiver shall use direct sequence spread spectrum RF technology.
 3. The WRZ Receiver shall operate on the 2.4 GHZ ISM Band.
 4. The WRZ Receiver shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.
 5. The WRZ Receiver shall be FCC compliant to CFR Part 15 subpart B Class A.
 6. The WRZ Receiver shall operate as a bidirectional transceiver with the sensors to confirm and synchronize data transmission.
 7. The WRZ Receiver shall be capable of communication with from one to five WRZ Sensors up to a distance of 200 Feet.
 8. The WRZ Receiver shall be assembled in a plenum rated plastic housing with flammability rated to UL94-5VB.
 9. The WRZ Receiver shall have LED indicators to provide information regarding the following conditions:
 - a. Power
 - b. SA Bus - Receiver Activity/No Activity

- c. Wireless RF - Transmission from sensors/No Transmission
 - d. Wireless Rapid Transmit Mode - No transmission/ weak signal/Adequate signal/Excellent signal
10. The WRZ Sensors shall sense and report room temperatures to the WRZ Receiver.
 11. The WRZ Sensors shall use direct sequence spread spectrum RF technology.
 12. The WRZ Sensors shall operate on the 2.4 GHZ ISM Band.
 13. The WRZ Sensors shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.
 14. The WRZ sensors shall be FCC compliant to CFR Part 15 subpart B Class A.
 15. The WRZ sensors shall be available with Warmer/Cooler Set Point Adjustment or Set Point Adjustment Scale - 55 to 85° F. COR will direct selection for installation.
 16. The WRZ sensors shall be assembled in NEMA 1 plastic housings.

2.11 INPUT DEVICES

- A. General Requirements: Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.
- B. Temperature Sensors - General Requirements:
 1. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
 2. The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD.
 3. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:

Point Type	Accuracy
Chilled Water	$\pm .5^{\circ}\text{F.}$
Room Temp	$\pm .5^{\circ}\text{F.}$
Duct Temperature	$\pm .5^{\circ}\text{F.}$
All Others	$\pm .75^{\circ}\text{F.}$

4. Room Temperature Sensors
 - a. Room sensors shall be constructed for either surface or wall box mounting.
 - b. Room sensors shall have the following options when specified:
 - c. Setpoint reset slide switch providing a ± 3 degree (adjustable) range.
 - d. Individual heating/cooling setpoint slide switches.

- e. A momentary override request push button for activation of after-hours operation.
 - f. Analog thermometer.
5. Room Temperature Sensors with Integral Display
- a. Room sensors shall be constructed for either surface or wall box mounting.
 - b. Room sensors shall have an integral LCD display and four button keypad with the following capabilities:
 - (1) Display room and outside air temperatures.
 - (2) Display and adjust room comfort setpoint.
 - (3) Display and adjust fan operation status.
 - (4) Timed override request push button with LED status for activation of after-hours operation.
 - (5) Display controller mode.
 - (6) Password selectable adjustment of setpoint and override modes.
 - c. Thermo wells
 - (1) When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.
 - (2) Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.
 - (3) Thermo wells and sensors shall be mounted in a threadolet or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement.
 - (4) Thermo wells shall be constructed of 316 stainless steel.
6. Outside Air Sensors
- a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
 - b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
 - c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
7. Duct Mount Sensors
- a. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
 - b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
 - c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
8. Averaging Sensors

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

9. Humidity Sensors

- a. The sensor shall be a solid-state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.
- b. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.
- c. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH @ 77 Deg F unless specified elsewhere.
- d. Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealtite fittings and stainless steel bushings.
- e. A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
- f. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.
- g. Acceptable Manufacturers: Johnson Controls, Veris Industries, and Mamac.

10. Differential Pressure Transmitters

- a. General Air and Water Pressure Transmitter Requirements:
 - (1) Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.
 - (2) Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.
 - (3) Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.
 - (4) A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.
 - (5) Low Differential Water Pressure Applications (0" - 20" w.c.)

- (6) The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points.
- (7) The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
 - (a) .01-20" w.c. input differential pressure range.
 - (b) 4-20 mA output.
 - (c) Maintain accuracy up to 20 to 1 ratio turndown.
 - (d) Reference Accuracy: +0.2% of full span.
- (8) Acceptable Manufacturers: Setra and Mamac.
- b. Medium to High Differential Water Pressure Applications (Over 21" w.c.)
 - (1) The differential pressure transmitter shall meet the low pressure transmitter specifications with the following exceptions:
 - (2) Differential pressure range 10" w.c. to 300 PSI.
 - (3) Reference Accuracy: +1% of full span (includes non-linearity, hysteresis, and repeatability).
 - (4) Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.
 - (5) Acceptable Manufacturers: Setra and Mamac.
- c. Building Differential Air Pressure Applications (-1" to +1" w.c.)
 - (1) The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
 - (2) The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
 - (a) -1.00 to +1.00 w.c. input differential pressure ranges.
(Select range appropriate for system application)
 - (b) 4-20 mA output.
 - (c) Maintain accuracy up to 20 to 1 ratio turndown.
 - (d) Reference Accuracy: +0.2% of full span.
 - (3) Acceptable Manufacturers: Johnson Controls and Setra.
- d. Low Differential Air Pressure Applications (0" to 5" w.c.)
 - (1) The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.

- (2) The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
 - (a) (0.00 - 1.00" to 5.00") w.c. input differential pressure ranges. (Select range appropriate for system application.)
 - (b) 4-20 mA output.
 - (c) Maintain accuracy up to 20 to 1 ratio turndown.
 - (d) Reference Accuracy: +0.2% of full span.
 - (3) Acceptable Manufacturers: Johnson Controls and Setra.
- e. Medium Differential Air Pressure Applications (5" to 21" w.c.)
- (1) The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:
 - (a) Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.
 - (b) Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG.
 - (c) Thermal Effects: <+.033 F.S./Deg F. over 40F. to 100F. (calibrated at 70F.).
 - (2) Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.
 - (3) Acceptable manufacturers: Johnson Controls and Setra.

C. Flow Monitoring

1. Air Flow Monitoring

a. Fan Inlet Air Flow Measuring Stations

- (1) At the inlet of each fan and near the exit of the inlet sound trap, airflow traverse probes shall be provided that shall continuously monitor the fan air volumes and system velocity pressure.
- (2) Each traverse probe shall be of a dual manifolded, cylindrical, type 3003 extruded aluminum configuration, having an anodized finish to eliminate surface pitting and unnecessary air friction. The multiple total pressure manifold shall have sensors located along the stagnation plane of the approaching airflow. The manifold should not have forward projecting sensors into the air stream. The static pressure manifold shall incorporate dual offset static tops on the opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as $\pm 20^\circ$ in the approaching air stream.
- (3) The airflow traverse probe shall not induce a measurable pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presence in the air stream. Each airflow-measuring probe shall contain multiple total and static pressure

sensors placed at equal distances along the probe length. The number of sensors on each probe and the quantity of probes utilized at each installation shall comply with the ASHRAE Standards for duct traversing.

- (4) Airflow measuring stations shall be manufactured by Air Monitor Corp., Tek-Air Systems, Inc., Ebtron, or Dietrich Standard.

b. Single Probe Air Flow Measuring Sensor: The single probe airflow-measuring sensor shall be duct mounted with an adjustable sensor insertion length of up to eight inches. The transmitter shall produce a 4-20 mA or 0-10 VDC signal linear to air velocity. The sensor shall be a hot wire anemometer and utilize two temperature sensors and a heater element temperature. The other sensor shall measure the downstream air temperature. The temperature differential shall be directly related to airflow velocity.

c. Duct Air Flow Measuring Stations

- (1) Each device shall be designed and built to comply with, and provide results in accordance with, accepted practice as defined for system testing in the ASHRAE Handbook of fundamentals, as well as in the Industrial Ventilation Handbook.
- (2) Airflow measuring stations shall be fabricated of 14-gauge galvanized steel welded casing with 90 Deg. connecting flanges in configuration and size equal to that of the duct into which it is mounted. Each station shall be complete with an air directionalizer and parallel cell profile suppressor (3/4" maximum cell) across the entering air stream and mechanically fastened to the casing in such a way to withstand velocities up to 6000 feet per minute. This air directionalizer and parallel cell honeycomb suppressor shall provide 98% free area, equalize the velocity profile, and eliminate turbulent and rotational flow from the air stream prior to the measuring point.
- (3) The total pressure measurement side (high side) will be designed and spaced to the Industrial Ventilation Manual 16th Edition, Page 9-5. The self-averaging manifolding will be manufactured of brass and copper components.
- (4) The static pressure sensing probes (low side) shall be bullet-nosed shaped, per detailed radius, as illustrated in Industrial Ventilation Manual 16th Edition, Page 9-5.
- (5) The main take-off point from both the total pressure and the static pressure manifolds must be symmetrical.
- (6) Total and static pressure manifolds shall terminate with external ports for connection to control tubing. An identification label shall be placed on each unit casing, listing model number, size, area, and specified airflow capacity.

d. Installation Considerations

- (1) The maximum allowable pressure loss through the Flow and Static Pressure elements shall not exceed .065" w.c. at 1000 feet per minute, or .23" w.c. at 2000 feet per minute. Each unit shall measure the airflow rate within an accuracy of plus 2% as determined by U.S. - GSA certification tests, and shall contain a minimum of one total pressure sensor per 36 square inches of unit measuring area.

- (2) The units shall have a self-generated sound rating of less than NC40, and the sound level within the duct shall not be amplified nor shall additional sound be generated.
- (3) Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.
- (4) Where control dampers are shown as part of the airflow measuring station, opposed blade precision controlled volume dampers integral to the station and complete with actuator, pilot positioner, and linkage shall be provided.
- (5) Stations shall be installed in strict accordance with the manufacturer's published requirements, and in accordance with ASME Guidelines affecting non-standard approach conditions.
- (6) Acceptable manufacturers: Air Monitor Corp., Tek-Air, Ebtron, and Dietrich Standard.

e. Static Pressure Traverse Probe

- (1) Duct static traverse probes shall be provided where required to monitor duct static pressure. The probe shall contain multiple static pressure sensors located along exterior surface of the cylindrical probe.
- (2) Acceptable manufacturers: Cleveland Controls

f. Shielded Static Air Probe: A shielded static pressure probe shall be provided at each end of the building. The probe shall have multiple sensing ports, an impulse suppression chamber, and airflow shielding. A suitable probe for indoor and outdoor locations shall be provided.

2. Water Flow Monitoring

- a. Water flow meters shall be electromagnetic type with integral microprocessor-Based electronics. The meter shall have an accuracy of 0.25%.
- b. Acceptable manufacturers: Onicon

D. Power Monitoring Devices

1. Current Measurement (Amps)

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

- c. Current Transducer - A current to voltage or current to mA transducer shall be provided. The current transducer shall include:
- (1) 6X input over amp rating for AC inrushes of up to 120 amps.
 - (2) Manufactured to UL 1244.
 - (3) Accuracy: $\pm 0.5\%$, Ripple $\pm 1\%$.
 - (4) Minimum load resistance 30kOhm.
 - (5) Input 0-20 Amps.
 - (6) Output 4-20 mA.
 - (7) Transducer shall be powered by a 24VDC regulated power supply (24 VDC $\pm 5\%$).
 - (8) Acceptable manufacturers: Veris Industries

E. Refrigerant Leak Detectors

1. The refrigerant leak detector shall be a standalone device and shall provide a SPDT output to directly energize the refrigeration room exhaust ventilation fans. The detector shall include a sensor or sensors connected to a control panel. Two relay contacts at the control panel shall provide trouble and alarm indication to the Facility Management System. The alarm relay contact shall also directly energize the exhaust fans.
2. The refrigerant leak detector shall sense the type of refrigerant used in the specified chillers. Multiple sensors shall be required to detect different refrigerants and/or provide proper sensing coverage for the area of the refrigeration room.
3. Acceptable manufacturers: Johnson Controls, MSA Instruments

- F. Smoke Detectors: Ionization type air duct detectors shall be furnished as specified elsewhere in Division 16 for installation under Division 15. All wiring for air duct detectors shall be provided under Division 16, Fire Alarm System.

2.12 STATUS AND SAFETY SWITCHES

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

B. Current Sensing Switches

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

4. Acceptable manufacturers: Veris Industries

C. Air Filter Status Switches

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

D. Air Flow Switches

1. Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.
2. Acceptable manufacturers: Johnson Controls, Cleveland Controls

E. Air Pressure Safety Switches

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

F. Water Flow Switches: Water flow switches shall be equal to the Johnson Controls P74.

G. Low Temperature Limit Switches

1. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.
2. The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.
3. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.
4. The low temperature limit switch shall be equal to Johnson Controls A70.

2.13 OUTPUT DEVICES

A. Actuators

1. Damper and valve actuators shall be electronic and/or pneumatic, as specified in the System Description section.
2. Electronic Damper Actuators
 - a. Electronic damper actuators shall be direct shaft mount.
 - b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized Based on actuator manufacturer's recommendations for face velocity,

differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.

- c. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
 - d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.
 - e. Acceptable manufacturers: Johnson Controls, Mamac.
3. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized Based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.
- d. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
 - e. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.
 - f. Acceptable manufacturers: Johnson Controls

B. Control Dampers

1. The BAS Contractor shall furnish automatic dampers as indicated on plans. Exception: Dampers integral to AHU. Automatic dampers shall be sized for

the application by the BAS Contractor or as specifically indicated on the Drawings.

2. All dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.
 3. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.
 4. Smoke Control Dampers: Subject to project requirements, provide Ruskin SD36 or approved equal
 - a. Pneumatic actuator: Shall be robust and selected for twice the expected typical inch pound of torque for the application.
 - b. 16 Ga. Galvanized steel blades, 6" wide with 16 Gauge galvanized frame. Parallel blade operation.
 - c. Performance class II (2) classified by UL as a leakage rated damper in a smoke control system. UL555S rated and UL labeled.
 - d. Seals: Blade Edge seals of silicone coated fiberglass. Jamb seals of flexible stainless steel compression type.
 - e. Leakage class II (10 CFM/sq ft. at 1.0" wg).
 5. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60". Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48"x48" size shall not leak in excess of 8.0 cfm per square foot when closed against 4" w.g. static pressure when tested in accordance with AMCA Std. 500.
 6. Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5" w.g., but no more than 4000 FPM or 6" w.g. Acceptable manufacturers are Johnson Controls D-7250 D-1250 or D-1300, Ruskin CD50, and Vent Products 5650.
 7. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below. Acceptable manufacturers are: Johnson Controls D-1600, Ruskin CD36, and Vent Products 5800.
 8. Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.
- C. Control Relays
1. Control Pilot Relays
 - a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
 - b. Mounting Bases shall be snap-mount.
 - c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.

- d. Contacts shall be rated for 10 amps at 120VAC.
- e. Relays shall have an integral indicator light and check button.
- f. Acceptable manufacturers: Johnson Controls, Lectro

2. Lighting Control Relays

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

D. Control Valves

- 1. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule elsewhere in this Specification.
- 2. Chilled water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer's recommendations for the given application. In general, valves (2 or 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 PSI. Valves (3-way) serving constant flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no less than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.
- 3. Ball valves shall be used for hot and chilled water applications, water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units except those described hereinafter. The JCI VG1000 series ball valves are the standard valve for terminal units. They shall have a threaded connection, stainless steel trim, and 24VAC, 0-10VDC signal, fail last position, electric actuators.

4. Acceptable manufacturers: Johnson Controls

E. Electronic Signal Isolation Transducers

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

F. External Manual Override Stations

1. External manual override stations shall provide the following:
2. An integral HAND/OFF/AUTO switch shall override the controlled device pilot relay.
3. A status input to the Facility Management System shall indicate whenever the switch is not in the automatic position.
4. A Status LED shall illuminate whenever the output is ON.
5. An Override LED shall illuminate whenever the HOA switch is in either the HAND or OFF position.
6. Contacts shall be rated for a minimum of 1 amp at 24 VAC.

G. Electronic/Pneumatic Transducers

1. Electronic to Pneumatic transducers shall provide:
2. Output: 3-15 PSIG.
3. Input: 4-20 mA or 0-10 VDC.
4. Manual output adjustment.
5. Pressure gauge.
6. External replaceable supply air filter.
7. Acceptable manufacturers: Johnson Controls, Mamac

H. Static Pressure Sensors: Non-directional, temperature compensated.

1. 4-20 ma output signal.
2. 0 to 5 inches wg for duct static pressure range.
3. 0 to 0.25 inch wg for Building static pressure range.

I. Pneumatic operators, spring return type with non-ferrous metal bellows or diaphragm of neoprene or other elastomer. Bellows or diaphragm shall be of sufficient size so that a change in operating pressure of not more than two (2) percent of the total motor operating pressure range will be required to start the valve or damper moving. Provide positive positioning or sequencing relays with adjustable operating range and starting point for operators sequenced with other operators to permit adjustment of control sequences, except for control valves in confined spaces in

terminal units, which may use springs with range selected to provide necessary sequencing. Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel.

J. Air Flow Measure Stations

1. Basis of Design: Subject to review by VA-Mpls, provide Paragon model FE-1000 AFMS.

2. Airflow and static pressure shall be controlled via digital controllers with inputs from airflow control measuring stations and static pressure inputs as specified. Controller outputs shall be analog or pulse width modulating output signals. The controllers shall include the capability to control via simple proportional (P) control, proportional plus integral (PI), proportional plus integral plus derivative (PID), and on-off. The airflow control programs shall be factory-tested programs that are documented in the literature of the control manufacturer.

3. Air Flow Measuring Station -- Pneumatic Type:

a) Airflow measuring stations shall measure airflow by dual integral chamber design. Each unit shall consist of a network of static and total pressure sensors, factory positioned and connected in parallel, to produce an equalized velocity pressure. The measured velocity pressure converted to airflow (cfm) shall have accuracy within 2 percent of the full scale throughout the velocity range from 200 to 1,200 meter per minute (700 to 4,000 fpm).

b) Each air flow measuring station shall be installed to meet at least the manufacturer's minimum installation conditions and shall not amplify the sound level within the duct. The maximum resistance to airflow shall not exceed 0.3 times the velocity head for the duct stations and 0.6 times the velocity head for the fan stations. The unit shall be suitable for continuous operation up to a temperature of 120°C (250°F).

2.14 MISCELLANEOUS DEVICES

A. Local Control Panels

1. All control panels shall be factory constructed, incorporating the BAS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and slotted flush latch.
2. In general, the control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices—such as relays, transducers, and so forth—that are not required to be

located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.

3. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.
4. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.
5. All wiring shall be neatly installed in plastic trays or tie-wrapped.
6. A convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers.

B. Power Supplies

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

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

Part 3 – Performance / Execution

3.1 BAS Specific Requirements

A. Graphic Displays

1. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.
2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.

- B. Custom Reports - Provide custom reports as required for this project:

C. Actuation / Control Type

1. Primary Equipment
 - a. Controls shall be provided by equipment manufacturer as specified herein.
 - b. All damper and valve actuation shall be electric.

2. Air Handling Equipment

- a. All air handlers shall be controlled with a HVAC-DDC Controller
- b. All damper and valve actuation shall be electric.

3. Terminal Equipment:

- a. Terminal Units (VAV, UV, etc.) shall have electric damper and valve actuation. The JCI VG1000 series ball valve is the standard valve for terminal units. They shall have a threaded connection, stainless steel trim, 24VAC, 0-10VDC signal, fail last position, electric actuators.
- b. All Terminal Units shall be controlled with HVAC-DDC Controller). Terminal units shall generally have controller: MS-VMA1620-OU, zone temperature sensor, valve (when applicable), and discharge air temperature sensor. The VMA controller shall be configured for use of a DIS plug-in display. The points the controller's application file shall be configured for include: zone temp, effective heating setpoint, effective cooling setpoint, nominal setpoint, effective occupancy mode, discharge air temp, valve position, damper position, supply CFM, supply CFM setpoint, k-factor, supply area, cooling min flow, heating minimum flow, cooling max flow.

D. Installation Practices

1. BAS Wiring

- a. All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BAS Contractor unless specifically shown on the Electrical Drawings under Division 16 Electrical. All wiring shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes, unless specified otherwise in this section.
- b. All BAS wiring materials and installation methods shall comply with BAS manufacturer recommendations.
- c. The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the BAS Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the BAS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.

2. Class 2 Wiring

- a. All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
- b. Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5' from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
- c. Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.

- d. Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.
3. BAS Line Voltage Power Source
- a. 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided by Division 16.
 - b. Circuits used for the BAS shall be dedicated to the BAS and shall not be used for any other purposes.
 - c. DDC terminal unit controllers may use AC power from motor power circuits.
4. BAS Raceway
- a. All wiring shall be installed in conduit or raceway. The only exception is wiring from zone temperature sensor through the wall and above a suspended ceiling for a VAV box terminal unit. When wiring reaches the bottom of the interstitial space (top of the suspended ceiling), the penetration through the barrier and all wiring in the interstitial shall be in raceway. Minimum control wiring conduit size 1/2".
 - b. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.
 - c. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
 - d. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.
 - e. All raceway for BAS shall be green. Junction boxes for BAS wiring shall have covers that are painted green.
5. Penetrations
- a. Provide fire stopping for all penetrations used by dedicated BAS conduits and raceways.
 - b. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
 - c. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
 - d. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.
6. BAS Identification Standards
- a. Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.
 - b. Cable types specified in Item A shall be color coded for easy identification and troubleshooting.
7. BAS Panel Installation

- a. The BAS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
- b. The BAS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.

8. Input Devices

- a. All Input devices shall be installed per the manufacturer recommendation. Standard analog sensors shall be 1K ohm nickel with 0-10VDC output control for devices.
- b. Locate components of the BAS in accessible local control panels wherever possible.

9. HVAC Input Devices - General

- a. All Input devices shall be installed per the manufacturer recommendation.
- b. Locate components of the BAS in accessible local control panels wherever possible.
- c. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.
- d. Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.

10. Outside Air Sensors

- a. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
- b. Sensors shall be installed with a rain proof, perforated cover.

11. Water Differential Pressure Sensors

- a. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.
- b. Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
- c. The transmitters shall be installed in an accessible location wherever possible.
- d. Medium to High Differential Water Pressure Applications (Over 21" w.c.):
- e. Air bleed units, bypass valves and compression fittings shall be provided.
- f. Building Differential Air Pressure Applications (-1" to +1" w.c.):
- g. Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
- h. The interior tip shall be inconspicuous and located as shown on the drawings.

12. Air Flow Measuring Stations: |

- a. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct.
 - b. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.
13. Duct Temperature Sensors:
- a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
 - b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
 - c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.
 - d. The sensor shall be mounted to suitable supports using factory approved element holders.
14. Space Sensors:
- a. Public space: blank face SA bus NS series net-stat, addressable: NS-BTN7003-0. If humidity or CO2 sensing is needed, refer to JCI for recommendation.
 - b. Interior Zones (spaces other than public corridors or open areas): SA bus NS series net-stat with display, setpoint adjust, terminal block, addressable: NS-BTB7003-0.
 - c. Shall be mounted per ADA requirements.
 - d. Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.
15. Low Temperature Limit Switches:
- a. Install on the discharge side of the first water or steam coil in the air stream.
 - b. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.
 - c. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.
16. Air Differential Pressure Status Switches: Install with static pressure tips, tubing, fittings, and air filter.
17. Water Differential Pressure Status Switches: Install with shut off valves for isolation.
18. HVAC Output Devices
- a. All output devices shall be installed per the manufacturers recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.
 - b. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any

pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.

- c. Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.
- d. Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.
- e. Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems

3.2 TRAINING - THE BAS CONTRACTOR SHALL PROVIDE THE FOLLOWING TRAINING SERVICES:

One day of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BAS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

3.3 COMMISSIONING

A. Fully commission all aspects of the Building Management System work.

B. Acceptance Check Sheet

- 1. Prepare a check sheet that includes all points for all functions of the BAS as indicated on the point list included in this specification.
- 2. Submit the check sheet to the Engineer for approval
- 3. The Engineer will use the check sheet as the basis for acceptance with the BAS Contractor.

C. VAV box performance verification and documentation:

- 1. The BAS Contractor shall test each VAV box for operation and correct flow. At each step, after a settling time, box air flows and damper positions will be sampled. Following the tests, a pass/fail report indicating results shall be produced. Possible results are Pass, No change in flow between full open and full close, Reverse operation or Maximum flow not achieved. The report shall be submitted as documentation of the installation.
- 2. The BAS Contractor shall issue a report based on a sampling of the VAV calculated loop performance metrics. The report shall indicate performance criteria, include the count of conforming and non-conforming boxes, list the non-conforming boxes along with their performance data, and shall also include graphical representations of performance.

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

- E. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- F. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.4 NAMING CONVENTIONS

- A. NxE Device Naming/Configuration: NxEBB-AF-X
 1. Replace BB with building number (two digits).
 2. Replace A with geographical area of building that the NAE resides in.
 3. Replace F with floor that the NAE resides on.
 4. Replace X with NAE number.
- B. Communication Bus Naming/Configuration: FC-1 = FC Trunk 1, N2-1 = N2 Trunk 1
- C. Controller Naming/Configuration: NxEBB-AF-X (example: 70.VAV-44-001)
 1. Replace DD with controller address (two digits).
 2. Replace BB with building number.
 3. Replace SYSTEM TYPE with type of system, i.e. AHU, HWS, CHWS, HV, UH, etc.
 4. Replace ## with the system equipment tag, i.e. AHU-44, HV-06, etc.
- D. Air Handler Unit Point Naming: BB.AHU-##.POINTNAME (example: 70.AHU-44.OCC-SCHEDULE)
 1. Replace BB with building number (two digits).
 2. Replace ## with the system equipment tag, i.e. AHU-44, HV-06, etc.
 3. Replace POINTNAME with description of point.
- E. Variable Air Volume Box (VAV Box) Point Naming: BB.VAV-AA-VVV.POINTNAME (example: 70.VAV-44-001.OCC-SCHEDULE)
 1. Replace BB with building number (two digits).
 2. Replace AA with AHU equipment tag.
 3. Replace VVV with VAV tag (always 3 digits).
 4. Replace POINTNAME with description of point.
- F. Chilled or Hot Water System Point Naming: BB.HWS-##.POINTNAME (example: 70.SEC-HWS-44-001.SYSTEM-EN)
 1. Replace BB with building number (two digits).
 2. Replace ## with the system equipment tag - example: DOMHX-44.
 3. Replace POINTNAME with description of point.
- G. Critical Monitoring Point Naming: BB-AA.POINTNAME (example: BB-AA.CRITICAL.PASS-ELEV#)
 1. Replace BB with building number (two digits).

2. Replace AA with area number.

3. Replace POINTNAME with description of point.

3.5 POINT LISTS – (Note some points may exist in current BAS.- Revise to add four-fan array with VFDs and humidifier)

Systems AHU-SW-09/70-SF-15

Point	Description	Type	Units	Trend	Alarm Totalize	
DA-P	Discharge Static Pressure	AI	in WC	X		
DA-T	Discharge Air Temperature	AI	Deg F	X		
PH-T	Preheat Temperature	AI	Deg F	X		
SF-S	Supply Fan1 Status	BI	Off On	X	X	X
SF-S	Supply Fan2 Status	BI	Off On	X	X	X
SF-S	Supply Fan3 Status	BI	Off On	X	X	X
SF-S	Supply Fan4 Status	BI	Off On	X	X	X
CLG-O	Cooling Output	AO	%	X		
HUM-SO	Humidifier Set Point	AO	%RH	X		
HUM-I	Humidifier actual	AI	% RH	X	X	
HUM-O	Humidifier Output	AO	%	X		
SF-O	Supply Fan1 Output	AO	%	X		
SF-O	Supply Fan2 Output	AO	%	X		
SF-O	Supply Fan3 Output	AO	%	X		
SF-O	Supply Fan4 Output	AO	%	X		
SF-C	Supply Fan Command	BO	Off On	X Four thus for Fan ARRAY		
PH-LCKO	Preheat Lockout Command	BO	Off On	X		
CLG-LCKO	Cooling Lockout Command	BO	Off On	X		
DAT-SP	Discharge Temperature Setpoint	AO	Deg F	X		

PHT-SP	Preheat Temperature Setpoint	AO	Deg F	X
DAP-SP	Discharge Static Pressure Setpoint	AO	in WC	X

Below: Typical of all DDC controlled VAV: 70.VAV.#

ZN-T	ZONE TEMP	AI	DEG	X
DA-T	DISCHARGE TEMP	AI	DEG	X
HTG-O	HEATING OUTPUT	AO	%	X
DPR-O	VAV DAMPER OUTPUT	AO	%	X
ZN-SP	ZONE TEMP SETPOINT	AO	DEG	X
SA-F	VAV AIRFLOW RATE CFM	AI	CFM	X
SA-FLOWSP	VAV FLOW SETPOINT	AI	CFM	X
HTGOCC-SP	HEATING OCC SETPOINT	AO	DEG	X
CLGOCC-SP	COOLING OCC SETPOINT	AO	DEG	X
HTGUNOCC-SP	HEATING UNOCC SETPOINT	AO	DEG	X
CLGUNOCC-SP	COOLING UNOCC SETPOINT	AO	DEG	X
CLG-O	COOLING PERCENT FLOW	AO	%	X FLOW CFM PERCENT
CLG-MAXFLOW	COOLING MAX CFM FLOW	AO	CFM	X
HTG-MINFLOW	HEATING MIN CFM FLOW	AO	CFM	X
CLG-MINFLOW	COOLING OCC MIN CFM FLOW	AO	CFM	X
HTG -EN	HEATING IS AVAILABLE	BI	T/F	X
SAD	SUPPLY AIR DPR OPEN	BI	T/F	X
SAD-TROUBLE	SUPPLY DAMPER TROUBLE	BI	T/F	X
SYSTEM MODE	SYSTEM MODE	BI	AUTO	X
OCC-SCHEDULE	OCCUPANCY SCHEDULE	BO	SCHEDULE	
OCC-MODE	OCCUPANCY STAUS DISPLAY	BO	STATUS	

--END--

SECTION 23 21 13
HYDRONIC PIPING**PART 1 - GENERAL****1.1 DESCRIPTION**

- A. Water piping to connect HVAC equipment, including the following:
 - 1. Heating hot water and drain piping.
 - 2. Chilled water piping and drain piping.

1.2 RELATED WORK

- A. Section 01 00 00, General Requirements.
- B. Section 01 33 23, Shop Drawings, Product Data, and Samples.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION:
General mechanical requirements and items, which are common to more than one section of Division 23.
- D. Section 23 07 11, HVAC and Boiler Plant Insulation.
- E. Section 23 09 23, Direct-Digital Control System for HVAC.

1.3 QUALITY ASSURANCE

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION, which includes welding qualifications.
- B. Submit prior to welding of steel piping a certificate of Welder's certification. The certificate shall be current and not more than one year old.
- C. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be the same manufacturer as the grooved components.
 - 1. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Pipe and tubing, with specification, class or type, and schedule.
 - 2. Pipe fittings, including miscellaneous adapters and special fittings.
 - 3. Flanges, gaskets and bolting.
 - 4. Grooved joint couplings and fittings.
 - 5. Valves of all types.
 - 6. Strainers.

- ## 1.5 APPLICABLE PUBLICATIONS

- 23 21 13-2

- B31.1-08Power Piping
- E. American Society for Testing and Materials (ASTM):
- A47/A47M-99 (2004)Ferritic Malleable Iron Castings
- A53/A53M-07Standard Specification for Pipe, Steel, Black
and Hot-Dipped, Zinc-Coated, Welded and
Seamless
- A106/A106M-08Standard Specification for Seamless Carbon
Steel Pipe for High-Temperature Service
- A126-04Standard Specification for Gray Iron Castings
for Valves, Flanges, and Pipe Fittings
- A183-03Standard Specification for Carbon Steel Track
Bolts and Nuts
- A216/A216M-08Standard Specification for Steel Castings,
Carbon, Suitable for Fusion Welding, for High
Temperature Service
- A234/A234M-07Piping Fittings of Wrought Carbon Steel and
Alloy Steel for Moderate and High Temperature
Service
- A307-07Standard Specification for Carbon Steel Bolts
and Studs, 60,000 PSI Tensile Strength
- A536-84 (2004)Standard Specification for Ductile Iron Castings
- A615/A615M-08Deformed and Plain Carbon Steel Bars for
Concrete Reinforcement
- A653/A 653M-08Steel Sheet, Zinc-Coated (Galvanized) or Zinc-
Iron Alloy Coated (Galvannealed) By the Hot-Dip
Process
- B32-08Standard Specification for Solder Metal
- B62-02Standard Specification for Composition Bronze or
Ounce Metal Castings
- B88-03Standard Specification for Seamless Copper Water
Tube
- B209-07Aluminum and Aluminum Alloy Sheet and Plate
- C177-04Standard Test Method for Steady State Heat Flux
Measurements and Thermal Transmission Properties
by Means of the Guarded Hot Plate Apparatus
- C533-07Calcium Silicate Block and Pipe Thermal
Insulation

- C552-07Cellular Glass Thermal Insulation
- C591-08Unfaced Preformed Rigid Cellular
Polyisocyanurate Thermal Insulation
- F. American Welding Society (AWS):
- B2.1-02Standard Welding Procedure Specification
- G. Copper Development Association, Inc. (CDA):
- CDA A4015-06Copper Tube Handbook
- H. Expansion Joint Manufacturer's Association, Inc. (EJMA):
- EMJA-2003Expansion Joint Manufacturer's Association
Standards, Ninth Edition
- I. Manufacturers Standardization Society (MSS) of the Valve and Fitting
Industry, Inc.:
- SP-67-02aButterfly Valves
- SP-70-06Gray Iron Gate Valves, Flanged and Threaded
Ends
- SP-71-05Gray Iron Swing Check Valves, Flanged and
Threaded Ends
- SP-80-08Bronze Gate, Globe, Angle and Check Valves
- SP-85-02Cast Iron Globe and Angle Valves, Flanged and
Threaded Ends
- SP-110-96Ball Valves Threaded, Socket-Welding, Solder
Joint, Grooved and Flared Ends
- SP-125-00Gray Iron and Ductile Iron In-line, Spring
Loaded, Center-Guided Check Valves

PART 2 - PRODUCTS**2.1 PIPE AND EQUIPMENT SUPPORTS, PIPE SLEEVES, AND WALL AND CEILING PLATES**

- A. Provide in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.2 PIPE AND TUBING

- A. Heating Hot Water, and Vent Piping:
1. Steel: ASTM A53 Grade B, seamless or ERW, Schedule 40.
 2. Copper water tube option: ASTM B88, Type K or L, hard drawn.
- B. Chilled Water, and Vent Piping:
1. Steel: ASTM A53 Grade B, seamless or ERW, Schedule 40.
 2. Copper water tube option: ASTM B88, Type K or L, hard drawn.
- C. Cooling Coil Condensate Drain Piping:
1. From air handling units: Copper water tube, ASTM B88, Type M.

2. From fan coil or other terminal units: Copper water tube, ASTM B88, Type L or M for runouts and Type L for mains.

D. Pipe supports, including insulation shields, for above ground piping: Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

2.3 FITTINGS FOR STEEL PIPE

- A. 50 mm (2 inches) and Smaller: Screwed or welded joints.
 1. Butt welding: ASME B16.9 with same wall thickness as connecting piping.
 2. Forged steel, socket welding or threaded: ASME B16.11.
 3. Screwed: 150 pound malleable iron, ASME B16.3. 125 pound cast iron, ASME B16.4, may be used in lieu of malleable iron. Bushing reduction of a single pipe size, or use of close nipples, is not acceptable.
 4. Unions: ASME B16.39.
 5. Water hose connection adapter: Brass, pipe thread to 20 mm (3/4 inch) garden hose thread, with hose cap nut.
- B. 65 mm (2-1/2 inches) and Larger: Welded or flanged joints. Contractor's option if prior approved by VA Resident engineer: Grooved mechanical couplings and fittings.
 1. Butt welding fittings: ASME B16.9 with same wall thickness as connecting piping. Elbows shall be long radius type, unless otherwise noted.
 2. Welding flanges and bolting: ASME B16.5:
 - a. Water service: Weld neck or slip-on, plain face, with 6 mm (1/8 inch) thick full face neoprene gasket suitable for 104 degrees C (220 degrees F).
 - 1) Contractor's option: Convolute, cold formed 150 pound steel flanges, with teflon gaskets, may be used for water service.
 - b. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A307, Grade B.
- C. Welded Branch and Tap Connections: Forged steel weldolets, or branchlets and threadolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 may be used for drain, vent and gage connections.
- D. Grooved Mechanical Pipe Couplings and Fittings: (Requires Prior approval and prior approval of manufacturer/model): Grooved Mechanical Pipe Couplings and Fittings, with cut or roll grooved pipe, in water

service up to 110 degrees C (230 degrees F) in lieu of welded, screwed or flanged connections. All joints must be rigid type.

1. Grooved mechanical couplings: Malleable iron, ASTM A47 or ductile iron, ASTM A536, fabricated in two or more parts, securely held together by two or more track-head, square, or oval-neck bolts, ASTM A449 and A183.
2. Gaskets: Rubber product recommended by the coupling manufacturer for the intended service.
3. Grooved end fittings: Malleable iron, ASTM A47; ductile iron, ASTM A536; or steel, ASTM A53 or A106, designed to accept grooved mechanical couplings. Tap-in type branch connections are acceptable.

2.4 FITTINGS FOR COPPER TUBING

A. Joints:

1. Solder Joints: Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.
2. Mechanically formed tee connection in water and drain piping: Form mechanically extracted collars in a continuous operation by drilling pilot hole and drawing out tube surface to form collar, having a height of not less than three times the thickness of tube wall. Adjustable collaring device shall insure proper tolerance and complete uniformity of the joint. Notch and dimple joining branch tube in a single process to provide free flow where the branch tube penetrates the fitting.

B. Bronze Flanges and Flanged Fittings: ASME B16.24.

C. Fittings: ANSI/ASME B16.18 cast copper or ANSI/ASME B16.22 solder wrought copper.

2.5 DIELECTRIC FITTINGS

- A. Provide where copper tubing and ferrous metal pipe are joined.
- B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.
- C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.
- D. Temperature Rating, 99 degrees C (210 degrees F).

2.6 SCREWED JOINTS

- A. Pipe Thread: ANSI B1.20.
- B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

2.7 VALVES

- A. Asbestos packing is not acceptable.
- B. All valves of the same type shall be products of a single manufacturer.
- C. Provide chain operators for valves 150 mm (6 inches) and larger when the centerline is located 2400 mm (8 feet) or more above the floor or operating platform.
- D. Shut-Off Valves
 - 1. Ball Valves (Pipe sizes 2" and smaller): MSS-SP 110, screwed or solder connections, brass or bronze body with chrome-plated ball with full port and Teflon seat at working pressure rating. Provide stem extension to allow operation without interfering with pipe insulation.
 - 2. Butterfly Valves (Pipe Sizes 2-1/2" and larger): Provide stem extension to allow 50 mm (2 inches) of pipe insulation without interfering with valve operation. MSS-SP 67, flange lug type or grooved end rated 1205 kPa (175 psig) working pressure at 93 degrees C (200 degrees F). Valves shall be ANSI Leakage Class VI and rated for bubble tight shut-off to full valve pressure rating.

Valve shall be rated for dead end service and bi-directional flow capability to full rated pressure. Not permitted for direct buried pipe applications.

- a. Body: Cast iron, ASTM A126, Class B. Malleable iron, ASTM A47 electro-plated, or ductile iron, ASTM A536, Grade 65-45-12 electro-plated.
- b. Trim: Bronze, aluminum bronze, or 300 series stainless steel disc, bronze bearings, 316 stainless steel shaft and manufacturer's recommended resilient seat. Resilient seat shall be field replaceable, and fully line the body to completely isolate the body from the product. A phosphate coated steel shaft or stem is acceptable, if the stem is completely isolated from the product.
- c. Actuators: Field interchangeable. Valves for balancing service shall have adjustable memory stop to limit open position.
 - 1) Valves 150 mm (6 inches) and smaller: Lever actuator with minimum of seven locking positions, except where chain wheel is required.

- 2) Valves 200 mm (8 inches) and larger: Enclosed worm gear with handwheel, and where required, chain-wheel operator.

E. Globe and Angle Valves

1. Globe Valves

- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Globe valves shall be union bonnet with metal plug type disc.
- b. 65 mm (2 1/2 inches) and larger: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for globe valves.

2. Angle Valves:

- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Angle valves shall be union bonnet with metal plug type disc.
- b. 65 mm (2 1/2 inches) and larger: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for angle.

F. Check Valves

1. Swing Check Valves:

- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.), 45 degree swing disc.
- b. 65 mm (2 1/2 inches) and larger: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-71 for check valves.

2. Non-Slam or Silent Check Valve: Spring loaded double disc swing check or internally guided flat disc lift type check for bubble tight shut-off. Provide where check valves are shown in chilled water and hot water piping. Check valves incorporating a balancing feature may be used.

- a. Body: MSS-SP 125 cast iron, ASTM A126, Class B, or steel, ASTM A216, Class WCB, or ductile iron, ASTM 536, flanged, grooved, or wafer type.
- b. Seat, disc and spring: 18-8 stainless steel, or bronze, ASTM B62. Seats may be elastomer material.

G. Water Flow Balancing Valves: For flow regulation and shut-off. Valves shall be line size rather than reduced to control valve size. Basis of Design: B&G circuit setter 'plus' or approved equal.

1. Ball style characterized valve.

2. A dual purpose flow balancing valve and adjustable flow meter, with bronze or cast iron body, calibrated position pointer, valved pressure taps or quick disconnects with integral check valves and preformed polyurethane insulating enclosure.
3. Provide a readout kit including flow meter, readout probes, hoses, flow charts or calculator, and carrying case.

2.9 WATER FLOW MEASURING DEVICES

- A. Minimum overall accuracy plus or minus three percent over a range of 70 to 110 percent of design flow. Select devices for not less than 110 percent of design flow rate.
- B. Wafer Type Circuit Sensor: Cast iron wafer-type flow meter equipped with readout valves to facilitate the connecting of a differential pressure meter. Each readout valve shall be fitted with an integral check valve designed to minimize system fluid loss during the monitoring process. Circuit Setter 'Plus' or equal.

2.10 STRAINERS

- A. Y Type.
 1. Screens: Bronze, monel metal or 18-8 stainless steel, free area not less than 2-1/2 times pipe area, with perforations as follows: 1.1 mm (0.045 inch) diameter perforations for 100 mm (4 inches) and larger: 3.2 mm (0.125 inch) diameter perforations.

2.11 PRESSURE/TEMPERATURE TEST PROVISIONS

- A. Pete's Plug: 6 mm (1/4 inch) MPT by 75 mm (3 inches) long, brass body and cap, with retained safety cap, nordel self-closing valve cores, permanently installed in piping where shown, or in lieu of pressure gage test connections shown on the drawings.
- B. Provide one each of the following test items to the Resident Engineer:
 1. 6 mm (1/4 inch) FPT by 3 mm (1/8 inch) diameter stainless steel pressure gage adapter probe for extra long test plug. PETE'S 500 XL is an example.
 2. 90 mm (3-1/2 inch) diameter, one percent accuracy, compound gage, -- 100 kPa (30 inches) Hg to 700 kPa (100 psig) range.
 3. 0 - 104 degrees C (220 degrees F) pocket thermometer one-half degree accuracy, 25 mm (one inch) dial, 125 mm (5 inch) long stainless steel stem, plastic case.

2.12 THERMOMETERS

- A. Mercury or organic liquid filled type, red or blue column, clear plastic window, with 150 mm (6 inch) brass stem, straight, fixed or adjustable angle as required for each in reading.
- B. Case: Chrome plated brass or aluminum with enamel finish.
- C. Scale: Not less than 225 mm (9 inches), range as described below, two degree graduations.
- D. Separable Socket (Well): Brass, extension neck type to clear pipe insulation.
- E. Scale ranges:
 - 1. Chilled Water and Glycol-Water: 0-38 degrees C (32-100 degrees F).
 - 2. Hot Water and Glycol-Water: -1 - 116 degrees C (30-240 degrees F).

2.13 FIRESTOPPING MATERIAL

Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

PART 3 - EXECUTION**3.1 GENERAL**

- A. The drawings show the general arrangement of pipe and equipment but do not show all required fittings and offsets that may be necessary to connect pipes to equipment, fan-coils, coils, radiators, etc., and to coordinate with other trades. Provide all necessary fittings, offsets and pipe runs based on field measurements and at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.
- B. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping relatively clean during installation and protect open ends when work is not in progress.
- C. Support piping securely. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION. Install heat exchangers at height sufficient to provide gravity flow of condensate to the flash tank and condensate pump.
- D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (one inch) minimum clearance between

adjacent piping or other surface. Unless shown otherwise, slope drain piping down in the direction of flow not less than 25 mm (one inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.

- E. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.
- F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted on the drawings.
- G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.
- H. Provide manual or automatic air vent at all piping system high points and drain valves at all low points. Install piping to floor drains from all automatic air vents.
- I. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:
 - 1. Water treatment pot feeders and condenser water treatment systems.
 - 2. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.
- J. Thermometer Wells: In pipes 65 mm (2-1/2 inches) and smaller increase the pipe size to provide free area equal to the upstream pipe area.
- K. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION.
- L. Where copper piping is connected to steel piping, provide dielectric connections.

3.2 PIPE JOINTS

- A. Welded: Beveling, spacing and other details shall conform to ASME B31.1 and AWS B2.1. See Welder's qualification requirements under "Quality

Assurance" in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

- B. Screwed: Threads shall conform to ASME B1.20; joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.
- C. Mechanical Joint: Pipe grooving shall be in accordance with joint manufacturer's specifications. Lubricate gasket exterior including lips, pipe ends and housing interiors to prevent pinching the gasket during installation. Lubricant shall be as recommended by coupling manufacturer.
- D. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.

3.3 LEAK TESTING ABOVEGROUND PIPING

- A. Inspect all joints and connections for leaks and workmanship and make corrections as necessary, to the satisfaction of the Resident Engineer. Tests may be either of those below, or a combination, as approved by the Resident Engineer.
- B. An operating test at design pressure, and for hot systems, design maximum temperature.
- C. A hydrostatic test at 1.5 times design pressure. For water systems the design maximum pressure would usually be the static head, or expansion tank maximum pressure, plus pump head. Factory tested equipment (convertors, exchangers, coils, etc.) need not be field tested. Isolate equipment where necessary to avoid excessive pressure on mechanical seals and safety devices.

3.4 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Water Piping: Clean systems as recommended by the suppliers of chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.
 - 1. Initial flushing: Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system component.

Provide temporary piping or hose to bypass coils, control valves, exchangers and other factory cleaned equipment unless acceptable means of protection are provided and subsequent inspection of

hide-out areas takes place. Isolate or protect clean system components, including pumps and pressure vessels, and remove any component which may be damaged. Open all valves, drains, vents and strainers at all system levels. Remove plugs, caps, spool pieces, and components to facilitate early debris discharge from system. Sectionalize system to obtain debris carrying velocity of 1.8 m/S (6 feet per second), if possible. Connect dead-end supply and return headers as necessary. Flush bottoms of risers. Install temporary strainers where necessary to protect down-stream equipment. Supply and remove flushing water and drainage by various type hose, temporary and permanent piping and Contractor's booster pumps. Flush until clean as approved by the Resident Engineer.

2. Cleaning: Using products supplied in Section 23 25 00, HVAC WATER TREATMENT, circulate systems at normal temperature to remove adherent organic soil, hydrocarbons, flux, pipe mill varnish, pipe joint compounds, iron oxide, and like deleterious substances not removed by flushing, without chemical or mechanical damage to any system component. Removal of tightly adherent mill scale is not required. Keep isolated equipment which is "clean" and where dead-end debris accumulation cannot occur. Sectionalize system if possible, to circulate at velocities not less than 1.8 m/S (6 feet per second). Circulate each section for not less than four hours. Blow-down all strainers, or remove and clean as frequently as necessary. Drain and prepare for final flushing.
3. Final Flushing: Return systems to conditions required by initial flushing after all cleaning solution has been displaced by clean make-up. Flush all dead ends and isolated clean equipment. Gently operate all valves to dislodge any debris in valve body by throttling velocity. Flush for not less than one hour.

3.5 SCHEDULE AND PIPE SIZE:

A. Hot and chilled water, 2 inches and smaller:

1. Above ground:

- a. Type K or L hard drawn temper copper with soldered joints.
- b. Steel 50 mm (2 inches) and Smaller: Screwed joints.

B. Hot and chilled water, 2 ½ inches and larger:

1. Steel pipe with welded and flanged joints.

C. Condensate drain lines: Type L or M as specified above, copper
with soldered joints.

- - - E N D - - -

SECTION 23 31 00
HVAC DUCTS AND CASINGS AND ACCESSORIES

PART 1 - GENERAL**1.1 DESCRIPTION**

- A. Ductwork and accessories for HVAC including the following:
 - 1. Supply air, return air, outside air, exhaust, make-up air, and relief systems.
- B. Definitions:
 - 1. SMACNA Standards as used in this specification means the HVAC Duct Construction Standards, Metal and Flexible.
 - 2. Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.
 - 3. Duct Pressure Classification: SMACNA HVAC Duct Construction Standards, Metal and Flexible.
 - 4. Exposed Duct: Exposed to view in a finished room, exposed to weather.

1.2 RELATED WORK

- A. Fire Stopping Material: Section 07 84 00, FIRESTOPPING.
- B. General Mechanical Requirements: Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- C. Duct Insulation: Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION
- D. Air Flow Control Valves and Terminal Units: Section 23 36 00, AIR TERMINAL UNITS.
- E. Testing and Balancing of Air Flows: Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
- F. Smoke control dampers and airflow measuring stations: Section 23 09 23, HVAC CONTROLS.

1.3 QUALITY ASSURANCE

- A. Refer to article, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. Fire Safety Code: Comply with NFPA 90A.
- C. Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.
- D. Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: Ducts shall be sealed as per duct sealing requirements of SMACNA HVAC Air Duct Leakage Test Manual for duct pressure classes shown on the drawings.
- E. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same

material as the duct or provide at least the same level of corrosion resistance.

F. Fire dampers and smoke control dampers shall be UL rated and labeled to the latest version of Underwriters Laboratory.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Rectangular ducts:
 - a. Schedules of duct systems, materials and selected SMACNA construction alternatives for joints, sealing, gage and reinforcement.
 - b. Duct liner.
 - c. Sealants and gaskets.
 - d. Access doors.
 - 2. Round ducts.
 - 3. Dampers.
 - 4. Hangers and supports.
 - 5. Fire dampers, fire doors, and smoke dampers with installation instructions.
- C. Coordination Drawings: Refer to article, SUBMITTALS, in Section 23 05 11 - Common Work Results for HVAC and Steam Generation.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Civil Engineers (ASCE):
 - ASCE7-05.....Minimum Design Loads for Buildings and Other Structures
- C. American Society for Testing and Materials (ASTM):
 - A167-99(2009).....Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
 - A653-09.....Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy coated (Galvannealed) by the Hot-Dip process

- A1011-09a.....Standard Specification for Steel, Sheet and Strip, Hot rolled, Carbon, structural, High-Strength Low-Alloy, High Strength Low-Alloy with Improved Formability, and Ultra-High Strength
- B209-07.....Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
- C1071-05e1.....Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
- E84-09a.....Standard Test Method for Surface Burning Characteristics of Building Materials
- D. National Fire Protection Association (NFPA):
- 90A-09.....Standard for the Installation of Air Conditioning and Ventilating Systems
- 96-08.....Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
- E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
- 2nd Edition - 2005.....HVAC Duct Construction Standards, Metal and Flexible
- 1st Edition - 1985.....HVAC Air Duct Leakage Test Manual
- 6th Edition - 2003.....Fibrous Glass Duct Construction Standards
- F. Underwriters Laboratories, Inc. (UL):
- 181-08.....Factory-Made Air Ducts and Air Connectors
- 555-06Standard for Fire Dampers
- 555S-06Standard for Smoke Dampers

PART 2 - PRODUCTS

2.1 DUCT MATERIALS AND SEALANTS

- A. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A653, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003 or 5052.
- B. Joint Sealing: Refer to SMACNA HVAC Duct Construction Standards, paragraph S1.9.
1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer. Generally provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable because they do not retain elasticity and bond.

2. Tape: Use only tape specifically designated by the sealant manufacturer and apply only over wet sealant. Pressure sensitive tape shall not be used on bare metal or on dry sealant.

3. Gaskets in Flanged Joints: Soft neoprene.

C. Approved factory made joints may be used.

2.2 DUCT CONSTRUCTION AND INSTALLATION

- A. Regardless of the pressure classifications outlined in the SMACNA Standards, fabricate and seal the ductwork in accordance with the following pressure classifications:

- B. Duct Pressure Classification:

- 0 to 50 mm (2 inch)
- > 50 mm to 75 mm (2 inch to 3 inch)
- > 75 mm to 100 mm (3 inch to 4 inch)

Show pressure classifications on the floor plans.

- C. Seal Class: All ductwork shall receive Class A Seal

- D. Duct for Negative Pressure Up to 750 Pa (3 inch W.G.): Provide for exhaust duct between HEPA filters and exhaust fan inlet ~~including systems for Autopsy Suite exhaust.~~

1. Round Duct: Galvanized steel, spiral lock seam construction with standard slip joints.
2. Rectangular Duct: Galvanized steel, minimum 1.0 mm (20 gage), Pittsburgh lock seam, companion angle joints 32 mm by 3.2 mm (1-1/4 by 1/8 inch) minimum at not more than 2.4 m (8 feet) spacing. Approved pre-manufactured joints are acceptable in lieu of companion angles.

- E. Round and Flat Oval Ducts: Furnish duct and fittings made by the same manufacturer to insure good fit of slip joints. When submitted and approved in advance, round and flat oval duct, with size converted on the basis of equal pressure drop, may be furnished in lieu of rectangular duct design shown on the drawings.

1. Elbows: Diameters 80 through 200 mm (3 through 8 inches) shall be two sections die stamped, all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.
2. Provide bell mouth, conical tees or taps, laterals, reducers, and other low loss fittings as shown in SMACNA HVAC Duct Construction Standards.
3. Ribbed Duct Option: Lighter gage round/oval duct and fittings may be furnished provided certified tests indicating that the rigidity and

performance is equivalent to SMACNA standard gage ducts are submitted.

- a. Ducts: Manufacturer's published standard gage, G90 coating, spiral lock seam construction with an intermediate standing rib.
 - b. Fittings: May be manufacturer's standard as shown in published catalogs, fabricated by spot welding and bonding with neoprene base cement or machine formed seam in lieu of continuous welded seams.
4. Provide flat side reinforcement of oval ducts as recommended by the manufacturer and SMACNA HVAC Duct Construction Standard S3.13. Because of high pressure loss, do not use internal tie-rod reinforcement unless approved by the Resident Engineer.
- F. Casings and Plenums: Construct in accordance with SMACNA HVAC Duct Construction Standards Section 6, including curbs, access doors, pipe penetrations, eliminators and drain pans. Access doors shall be hollow metal, insulated, with latches and door pulls, 500 mm (20 inches) wide by 1200 - 1350 mm (48 - 54 inches) high. Provide view port in the doors where shown. Provide drain for outside air louver plenum. Outside air plenum shall have exterior insulation. Drain piping shall be routed to the nearest floor drain.
- G. Volume Dampers: Single blade or opposed blade, multi-louver type as detailed in SMACNA Standards. Refer to SMACNA Detail Figure 2-12 for Single Blade and Figure 2.13 for Multi-blade Volume Dampers. Dampers shall be reinforced to prevent vibration and shall be equipped with approved damper rods, quadrants and locking devices. Quadrants shall be marked to indicate final balanced position. Where ducts are insulated, quadrants shall have extensions to be visible beyond the duct insulation. Provide lockable volume dampers at every diffuser take-off.
- H. Duct Hangers and Supports: Refer to SMACNA Standards Section IV. Avoid use of trapeze hangers for round duct.

2.3 DUCT LINER (WHERE INDICATED ON DRAWINGS)

- A. Duct sizes shown on drawings for lined duct are clear opening inside lining.
- B. Duct liner is only permitted to be used for return, relief and general exhaust ducts. Duct liner is not permitted for outside air ducts, supply air ducts or any other positive pressure ductwork (provide exterior insulation only).
- C. Rectangular Duct or Casing Liner: ASTM C1071, Type I (flexible), or Type II (board), 25 mm (one inch) minimum thickness, applied with mechanical

fasteners and 100 percent coverage of adhesive in conformance with SMACNA, Duct Liner Application Standard.

- D. Round and Oval Duct Liner: Factory fabricated double-walled with 25mm one inch thick sound insulation and inner perforated galvanized metal liner. Construction shall comply with flame and smoke rating required by NFPA 90A. Metal liner shall be 1.0 to 0.60 mm (20 to 24 gage) having perforations not exceeding 2.4 mm (3/32 inch) diameter and approximately 22 percent free area. Metal liner for fittings need not be perforated. Assemblies shall be complete with continuous sheet Mylar liner, 2 mil thickness, between the perforated liner and the insulation to prevent erosion of the insulation. Provide liner couplings/spacer for metal liner. At the end of insulated sections, provide insulation end fittings to reduce outer shell to liner size. Provide liner spacing/concentricity leaving airway unobstructed.

2.4 DUCT ACCESS DOORS, PANELS AND SECTIONS

- A. Provide access doors, sized and located for maintenance work, upstream, in the following locations:
1. Each duct mounted coil and humidifier.
 2. Each fire damper (for link service), smoke damper and automatic control damper.
 3. Each duct mounted smoke detector.
 4. Each smoke control damper.
- B. Openings shall be as large as feasible in small ducts, 300 mm by 300 mm (12 inch by 12 inch) minimum where possible. Access sections in insulated ducts shall be double-wall, insulated. Transparent shatterproof covers are preferred for uninsulated ducts.
1. Access doors shall be cam-latched. Doors shall be gasketed.
 2. For rectangular ducts: Refer to SMACNA HVAC Duct Construction Standards (Figure 2-12).
 3. For round and flat oval duct: Refer to SMACNA HVAC duct Construction Standards (Figure 2-11).

2.5 FIRE DAMPERS

- A. Galvanized steel, interlocking blade type, UL listing and label, 1-1/2 hour rating, 70 degrees C (160 degrees F) fusible line, 100 percent free opening with no part of the blade stack or damper frame in the air stream.
- B. Fire dampers in wet air exhaust shall be of stainless steel construction, all others may be galvanized steel.
- C. Minimum requirements for fire dampers:

1. The damper frame may be of design and length as to function as the mounting sleeve, thus eliminating the need for a separate sleeve, as allowed by UL 555. Otherwise provide sleeves and mounting angles, minimum 1.9 mm (14 gage), required to provide installation equivalent to the damper manufacturer's UL test installation.
2. Submit manufacturer's installation instructions conforming to UL rating test.

2.6 FLEXIBLE AIR DUCT

- A. General: Factory fabricated, complying with NFPA 90A for connectors not passing through floors of buildings. Flexible ducts shall not penetrate any fire or smoke barrier which is required to have a fire resistance rating of one hour or more. Flexible duct length shall not exceed 1.5 m (5 feet). Flexible ducts shall be connected to supply diffusers and grilles (and elsewhere as indicated) without tight bends or restrictions and shall have a maximum one elbow. Provide insulated flexible air ducts with acoustical air duct connectors in supply air duct systems. Provide elsewhere as shown.
- B. Flexible ducts shall be listed by Underwriters Laboratories, Inc., complying with UL 181. Ducts larger than 200 mm (8 inches) in diameter shall be Class 1. Ducts 200 mm (8 inches) in diameter and smaller may be Class 1 or Class 2.
- C. Insulated Flexible Air Duct: Factory made including mineral fiber insulation with maximum C factor of 0.25 at 24 degrees C (75 degrees F) mean temperature, encased with a low permeability moisture barrier outer jacket, having a puncture resistance of not less than 50 Beach Units. Composed of corrosion-resistant reinforcing wire helix permanently bonded and enclosed in Tedlar film, and covered with 1" thick, $\frac{3}{4}$ lb. density fiberglass insulation blanket sheathed in a vapor barrier. Acoustic insertion loss shall not be less than 3 dB per 300 mm (foot) of straight duct, at 500 Hz, based on 150 mm (6 inch) duct, of 750 m/min (2500 fpm).
- D. Application Criteria:
 1. Temperature range: -18 to 93 degrees C (0 to 200 degrees F) internal.
 2. Maximum working velocity: 1200 m/min (4000 feet per minute).
 3. Minimum working pressure, inches of water gage: 2500 Pa (10 inches) positive, 500 Pa (2 inches) negative.
- E. Duct Clamps: 100 percent nylon strap, 80 kg (175 pounds) minimum loop tensile strength manufactured for this purpose or stainless steel strap with cadmium plated worm gear tightening device. Apply clamps with sealant and as approved for UL 181, Class 1 installation.

2.7 FLEXIBLE DUCT CONNECTIONS

Where duct connections are made to fans, air terminal units, and air handling units, install a non-combustible flexible connection of 822 g (29 ounce) neoprene coated fiberglass fabric approximately 150 mm (6 inches) wide. For connections exposed to sun and weather provide hypalon coating in lieu of neoprene. Burning characteristics shall conform to NFPA 90A. Securely fasten flexible connections to round ducts with stainless steel or zinc-coated iron draw bands with worm gear fastener. For rectangular connections, crimp fabric to sheet metal and fasten sheet metal to ducts by screws 50 mm (2 inches) on center. Fabric shall not be stressed other than by air pressure. Allow at least 25 mm (one inch) slack to insure that no vibration is transmitted.

2.8 FIRESTOPPING MATERIAL

Refer to Section 07 84 00, FIRESTOPPING.

2.9 TURNING VANES

- A. Manufactured Turning Vanes for metal Ducts: Fabricate curved blades of galvanized steel. Support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- C. Vane Construction: Double wall. Vanes shall be same gauge as the duct in which they are installed.

PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION, particularly regarding coordination with other trades and work in existing buildings.
- B. Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards:
 - 1. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions

- with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.
2. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards, Section II. Provide streamliner, when an obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.
 3. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA Standards.
 4. Construct casings, eliminators, and pipe penetrations in accordance with SMACNA Standards, Chapter 6. Design casing access doors to swing against air pressure so that pressure helps to maintain a tight seal.
- C. Install duct hangers and supports in accordance with SMACNA Standards, Chapter 4.
- D. Install fire dampers, smoke dampers and combination fire/smoke dampers in accordance with the manufacturer's instructions to conform to the installation used for the rating test. Install fire dampers, smoke dampers and combination fire/smoke dampers at locations indicated and where ducts penetrate fire rated and/or smoke rated walls, shafts and where required by the Resident Engineer. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges per UL and NFPA. Demonstrate re-setting of fire dampers and operation of smoke dampers to the Resident Engineer.
- E. Install smoke control dampers and air-flow measuring stations as furnished by temperature control contractor. Install smoke dampers in accordance with the manufacturer's instructions to conform to the installation used for the rating test. Install at locations indicated and where required by the Resident Engineer. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges per UL and NFPA.
- F. Flexible duct installation: Refer to SMACNA Standards, Chapter 3. Ducts shall be continuous, single pieces not over 1.5 m (5 feet) long (NFPA 90A), as straight and short as feasible, adequately supported. Centerline radius of bends shall be not less than two duct diameters. Make connections with clamps as recommended by SMACNA. Clamp per SMACNA with one clamp on the core duct and one on the insulation jacket. Flexible ducts shall not penetrate floors, or any chase or partition

designated as a fire or smoke barrier, including corridor partitions fire rated one hour or two hour. Support ducts SMACNA Standards.

- G. Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.
- H. Low Pressure Duct Liner: Install in accordance with SMACNA, Duct Liner Application Standard.
- I. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement, as determined by Resident Engineer. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to existing ductwork, clean both new and existing ductwork by mopping and vacuum cleaning inside and outside before operation.

3.2 DUCT LEAKAGE TESTS AND REPAIR

- A. Ductwork leakage testing shall be performed by the Testing and Balancing Contractor directly contracted by the General Contractor and independent of the Sheet Metal Contractor.
- B. Ductwork leakage testing shall be performed for the entire air distribution system within the work provided by this scope of work, (including supply, return, exhaust and relief ductwork).
- C. Test procedure, apparatus and report shall conform to SMACNA Leakage Test manual. The maximum leakage rate allowed is 4 percent of the design air flow rate.
- D. All tests shall be performed in the presence of the Resident Engineer and the Test and Balance agency. The Test and Balance agency shall measure and record duct leakage and report to the Resident Engineer and identify leakage source with excessive leakage.
- E. If any portion of the duct system tested fails to meet the permissible leakage level, the Contractor shall rectify sealing of ductwork to bring it into compliance and shall retest it until acceptable leakage is demonstrated to the Resident Engineer.
- F. All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.
- G. Make sure all openings used for testing flow and temperatures by TAB Contractor are sealed properly.

3.3 TESTING, ADJUSTING AND BALANCING (TAB)

Refer to Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

3.4 OPERATING AND PERFORMANCE TESTS

Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM
GENERATION

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SECTION 23 34 00
HVAC FANS**PART 1 - GENERAL****1.1 DESCRIPTION**

- A. Fans for heating, ventilating and air conditioning.
- B. Product Definitions: AMCA Publication 99, Standard 1-66.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- D. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- E. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
- F. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- G. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- H. Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- I. Section 23 82 16, AIR COILS.
- J. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

1.3 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. Fans shall be listed in the current edition of AMCA 261, and shall bear the AMCA performance seal.
- C. Operating Limits for Centrifugal Fans: AMCA 99 (Class I, II, and III).
- D. Fans shall comply with the following standards:
 - 1. Testing and Rating: AMCA 210.
 - 2. Sound Rating: AMCA 300.
- E. Vibration Tolerance for Fans and Power Ventilators: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- F. Performance Criteria:
 - 1. The fan schedule shall show the design air volume and static pressure. Select the fan motor HP by increasing the fan BHP by 10 percent to account for the drive losses and field conditions.
 - 2. Select the fan operating point as follows:
 - a. Air Foil, Backward Inclined, or Tubular: At or near the peak static efficiency

G. Safety Criteria: Provide manufacturer's standard screen on fan inlet and discharge where exposed to operating and maintenance personnel.

H. Corrosion Protection:

1. Except for fans in fume hood exhaust service, all steel shall be mill-galvanized, or phosphatized and coated with minimum two coats, corrosion resistant enamel paint. Manufacturers paint and paint system shall meet the minimum specifications of: ASTM D1735 water fog; ASTM B117 salt spray; ASTM D3359 adhesion; and ASTM G152 and G153 for carbon arc light apparatus for exposure of non-metallic material.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturers Literature and Data:
 1. Fan sections, motors and drives.
 2. Motors, drives, dampers, enclosures.
 3. Fan assemblies and fan curves.
- C. Certified Sound power levels for each fan.
- D. Motor ratings types, electrical characteristics and accessories.
- E. Maintenance and Operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
- F. Certified fan performance curves for each fan showing cubic feet per minute (CFM) versus static pressure, efficiency, and horsepower for design point of operation.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Movement and Control Association International, Inc. (AMCA):
 - 99-86Standards Handbook
 - 210-06Laboratory Methods of Testing Fans for
Aerodynamic Performance Rating
 - 261-09Directory of Products Licensed to bear the AMCA
Certified Ratings Seal - Published Annually
 - 300-08Reverberant Room Method for Sound Testing of
Fans

C. American Society for Testing and Materials (ASTM):

- B117-07aStandard Practice for Operating Salt Spray
(Fog) Apparatus
- D1735-08Standard Practice for Testing Water Resistance
of Coatings Using Water Fog Apparatus
- D3359-08Standard Test Methods for Measuring Adhesion by
Tape Test
- G152-06Standard Practice for Operating Open Flame
Carbon Arc Light Apparatus for Exposure of Non-
Metallic Materials
- G153-04Standard Practice for Operating Enclosed Carbon
Arc Light Apparatus for Exposure of Non-
Metallic Materials

D. National Fire Protection Association (NFPA):

- NFPA 96-08Standard for Ventilation Control and Fire
Protection of Commercial Cooking Operations

E. National Sanitation Foundation (NSF):

- 37-07Air Curtains for Entrance Ways in Food and Food
Service Establishments

F. Underwriters Laboratories, Inc. (UL):

- 181-2005Factory Made Air Ducts and Air Connectors

1.6 EXTRA MATERIALS

- A. Provide one additional set of belts for all belt-driven fans.

PART 2 - PRODUCTS**2.1 FAN SECTION (CABINET FAN)**

Refer to specification Section 23 73 00, INDOOR CENTRAL-STATION AIR-
HANDLING UNITS.

2.4 POWER FAN WALL

- A. Standards and Performance Criteria: Refer to Paragraph, QUALITY
ASSURANCE.
- B. Type: Modular Plenum Fan array, N+1 capability in a four (4) fan array.
Basis of Design: Twin City Fan model MPQN-245, SWSI, Class 3, or
approved equal.
 - 1. Subject to project requirements, provide fans by the following:
 - a. Twin City Fan
 - b. Daikin
 - c. JCI (York)
- C. Direct Drive.

- D. Heavy Duty enclosure and heavy duty back-draft damper on each fan.
- E. Construction: Aluminum, Fan-wall mounting, drive assembly readily removable for servicing, aluminum airfoil blades continuously welded, 12 blades. Arrangement 4. Fan frame and inlet panels shall be heavy-duty gauge reinforced steel construction. The fan inlet panel shall include a spun inlet cone and contain a wire safety cage. Fan box shall include perforated insulated 2" thick insulation enclosure and Heavy duty backdraft damper; basis of design United Enertech HCB-750 or approved equal. Provide fan enclosure/backdraft stand. Stand shall be field fabricated of solid angle iron to accommodate weight of enclosures and dampers, galvanized and shop painted.
- F. Provide conduit for wiring, vibration isolators for wheel and motor/drive assembly.
- G. Motor and Drive: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- H. Controls: Provide control package for optimization of a 4-fan array. Under normal operation all 4 fans shall ramp together. If one fan is inoperable, the algorithm shall control the remaining 3 fans to maintain a pressure differential set-point (as controlled by building automation). Each motor shall have its own VFD drive. See Div 26 for VFD's for each fan motor, and shall be provided and shall be mounted to be accessible without use of ladder.
- I. Motors: Motors shall be premium efficiency inverter duty motors. Fan motors shall be of type suitable for service conditions, sealed ball bearings, resilient mounting and automatic thermal overload switch. Provide Aegis shaft grounding kit.
- J. 3-fan mode: Motors shall be designed for over-speed with the utilization of VFD's operating up to a maximum of 90 HZ while in the '3-fan' mode wherein one of the 4 fans are out of service. The motors and fans shall have sufficient motor torque to deliver the full unit CFM under this mode. The scheduled motor HP has been intentionally over-sized to accommodate this mode.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install fan, motor and drive in accordance with manufacturer's instructions.
- B. Align fan and inlet cone on fan array.

- C. Provide field-fabricated plenum wall and bolt equipment to existing 4" insulated built-up air handler.

3.2 PRE-OPERATION MAINTENANCE

- A. Lubricate bearings, and other moving parts with manufacturer recommended lubricants.
- B. Rotate impeller by hand and check for shifting during shipment and check all bolts, collars, and other parts for tightness.
- C. Clean fan interiors to remove foreign material and construction dirt and dust.

3.3 START-UP AND INSTRUCTIONS

- A. Verify operation of motor, drive system and fan wheel according to the drawings and specifications.
- B. Check vibration and correct as necessary for air balance work.
- C. After air balancing is complete perform necessary field mechanical balancing to meet vibration tolerance in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- D. The Commissioning Agent will observe startup and contractor testing of all equipment. Coordinate the startup and contractor testing schedules with Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.4 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.5 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 36 00
AIR TERMINAL UNITS**PART 1 - GENERAL****1.1 DESCRIPTION**

Air terminal units, air flow control valves.

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION:
General mechanical requirements and items, which are common to more than one section of Division 23.
- B. Section 23 31 00, HVAC DUCTS AND CASINGS: Ducts and flexible connectors.
- C. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Valve operators.
- D. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC: Flow rates adjusting and balancing.
- E. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- F. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Air Terminal Units: Submit test data.
- C. Certificates:
 - 1. Compliance with paragraph, QUALITY ASSURANCE.
 - 2. Compliance with specified standards.
- D. Operation and Maintenance Manuals: Submit in accordance with paragraph, INSTRUCTIONS, in Section 01 00 00, GENERAL REQUIREMENTS.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning and Refrigeration Institute (AHRI)/(ARI):
 - 880-08Air Terminals Addendum to ARI 888-98
incorporated into standard posted 15th December
2002

C. National Fire Protection Association (NFPA):

90A-09Standard for the Installation of Air
Conditioning and Ventilating Systems

D. Underwriters Laboratories, Inc. (UL):

181-08Standard for Factory-Made Air Ducts and Air
Connectors

E. American Society for Testing and Materials (ASTM):

C 665-06Standard Specification for Mineral-Fiber
Blanket Thermal Insulation for Light Frame
Construction and Manufactured Housing

1.6 GUARANTY

In accordance with the GENERAL CONDITIONS

PART 2 - PRODUCTS**2.1 GENERAL**

A. Coils:

1. Air-Terminals: Provide aluminum fins and copper coils for all hot water reheat coils.
2. Water Heating Coils:
 - a. ARI certified, continuous plate or spiral fin type, leak tested at 2070 kPa (300 PSI).
 - b. Capacity: As indicated, based on scheduled entering water temperature.
 - c. Headers: Copper or Brass.
 - d. Fins: Aluminum, maximum 315 fins per meter (8 fins per inch).
 - e. Tubes: Copper, arrange for counter-flow of heating water.
 - f. Water Flow Rate: Minimum 0.032 Liters/second (0.5 GPM).
 - g. Provide vent and drain connection at high and low point, respectively of each coil.
 - h. Coils shall be guaranteed to drain.

B. Labeling: Control box shall be clearly marked with an identification label that lists such information as nominal CFM, maximum and minimum factory-set airflow limits, coil type and coil connection orientation, where applicable.

C. Calibrate air terminal units to air flow rate indicated. All settings including maximum and minimum air flow shall be field adjustable.

2.2 AIR TERMINAL UNITS (BOXES)

A. General: Factory built, pressure independent units, FACTORY LABELED CFM, field adjustable air flow rate, suitable for single duct

applications. Use of dual-duct air terminal units is not permitted. Clearly show on each unit the unit number and factory (and TAB set) air volumes corresponding to the contract drawings. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC work shall set final air volumes. Coordinate flow controller sequence and damper operation details with the drawings and Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. All air terminal units shall be brand new products of the same manufacturer.

- B. Controls contractor shall provide new controls, and actuators for VAV terminal units. BAS shall furnish new hydronic 2-way control valves for installation by Div 23 fitter. VAV controls shall be provided by BAS and shall be field installed.
- C. VAV boxes shall have hydronic heating coils. BAS shall provide new actuators.
- D. Capacity and Performance: The Maximum Capacity of a single terminal unit shall not exceed 566 Liters/second (1,200 CFM) with the exception of operating rooms and Cystoscopy rooms, which shall be served by a single air terminal unit at a maximum of 1,250 Liters/second (3,000 CFM).
- E. Casing: Unit casing shall be constructed of galvanized steel no lighter than 0.85 mm (22 Gauge). Air terminal units serving the operating rooms and Cystoscopy rooms shall be fabricated without lining. Provide hanger brackets for attachment of supports.
 - 1. Lining material: Suitable to provide required acoustic performance, thermal insulation and prevent sweating. Meet the requirements of NFPA 90A and comply with UL 181 for erosion as well as ASTM C 665 antimicrobial requirements. Insulation shall consist of 13 mm (1/2 IN) thick non-porous foil faced rigid fiberglass insulation of 4-lb/cu.ft, secured by full length galvanized steel z-strips which enclose and seal all edges. Tape and adhesives shall not be used. Materials shall be non-friable and with surfaces, including all edges, fully encapsulated and faced with perforated metal or coated so that the air stream will not detach material. No lining material is permitted in the boxes serving operating rooms and Cystoscopy rooms.
 - 2. Access panels (or doors): Provide panels large enough for inspection, adjustment and maintenance without disconnecting ducts, and for cleaning heating coils attached to unit, even if there are

- no moving parts. Panels shall be insulated to same standards as the rest of the casing and shall be secured and gasketed airtight. It shall require no tool other than a screwdriver to remove.
3. Total leakage from casing: Not to exceed 2 percent of the nominal capacity of the unit when subjected to a static pressure of 750 Pa (3 inch WG), with all outlets sealed shut and inlets fully open.
- F. Construct dampers and other internal devices of corrosion resisting materials which do not require lubrication or other periodic maintenance.
1. Damper Leakage: Not greater than 2 percent of maximum rated capacity, when closed against inlet static pressure of 1 kPa (4 inch WG).
- G. Provide multi-point velocity pressure sensors with external pressure taps.
1. Provide direct reading air flow rate table pasted to box.
- H. Provide static pressure tubes.
- I. Externally powered DDC variable air volume controller and damper actuator to be furnished under Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC for factory mounting on air terminal units. The DDC controller shall be electrically actuated.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.
- B. Handle and install units in accordance with manufacturer's written instructions.
- C. Support units rigidly so they remain stationary at all times. Cross-bracing or other means of stiffening shall be provided as necessary. Method of support shall be such that distortion and malfunction of units cannot occur.
- D. Locate air terminal units to provide a straight section of inlet duct for proper functioning of volume controls. See VA Standard Detail.

3.2 OPERATIONAL TEST

Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection,

start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

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

- A. Air Outlets and Inlets: Diffusers, Registers, and Grilles.

1.2 RELATED WORK

- A. General Mechanical Requirements: Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- B. Testing and Balancing of Air Flows: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

1.3 QUALITY ASSURANCE

- A. Refer to article, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- B. Fire Safety Code: Comply with NFPA 90A.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
1. Air intake/exhaust hoods.
 2. Diffusers, registers, grilles and accessories.
- C. Coordination Drawings: Refer to article, SUBMITTALS, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Diffusion Council Test Code:
- 1062 GRD-84.....Certification, Rating, and Test Manual 4th
Edition
- C. American Society of Civil Engineers (ASCE):
- ASCE7-05.....Minimum Design Loads for Buildings and Other
Structures
- D. American Society for Testing and Materials (ASTM):
- A167-99 (2004).....Standard Specification for Stainless and
Heat-Resisting Chromium-Nickel Steel Plate,
Sheet and Strip
- B209-07.....Standard Specification for Aluminum and
Aluminum-Alloy Sheet and Plate

E. National Fire Protection Association (NFPA):

90A-09.....Standard for the Installation of Air
Conditioning and Ventilating Systems

F. Underwriters Laboratories, Inc. (UL):

181-08.....UL Standard for Safety Factory-Made Air Ducts
and Connectors

PART 2 - PRODUCTS**2.1 AIR OUTLETS AND INLETS**

A. Materials:

1. Steel or aluminum except that all supply air outlets installed in operating rooms and Cystoscopy rooms (see Article 2.3C.3) shall be stainless steel. Use aluminum air outlets and inlets for facilities located in high-humidity areas. Exhaust air registers located in combination toilets and shower stalls shall be constructed from aluminum. Provide manufacturer's standard gasket.
2. Exposed Fastenings: The same material as the respective inlet or outlet. Fasteners for aluminum may be stainless steel.
3. Contractor shall review all ceiling drawings and details and provide all ceiling mounted devices with appropriate dimensions and trim for the specific locations.

B. Performance Test Data: In accordance with Air Diffusion Council Code 1062GRD. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT for NC criteria.

C. Air Supply Outlets:

1. Ceiling Diffusers: Suitable for surface mounting, exposed T-bar or special tile ceilings, off-white finish, square or round neck connection as shown on the drawings. Provide plaster frame for units in plaster ceilings.
 - a. Square, louver, fully adjustable pattern: Round neck, surface mounting unless shown otherwise on the drawings. Provide equalizing or control grid and volume control damper.
 - b. Louver face type: Square or rectangular, removable core for 1, 2, 3, or 4 way directional pattern. Provide equalizing or control grid and opposed blade damper.

- c. Perforated face type: Manual adjustment for one-, two-, three-, or four-way horizontal air distribution pattern without change of air volume or pressure. Provide equalizing or control grid and opposed blade over overlapping blade damper. Perforated face diffusers for VAV systems shall have the pattern controller on the inner face, rather than in the neck and designed to discharge air horizontally at the ceiling maintaining a Coanda effect.
- 4. Supply Registers: Double deflection type with horizontal face bars and opposed blade damper with removable key operator.
 - a. Margin: Flat, 30 mm (1-1/4 inches) wide.
 - b. Bar spacing: 20 mm (3/4 inch) maximum.
 - c. Finish: Off white baked enamel for ceiling mounted units. Wall units shall have a prime coat for field painting, or shall be extruded with manufacturer's standard finish.
- 5. Supply Grilles: Same as registers but without the opposed blade damper.
- D. Return and Exhaust Registers and Grilles: Provide opposed blade damper without removable key operator for registers.
 - 1. Finish: Off-white baked enamel for ceiling mounted units. Wall units shall have a prime coat for field painting, or shall be extruded aluminum with manufacturer's standard aluminum finish.
 - 2. Standard Type: Fixed horizontal face bars set at 30 to 45 degrees, approximately 30 mm (1-1/4 inch) margin.
 - 3. Perforated Face Type: To match supply units.
 - 4. Grid Core Type: 13 mm by 13 mm (1/2 inch by 1/2 inch) core with 30 mm (1-1/4 inch) margin.
 - 5. Linear Type: To match supply units.
 - 6. Door Grilles: Are furnished with the doors.
 - 7. Egg Crate Grilles: Aluminum or Painted Steel 1/2 by 1/2 by 1/2 inch grid providing 90% free area.
 - a. Heavy extruded aluminum frame shall have countersunk screw mounting. Unless otherwise indicated, register blades and frame shall have factory applied white finish.
 - b. Grille shall be suitable for duct or surface mounting as indicated on drawings. All necessary appurtenances shall be provided to allow for mounting.

- E. Acoustic Transfer Grille: Aluminum, suitable for partition or wall mounting.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION, particularly regarding coordination with other trades and work in existing buildings.
- B. Protection and Cleaning: Protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement, as determined by Resident Engineer. Protect equipment during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting.

3.2 TESTING, ADJUSTING AND BALANCING (TAB)

Refer to Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.3 OPERATING AND PERFORMANCE TESTS

Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION

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SECTION 23 73 00
INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL**1.1 DESCRIPTION**

- A. Air handling units including integral components specified herein.
- B. Definitions: Air Handling Unit (AHU): A factory fabricated and tested assembly of modular sections consisting of multiple plenum fans with direct-drive, coils, filters, and other necessary equipment to perform one or more of the following functions of circulating, cleaning, heating, cooling, humidifying, dehumidifying, and mixing of air. Design capacities of units shall be as scheduled on the drawings.

1.2 RELATED WORK

- A. General mechanical requirements and items, which are common to more than one section of Division 23: Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- B. Piping and duct insulation: Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION.
- C. Piping and valves: Section 23 21 13 HYDRONIC PIPING.
- D. Heating and cooling coils and pressure requirements: Section 23 82 16, AIR COILS.
- E. Fans: Section 23 34 00, HVAC FANS.
- F. HVAC controls: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- G. Testing, adjusting and balancing of air and water flows: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- H. Types of motors: Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.
- I. Types of motor starters: Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.
- J. General Commissioning: Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS
- K. HVAC Commissioning: Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS

1.3 QUALITY ASSURANCE

- A. Refer to Article, Quality Assurance, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- B. Air Handling Units Certification
 - 1. Air Handling Units with Plenum Fans:
 - a. Air handling Units with Multiple Fans in an Array shall be tested and rated in accordance with AHRI 430 and AHRI 260.
- C. Heating, Cooling, and Air Handling Capacity and Performance Standards: AHRI 430, AHRI 410, ASHRAE 51, and AMCA 210.
- D. Performance Criteria:

1. The fan BHP shall include all system effects for all fans and v-belt drive losses for housed centrifugal fans.
 2. The fan motor shall be selected within the rated nameplate capacity, without relying upon NEMA Standard Service Factor.
- E. **Unit in this project is an existing built-up unit with 4" thick insulated double wall construction.** Interior panel is perforated -lined for sound absorption.
- F. The contractor shall remove a knock-out panel which exists in the unit fan section provided for such purpose. Contractor shall demolish existing fan and related wall plate, motor, and fan base. Demolish existing diffuser plate in downstream section. Provide new wall plates including fasteners, stiffeners, and associated connections for a complete and operating new fan wall arrangement. The existing panel has cam latches and is gasketed and sealed. Provide services to remove existing panel, install the final complete installation and replace the fan knock-out section. Reseal and repaint the exterior panel. Sealant and repair shall withstand 6" water column static pressure. Repaint the section to a reasonable color and quality of the existing exterior.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI)/(ARI):
410-01.....Standard for Forced-Circulation Air-Heating and Air-Cooling Coils
430-09.....Central Station Air Handling Units
- C. Air Movement and Control Association International, Inc. (AMCA):
210-07.....Laboratory Methods of Testing Fans for Rating
- D. American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc. (ASHRAE):
170-2008.....Ventilation of Health Care Facilities
- E. American Society for Testing and Materials (ASTM):
ASTM B117-07a.....Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D1654-08.....Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

ASTM D1735-08.....Standard Practice for Testing Water Resistance
of Coatings Using Water Fog Apparatus

ASTM D3359-08.....Standard Test Methods for Measuring Adhesion by
Tape Test

F. Military Specifications (Mil. Spec.):

MIL-P-21035B-2003.....Paint, High Zinc Dust Content, Galvanizing
Repair (Metric)

G. National Fire Protection Association (NFPA):

NFPA 90A.....Standard for Installation of Air Conditioning
and Ventilating Systems, 2009

H. Energy Policy Act of 2005 (P.L.109-58)

PART 2 - PRODUCTS

2.1 AIR HANDLING UNITS

A. General:

1. AHUs shall be fabricated from insulated, double-wall galvanized steel. Casing shall be fabricated as specified in section 2.1.C. Galvanizing shall be hot dipped conforming to ASTM A525 and shall provide a minimum of 0.275 kg of zinc per square meter (0.90 oz. of zinc per square foot) (G90).
2. The contractor and the AHU manufacturer shall be responsible for ensuring that the unit will not exceed the allocated space shown on the drawings, including required clearances for service and future overhaul or removal of unit components. All structural, piping, wiring, and ductwork alterations of units, which are dimensionally different than those specified, shall be the responsibility of the contractor at no additional cost to the government.
3. The **contractor** shall provide the necessary gasketing, caulking, and all screws, nuts, and bolts required for assembly. The manufacturer shall provide a factory-trained and qualified local representative at the job site to supervise the assembly and to assure that the units are assembled to meet manufacturer's recommendations and requirements noted on the drawings. Provide documentation to the Contracting Officer that the local representative has provided services of similar magnitude and complexity on jobs of comparable size.
5. Gaskets: All door and casing and panel gaskets and gaskets between air handling unit components, if joined in the field, shall be high quality which seal air tight and retain their structural integrity and sealing capability after repeated assembly and disassembly of bolted panels and opening and closing of hinged components. Bolted sections may use a more permanent gasketing method.

6. Structural Rigidity: Provide structural reinforcement when required by span or loading so that the deflection of the assembled structure shall not exceed 1/200 of the span based on a differential static pressure of 1991 PA (8 inch WG) or higher.

B. Casing:

1. General: AHU casing shall be constructed as **4" thick** double wall, galvanized steel insulated panels. Interior shall have perforations to match existing, integral of or attached to a structural frame. The thickness of insulation, mode of application and thermal breaks shall be such that there is no visible condensation on the exterior panels of the AHU located in the non-conditioned spaces.
2. **Under this project the built-up casing is existing. Contractor shall match the casing after certain panels are removed and replaced.**
3. Casing Construction (see item 2 above):

Table 2.1.C.3

Outer Panel	1.3 mm (18 Gage) Minimum
Inner Panel	1.0 mm (20 Gage) Minimum
Insulation	Fiberglass
Thickness	50 mm (2 inch) Minimum
Density	24 kg/m ³ (1.5 lb/ft ³) Minimum
Total R Value	1.4 m ² .K/W (8.0 ft ² .°F.hr/Btu) Minimum

4. Blank-Off: Provide blank-offs as required to prevent air bypass between the AHU sections, around coils, and filters.
5. Casing panels shall be secured to the support structure with stainless steel or zinc-chromate plated screws and gaskets installed around the panel perimeter. Panels shall be completely removable to allow removal of fan, coils, and other internal components for future maintenance, repair, or modifications. Welded exterior panels are not acceptable.
6. Access Doors: **Under this project the doors are existing, but may need to be removed depending on means and methods:** Provide in each access section and where shown on drawings. Show single-sided and double-sided access doors with door swings on the floor plans. Doors shall be a minimum of 50 mm (2 inch) thick with same double wall construction as the unit casing. Doors shall be a minimum of 600 mm (24 inches) wide, unless shown of different size on drawings, and shall be the full casing height up to a maximum of 1850 mm (6 feet).

Doors shall be gasketed, hinged, and latched to provide an airtight seal. The access doors for fan section, shall include a minimum 4" double thickness, with air space between the glass panes tightly sealed, reinforced glass or Plexiglas window in a gasketed frame.

- a. Hinges: Manufacturers standard, designed for door size, weight and pressure classifications. Hinges shall hold door completely rigid with minimum 45 kg (100 lb) weight hung on latch side of door.
 - b. Latches: Non-corrosive alloy construction, with operating levers for positive cam action, operable from either inside or outside. Doors that do not open against unit operating pressure shall allow the door to ajar and then require approximately 0.785 radian (45 degrees) further movement of the handle for complete opening. Latch shall be capable of restraining explosive opening of door with a force not less than 1991 Pa (8 inch WG).
 - c. Gaskets: Neoprene, continuous around door, positioned for direct compression with no sliding action between the door and gasket. Secure with high quality mastic to eliminate possibility of gasket slipping or coming loose.
 - d. **Under this project, inspect and field measure existing door seals. Replace door seal gaskets on all access doors with new material to match the existing.**
7. The contractor shall remove a knock-out panel which exists in the unit fan section provided for such purpose. Contractor shall demolish existing fan and related wall plate, motor, and fan base. Demolish existing diffuser plate in downstream section. Provide new wall plates including fasteners, stiffeners, and associated connections for a complete and operating new fan wall arrangement. The existing panel has cam latches and is gasketed and sealed. Provide services to remove existing panel, install the final complete installation and replace the fan knock-out section. Reseal and repaint the exterior panel. Sealant and repair shall withstand 6" water column static pressure. Repaint the section to a reasonable color and quality of the existing exterior.
8. Provide sealed sleeves, metal or plastic escutcheons or grommets for penetrations through casing for power and temperature control wiring and pneumatic tubing. Coordinate with electrical and temperature control subcontractors for number and location of penetrations. Coordinate lights, switches, and duplex receptacles and disconnect switch location and mounting. All penetrations and equipment mounting

may be provided in the factory or in the field. All field penetrations shall be performed neatly by drilling or saw cutting. No cutting by torches will be allowed. Neatly seal all openings airtight.

C. Floor and floor slope: Existing. Drain pan shall be pitched in all directions to drain line.

1. An intermediate, stainless-steel (304) condensate drip pan with copper downspouts shall be provided on stacked cooling coils. Use of intermediate condensate drain channel on upper casing of lower coil is permissible provided it is readily cleanable. Design of intermediate condensate drain shall prevent upper coil condensate from flowing across face of lower coil.
2. Drain pan shall be piped to the exterior of the unit. Drain pan shall be readily cleanable.
3. Installation, including frame, shall be designed and sealed to prevent blow-by.

D. Plenum Fans -Multiple Fans in an Array:

1. General: See 23 34 00 HVAC Fans. The fan wheel shall be mounted on the directly-driven motor shaft in AMCA Arrangement 4. Fans shall be dynamically balanced and internally isolated to minimize the vibrations. Provide a steel inlet cone for each wheel to match with the fan inlet. Locate fan in the air stream to assure proper flow. The fan performance shall be rated in accordance with AMCA 210 or ASHRAE 51.
2. Allowable vibration tolerances for fan shall not exceed a self-excited vibration maximum velocity of 0.005 m/s (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions or measured at equipment mounting feet if bearings are concealed. After field installation, compliance to this requirement shall be demonstrated with field test in accordance with Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT and Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC. Following fan assembly, the complete fan assembly balance shall be tested using an electronic balance analyzer with a tunable filter and stroboscope. Vibration measurements shall be taken on each motor bearing housing in the vertical, horizontal, and axial planes (5 total measurements, 2 each motor bearing and 1 axial).
3. The plenum fans shall be driven by individual variable speed drives. *Use of a drive with bypass is not permitted.*

4. Multiple fans shall be installed in a pre-engineered structural frame to facilitate fan stacking. All fans shall modulate in unison, above or below the synchronous speed within the limits specified by the manufacturer, by a common control sequence. Staging of the fans is not permitted. Redundancy requirement shall be met by N+1 arrangement with all operating fans normally in an array.

5. Fan Accessories

- a. Fan Isolation: Provide an automatic back draft damper to isolate the fan not in operation due to failure.
- b. Fan Airflow Measurement: Shall be in supply ductwork downstream.

J. Fan Motor, Drive, and Mounting Assembly (Plenum Fans):

Fan Motor and Drive: Motors shall be premium energy efficient type, as mandated by the Energy Policy Act of 2005, with efficiencies as shown in the Specifications Section 23 05 12 (General Motor Requirements For HVAC and Steam Equipment), on drawings and suitable for use in variable frequency drive applications. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION, for additional motor and drive specifications. Refer to Specification Section 26 29 11, LOW-VOLTAGE

N. Filter Section:

1. Filters are existing.

- P. Coils: Remove and replace the existing cooling coils. Coils shall be mounted on hot dipped galvanized steel supports to assure proper anchoring of coil and future maintenance. Coils shall be side removable for future replacement thru the access doors or removable panels. Each coil shall be removable without disturbing adjacent coil. Cooling coils shall be designed and installed to insure no condensate carry over. Provide an intermediate stainless steel drain pan under the top coil and a stainless steel drain pan under the bottom coil. Provide ¾" copper equipment drains from each drain pan and join them to a 1" copper equipment drain and P-trap. The P-trap shall be outside the AHU casing and be sized for manometer height of 1.5 times the component static pressure of the section. The coils and supports shall be arranged in a 2-coil bank. Provide factory installed extended supply, return, drain, and vent piping connections. Refer to Drawings and Section 23 82 16, AIR COILS for additional coil requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install air handling unit in conformance with ARI 435.

- B. Assemble air handling unit components following manufacturer's instructions for handling, testing and operation. Repair damaged galvanized areas with paint in accordance with Military Spec. DOD-P-21035. Repair painted units by touch up of all scratches with finish paint material. Vacuum the interior of air handling units clean prior to operation.
- C. Seal and/or fill all openings between the casing and AHU components and utility connections to prevent air leakage or bypass.

3.2 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of all equipment. Coordinate the startup and contractor testing schedules with Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 23 82 16
AIR COILS**PART 1 - GENERAL****1.1 DESCRIPTION**

Cooling coils for air handling unit and duct applications

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Section 23 31 00, HVAC DUCTS AND CASINGS
- C. Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.
- E. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS
- F. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.3 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE, Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Unless specifically exempted by these specifications, heating and cooling coils shall be tested, rated, and certified in accordance with AHRI Standard 410 and shall bear the AHRI certification label.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data for Heating and Cooling Coils: Submit type, size, arrangements and performance details. Present application ratings in the form of tables, charts or curves.
- C. Provide installation, operating and maintenance instructions.
- D. Certification Compliance: Evidence of listing in current ARI Directory of Certified Applied Air Conditioning Products.
- E. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning and Refrigeration Institute (AHRI):
Directory of Certified Applied Air Conditioning Products
AHRI 410-01.....Forced-Circulation Air-Cooling and Air-Heating
Coils

- C. American Society for Testing and Materials (ASTM):
B75/75M-02.....Standard Specifications for Seamless Copper Tube
- D. National Fire Protection Association (NFPA):
70-11.....National Electric Code
- E. National Electric Manufacturers Association (NEMA):
250-11.....Enclosures for Electrical Equipment (1,000 Volts
Maximum)
- F. Underwriters Laboratories, Inc. (UL):
1996-09.....Electric Duct Heaters

PART 2 - PRODUCTS

2.1 COOLING COILS

- A. Conform to ASTM B75 and AHRI 410.
- B. Tubes: Minimum 5/8" (0.625 inch) tube diameter; Seamless copper tubing. No turbulators shall be used.
- C. Fins: 0.19 mm (0.0075 inch) aluminum mechanically bonded or soldered or helically wound around tubing.
- D. Headers: Copper, Red brass. Provide seamless copper tubing.
- E. "U" Bends, Where Used: Machine die-formed, silver brazed to tube ends.
- F. Coil Casing: 1.6 mm (16 gage) galvanized steel with tube supports at 1200 mm (48 inch) maximum spacing. Construct casing to eliminate air bypass and moisture carry-over. Provide duct connection flanges.
- G. Pressures kPa (PSIG):

Pressure	Water Coil	Steam Coil	Refrigerant Coil
Test	2070 (300)	1725 (250)	2070 (300)
Working	1380 (200)	520 (75)	1725 (250)

- H. Protection: Unless protected by the coil casing, provide cardboard, plywood, or plastic material at the factory to protect tube and finned surfaces during shipping and construction activities.
- I. Vents and Drain: Coils shall be vented and drainable by the piping system. Provide adequate P-trap for 1.5 times the expected static pressure of the coil section. Drain connections shall be extended through coil casing with gasketed and sealed penetrations. Drains shall be 3/4" copper and routed to nearest floor drain.
- J. Cooling Coil Condensate Drain Pan: Provide a stainless steel welded and water-tight intermediate drain pan under each of two coils. Provide copper 3/4" piping from each drain pan and communicate to a P-trap and 1" air gap above a floor drain.
- K. Field installation: Install cooling coils with coil casing for field mounting inside an existing air handler. Provide galvanized blank-off

and connect to the existing interior panel of the built-up air handler. Provide galvanized steel stand of welded angle iron and epoxy painted, to accommodate the coil bank and intermediate drain pans.

- L. Basis of design: Heatcraft cooling coil, Heatcraft model as scheduled. Johnson or Daikin approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Follow coil manufacturer's instructions for handling, cleaning, installation and piping connections.
- B. Comb fins, if damaged. Eliminate air bypass or leakage at coil sections.

3.2 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.4 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS.

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