

SECTION 22 00 60
PLUMBING DEMOLITION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the demolition and removal of water, waste, vent, condensate, plumbing fixtures and accessories in existing building.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and equipment for patching and extending work: As specified in individual sections.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify field measurements and existing piping arrangements are as shown on drawings.
- B. Verify that abandoned equipment serve only abandoned facilities.
- C. Demolition drawings are based on casual field observation and existing record documents. The demolition drawings are diagrammatic and show the general scope of demolition work and do not show all the construction detail of the original record drawings. Report discrepancies to the VA Project Engineer before disturbing existing installation.
- D. The contractor shall visit the existing building and grounds and review the existing building record drawings for details of existing installation to familiarize himself with existing conditions prior to submitting bid. No allowance will be made subsequently, in this connection, on behalf of the contractor for any error or negligence on his part.
- E. Beginning of demolition means the contractor accepts existing conditions.

3.2 PREPARATION

- A. Disconnect mechanical systems in areas scheduled for removal. Notify the VA Project Engineer of areas to be affected by mechanical demolition work prior to commencing.
- B. Disconnect water and sewer system in areas scheduled for removal. Notify the VA Project Engineer of areas to be affected by plumbing demolition work prior to commencing.

3.3 DEMOLITION AND EXTENSION OF EXISTING PLUMBING WORK

- A. Demolish and remove from site, and extend existing mechanical work under provisions of this division and as indicated on the drawings unless otherwise noted.
- B. Unless otherwise noted on the drawings, all salvage items removed in connection with this contract are to become the property of the contractor. Salvage items noted to remain the property of the VA shall be delivered to a location to be designated by the VA Project Engineer. Contractor shall remove from construction areas all trash or debris as it accumulates and dispose of it off campus at no additional cost. All construction areas shall be kept clean, safe, and orderly at all times. At the completion and acceptance for work, contractor shall remove from the site all debris and surplus materials resulting from this work and dispose of them off campus at no additional cost.
- C. Remove, relocate, and extend existing installations to accommodate new construction as required for proper installation and system operation.
- D. Remove all accessories above grade. Cut piping flush with walls and floors, and patch surfaces.
- E. Remove, relocate or provide brackets, hangers, and other accessories as required.
- F. Repair adjacent construction and finishes damaged during demolition and extension work.
- G. Maintain access to existing mechanical installations, which remain active.

3.4 CLEANING AND REPAIR

- A. Clean and repair existing materials and equipment, which remain or are to be returned to the VA Project Engineer.
- B. All building surfaces damaged and openings left by new work or the removal or relocation of mechanical equipment, piping, etc., shall be repaired to original condition and painted by the Contractor.
- C. All piping identified as remaining shall be reinsulated per specification section 23 07 11.

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SECTION 22 05 11
COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this section apply to all sections of Division 22.

B. Definitions:

1. Exposed: Piping and equipment exposed to view in finished rooms.
2. Option or Optional: Contractor's choice of an alternate material or method.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 09 91 00, PAINTING.
- D. Section 22 07 11, PLUMBING INSULATION.
- E. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

1.3 QUALITY ASSURANCE

A. 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. 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.
2. Equipment Service: There shall be permanent service organizations, authorized and trained by manufacturers of the equipment supplied, located within 100 miles of the project. These organizations shall come to the site and provide acceptable service to restore operations within four hours of receipt of notification by phone, e-mail or fax in event of an emergency, such as the shut-down of equipment; or within 24 hours in a non-emergency. Submit names, mail and e-mail addresses and phone numbers of service organizations providing service under these conditions for (as applicable to the project): pumps, critical instrumentation, computer workstation and programming.
3. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.

4. 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 VA Project Engineer (PE)/Contracting Officers Representative (COR).
 5. 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.
 6. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.
 7. 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.
 8. Asbestos products or equipment or materials containing asbestos shall not be used.
- B. Welding: Before any welding is performed, contractor shall submit a certificate certifying that welders comply with the following requirements:
1. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualifications".
 2. Comply with provisions of ASME B31 series "Code for Pressure Piping".
 3. Certify that each welder has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.
 4. All welds shall be stamped according to the provisions of the American Welding Society.
- C. 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 VA Project Engineer 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.
- D. 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 PE/COR for resolution. Provide written hard copies or computer files of manufacturer's installation instructions to the PE/COR at least two weeks 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, control devices. Prior to commencing installation work, refer conflicts between this requirement and contract drawings to the PE/COR for resolution.
3. Provide complete layout drawings required by Paragraph, SUBMITTALS. Do not commence construction work on any system until the layout drawings have been approved.

E. Plumbing Systems: IPC, International Plumbing Code.

F. Licensing: The contractor shall be licensed to perform the contracted services. The contractor shall furnish details of all applicable local and state licensing requirements to VA as a part of the qualification requirements. The licenses shall be current, valid through the term of the contract and in the name of the contractor.

1.4 SUBMITTALS

- A. Submit 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 "Group" number.
- C. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements.
- 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. 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.

G. Manufacturer's Literature and Data: Submit under the pertinent section rather than under this section.

1. Equipment and materials identification.
2. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.
3. Wall, floor, and ceiling plates.

H. Provide details of the following.

1. Hangers, inserts, supports, and bracing.
2. Pipe sleeves.

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.
2. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment.

1.5 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 VA PE/COR. 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. Clean interior of all tanks prior to delivery for beneficial use by the Government.
4. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

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 the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
Boiler and Pressure Vessel Code (BPVC):
SEC IX-98.....Qualifications Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators
- C. American Society for Testing and Materials (ASTM):
A36/A36M-2001.....Carbon Structural Steel
A575-96.....Steel Bars, Carbon, Merchant Quality, M-Grades R (2002)
E84-2003.....Standard Test Method for Burning Characteristics of Building Materials
E119-2000.....Standard Test Method for Fire Tests of Building Construction and Materials
- D. Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry, Inc:
SP-58-93.....Pipe Hangers and Supports-Materials, Design and Manufacture
SP 69-2003.....Pipe Hangers and Supports-Selection and Application
- E. National Electrical Manufacturers Association (NEMA):
MG1-2003, Rev. 1-2004...Motors and Generators
- F. National Association of Plumbing - Heating - Cooling Contractors (NAPHCC): National Standard Plumbing Code

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

- A. Provide maximum standardization of components to reduce spare part requirements.

- B. 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.
- C. Major items of equipment, which serve the same function, must be the same make and model.

2.2 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.

2.3 LIFTING ATTACHMENTS

- A. Provide equipment 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.

2.4 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. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 48 mm (3/16-inch) high riveted or bolted to the equipment.
- D. Control Items: Label all temperature and humidity sensors, controllers and control dampers. Identify and label each item as they appear on the control diagrams.
- E. Valve Tags and Lists:
 - 1. Plumbing: Provide for all valves (fixture stops not included).
 - 2. 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. Coordinate the valve tags with the Shops Foreman prior to installation for compliance.
 - a. Valve number shall be labeled as follows: M-V-XXX-XXXXX-XXX.

- 1) The first letter(s) or number(s) of the valve tag refers to the building number. M refers to Main Hospital.
 - 2) V stands for "Valve."
 - 3) The first grouping of XXX indicates the type of piping. Refer to 09 91 00 Painting specification for labels for different types of piping (i.e. HWH is Hot Water Heating, DC is Domestic Cold Water, DH is Domestic Hot Water, and DR is Domestic Recirculating Hot Water).
 - 4) The second grouping of XXXXX indicates the room number.
 - 5) The final grouping of XXX refers to the valve number in the room.
3. Valve lists: Typed (using a word processing program) 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 of the valve list for a 3-ring notebook. A copy of the valve list shall be placed in picture frame and mounted to a wall (coordinate location with VA).
 4. Provide detailed plan for each floor of the building indicating the location and valve number for each valve. Additionally provide a hardcopy drawing and AutoCADD copy (compatible with current Fargo VA version of CADD) of valve locations.

2.5 PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

- A. In lieu of the paragraph which follows, suspended equipment support and restraints may be designed and installed in accordance with the National Uniform Seismic Installation Guidelines (NUSIG), most current edition. Submittals based on either the NUSIG guidelines or the following paragraphs of this Section shall be stamped and signed by a professional engineer registered in a state where the project is located. Support of suspended equipment over 227 kg (500 pounds) shall be submitted for approval of the VA Project Engineer in all cases.
- B. Type Numbers Specified: 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.
- C. For Attachment to Concrete Construction:
 1. Concrete insert: Type 18, MSS SP-58.
- D. 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 23mm (7/8-inch) outside diameter.

E. 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.

F. Multiple (Trapeze) Hangers: Galvanized, cold formed, lipped steel channel horizontal member, not less than 41mm by 41mm (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.

G. 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 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.

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. 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 supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.

- 3) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.
- 2. Plumbing Piping (Other Than General Types):
 - a. Horizontal piping: Type 1, 5, 7, 9, and 10.
- 3. Pre-insulated Calcium Silicate Shields:
 - a. Provide 360 degree water resistant high density 965 kPa (140 psi) compressive strength calcium silicate shields encased in galvanized metal.
 - b. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
 - c. 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.
 - c. Shields may be used on steel clevis hanger type supports, roller supports or flat surfaces.

2.6 PIPE PENETRATIONS

- A. Penetrations are not allowed through beams or ribs.
- B. 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.
- C. Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Interior openings shall be caulked tight.

2.7 TOOLS AND LUBRICANTS

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

2.8 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. Use also where insulation ends on exposed water supply pipe drop from overhead. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

2.9 ASBESTOS

- A. 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, and equipment, access provisions, and work of all trades. Locate piping, sleeves, inserts, hangers, 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.
- B. Follow manufacturer's published recommendations for installation methods not otherwise specified.
- C. 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.
- D. Equipment and Piping Support: Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations 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. 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 PE/COTR 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 PE/COTR.
 3. Do not penetrate membrane waterproofing. Pipe floor penetration block outs shall be provided outside the extents of the waterproof membrane.
- G. Interconnection of Instrumentation or Control Devices: Generally, electrical and 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 VA Project Engineer. Damaged or defective items in the opinion of the VA Project 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. 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.
- L. 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 VA Project Engineer. Locate openings that will not effect structural slabs, columns, ribs or beams.
- M. Switchgear and IRM/HUB Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear. If this is not possible, provide a drain pan with drain routed to the nearest floor drain/mop basin below the entire section of piping.
- N. 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, or without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

3.2 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.
- B. Use of chain, wire or strap hangers; wood for blocking, stays and bracing; or, hangers suspended from piping above will not be permitted. Rusty products shall be replaced.
- 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. For horizontal and vertical plumbing pipe supports, refer to the International Plumbing Code (IPC), latest edition, 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.

3.3 LUBRICATION

A. Lubricate all devices requiring lubrication prior to initial operation. Field-check all devices for proper lubrication.

3.4 PLUMBING SYSTEMS DEMOLITION

A. Rigging access, other than indicated on the drawings, shall be provided by the Contractor after approval for structural integrity by the PE/COTR. 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 plant, 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 PE or COTR with regard to rigging, safety, fire safety, and maintenance of operations.

C. Completely remove from Government property all piping, wiring, conduit, and other devices associated with the equipment not to be re-used in the new work unless specified otherwise. This includes all concrete equipment pads, 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, all pressure gages and thermometers with wells shall remain Government property and shall be removed and delivered to PE/COTR 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. Control and instrument panels shall be cleaned and damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.
 - 3. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats.
 - 4. 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 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 STARTUP AND TEMPORARY OPERATION

- A. 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.

3.8 OPERATING AND PERFORMANCE TESTS

- A. Prior to the final inspection, perform required tests as specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TESTS and submit the test reports and records to the VA Project 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.

3.9 OPERATION AND MAINTENANCE MANUALS

- A. Provide two bound copies and pdf electronic copies. Deliver to PE/COTR not less than 30 days prior to completion of a phase or final inspection.
- B. Include all new and temporary equipment and all elements of each assembly.
- C. Data sheet on each device listing model, size, capacity, pressure, speed, horsepower, impeller size, other data.
- D. Manufacturer's installation, maintenance, repair, and operation instructions for each device. Include assembly drawings and parts lists. Include operating precautions and reasons for precautions.
- E. Lubrication instructions including type and quantity of lubricant.
- F. Schematic diagrams and wiring diagrams of all control systems corrected to include all field modifications.
- G. Set points of all interlock devices.
- H. Trouble-shooting guide for the control system troubleshooting guide shall be inserted into the Operations and Maintenance Manual.
- I. Emergency procedures.

3.10 INSTRUCTIONS TO VA PERSONNEL

- A. Provide in accordance with Article, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS.

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SECTION 22 05 19
METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the requirements for water meters and pressure gages.

1.2 RELATED WORK

A. 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. Manufacturer's Literature and Data:

1. Water Meter.
2. Pressure Gages.
3. BACnet communication protocol
4. Product certificates for each type of meter and gauge

C. Operations and Maintenance manual shall include:

1. System Description
2. Major assembly block diagrams
3. Troubleshooting and preventive maintenance guidelines
4. Spare parts information.

D. Shop Drawings shall include the following:

1. One line, wiring and terminal diagrams including terminals identified, protocol or communication modules, and Ethernet connections.

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 Standards Institute (ANSI):

American Society of Mechanical Engineers (ASME): (Copyrighted Society)
 B40.1-01.....Gauges-Pressure Indicating Dial Type-Elastic

C. American Water Works Association (AWWA):

C700-07 (R 2003).....Standard for Cold Water Meters, Displacement Type, Bronze Main Case

C701-02.....Cold Water Meters-Turbine Type, for Customer Service AWWA/ ANSI

C702-01.....Cold water meters - Compound Type

D. National Association of Plumbing - Heating - Cooling Contractors
(PHCC):National Standard Plumbing Code - 1996

E. International Code Council (ICC):

IPC-06 (2007 Supplement) International Plumbing Code

1.5 AS-BUILT DOCUMENTATION

A. The electronic documentation and copies of the Operations and Maintenance Manual, approved submittals, shop drawings, and other closeout documentation shall be prepared by a computer software program complying with Section 508 of the Rehabilitation Act of 1973, as amended (29 U.S.C 794d). The manufacturer or vendor of the software used to prepare the electronic documentation shall have a Voluntary Product Accessibility Template made available for review and included as part of the Operations and Maintenance Manual or closeout documentation. All available accessibility functions listed in the Voluntary Accessibility Template shall be enabled in the prepared electronic files. As Adobe Acrobat is a common industry format for such documentation, following the document, "Creating Accessible Adobe PDF files, A Guide for Document Authors" that is maintained and made available by Adobe free of charge is recommended."

B. Four sets of manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.

C. Four sets of operation and maintenance data updated to include submittal review comments 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.

PART 2 - PRODUCTS

2.1 WATER METER

A. Turbine type, Class II, AWWA C701. Peak domestic flow shall be 300 gpm at a pressure drop less than 2 psi for the building meter and 200 gpm

at a pressure drop less than 2 psi for the make-up water meter. Local readout shall indicate in U.S. gallons. Provide auxiliary contacts on water meter for connection to Building Automation System. Meter to have the capability to report daily instantaneous usage and peak daily flow rates.

- B. Provide separate meters at building service and at water connection to cooling tower fill line.

2.2 PRESSURE GAGES FOR WATER

- A. ANSI B40.1 all metal case 114 mm (4-1/2 inches) diameter, bottom connected throughout, graduated as required for service, and identity labeled. Range shall be 415 kPa (0 to 60 psi) gauge. Pressure gauge shall be installed on incoming water service line serving the domestic water system.
- B. The pressure element assembly shall be bourdon tube. The mechanical movement shall be lined to pressure element and connected to pointer.
- C. The dial shall be non-reflective aluminum with permanently etched scale markings graduated in kPa and psi.
- D. The pointer shall be dark colored metal.
- E. The window shall be glass.
- F. The ring shall be brass or stainless steel.
- G. The accuracy shall be grade A, plus or minus 1 percent of middle half of scale range.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Comply with the PHCC National Standard Plumbing Code and manufacturers' recommendations.
- B. Direct mounted pressure gages shall be installed in piping tees with pressure gage located on pipe at the most readable position.
- C. Valves and snubbers shall be installed in piping for each pressure gage.
- D. Test plugs shall be installed on the inlet and outlet pipes all heat exchangers or water heaters serving more than one plumbing fixture.
- E. Pressure gages shall be installed where indicated on the drawings and at the following locations:
 - 1. Building water service entrance into building
- F. Water meter installation shall conform to AWWA C700, AWWA C701, and AWWA C702. Electrical installations shall conform to IEEE C2, NFPA 70

(National Electric Code), and to the requirements specified herein.
New materials shall be provided.

- G. Each water meter shall communicate with the building energy management and control system and report instantaneous daily water consumption and peak daily flow rate.

3.2 FIELD QUALITY CONTROL

- A. The meter assembly shall be visually inspected and operationally tested. The correct multiplier placement on the face of the meter shall be verified.

3.3 TRAINING

- A. A minimum two hour training course shall be provided to the Medical Center on meter configuration and maintenance. Training manuals shall be supplied for all attendee with four additional copies supplied. The training course shall cover meter configuration, troubleshooting, and diagnostic procedures.

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SECTION 22 05 23
GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. General-duty valves for domestic water and sewer systems.

1.2 RELATED WORK

A. 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. Manufacturer's Literature and Data:

1. Valves.
2. Backflow Preventers.
3. All items listed in Part 2 - Products.

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 Society for Testing and Materials (ASTM):

1.5 A536-84(R1999) E1.....Ductile Iron Castings

A. National Association of Plumbing - Heating - Cooling Contractors (PHCC):

National Standard Plumbing Code - 1996

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

SP-70-98.....Cast Iron Gate Valves, Flanged and Threaded Ends.

SP-72-99.....Ball Valves With Flanged or Butt Welding For General Purpose

SP-80-03.....Bronze Gate, Globe, Angle and Check Valves.

SP-110-96.....Ball Valve Threaded, Socket Welding, Solder Joint, Grooved and Flared Ends

PART 2 - PRODUCTS

2.1 VALVES

A. Asbestos packing is prohibited.

B. Shut-off:

1. Cold, Hot and Recirculating Hot Water:
 - a. Fifty millimeter (4 inches) and smaller:

- 1) Ball, Mss SP-72, SP-110, Type II, Class 125, Style 1, three piece or double union end construction, full ported, full flow, with solder end connections, 2750 kPa (400 psi) WOG, MSS-SP-67.

2.2 BACKFLOW PREVENTERS

- A. Provide a backflow prevention device at any point in the plumbing system where the potable water supply comes in contact with a potential source of contamination. Device shall be certified by the American Society of Sanitary Engineers. Listed below is a partial list of connection to the potable water system which shall be protected against backflow or back siphonage.
- B. Reduced Pressure Backflow Preventer: ASSE 1013.
 1. Water make-up to cooling tower and chilled water system.
- C. Atmospheric Vacuum Breaker: ASSE 1001
 1. Hose bibs and sinks w/threaded outlets.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Comply with the PHCC National Standard Plumbing Code and the following:
 1. Install valves with stem in horizontal position whenever possible. All valves shall be easily accessible. Install valve in each water connection to fixture.
 2. Install union and shut-off valve on pressure piping at connections to equipment.
 3. Backflow prevention device shall be installed in an accessible location, 5 (five) feet above finish floor. Provide drain from device to nearest floor drain.

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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.

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. Exposed: Piping and equipment exposed to view in finished areas including mechanical equipment rooms or exposed to outdoor weather. Shafts, chases, unfinished attics, crawl spaces and pipe basements are not considered finished areas.
5. FSK: Foil-scrim-kraft facing.
6. Hot: Plumbing equipment or piping handling media above 41 degrees C (105 degrees F).
7. Density: kg/m³ - kilograms per cubic meter (Pcf - pounds per cubic foot).
8. 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).
9. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).
10. 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.
11. CW: Cold water.

12. HW: Hot water.

13. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

1.2 RELATED WORK

A. 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.

B. Section 22 05 19, METERS AND GAGES FOR PLUMBING PIPING and 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).

4.3.10.2.6.7 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.

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.
 - 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

A. 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)-91.....Plastic Sheet (Sheeting): Plastic Strip; Poly
(Vinyl Chloride) and Poly (Vinyl Chloride -
Vinyl Acetate), Rigid.

C. Military Specifications (Mil. Spec.):

MIL-A-3316C (2)-90.....Adhesives, Fire-Resistant, Thermal Insulation

MIL-A-24179A (1)-87.....Adhesive, Flexible Unicellular-Plastic
Thermal Insulation

MIL-C-19565C (1)-88.....Coating Compounds, Thermal Insulation, Fire-and
Water-Resistant, Vapor-Barrier

MIL-C-20079H-87.....Cloth, Glass; Tape, Textile Glass; and Thread,
Glass and Wire-Reinforced Glass

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

B209-07.....Standard Specification for Aluminum and
Aluminum-Alloy Sheet and Plate

C411-05.....Standard 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

C534-08Standard 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

C585-09.....Standard 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

- C1126-10.....Standard 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
- E119-09C.....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
- 251-06.....Standard methods of Tests of Fire Endurance of
Building Construction Materials
- 255-06.....Standard Method of tests of Surface Burning
Characteristics of Building Materials
- F. Underwriters Laboratories, Inc (UL):
- 723.....UL 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):
- SP58-2002.....Pipe Hangers and Supports Materials, Design,
and Manufacture

PART 2 - PRODUCTS

2.1 MINERAL WOOL FIBER(NO FIBERGLASS ALLOWED)

- A. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation),
Class 1, k = 0.033 (0.23) at 24 degrees C (75 degrees F), for use at
temperatures up to 538 degrees C (1000 degrees F) with an all service
vapor retarder jacket with polyvinyl chloride premolded fitting
covering. PVC covering shall be applied to all exposed piping below 8'-
0" above finished floor. The insulation shall not contain any
formaldehyde or petroleum products.

B. No fiberglass insulation products shall be allowed. Even though fiberglass meets ASTM and other standards, it will not be approved.

2.2 FLEXIBLE ELASTOMERIC CELLULAR THERMAL

A. 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 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. 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. Provide PVC jackets on piping in all rooms below 8-feet above the finished floor.

2.4 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

Nominal Pipe Size and Accessories Material (Insert Blocks)	
Nominal Pipe Size mm (inches)	Insert Blocks mm (inches)
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).

2.5 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 or Type II: Vapor barrier compound for indoor use.
- E. ASTM C449: Mineral fiber hydraulic-setting thermal insulating and finishing cement.
- F. Other: Insulation manufacturers' published recommendations.

2.6 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.

2.7 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.

2.8 FLAME AND SMOKE

- A. 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 VA Project 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. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.
- H. 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.

3.2 INSULATION INSTALLATION

- A. 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.
 - 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 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.

B. 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. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.
3. Pipe insulation: nominal thickness in millimeters (inches as specified in the schedule at the end of this section.
4. Water meter shall be insulated with 3/4" thick foam sheet insulation. Insulation edges shall be cut straight and all joints adhered using an approved adhesive. Insulation shall be cut and formed to match the contour of the water meter. Insulation shall be installed to minimize any void between the insulation and water meter. Installation of insulation shall be a neat workmanlike manner.

3.3 PIPE INSULATION SCHEDULE

A. 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
38-60 degrees C (100-140 degrees F) (Domestic Hot Water Supply)	Mineral Wool Fiber	25 (1.0)	25 (1.0)	25 (1.0)	38 (1.5)
(4-16 degrees C (40-60 degrees F) (Domestic Cold	Mineral Wool Fiber	13 (0.5)	13(0.5)	25 (1.0)	25 (1.0)

Water)					
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**SECTION 22 11 00
FACILITY WATER DISTRIBUTION**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Domestic water systems, including piping, equipment and all necessary accessories as designated in this section.

1.2 RELATED WORK

- A. Section 09 91 00, PAINTING.
B. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
C. Section 22 07 11, PLUMBING INSULATION.

1.3 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
B. Provide a system sterilization plan for flushing, cleaning, and testing domestic water piping. Plan shall include a marked-up drawing to indicate the location of cleaning work.
C. Manufacturer's Literature and Data:
1. All items listed in Part 2 - Products.

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 Standards Institute (ANSI):
American Society of Mechanical Engineers (ASME): (Copyrighted Society)
A13.1.....Scheme for Identification of Piping Systems
B16.3-2011.....Malleable Iron Threaded Fittings Classes 150
and 300
B16.9-2007.....Factory-Made Wrought Butt Welding Fittings
B16.11-2011.....Forged Fittings, Socket-Welding and Threaded
B16.12-2009Cast Iron Threaded Drainage Fittings
B16.15-2006Cast Copper Alloy Threaded Fittings Classes 125
and 250
B16.18-2001 (R2005).....Cast Copper Alloy Solder-Joint Pressure
Fittings
B16.22-2012.....Wrought Copper and Copper Alloy Solder Joint
Pressure Fittings
B16.51-2011.....Copper and Copper Alloy Press-Connect Fittings

NSF/ANSI 61-2012.....Drinking Water System Components - Health
Effects

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

A47/A47M-99(2009).....Ferritic Malleable Iron Castings
A53/A53M-12.....Pipe, Steel, Black and Hot-Dipped, Zinc Coated
Welded and Seamless
A183-03(2009).....Carbon Steel Track Bolts and Nuts
A269-10.....Seamless and Welded Austenitic Stainless Steel
Tubing for General Service
A312/A312M-12.....Seamless, Welded, and Heavily Cold Worked
Austenitic Stainless Steel Pipes
A403/A403M-12.....Wrought Austenitic Stainless Steel Piping
Fittings
A536-84(2009).....Ductile Iron Castings
A733-03(2009)e1.....Welded and Seamless Carbon Steel and Austenitic
Stainless Steel Pipe Nipples
B32-08.....Solder Metal
B61-08.....Steam or Valve Bronze Castings
B62-09.....Composition Bronze or Ounce Metal Castings
B75/B75M-11.....Seamless Copper Tube
B88-09.....Seamless Copper Water Tube
B584-12a.....Copper Alloy Sand Castings for General
Applications
B687-99(2011).....Brass, Copper, and Chromium-Plated Pipe Nipples
D2000-12.....Rubber Products in Automotive Applications
E1120-08.....Liquid Chlorine
E1229-08.....Calcium Hypochlorite

D. American Water Works Association (AWWA):

C110/A21.10-12.....Ductile Iron and Gray Iron
C151/A21.51-09.....Ductile-Iron Pipe, Centrifugally Cast
C153/A21.53-11.....Ductile-Iron Compact Fittings
C203-08.....Coal-Tar Protective Coatings and Linings for
Steel Water Pipelines - Enamel and Tape - Hot
Applied
C213-07.....Fusion Bonded Epoxy Coating for the Interior &
Exterior of Steel Water Pipelines
C651-05.....Disinfecting Water Mains

E. American Welding Society (AWS):

A5.8/A5.8M-2011.....Filler Metals for Brazing

F. American Society of Sanitary Engineers (ASSE):

ANSI/ASSE 1001-2008.....Pipe Applied Atmospheric Type Vacuum Breakers

ANSI/ASSE 1010-2004.....Water Hammer Arresters

ANSI/ASSE 1018-2001.....Trap Seal Primer Valves - Potable Water
Supplied

ANSI/ASSE 1020-2004.....Pressure Vacuum Breaker Assembly

G. International Code Council (ICC)

ICC IPC (2012).....International Plumbing Code

H. 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

I. Plumbing and Drainage Institute (PDI):

PDI WH-201 2010.....Water Hammer Arrestor

1.5 QUALITY ASSURANCE

A. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be by the same manufacturer as the groove components.

B. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

1.6 SPARE PARTS

A. For mechanical press-connect fittings, provide tools required for each pipe size used at the facility.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Material or equipment containing any amount of lead shall not be permitted. Any equipment of material 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.

2.2 UNDERGROUND WATER SERVICE CONNECTIONS TO BUILDINGS

A. From inside face of exterior wall to a distance of approximately 5 feet (1500 mm) outside of building and underground inside building, material to be as described in following paragraph.

B. Three inches (75 mm) Diameter and Over: PVC, AWWA Pipe: AWWA C900, Class 200, with bell end with gasket, and with spigot end.

1. PVC Fabricated Fittings: AWWA C900, Class 200, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.

2.3 ABOVE GROUND WATER PIPING

A. Pipe: Copper tube, ASTM B88, Type K or L, drawn.

B. Fittings for Copper Tube:

1. Wrought copper or bronze castings conforming to ANSI B16.18 and B16.22. Unions shall be bronze, MSS SP72 & SP 110, Solder or braze joints. Use 95/5 tin and antimony for all soldered joints.
2. Grooved fittings, 2 to 6 inch (50 to 150 mm) wrought copper ASTM B75 C12200, 5 to 6 inch (125 to 150 mm) bronze casting ASTM B584, CDA 844. Mechanical grooved couplings, ductile iron, ASTM A536 (Grade 65-45-12), or malleable iron, ASTM A47 (Grade 32510) housing, with EPDM gasket, steel track head bolts, ASTM A183, coated with copper colored alkyd enamel.
3. Mechanical press-connect fittings for copper pipe and tube shall conform to the material and sizing requirements of ASME B16.51, 2 inch (50 mm) size and smaller mechanical press-connect fittings, double pressed type, with EPDM (ethylene propylene diene monomer) non-toxic synthetic rubber sealing elements and un-pressed fitting identification feature.
4. Mechanically formed tee connection: 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 ensure 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. Braze joints.

2.4 EXPOSED WATER PIPING

A. Unfinished Rooms and Mechanical Rooms: Chrome-plated brass piping is not required. Paint piping systems as specified in Section 09 91 00, PAINTING.

2.5 STRAINERS

A. Provide on high pressure side of pressure reducing valves, on suction side of pumps, on inlet side of indicating and control instruments/meters and equipment subject to sediment damage and where shown on drawings. Strainer element shall be removable without disconnection of piping.

- B. Water: Basket or "Y" type with easily removable cover and brass strainer basket.
- C. Body: Smaller than 3 inches (80 mm), brass or bronze; 3 inches (80 mm) and larger, cast iron or semi-steel.

2.6 DIELECTRIC FITTINGS

- A. Provide dielectric couplings or unions between ferrous and non-ferrous pipe.

2.7 STERILIZATION CHEMICALS

- A. Hypochlorite: ASTM E1120-08
- B. Liquid Chlorine: ASTM E1229-08

2.8 THERMOMETERS

- A. 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 may be slightly greater than shown to meet manufacturer's standard. Required ranges in degrees C (F):

Hot Water:
-1 to 116 degrees C (30 to 240 degrees F).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Comply with the International Plumbing Code and the following:
 1. Install branch piping for water from the piping system and connect to all fixtures, valves, cocks, outlets, and equipment, including those furnished by the Government or specified in other sections.
 2. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for plastic and glass, shall be reamed to full size after cutting.
 3. All pipe runs shall be laid out to avoid interference with other work.
 4. Install union and shut-off valve on pressure piping at connections to equipment.
 5. Pipe Hangers, Supports and Accessories:

- a. All piping shall be supported per the International Plumbing Code.
- b. Floor, Wall and Ceiling Plates, Supports, Hangers:
 - 1) Solid or split un-plated cast iron.
 - 2) All plates shall be provided with set screws.
 - 3) Pipe Hangers: Height adjustable clevis type.
 - 4) Adjustable Floor Rests and Base Flanges: Steel.
 - 5) Concrete Inserts: "Universal" or continuous slotted type.
 - 6) Hanger Rods: Mild, 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.
 - 7) Riser Clamps: Malleable iron or steel.
 - 8) Rollers: Cast iron.
 - 9) Self-drilling type expansion shields shall be "Phillips" type, with case hardened steel expander plugs.
 - 10) Hangers and supports utilized with insulated pipe and tubing shall have 180 degree (min.) metal protection shield centered on and welded to the hanger and support. The shield shall be 4 inches in length and be 16 gauge steel. The shield shall be sized for the insulation.
 - 11) Miscellaneous Materials: As specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. Provide all necessary auxiliary steel to provide that support.
 - 12) With the installation of each flexible expansion joint, provide piping restraints for the upstream and downstream section of the piping at the flexible expansion joint. Provide calculations supporting the restraint length design and type of selected restraints.
- 6. Install chrome plated cast brass escutcheon with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
- 7. Penetrations:
 - a. Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant as specified in Section 07 92 00.

8. Mechanical press-connect fitting connections shall be made in accordance with the manufacturer's installation instructions. Depth of insertion must be marked on the tube prior to inserting the tube into the fitting. Ensure the tube is completely inserted to the fitting stop (appropriate depth) and squared with the fitting prior to applying the pressing jaws onto the fitting. The joints shall be pressed using the tool(s) approved by the manufacturer. Minimum distance between fittings shall be in accordance with the manufacturer's requirements. When the pressing cycle is complete, visually inspect the joint to ensure the tube has remained fully inserted, as evidenced by the visible insertion mark.

B. Piping shall conform to the following:

1. Domestic Water:
 - a. Grade all lines to facilitate drainage. Provide drain valves at bottom of risers and all low points in system. Design domestic hot water circulating lines with no traps.
 - b. Connect branch lines at bottom of main serving fixtures below and pitch down so that main may be drained through fixture. Connect branch lines to top of main serving only fixtures located on floor above.

3.2 TESTS AND STERILIZATION PLAN

- A. General: Test system either in its entirety or in sections. Submit testing and sterilization plans to VA Project Engineer/COTR 21 days prior to proposed test date.
- B. Potable Water System: Test after installation of piping and domestic water heaters, but before piping is concealed, before covering is applied, and before plumbing fixtures are connected. Fill systems with water and maintain hydrostatic pressure of 150 psi (1040 kPa) gage for two hours. No decrease in pressure is allowed. Provide a pressure gage with a shutoff and bleeder valve at the highest point of the piping being tested. Tests shall be witnessed by VA COTR.
- C. All Other Piping Tests: Test new installed piping under 1-1/2 times actual operating conditions and prove tight.

3.3 STERILIZATION

- A. After tests have been successfully completed, thoroughly flush and sterilize the new interior domestic water distribution system in accordance with AWWA C651.
- B. Use liquid chlorine or hypochlorite for sterilization.

- - - E N D - - -

**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.

1.2 RELATED WORK

- A. Preparation and finish painting and identification of piping systems:
Section 09 91 00, PAINTING.
- B. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- C. Pipe Insulation: Section 22 07 11, PLUMBING INSULATION.
- D. Section 07 92 00 Joint Sealants: Sealant products.

1.3 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:
1. Piping.
 2. Trench Drains.
 3. Cleanouts.
 4. All items listed in Part 2 - Products.
- C. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane or the floor drain.

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 Society of Mechanical Engineers (ASME): (Copyrighted Society)
- A112.6.3-01 (R 2007)....Standard for Floor and Trench Drains
- A13.1-07.....Scheme for Identification of Piping Systems
- B16.3-98.....Malleable Iron Threaded Fittings, Classes 150 and 300.
- B16.4-06.....Standard for Grey Iron Threaded Fittings
Classes 125 and 250
- B16.4-98.....Cast Iron Threaded Fittings Classes 125 and 250
ANSI/ASME
- B16.12-98 (R 2006).....Cast Iron Threaded Drainage Fittings

- B16.15-06.....Cast Bronze Threaded Fittings, Classes 125 and 250
- C. American Society for Testing and Materials (ASTM):
- A47/A47M-99 (R 2004)....Standard Specification for Steel Sheet, Aluminum Coated, by the Hot Dip Process
- A53/A53M-07.....Standard Specification for Pipe, Steel, Black And Hot-Dipped, Zinc-coated, Welded and Seamless
- A74-06.....Standard Specification for Cast Iron Soil Pipe and Fittings
- A183-03.....Standard Specification for Carbon Steel Track Bolts and Nuts
- A536-84(R 2004).....Standard Specification for Ductile Iron Castings
- B32-08.....Standard Specification for Solder Metal
- B75-02.....Standard Specification for Seamless Copper Tube
- B306-02.....*Standard Specification for Copper Drainage Tube (DWV)*
- B584-06a.....Standard Specification for Copper Alloy Sand Castings for General Applications
- C564-03a.....Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
- D2000-08.....Standard Classification System for Rubber Products in Automotive Applications
- D. International Code Council:
- IPC-06.....International Plumbing Code
- E. Cast Iron Soil Pipe Institute (CISPI):
- 301-05.....Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
- 310-04.....Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
- F. American Society of Sanitary Engineers (ASSE):
- 1018-01.....Trap Seal Primer Valves - Potable, Water Supplied

PART 2 - PRODUCTS**2.1 SANITARY 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 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 Standard 301, ASTM A-888, or ASTM A-74.
4. 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 Standard C-564.

2.2 EXPOSED WASTE PIPING

- A. In unfinished rooms such as mechanical rooms, 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 860 kPa (125 psig) at a minimum temperature of 82°C (180°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 F 1545 with a pressure rating of 2070 kPa (300 psig) at 107°C (225°F). The end connection shall be male threaded. The lining shall be inert and noncorrosive polyethylene.

2.4 CLEANOUTS

- A. Same size as the pipe, up to 100 mm (4 inches); not less than 100 mm (4 inches) for larger pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. Provide a minimum clearance of 600 mm (24 inches) 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. 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/no hub cast iron ferrule. Plain end (no-hub) piping in interstitial space or above ceiling may use plain end (no-hub) blind plug and clamp.

2.5 TRAPS

- A. Provide 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 pipe connected to. Slip joints 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.

2.6 TRENCH DRAINS:

- A. Trench drains (TD-1) as shown on plans shall be modular trench drain system (6-inch internal width drain). Trench drain channels shall be pre-cast, pre-sloped and interlocking, incorporating polyester or vinylester resins and formulated aggregate. System shall include ductile iron slotted rails grates (class E - 135,000 lbs weight capacity). Grates shall lock down with 'QuickLock' fastening system.
- B. Furnish to the Owner, two (2) shovel heads with handles shaped to match channel for cleaning.

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. Unless specifically indicated on the drawings, the minimum slope shall be 2% slope.
- H. The piping shall be installed free of sags and bends.
- 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"

3.2 JOINT CONSTRUCTION

- A. 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.
- B. 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.

C. Copper tube and fittings with soldered joints shall be joined according to ASTM B828. A water flushable, lead free flux conforming to ASTM B813 and a lead free alloy solder conforming to ASTM B32 shall be used.

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, 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 shop coated with zinc chromate primer paint. 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. 80 mm or DN 80 (NPS 3 inch): 1500 mm (60 inches) with 13 mm (½ inch) rod.
 - 3. 100 mm or DN100 to 125 mm or DN125 (NPS 4 to NPS 5): 1500 mm (60 inches) with 16 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 19 mm (¾ inch) rod.
 - 5. 250 mm or DN250 to 300 mm or DN 300 (NPS 10 inch to NPS 12 inch): 1500 mm (60 inch) with 22 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 4.57 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 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. 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. Piping shall conform to the following:

1. Waste and Vent Drain to main stacks:

Pipe Size	Minimum Pitch
80 mm or DN 80 (3 inches) and smaller	2%
100 mm or DN 100 (4 inches) and larger	1%

2. Ventilation exhaust vents shall be extended separately out of the building. Sanitary vents shall not connect to any other venting system.

3.5 TESTS

A. General: Test system either in its entirety or in sections.

B. Waste Systems: Conduct before trenches are backfilled or fixtures are connected. Conduct water test or air test, as directed.

1. Water Test: If entire system is tested, tightly close all openings in pipes except highest opening, and fill system with water to point of overflow. If 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. Keep water in system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
2. Air Test: Maintain air pressure of 35 kPa (5 psi) gage for at least 15 minutes without leakage. Use force pump and mercury column gage.
3. All air and water tests shall be witnessed by the VA COR at the beginning and end of any tests.
4. 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.

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SECTION 22 33 00
ELECTRIC DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section describes the requirements for installing a complete electric domestic water heater system ready for operation including the water heaters, thermometers, and all necessary accessories, connections, and equipment.

1.2 RELATED WORK:

- A. Preparation and finish painting Section 09 91 00, PAINTING.
B. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
C. Piping, Fittings, Valves and Gages: Section 22 05 19, METERS AND GAGES FOR PLUMBING PIPING, 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING, and 22 11 00, FACILITY WATER DISTRIBUTION.

1.3 QUALITY ASSURANCE:

- A. Comply with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) for efficiency performance:
1. ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings "for commercial water heaters."
B. Electrical components, devices and accessories shall be listed and labeled B as defined in NFPA 70 by a qualified testing agency, and marked for intended location and application.
C. ASME code construction shall be a vessel fabricated in compliance with the ASME boiler and Pressure Vessel Code: Section VIII, Division 1.
D. Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61, "Drinking Water System Components - Health Effects"

1.4 SUBMITTALS:

- A. Submit manufacturer's literature and data pertaining to the water heater in properly bound package, in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Include the following as a minimum:
1. Water Heaters.
2. Pressure and Temperature Relief Valves.
3. Thermometers.
B. For each electric domestic hot water heater type and size, the following characteristics shall be submitted:
1. Rated Capacities.
2. Operating characteristics.
3. Electrical characteristics.

- 4. Furnished specialties and accessories.
- 5. A form U-1 or other documentation stating compliance with the ASME Boiler and Pressure Vessel code.
- C. Shop drawings shall include wiring diagrams for power, signal and control functions.
- D. The domestic water heater shall be certified and labeled by a testing agency.

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 National Standard Institute (ANSI):
Z21.22-00/4.4A-00.....Relief Valves for Hot Water Supply systems
- C. American Society Of Mechanical Engineers (ASME):
B1.20.1-83(R 1992).....Pipe Threads, General Purpose (Inch)
B16.5-03.....Pipe Flanges and Flanged Fittings
B16.24-01.....Cast Copper Alloy Pipe Flanges
PTC 25.3-02.....Pressure Relief Devices
Section IV-04.....Heating Boilers
Section VIII-04.....Pressure Vessels Division 1
- D. National Fire Protection Association (NFPA)
National Electrical Code
- E. Underwriters Laboratories, Inc. (UL):
Household Electric Storage Tank Water Heaters
1453-95(Amendment 1/ 1998) Water Heaters, Electric Booster and Commercial Storage Tank

1.6 AS-BUILT DOCUMENTATION

- A. The electronic documentation and copies of the Operations and Maintenance Manual, approved submittals, shop drawings, and other closeout documentation shall be in pdf and bound hardcopy format.
- B. Two sets of manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- C. Two sets of operation and maintenance data updated to include submittal review comments 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.

PART 2 - PRODUCTS

2.1 ELECTRIC WATER HEATERS:

- A. The tank construction shall be steel shell, with a inner tank liner complying with NSF 61 for barrier materials for potable water. The inner liner shall be extended into the tappings. The vessel shall be ASME Boiler and Pressure Vessel Code (BPVC), section VIII, fabricated with a pressure rating of 1035 kPa (150 psig).
- B. Tapping (openings): Factory fabricated of materials compatible with the tank and in accordance with appropriate ASME standards for piping connection, pressure and temperature relief valve, pressure gauge, thermometer, drain valve, anode rods and controls as required.
- C. Insulation: Comply with ASHRAE 90.1.
 - 1. 50-mm (2 inch) and smaller: Threaded ends according to ASME B1.20.1.
 - 2. 65-mm (2 1/2-inch) and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges, and according to ASME B 16.24.
 - 3. Provide separate 2-inch thick removable insulation jacket for installation on outside of water heater.
- D. Heating Element: double, non-simultaneous element, immersion type, thermostatically adjustable. Set thermostat for maximum water temperature of 49 degrees C (120 degrees F). Phase and voltage as shown on the drawings.
- E. The domestic hot water heaters shall have screw in or bolt in immersion type, thermostatically adjustable. Set thermostat for maximum water temperature of 49°C (120°F). The electrical characteristics are scheduled on the drawings.
- F. Combination Pressure and Temperature Relief Valves: ASME rated, constructed of all brass or bronze with a self-closing reseating valve. Pressure setting shall be less than water heater working pressure, and relieving capacity shall not be less than heat input.
- G. The anode rod shall be replaceable magnesium.
- H. The drain valve shall be corrosion resistant metal complying with ASSE 1005.

2.2 THERMOMETERS:

- A. Electric Water Heaters: Straight stem, iron case, red liquid-filled thermometers, approximately 175 mm (7 inches) high, 4 to 115 degrees C

(40 to 240 degrees F). Install in hot water pipe close to outlet of tank.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Install water heaters level and plumb.
- B. Install and connect water heaters in accordance with manufacturer's written instructions.
- C. Pipe all pressure and temperature relief valves discharge to nearby floor drains.
- D. Install thermometers on water heater inlet and outlet piping.
- E. Set the thermostats for a maximum setting of 49 degrees C (120 degrees F).
- F. All manufacturers' required clearances shall be maintained.
- G. A combination temperature and pressure relief valve shall be installed at the top portion of the storage tank. The sensing element shall extend into the tank. The relief valve outlet drain piping shall discharge by positive air gap into a floor drain.
- H. Piping type heat traps shall be installed on the inlet and outlet piping of the electric domestic hot water heater storage tanks.
- I. Water heater drain piping shall be installed as indirect waste to spill by positive air gap into open drains or over floor drains. Hose end drain valves shall be installed at low points in water piping for electric domestic hot water heaters without integral drains.

3.2 STERILIZATION

- A. After tests have been successfully completed, thoroughly flush and sterilize the new interior domestic water heater in accordance with AWWA C651.
- B. Use liquid chlorine or hypochlorite for sterilization.
- C. Refer to 22 11 00 for testing and sterilization plan.

3.3 LEAKAGE TEST:

- A. Before piping connections are made, test water heaters with hydrostatic pressure of 1375 kPa (200 psi and 240 psi for a unit with a MAWP of 160 psi. Correct any leakage or replace water heater and retest at no additional cost to the VA.

3.4 PERFORMANCE TEST:

- A. Ensure that all of the remote water outlets will have a minimum of 48 degrees C (118 degrees F) and a maximum of 50 degrees C (122 degrees F) water flow at all times. If necessary, reset the thermostat to make the system comply with design requirements.

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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
A112.19.1M-08.....Enameled Cast Iron Plumbing fixtures
A112.19.2M-03.....Vitreous China Plumbing Fixtures
A112.19.3-2001(R2008)...Stainless Steel Plumbing fixtures (Designed for
Residential Use)
- C. American Society for Testing and Materials (ASTM):
A276-2010.....Stainless and Heat-Resisting Steel Bars and
Shapes
- D. National Association of Architectural Metal Manufacturers (NAAMM): NAAMM
AMP 500-505
Metal Finishes Manual (1988)
- E. American Society of Sanitary Engineers (ASSE):
1016-05.....Performance Requirements for Individual
Thermostatic, Pressure Balancing and Combination
Pressure Balancing and Thermostatic Control
Valves for Individual Fixture Fittings

F. 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

G. American with Disabilities Act(A.D.A) Section 4-19.4 Exposed Pipes
and Surfaces

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

I. International Building Code, ICC IPBC 2009.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Material or equipment shall not contain any lead 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.

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. Locate stops centrally above or below fixture in accessible location.

B. Furnish keys for lock shield stops to VA Project 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.

2.4 ESCUTCHEONS

A. 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 EMERGENCY FIXTURES

A. (P-707) Emergency Shower and Eye and Face Wash (Free Standing):

1. Shower Head: Polished chrome plated, 200 mm (8 inches) in diameter, install head 2100 mm (84 inches) above floor. Equip with stay-open ball valve, chrome plated. Operate valve with 600 mm (24-inch) stainless steel pull-rod with triangle handle. Pull-down opens valve; push-up closes valve.
2. Emergency Eye and Face Wash: CRS receptor. Equipment with a 15 mm (1/2-inch) stay open ball valve operated by push flag handle. Mount eye and face wash spray heads 1065 mm (42 inches) above finished floor.
3. Shower head and emergency eye and face wash shall be mounted to stanchion with floor flange through floor waste connection and P-trap. Paint stanchion same color as room interior. Provide thermostatic mixing valve for each shower/eye wash. Controller shall be rough bronze finished thermostatic mixing valve with thermometers. Discharge temperature shall be set at 85°F. Provide stops and check valves for installation.

2.6 HYDRANT, HOSE BIBB AND MISCELLANEOUS DEVICES

- A. (P-801) Wall Hydrant: Cast bronze non-freeze hydrant with detachable T-handle. Brass operating rod within casing of bronze pipe of sufficient length to extend through wall and place valve inside building. Brass valve with coupling and union elbow having metal-to-metal seat. Valve rod and seat washer removable through face of hydrant; 20 mm (3/4-inch) hose thread on spout; 20 mm (3/4-inch) pipe thread on inlet. Finish may be rough; exposed surfaces shall be chrome plated. Set not less than 460 mm (1-1/2 feet) nor more than 920 mm (36 inches) above grade. On porches and platforms, set approximately 760 mm (30 inches) above finished floor. Provide integral vacuum breaker which automatically drains when shut off.
- B. (P-802) Hose Bibb (Combination Faucet, Wall Mounted to Exposed Supply Pipes): Cast or wrought copper alloy, combination faucet with replaceable monel seat, removable replacement unit containing all parts subject to wear, mounted on wall 914 mm (36 inches) above floor to supply pipes. Provide faucet without top or bottom brace and with 20 mm (3/4-inch) hose coupling threads on spout, integral stops and vacuum breaker. Design valves with valve disc arranged to eliminate rotation on seat. Four-arm handles on faucets shall be cast, formed or drop forged copper alloy. Escutcheons shall be either forged copper alloy or CRS.

Exposed metal parts, including exposed part under valve handle when in open position, shall have a bright finish.

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. Tightly cover and protect fixtures and equipment against dirt, water and chemical or mechanical injury.
- D. Where waste pipe has to be offset due to beam interference, provide correct and additional piping necessary to eliminate relocation of fixture.

3.2 CLEANING

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

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SECTION 23 00 60
HVAC DEMOLITION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the demolition and removal of chillers, piping, piping insulation and accessories, air movement fans, and ductwork in existing building and at existing chiller plant.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and equipment for patching and extending work: As specified in individual Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify field measurements and existing ductwork arrangements are as shown on drawings.
- B. Verify that abandoned equipment serve only abandoned facilities.
- C. Demolition drawings are based on casual field observation and existing record documents. The demolition drawings are diagrammatic and show the general scope of demolition work and do not show all the construction detail of the original record drawings. Report discrepancies to the VA Project Engineer before disturbing existing installations.
- D. The contractor shall visit the existing building and grounds and review the existing building record drawings for details of existing installation to familiarize himself with existing conditions prior to submitting bid. No allowance will be made subsequently, in this connection, on behalf of the contractor for any error or negligence on his part.
- E. Beginning of demolition means the contractor accepts existing conditions.

3.2 PREPARATION

- A. Disconnect mechanical systems in areas scheduled for removal. Notify the VA Project Engineer of areas to be affected by mechanical demolition work prior to commencing.

3.3 DEMOLITION AND EXTENSION OF EXISTING MECHANICAL WORK

- A. Demolish and remove from site, and extend existing mechanical work under provisions of this division and as indicated on the drawings unless otherwise noted.

- B. Unless otherwise noted on the drawings, all salvage items removed in connection with this contract are to become the property of the contractor. Salvage items noted to remain the property of the VA shall be delivered to a location to be designated by the VA Project Engineer. Contractor shall remove from construction areas all trash or debris as it accumulates and dispose of it off campus at no additional cost to the VA. All construction areas shall be kept clean, safe, and orderly at all times. At the completion and acceptance for work, contractor shall remove from the site all debris and surplus materials resulting from this work and dispose of them off campus at no additional cost to the VA.
- C. The existing chillers called to be removed on plan shall be sold back to the equipment supplier. The reimbursement cost shall be included in the project bid.
- D. Remove, relocate, and extend existing installations to accommodate new construction as required for proper installation and system operation.
- E. Remove all accessories above grade.
- F. Seal all existing roof penetrations, which will not be reused.
- G. Remove, relocate or provide brackets, hangers, and other accessories as required.
- H. Repair adjacent construction and finishes damaged during demolition and extension work.
- I. Maintain access to existing mechanical installations, which remain active.
- J. The contractor shall remove diffusers, ductwork, and their appurtenances no longer required unless otherwise noted.
- K. All controls demolition shall include all conduit, wiring, tubing, cables, programming, devices, etc.

3.4 CLEANING AND REPAIR

- A. Clean and repair existing materials and equipment, which remain or are to be returned to the VA Project Engineer.
- B. All building surfaces damaged and openings left by new work or the removal or relocation of mechanical equipment, shall be repaired to original condition and painted by the contractor.

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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. PE: VA Project Engineer
 - 4. COR: Contracting Officer's Representative.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES
- C. Section 31 20 00, EARTH WORK: Excavation and Backfill
- D. Section 03 30 00, CAST-IN-PLACE CONCRETE: Concrete and Grout
- E. Section 07 92 00, JOINT SEALANTS
- F. Section 09 91 00, PAINTING
- G. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC
- H. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT
- I. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC
- J. Section 23 07 11, HVAC Insulation
- K. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC
- L. Section 23 21 13, HYDRONIC PIPING
- M. Section 23 21 23, HYDRONIC PUMPS
- N. Section 23 25 00, HVAC WATER TREATMENT
- O. Section 23 31 00, HVAC DUCTS and CASINGS and BLOWER COIL UNITS
- P. Section 23 34 00, HVAC FANS
- Q. Section 23 64 00, PACKAGED WATER CHILLERS
- R. Section 23 64 10, MODULAR CHILLER PLANT
- S. Section 23 65 00, COOLING TOWERS
- T. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training
- U. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

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 or steam boiler plant construction, as applicable.

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. 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.
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 Contracting Officers Technical Representative (COTR).
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. HVAC Mechanical Systems Welding: Before any welding is performed, contractor shall submit a certificate certifying that welders comply with the following requirements:

1. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualifications".
2. Comply with provisions of ASME B31 series "Code for Pressure Piping".
3. Certify that each welder has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.

G. 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 PE/COTR for resolution. Provide written hard copies or computer files of manufacturer's installation instructions to the PE/COTR 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.

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 installation.
- F. Samples: Samples will not be required, except for insulation or where materials offered differ from specification requirements. Samples shall be accompanied by full description of characteristics different from specification. The Government, at the Government's expense, will perform evaluation and testing if necessary. The Contractor may submit samples of additional material at the Contractor's option; however, if additional samples of materials are submitted later, pursuant to Government request, adjustment in contract price and time will be made as provided under Article CHANGES of Section 00 72 00, GENERAL CONDITIONS.
- 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 VA Project Engineer.
 - 2. Submit electric motor data and variable speed drive data with the driven equipment.
 - 3. Equipment and materials identification.
 - 4. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.
 - 5. 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 and Refrigeration Institute (ARI):
430-99.....Central Station Air-Handling Units
- C. American National Standard Institute (ANSI):
B31.1-2004.....Power Piping
- D. Rubber Manufacturers Association (ANSI/RMA):
IP-20-2007.....Drives Using Classical V-Belts and Sheaves
IP-21-1991(1997).....Drives Using Double-V (Hexagonal) Belts
IP-22-2007.....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 IX-2007.....Welding and Brazing Qualifications
Code for Pressure Piping:
B31.1-2004.....Power Piping, with Amendments
- G. American Society for Testing and Materials (ASTM):
A36/A36M-05.....Carbon Structural Steel
A575-96(2002).....Steel Bars, Carbon, Merchant Quality, M-Grades R
(2002)
E84-07.....Standard Test Method for Burning Characteristics
of Building Materials
E119-07.....Standard Test Method for Fire Tests of Building
Construction and Materials

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

SP-58-2002.....Pipe Hangers and Supports-Materials, Design and Manufacture

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-1-2006 Motors and Generators

J. National Fire Protection Association (NFPA):

70-08.....National Electrical Code

90A-02.....Installation of Air Conditioning and Ventilating Systems

101-06.....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 PE/COTR. 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. Phasing of Work: Comply with all requirements shown on drawings or specified.
- D. 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.
- E. 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

- 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 plant that conforms to contract requirements.

2.3 BELT DRIVES

- A. Type: ANSI/RMA standard V-belts with proper motor pulley and driven sheave. Belts shall be constructed of reinforced cord and rubber.
- B. Dimensions, rating and selection standards: ANSI/RMA IP-20 and IP-21.
- C. Minimum Horsepower Rating: Motor horsepower plus recommended ANSI/RMA service factor (not less than 20 percent) in addition to the ANSI/RMA allowances for pitch diameter, center distance, and arc of contact.
- D. Maximum Speed: 25 m/s (5000 feet per minute).
- E. Adjustment Provisions: For alignment and ANSI/RMA standard allowances for installation and take-up.
- F. Drives may utilize a single V-Belt (any cross section) when it is the manufacturer's standard.
- G. Multiple Belts: Matched to ANSI/RMA specified limits by measurement on a belt measuring fixture. Seal matched sets together to prevent mixing or partial loss of sets. Replacement, when necessary, shall be an entire set of new matched belts.
- H. Sheaves and Pulleys:
 - 1. Material: Pressed steel, or close grained cast iron.
 - 2. Bore: Fixed or bushing type for securing to shaft with keys.
 - 3. Balanced: Statically and dynamically.
 - 4. Groove spacing for driving and driven pulleys shall be the same.
- I. Drive Types, Based on ARI 435:
 - 1. Provide adjustable-pitch or fixed-pitch drive as follows:
 - a. Fan speeds up to 1800 RPM: 7.5 kW (10 horsepower) and smaller.
 - b. Fan speeds over 1800 RPM: 2.2 kW (3 horsepower) and smaller.
 - 2. Provide fixed-pitch drives for drives larger than those listed above.
 - 3. The final fan speeds required to just meet the system CFM and pressure requirements, without throttling, shall be determined by

adjustment of a temporary adjustable-pitch motor sheave or by fan law calculation if a fixed-pitch drive is used initially.

2.4 DRIVE GUARDS

- A. For machinery and equipment, provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor to prevent damage to equipment and injury to personnel. Drive guards may be excluded where motors and drives are inside factory fabricated air handling unit casings.
- B. 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 6 mm (1/4-inch) bolts. Reinforce guard as necessary to prevent side play forcing guard onto couplings.
- C. V-belt and sheave assemblies shall be totally enclosed, firmly mounted, non-resonant. Guard shall be an assembly of minimum 22-gage sheet steel and expanded or perforated metal to permit observation of belts. 25 mm (one-inch) diameter hole shall be provided at each shaft centerline to permit speed measurement.
- D. Materials: Sheet steel, cast iron, expanded metal or wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.
- E. Access for Speed Measurement: 25 mm (One inch) diameter hole at each shaft center.

2.5 LIFTING ATTACHMENTS

- A. Provide equipment 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 ELECTRIC MOTORS

- A. All material and equipment furnished and installation methods shall conform to the requirements of Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT; Section 26 29 11, MOTOR CONTROLLERS; and, Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide special energy efficient premium efficiency type motors as scheduled. The mechanical contractor shall provide all motor starters for all motors that are not listed with variable speed controllers.

2.7 VARIABLE SPEED MOTOR CONTROLLERS

- A. Refer to Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS and Section 26 29 11, MOTOR CONTROLLERS for specifications.
- B. The combination of controller and motor shall be provided by the manufacturer of the driven equipment, such as pumps and fans, and shall be rated for 100 percent output performance. Multiple units of the same class of equipment, i.e. air handlers, fans, pumps, shall be product of a single manufacturer.
- C. Motors shall be energy efficient type and be approved by the motor controller manufacturer. The controller-motor combination shall be guaranteed to provide full motor nameplate horsepower in variable frequency operation. Both driving and driven motor/fan sheaves shall be fixed pitch.
- D. Controller shall not add any current or voltage transients to the input AC power distribution system, DDC controls, sensitive medical equipment, etc., nor shall be affected from other devices on the AC power system.
- E. Controller shall be provided with the following operating features and accessories:
 - 1. Suitable for variable torque load.
 - 2. Provide thermal magnetic circuit breaker or fused switch with external operator and incoming line fuses. Unit shall be rated for minimum 30,000 AIC. Provide AC input line reactors (3% impedance) on incoming power line. Provide output line reactors on line between drive and motor where the distance between the breaker and motor exceeds 50 feet.

2.8 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 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. Coordinate the valve tags with the Shops Foreman prior to installation for compliance.

a. Valve number shall be labeled as follows: M-V-XXX-XXXXX-XXX.

- 1) The first letter of the valve tag refers to the building number. M refers to Main Hospital.
 - 2) V stands for "Valve."
 - 3) The first grouping of XXX indicates the type of piping. Refer to 09 91 00 Painting specification for labels for different types of piping (i.e. HWH is Hot Water Heating, DC is Domestic Cold Water, DH is Domestic Hot Water, and DR is Domestic Recirculating Hot Water).
 - 4) The second grouping of XXXXX indicates the room number.
 - 5) The final grouping of XXX refers to the valve number in the room.
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. Additionally, provide a hardcopy drawing and AutoCADD copy (version compatible with Fargo VA current version of CADD) of valve locations.

2.9 GALVANIZED REPAIR COMPOUND

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

2.10 HVAC PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

- A. Vibration Isolators: Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- 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.
- D. 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.

E. 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.

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.

F. Supports for Piping Systems:

1. Select hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC 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:
 - 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 copper to prevent electrolysis.
 - 2) For vertical runs use copper 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.

G. 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.

2.11 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 structural members..
- D. Sheet Metal 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 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 in drywall construction.
- I. Sleeve Clearance: Sleeve through floors 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.

2.12 SPECIAL TOOLS AND LUBRICANTS

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

2.13 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 in exposed locations. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

2.14 ASBESTOS

- A. 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, lights, 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 PE/COR 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 PE/COR.
 - 3. Do not penetrate membrane waterproofing.
- F. Interconnection of Instrumentation or Control Devices: Generally, electrical 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 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 VA Project Engineer. Damaged or defective items in the opinion of the VA Project 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. Concrete and Grout: Use concrete and shrink compensating grout 25 MPa (3000 psi) minimum, specified in Section 03 30 53, CAST-IN-PLACE CONCRETE.
- K. 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.
- L. 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 VA Project Engineer. Locate openings that will not affect structural slabs, columns, ribs or beams.
- M. Switchgear/Electrical Equipment and OI&T/IRM/HUB Rooms and Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear. If this is not possible, drip pans shall be installed below piping to protect electrical and telephone switchgear. Provide a drain line from the drain pan to the nearest floor drain or mop basin. 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).
- N. 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, or without climbing or crawling under or over obstacles such as 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 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 Para. 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 RIGGING

- A. Design is based on application of available equipment. Openings in building structures are planned to accommodate design scheme.
- B. Alternative methods of equipment delivery may be offered by Contractor and will be considered by Government under specified restrictions of phasing and maintenance of service as well as structural integrity of the building.
- C. Close all openings in the building 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 offer 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 PE/COTR for evaluation prior to actual work.
- G. Restore building to original condition upon completion of rigging 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. Do not drill or burn holes in structural steel. Notify the structural engineer prior to work being done in order for support plan to be approved.
- 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.
- G. Floor Supports:
 - 1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Anchor and dowel concrete bases and structural systems to resist forces under operating conditions without excessive displacement or structural failure.
 - 2. Do not locate or install bases and supports until equipment mounted thereon has been approved. Size bases to match equipment mounted thereon plus 50 mm (2 inch) excess on all edges. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top.

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 granular material to permit alignment and realignment.

3.5 MECHANICAL DEMOLITION

- A. Rigging access, other than indicated on the drawings, shall be provided by the Contractor after approval for structural integrity by the PE/COTR. Such access shall be provided without additional cost or time to the Government.
- 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 PE 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 PE/COTR 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.

3.6 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. 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. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.
 - 3. 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.

3.7 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.

3.8 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.

3.9 LUBRICATION

- A. Lubricate all devices requiring lubrication prior to initial operation. Field-check all devices for proper lubrication.
- B. Equip all devices with required lubrication fittings or devices.
- C. Provide any specialized grease gun(s) with attachments for applicable fittings for each type of grease applied.

- D. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.

3.10 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 specifications 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.

3.11 STARTUP AND TEMPORARY OPERATION

- A. 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.

3.12 OPERATING AND PERFORMANCE TESTS

- A. Prior to the final inspection, perform required tests as specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TESTS, and submit the test reports and records to the PE/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 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.

3.13 INSTRUCTIONS TO VA PERSONNEL

- A. Provide in accordance with Article, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS.

- - - E N D O F S E C T I O N - - -

SECTION 23 05 12
GENERAL MOTOR REQUIREMENTS FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies the furnishing, installation and connection of motors for HVAC equipment.

1.2 RELATED WORK:

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements common to more than one Section of Division 26.
- B. Section 26 29 11, MOTOR CONTROLLERS: Starters, control and protection for motors.
- C. Other sections specifying motor driven equipment in Division 23.
- D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- E. Section 23 21 23, HYDRONIC PUMPS.
- F. Section 23 34 00, HVAC FANS.
- G. Section 23 64 00, PACKAGED WATER CHILLERS.
- H. Section 23 64 10, MODULAR CHILLER PLANT.
- I. Section 23 65 00, COOLING TOWERS.
- J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.3 SUBMITTALS:

- A. In accordance with Section, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Shop Drawings:
1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 2. Include electrical ratings, dimensions, mounting details, materials, horsepower, 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 maintenance and operating manuals, including technical data sheets and application data.
- D. Certification: Two weeks prior to final inspection, unless otherwise noted, submit two copies of the following certification to the VA Project 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.

1.4 APPLICABLE PUBLICATIONS:

A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. National Electrical Manufacturers Association (NEMA):

MG 1-98.....Motors and Generators

MG 2-01.....Safety Standard and Guide for Selection,
Installation and Use of Electric Motors and
Generators

C. National Fire Protection Association (NFPA):

70-02.....National Electrical Code (NEC)

D. Institute of Electrical and Electronics Engineers (IEEE):

112-04.....Standard Test Procedure for Polyphase Induction
Motors and Generators

E. American Society of Heating, Refrigerating and Air-Conditioning
Engineers (ASHRAE):

90.1-2007.....Energy 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, MOTOR CONTROLLERS; and Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. 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.

1. Contractor's Option - Electrically Commutated Motor (EC Type): Motor shall be brushless DC type specifically designed for applications with heavy duty ball bearings and electronic commutation. The motor shall be speed controllable 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.
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: 230/460 volts, dual connection.
 - c. Motors, 74.6 kW (100 HP) or larger, connected to 480-volt systems: 460 volts.

F. Number of phases shall be as follows:

1. Motors, less than (3/4 HP or as scheduled): Single phase.
2. Motors, (3/4 HP or as scheduled) 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.

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 511 classified 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.
 - b. Other wiring 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 or as stipulated by ASHRAE 90.1-2010 (whichever is more stringent). 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:

A. 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.

3.3 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with VA Project Engineer and Commissioning Agent. Provide a minimum of 21 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 two hours to instruct VA personnel in operation and maintenance of units.

- - - E N D O F S E C T I O N - - -

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

PART 1 - GENERAL

1.1 DESCRIPTION

- A. 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.
 C. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
 D. Section 23 64 10, MODULAR CHILLER PLANT

1.3 QUALITY ASSURANCE

- A. Refer to article, QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
 B. Noise Criteria:
 1. Noise levels in all 8 octave bands due to equipment and duct systems shall not exceed following NC levels:

TYPE OF ROOM	NC LEVEL
Chiller Plant	55

2. 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.

- C. 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
 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-09.....Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- A307-07b.....Standard 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-58-2009.....Pipe Hangers and Supports-Materials, Design and Manufacture
- E. Occupational Safety and Health Administration (OSHA):
- 29 CFR 1910.95.....Occupational Noise Exposure

F. American Society of Civil Engineers (ASCE):

ASCE 7-10Minimum Design Loads for Buildings and Other
Structures.

G. International Code Council (ICC):

2009 IBC.....International Building Code.

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 VIBRATION ISOLATORS

- A. Floor Mountings:
 - 1. Spring Isolators with Vertical Limit Stops (Type SP): Similar to spring isolators noted above, except include a vertical limit stop to limit upward travel if weight is removed and also to reduce movement and spring extension due to wind loads. Provide clearance around restraining bolts to prevent mechanical short circuiting.
 - 2. Pads (Type D): Pads shall be natural rubber or neoprene waffle. Size pads for a maximum load of 345 kPa (50 pounds per square inch).

2.3 BASES

- A. Integral Structural Steel Base (Type B): Design base with isolator brackets to reduce mounting height of equipment which require a complete supplementary rigid base. To assure adequate stiffness, height

of members shall be a minimum of 1/12 of longest base dimension, but not less than 100 mm (four inches).

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.

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.

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.

- - E N D - - -

SELECTION GUIDE FOR VIBRATION ISOLATORS

EQUIPMENT	ON GRADE			20FT FLOOR SPAN			30FT FLOOR SPAN			40FT FLOOR SPAN			50FT FLOOR SPAN		
	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL
REFRIGERATION MACHINES															
OPEN CENTRIFUGAL	B	D	0.3	B	SP	0.8	---	SP	1.5	B	SP	1.5	B	SP	3.5
COOLING TOWERS															
UP TO 500 RPM	---	---	---	---	SP	2.5	---	SP	2.5	---	SP	2.5	---	SP	3.5
501 RPM & OVER	---	---	---	---	SP	0.75	---	SP	0.75	---	SP	1.5	---	SP	2.5

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. Sound measurements.
7. Recording and reporting results.

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.

Hydronic Systems: Includes chilled water and glycol-water systems.

a. Air Systems: Includes all outside air, supply air, return air, exhaust air and relief air systems.

b. Flow rate tolerance: The allowable percentage variation, minus to plus, of actual flow rate from values (design) in the contract documents.

1.2 RELATED WORK

A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General Mechanical Requirements.

B. Section 23 07 11, HVAC INSULATION: Piping and Equipment Insulation.

C. Section 23 64 00, PACKAGED WATER CHILLERS: Testing Refrigeration Equipment.

D. Section 23 65 00, COOLING TOWERS: Cooling Tower Performance Testing.

E. Section 23 31 00, HVAC DUCTS AND CASINGS: Duct Leakage.

F. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Controls and Instrumentation Settings.

- G. Section 23 34 00, HVAC FANS
- H. Section 23 21 23, HYDRONIC PUMPS
- I. Section 23 37 00, AIR OUTLETS AND INLETS
- J. Section 23 21 13, HYDRONIC PIPING
- K. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS. Requirements for commissioning, systems readiness checklists, and training
- L. Section 23 05 12 GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT

1.3 QUALITY ASSURANCE

- A. Refer to Articles, Quality Assurance and Submittals, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- 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 VA Project 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 VA Project 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 VA Project 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.
 - a. Blower coil unit and all other fans, cubic meters/min (cubic feet per minute): Minus 0 percent to plus 10 percent.
 - b. Exhaust fan: 0 percent to plus 10 percent.
 - c. Chilled water pumps: Minus 0 percent to plus 5 percent.
 - d. Chilled water coils: Minus 0 percent to plus 5 percent.
3. Systems shall be adjusted for energy efficient operation as described in PART 3.

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. Submit Following for Review and Approval:
 1. Design Review Report after the system layout on air and water side is completed by the Contractor.
 2. Systems inspection report on equipment and installation for conformance with design.
 3. Systems Readiness Report.
 4. Final TAB reports covering flow balance and adjustments and performance tests.
 5. Include in final reports uncorrected installation deficiencies noted during TAB and applicable explanatory comments on test results that differ from design requirements.
- D. 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):

2002.....AABC 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

A. Provide plastic plugs to seal holes drilled in ductwork for test
purposes. The plastic plugs shall be caulked in place to completely
seal the holes.

2.2 INSULATION REPAIR MATERIAL

A. See Section 23 07 11, HVAC 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

A. The TAB Specialist shall review the contract plans and specifications
and advise the VA Project 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.

3.4 DUCT AIR LEAKAGE TEST REPORT

- A. TAB Agency shall perform the leakage test as outlined in "Duct leakage Tests and Repairs" in Section 23 31 00, HVAC DUCTS and CASINGS for TAB agency's role and responsibilities in witnessing, recording and reporting of deficiencies.

3.5 SYSTEM READINESS REPORT

- A. Inspect each system to ensure that it is complete including installation and operation of controls. Submit report to PE in standard format.
- B. Verify that all items such as ductwork, piping, ports, terminals, connectors, etc., that is required for TAB are installed. Provide a report to the VA Project Engineer.

3.6 TAB REPORTS

- A. Submit report for systems and equipment tested and balanced to establish satisfactory test results.
- B. The TAB contractor shall provide raw data immediately in writing to the VA Project Engineer if there is a problem in achieving intended results before submitting a formal report.

3.7 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 and motor loads 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 each phase of the project prior to partial final inspections of each phase of the project.
- D. Allow sufficient time in construction schedule for TAB and submission of all reports for an organized and timely correction of deficiencies.
- E. Air Balance and Equipment Test: Include blower coil units, supply fans, exhaust fans, and room outlets/inlets.
 - 1. Artificially load air filters by partial blanking to produce air pressure drop of manufacturer's recommended pressure drop.
 - 2. Adjust fan speeds to provide design air flow. V-belt drives, including fixed pitch pulley requirements, are specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
 - 3. 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.
 - 4. Record final measurements for air handling equipment performance data sheets.
- F. Water Balance and Equipment Test: Include circulating pumps, chillers, each flow measuring device including coils, and condensers:
 - 1. Coordinate water chiller flow balancing with Section 23 64 00, PACKAGED WATER CHILLERS.
 - 2. Adjust flow rates for equipment. Set coils to values on equipment submittals, if different from values on contract drawings.
 - 3. Primary-secondary (variable volume) systems: Coordinate TAB with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. Balance systems at design water flow and then verify that variable flow controls function as designed.
 - 4. 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) for air handling units and reheat coils. Make air and water temperature measurements at the same time.

3.8 SOUND TESTING

- A. Perform and record required sound measurements.
 - 1. Provide cooling tower sound measurements. Refer to Section 23 65 00, COOLING TOWERS for requirements.

- B. Take measurements with a calibrated sound level meter and octave band analyzer of the accuracy required by AABC or NEBB.
- C. Sound reference levels, formulas and coefficients shall be according to ASHRAE Handbook, "HVAC Applications", Chapter 46, SOUND AND VIBRATION CONTROL.
- D. Determine compliance with specifications as follows:

1. When sound pressure levels are specified:

- a. Reduce the background noise as much as possible by shutting off unrelated audible equipment.
- b. Measure octave band sound pressure levels with specified equipment "off."
- c. Measure octave band sound pressure levels with specified equipment "on."
- d. Use the DIFFERENCE in corresponding readings to determine the sound pressure due to equipment.

DIFFERENCE:	0	1	2	3	4	5 to 9	10 or More
FACTOR:	10	7	4	3	2	1	0

- e. Sound pressure level due to equipment equals sound pressure level with equipment "on" minus FACTOR.
 - f. Plot octave bands of sound pressure level due to equipment for typical rooms on a graph which also shows noise criteria (NC) curves.
2. When sound power levels are specified:
- a. Perform steps 1.a. thru 1.d., as above.
 - b. For outdoor equipment: Use directivity factor and distance from noise source to determine distance factor, i.e., difference between sound power level and sound pressure level. Measured sound power level will be the sum of sound pressure level due to equipment plus the distance factor. Use 10 meters (30 feet) for sound level location.
3. Where sound pressure levels are specified in terms of dB(A), as in Section 23 65 00, COOLING TOWERS, measure sound levels using the "A" scale of meter. Single value readings will be used instead of octave band analysis.

- E. Where measured sound levels exceed specified level, the installing contractor or equipment manufacturer shall take remedial action

approved by the VA Project Engineer and the necessary sound tests shall be repeated.

- F. Test readings for sound testing could go higher than 5 percent if determination is made by the VA Project Engineer based on the recorded sound data.

3.9 MARKING OF SETTINGS

- A. Following approval of TAB final report, the setting of all HVAC adjustment devices including 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 VA Project Engineer.

3.10 IDENTIFICATION OF TEST PORTS

- A. 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.

3.11 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.

3.12 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 INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Field applied insulation for thermal efficiency and condensation control for:

1. HVAC piping and 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).
8. Density: kg/m³ - 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. GC: Chilled glycol-water supply.
14. GCR: Chilled glycol-water return.

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.
- B. Section 23 21 23, HYDRONIC PUMPS
- C. Section 23 21 13, HYDRONIC PIPING: Piping and equipment.
- D. Section 23 31 00, HVAC DUCTS AND CASINGS: Ductwork, plenum and fittings.
- E. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS. Requirements for commissioning, systems readiness checklists, and training.
- F. Section 23 64 10, MODULAR CHILLER PLANT

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 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.

4.3.3.6 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.

4.3.10.2.6.6 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.
- C. Samples:
1. Each type of insulation: Minimum size 100 mm (4 inches) square for board/block/blanket; 150 mm (6 inches) long, full diameter for round types.

2. Each type of facing and jacket: Minimum size 100 mm (4 inches square).
3. Each accessory material: Minimum 120 ML (4 ounce) liquid container or 120 gram (4 ounce) dry weight for adhesives/cement/mastic.

1.5 STORAGE AND HANDLING OF MATERIAL

- A. 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)- 99.....Plastic Sheet (Sheeting): Plastic Strip; Poly (Vinyl Chloride) and Poly (Vinyl Chloride - Vinyl Acetate), Rigid.
- C. Military Specifications (Mil. Spec.):
 - MIL-A-3316C (2)-90.....Adhesives, Fire-Resistant, Thermal Insulation
 - MIL-A-24179A (1)-87.....Adhesive, Flexible Unicellular-Plastic Thermal Insulation
 - MIL-C-19565C (1)-88.....Coating Compounds, Thermal Insulation, Fire-and Water-Resistant, Vapor-Barrier
 - MIL-C-20079H-87.....Cloth, 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
 - B209-07.....Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
 - C411-05.....Standard 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
- C1126-04.....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
- E136-09b.....Standard Test Methods for Behavior of Materials
in a Vertical Tube Furnace at 750 degrees C
(1380 F)
- E. National Fire Protection Association (NFPA):
- 90A-09.....Standard for the Installation of Air
Conditioning and Ventilating Systems
- 96-08.....Standards for Ventilation Control and Fire
Protection of Commercial Cooking Operations
- 101-09.....Life Safety Code

251-06.....Standard methods of Tests of Fire Endurance of
Building Construction Materials

255-06.....Standard Method of tests of Surface Burning
Characteristics of Building Materials

F. Underwriters Laboratories, Inc (UL):

723.....UL 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):

SP58-2009.....Pipe Hangers and Supports Materials, Design,
and Manufacture

PART 2 - PRODUCTS

2.1 MINERAL WOOL FIBER

A. ASTM C1136 (Board, Block), Class 1 or 2, density 48 kg/m³ (3 pcf), k = 0.033 (0.24) at 24 degrees C (75 degrees F), external insulation for temperatures up to 121 degrees C (250 degrees F) with foil scrim (FSK) facing.

B. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, k = 0.033 (0.23) at 24 degrees C (75 degrees F), for use at temperatures up to 538 degrees C (1000 degrees F) with an all service vapor retarder jacket with polyvinyl chloride premolded fitting covering for all piping. PVC cover shall be provided for exposed insulated piping in all areas where piping is below 8'-0" above the finished floor.

C. The insulation shall not contain any formaldehyde or petroleum products.

D. No fiberglass insulation products shall be allowed. Even though fiberglass meets ASTM and other standards, it will not be approved.

2.2 POLYISOCYANURATE CLOSED-CELL RIGID

A. Preformed (fabricated) pipe insulation, ASTM C591, type IV, K=0.027(0.19) at 24 degrees C (75 degrees F), flame spread not over 25, smoke developed not over 50, for use at temperatures up to 149 degree C (300 degree F) with factory applied PVDC or all service vapor retarder jacket with polyvinyl chloride premolded fitting covers.

2.3 FLEXIBLE ELASTOMERIC CELLULAR THERMAL

- A. 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).

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 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. Provide PVC jackets for all exposed piping below 8-feet above the finished floor.
- F. Aluminum Jacket-Piping systems: ASTM B209, 3003 alloy, H-14 temper, 0.6 mm (0.023 inch) minimum thickness with locking longitudinal joints. Jackets for elbows, tees and other fittings shall be factory-fabricated to match shape of fitting and of 0.6 mm (0.024) inch minimum thickness aluminum. Fittings shall be of same construction as straight run jackets but need not be of the same alloy. Factory-fabricated stainless steel bands shall be installed on all circumferential joints.

Bands shall be 13 mm (0.5 inch) wide on 450 mm (18 inch) centers.
System shall be weatherproof if utilized for outside service.

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

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-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.

2.7 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.

2.8 REINFORCEMENT AND FINISHES

- A. Hexagonal wire netting: 25 mm (one inch) mesh, 0.85 mm thick (22 gage) galvanized steel.
- B. 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.
- C. 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 FLAME AND SMOKE

- A. 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 VA Project 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. 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 at 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. Insulate flow meters.
- 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. Use of polyurethane spray-foam to fill a PVC elbow jacket is prohibited.
- K. Provide metal jackets over insulation as follows:
 - 1. All piping and ducts exposed to outdoor weather.
 - 2. A 50 mm (2 inch) overlap is required at longitudinal and circumferential joints.

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 cold equipment: Apply meshed glass fabric in a tack coat 1.5 to 1.7 square meter per liter (60 to 70 square feet per gallon) of vapor mastic and finish with mastic at 0.3 to 0.4 square meter per liter (12 to 15 square feet per gallon) over the entire fabric surface.
 - c. Chilled water pumps: Insulate with removable and replaceable 1 mm thick (20 gage) aluminum or galvanized steel covers lined with insulation. Seal closure joints/flanges of covers with gasket material. Fill void space in enclosure with flexible mineral fiber insulation.
- 3. Exposed, unlined ductwork and equipment in unfinished areas, mechanical and electrical equipment rooms and attics, and duct work exposed to outdoor weather:
 - a. 50 mm (2 inch) thick insulation faced with ASJ: Exhaust air duct.
 - b. Outside air intake ducts: 75 mm (three inch) thick insulation faced with ASJ.
- B. 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.
 - 2. Nominal thickness in millimeters and inches specified in the schedule at the end of this section.
- C. Polyisocyanurate Closed-Cell Rigid Insulation:
 - 1. Polyisocyanurate closed-cell rigid insulation (PIR) may be provided for exterior piping, equipment and ductwork for temperature up to 149 degree C (300 degree F).
 - 2. Install insulation, vapor barrier and jacketing per manufacturer's recommendations. Particular attention should be paid to recommendations for joint staggering, adhesive application, external

hanger design, expansion/contraction joint design and spacing and vapor barrier integrity.

3. Install insulation with all joints tightly butted (except expansion joints in hot applications).
4. If insulation thickness exceeds 63 mm (2.5 inches), install as a double layer system with longitudinal (lap) and butt joint staggering as recommended by manufacturer.
5. For cold applications, vapor barrier shall be installed in a continuous manner. No staples, rivets, screws or any other attachment device capable of penetrating the vapor barrier shall be used to attach the vapor barrier or jacketing. No wire ties capable of penetrating the vapor barrier shall be used to hold the insulation in place. Banding shall be used to attach PVC or metal jacketing.
6. 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. Use of polyurethane spray-foam to fill PVC elbow jacket is prohibited.
7. For cold applications, the vapor barrier on elbows/fittings shall be either mastic-fabric-mastic or 2 mil thick PVDC vapor barrier adhesive tape.
8. All PVC and metal jacketing shall be installed so as to naturally shed water. Joints shall point down and shall be sealed with either adhesive or caulking (except for periodic slip joints). Provide metal jackets for all insulated piping on the exterior of the building.
9. Note the NFPA 90A burning characteristic requirements of 25/50 in paragraph 1.3B. Refer to paragraph 3.1 for items not to be insulated.
10. Minimum thickness in millimeter (inches) specified in the schedule at the end of this section.

D. 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. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.
3. Use Class S (Sheet), 20 mm (3/4 inch) thick for the following:
 - a. Chilled water pumps.
 - b. Water filter, chemical feeder pot or tank.
 - c. Bottom and sides of metal basins for winterized cooling towers (where basin water is heated).
 - d. Chillers, insulate any cold chiller surfaces subject to condensation which has not been factory insulated.

3.3 PIPE INSULATION SCHEDULE

A. 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 C (40-60 degrees F) (GC, GCR)	Mineral Fiber (Interior, Above ground piping only)	25 (1.0)	38 (1.5)	38 (1.5)	50 (2.0)
4-16 degrees C (40-60 degrees F) (GC, GCR)	Polyiso-cyanurate Closed-Cell Rigid (Exterior Locations only)	38 (1.5)	38 (1.5)	38 (1.5)	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. This section shall be removed in its entirety under a Deduct Alternate. Refer to Specification Section 01 00 00 General Requirements for more information.
- B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned are 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) hired by the general contractor and approved by the VA during the submittal process will manage the commissioning process. The commissioning agent may in no way be related to or otherwise work for the architect, engineer, general contractor, or sub-contractors.

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 HVAC systems, subsystems and equipment. This section supplements the general requirements specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.
- B. The commissioning activities have been developed to support the VA requirements to meet guidelines for Federal Leadership in Environmental, Energy, and Economic Performance.
- C. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more specifics 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 A/E, VA and the Commissioning Agent.

1.6 SUBMITTALS

A. The commissioning process requires review of selected submittals. 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 and A/E 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 19 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 A/E, 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. The Commissioning Agent will witness selected contractor tests. 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 Project Engineer and A/E. 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's operation and maintenance personnel is required in cooperation with the VA Project Engineer, A/E, 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. The instruction shall be scheduled in coordination with the VA Project 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
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide (a) direct-digital control system(s) as indicated on the project documents, point list, interoperability tables, drawings and as described in these specifications. Include a complete and working direct-digital control system. Include all engineering, programming, controls and installation materials, installation labor, commissioning and start-up, training, final project documentation and warranty.
1. The direct-digital control system(s) shall consist of high-speed, peer-to-peer network of DDC controllers, and a control system server.
 2. The direct-digital control system(s) shall be native BACnet. All new workstations, controllers, devices and components shall be listed by BACnet Testing Laboratories. All new workstations, controller, devices and components shall be accessible using a Web browser interface and shall communicate exclusively using the ASHRAE Standard 135 BACnet communications protocol without the use of gateways, unless otherwise allowed by this section of the technical specifications, specifically shown on the design drawings and specifically requested otherwise by the VA.
 3. The work administered by this section of the technical specifications shall include all labor, materials, special tools, equipment, enclosures, power supplies, software, software licenses, Project specific software configurations and database entries, interfaces, wiring, installation, labeling, engineering, calibration, documentation, submittals, testing, verification, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, Warranty, specified services and items required for complete and fully functional controls systems.
 4. The control systems shall be designed such that each mechanical system shall operate under stand-alone mode. The contractor administered by this section of the technical specifications shall provide controllers for each mechanical system. In the event of a network communication failure, or the loss of any other controller, the control system shall continue to operate independently. Failure

of the ECC shall have no effect on the field controllers, including those involved with global strategies.

5. The control system shall accommodate the existing Engineering Control Center(s) and the control system shall accommodate at least 3 web-based users simultaneously, and the access to the system should be limited only by operator password.

B. Control components in the chiller enclosure are provided by the chiller enclosure manufacturer. Refer to 23 64 10 for control items being provided by the chiller enclosure manufacturer.

C. Some products are furnished but not installed by the contractor administered by this section of the technical specifications. The contractor administered by this section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the installation of the products. These products include the following:

1. Control valves.
2. Flow switches.
3. Flow meters.
4. Sensor wells and sockets in piping.
5. Terminal unit controllers.

D. Some products are not provided by, but are nevertheless integrated with the work executed by, the contractor administered by this section of the technical specifications. The contractor administered by this section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the particulars of the products. These products include the following:

1. Chiller controls. These controls, if not native BACnet, will require a BACnet Gateway. Provide connection and all required wiring/conduit to chiller plant controls system. Refer to section 23 64 10 for list of required BACnet points to be obtained. Provide graphics for all monitored and controlled points from the new chiller plant on the building controls system.
2. Variable frequency drives. These controls, if not native BACnet, will require a BACnet Gateway.

- a. The following points shall be made available as a minimum to be communicated via the communications interface into the Building Automation System:

- 1) Fault diagnostics
- 2) Meter points:
- 3) Motor power in HP
- 4) Motor power in kW
- 5) Motor kW-hr
- 6) Motor current
- 7) Motor voltage
- 8) Hours run
- 9) Feedback signal #1
- 10) Feedback signal #2
- 11) DC link voltage
- 12) Thermal load on motor
- 13) Thermal load on VFD
- 14) Heatsink temperature

3. The following systems have limited control (as individually noted below) from the ECC:

- a. Domestic water systems: Water meter flow rates and consumption.

E. Responsibility Table:

Work/Item/System	Furnish	Install	Low Voltage Wiring	Line Power
Control system low voltage and communication wiring	23 09 23	23 09 23	23 09 23	N/A
LAN conduits and raceway	23 09 23	23 09 23	N/A	N/A
Automatic damper actuators	23 09 23	23 09 23	23 09 23	23 09 23
Manual valves	23	23	N/A	N/A
Automatic valves	23 09 23	23	23 09 23	23 09 23
Pipe insertion devices and taps, flow and pressure stations.	23	23	N/A	N/A
Thermowells	23 09 23	23	N/A	N/A
Current Switches	23 09 23	23 09 23	23 09 23	N/A
Control Relays	23 09 23	23 09 23	23 09 23	N/A
All control system nodes, equipment, housings,	23 09 23	23 09 23	23 09 23	26

Work/Item/System	Furnish	Install	Low Voltage Wiring	Line Power
enclosures and panels.				

F. This facility's existing direct-digital control system and its ECC is located at the engineering shop. Provide all required software, hardware, licensing, and programming for access at the campus boiler plant. Coordinate with the IT department. The contractor administered by this section of the technical specifications shall observe the capabilities, communication network, services, spare capacity of the existing control system and its ECC prior to beginning work.

1. Upgrade the existing direct-digital control system's ECC to include all properties and services required by an ASHRAE Standard 135 BACnet B-AWS Profile. The upgraded ECC shall continue to communicate with the existing direct-digital control system's devices. The upgraded ECC shall communicate directly with the new native-BACnet devices over the existing control system's communications network without the use of a gateway. The contractor administered by this section of the technical specifications shall provide all necessary investigation and site-specific programming to execute the interoperability schedules. The ECC shall be upgraded to the control contractor's current software.

2. Leave existing direct-digital control system intact and in place. Provide a new ASHRAE Standard 135 BACnet-compliant ECC in the same room as the existing system's ECC, and provide a new standalone BACnet-compliant control system serving the work in this project. No interoperability is required. In addition, a new access point at the boiler plant as described above.

G. This campus has multiple control systems (BAS/ECC) currently installed on site. Provide new controls on one of the existing control systems on site. Refer to plans for control updates to existing chilled water pump system currently being controlled by the existing Siemens system. G & R (Siemens) controls shall provide all controls upgrades to this existing system.

1. The contractor administered by this section of the technical specifications shall provide a peer-to-peer networked, stand-alone, distributed control system. This direct digital control (DDC) system shall include microprocessor-based controllers, instrumentation, end

control devices, wiring, piping, software, and related systems. This contractor is responsible for all device mounting and wiring.

2. Responsibility Table:

Item/Task	Section 23 09 23 contractor	VA
ECC expansion	X	
ECC programming	X	
Devices, controllers, control panels and equipment	X	
Point addressing: all hardware and software points including setpoint, calculated point, data point(analog/binary), and reset schedule point	X	
Point mapping	X	
Network Programming	X	
ECC Graphics	X	
Controller programming and sequences	X	
Integrity of LAN communications	X	
Electrical wiring	X	
Operator system training	X	
LAN connections to devices	X	
LAN connections to ECC	X	
IP addresses		X
Overall system verification	X	
Controller and LAN system verification	X	

1.2 RELATED WORK

- A. Section 22 05 19, Meters and Gauges for Plumbing Piping.
- B. Section 23 21 13, Hydronic Piping.
- C. Section 23 31 00, HVAC Ducts and Casings.
- D. Section 23 64 00, Packaged Water Chillers.
- E. Section 23 65 00, Cooling Tower.
- F. Section 26 05 11, Requirements for Electrical Installations.
- G. Section 26 05 19, Low-Voltage Electrical Power Conductors and Cables (600 Volts and Below).
- H. Section 26 05 26, Grounding and Bonding for Electrical Systems.
- I. Section 26 05 33, Raceway and Boxes for Electrical Systems.
- J. Section 23 64 10, Modular Chiller Plant
- K. Section 26 27 26, Wiring Devices.
- L. Section 27 10 05, Computer Network and Telephone Wiring System

1.3 DEFINITION

- A. Algorithm: A logical procedure for solving a recurrent mathematical problem; A prescribed set of well-defined rules or processes for the solution of a problem in a finite number of steps.

- B. Analog: A continuously varying signal value (e.g., temperature, current, velocity etc.
- C. BACnet: A Data Communication Protocol for Building Automation and Control Networks, ANSI/ASHRAE Standard 135. This communications protocol allows diverse building automation devices to communicate data over and services over a network.
- D. BACnet/IP: Annex J of Standard 135. It defines and allows for using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP sub-networks that share the same BACnet network number.
- E. BACnet Internetwork: Two or more BACnet networks connected with routers. The two networks may use different LAN technologies.
- F. BACnet Network: One or more BACnet segments that have the same network address and are interconnected by bridges at the physical and data link layers.
- G. BACnet Segment: One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.
- H. BACnet Broadcast Management Device (BBMD): A communications device which broadcasts BACnet messages to all BACnet/IP devices and other BBMDs connected to the same BACnet/IP network.
- I. BACnet Interoperability Building Blocks (BIBBs): BACnet Interoperability Building Blocks (BIBBs) are collections of one or more BACnet services. These are prescribed in terms of an "A" and a "B" device. Both of these devices are nodes on a BACnet internetwork.
- J. BACnet Testing Laboratories (BTL). The organization responsible for testing products for compliance with the BACnet standard, operated under the direction of BACnet International.
- K. Baud: It is a signal change in a communication link. One signal change can represent one or more bits of information depending on type of transmission scheme. Simple peripheral communication is normally one bit per Baud. (e.g., Baud rate = 78,000 Baud/sec is 78,000 bits/sec, if one signal change = 1 bit).
- L. Binary: A two-state system where a high signal level represents an "ON" condition and an "OFF" condition is represented by a low signal level.
- M. BMP or bmp: Suffix, computerized image file, used after the period in a DOS-based computer file to show that the file is an image stored as a series of pixels.

- N. Bus Topology: A network topology that physically interconnects workstations and network devices in parallel on a network segment.
- O. Control Unit (CU): Generic term for any controlling unit, stand-alone, microprocessor based, digital controller residing on secondary LAN or Primary LAN, used for local controls or global controls
- P. Deadband: A temperature range over which no heating or cooling is supplied, i.e., 22-25 degrees C (72-78 degrees F), as opposed to a single point change over or overlap).
- Q. Device: a control system component that contains a BACnet Device Object and uses BACnet to communicate with other devices.
- R. Device Object: Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet internetwork. This number is often referred to as the device instance.
- S. Device Profile: A specific group of services describing BACnet capabilities of a device, as defined in ASHRAE Standard 135-2008, Annex L. Standard device profiles include BACnet Operator Workstations (B-OWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS). Each device used in new construction is required to have a PICS statement listing which service and BIBBs are supported by the device.
- T. Diagnostic Program: A software test program, which is used to detect and report system or peripheral malfunctions and failures. Generally, this system is performed at the initial startup of the system.
- U. Direct Digital Control (DDC): Microprocessor based control including Analog/Digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices in order to achieve a set of predefined conditions.
- V. Distributed Control System: A system in which the processing of system data is decentralized and control decisions can and are made at the subsystem level. System operational programs and information are provided to the remote subsystems and status is reported back to the Engineering Control Center. Upon the loss of communication with the

- Engineering Control center, the subsystems shall be capable of operating in a stand-alone mode using the last best available data.
- W. Download: The electronic transfer of programs and data files from a central computer or operation workstation with secondary memory devices to remote computers in a network (distributed) system.
- X. DXF: An AutoCAD 2-D graphics file format. Many CAD systems import and export the DXF format for graphics interchange.
- Y. Electrical Control: A control circuit that operates on line or low voltage and uses a mechanical means, such as a temperature sensitive bimetal or bellows, to perform control functions, such as actuating a switch or positioning a potentiometer.
- Z. Electronic Control: A control circuit that operates on low voltage and uses a solid-state components to amplify input signals and perform control functions, such as operating a relay or providing an output signal to position an actuator.
- AA. Engineering Control Center (ECC): The centralized control point for the intelligent control network. The ECC comprises of personal computer and connected devices to form a single workstation.
- BB. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.
- CC. Firmware: Firmware is software programmed into read only memory (ROM) chips. Software may not be changed without physically altering the chip.
- DD. Gateway: Communication hardware connecting two or more different protocols. It translates one protocol into equivalent concepts for the other protocol. In BACnet applications, a gateway has BACnet on one side and non-BACnet (usually proprietary) protocols on the other side.
- EE. GIF: Abbreviation of Graphic interchange format.
- FF. Graphic Program (GP): Program used to produce images of air handler systems, fans, chillers, pumps, and building spaces. These images can be animated and/or color-coded to indicate operation of the equipment.
- GG. Graphic Sequence of Operation: It is a graphical representation of the sequence of operation, showing all inputs and output logical blocks.
- HH. I/O Unit: The section of a digital control system through which information is received and transmitted. I/O refers to analog input

(AI, digital input (DI), analog output (AO) and digital output (DO). Analog signals are continuous and represent temperature, pressure, flow rate etc, whereas digital signals convert electronic signals to digital pulses (values), represent motor status, filter status, on-off equipment etc.

- II. I/P: a method for conveying and routing packets of information over LAN paths. User Datagram Protocol (UDP) conveys information to "sockets" without confirmation of receipt. Transmission Control Protocol (TCP) establishes "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.
- JJ. JPEG: A standardized image compression mechanism stands for Joint Photographic Experts Group, the original name of the committee that wrote the standard.
- KK. Local Area Network (LAN): A communication bus that interconnects operator workstation and digital controllers for peer-to-peer communications, sharing resources and exchanging information.
- LL. Network Repeater: A device that receives data packet from one network and rebroadcasts to another network. No routing information is added to the protocol.
- MM. Native BACnet Device: A device that uses BACnet as its primary method of communication with other BACnet devices without intermediary gateways. A system that uses native BACnet devices at all levels is a native BACnet system.
- NN. Network Number: A site-specific number assigned to each network segment to identify for routing. This network number must be unique throughout the BACnet internetwork.
- OO. Object: The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.
- PP. Object Identifier: An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.
- QQ. Object Properties: Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in ASHRAE 135; some are optional and some are required. Objects are controlled by reading from and writing to object properties.

- RR. Operating system (OS): Software, which controls the execution of computer application programs.
- SS. PCX: File type for an image file. When photographs are scanned onto a personal computer they can be saved as PCX files and viewed or changed by a special application program as Photo Shop.
- TT. Peripheral: Different components that make the control system function as one unit. Peripherals include monitor, printer, and I/O unit.
- UU. Peer-to-Peer: A networking architecture that treats all network stations as equal partners- any device can initiate and respond to communication with other devices.
- VV. PICS: Protocol Implementation Conformance Statement, describing the BACnet capabilities of a device. All BACnet devices have published PICS.
- WW. PID: Proportional, integral, and derivative control, used to control modulating equipment to maintain a setpoint.
- XX. Repeater: A network component that connects two or more physical segments at the physical layer.
- YY. Router: a component that joins together two or more networks using different LAN technologies. Examples include joining a BACnet Ethernet LAN to a BACnet MS/TP LAN.
- ZZ. Sensors: devices measuring state points or flows, which are then transmitted back to the DDC system.
- AAA. Thermostats : devices measuring temperatures, which are used in control of standalone or unitary systems and equipment not attached to the DDC system.

1.4 QUALITY ASSURANCE

A. Criteria:

1. Single Source Responsibility of subcontractor: The contractor shall obtain hardware and software supplied under this section and delegate the responsibility to a single source controls installation subcontractor. The controls subcontractor shall be responsible for the complete design, installation, and commissioning of the system. The controls subcontractor shall be in the business of design, installation and service of such building automation control systems similar in size and complexity.
2. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in production and

installation of HVAC control systems. Products shall be manufacturer's latest standard design and have been tested and proven in actual use.

3. The controls subcontractor shall provide a list of no less than five similar projects which have building control systems as specified in this section. These projects must be on-line and functional such that the Department of Veterans Affairs (VA) representative would observe the control systems in full operation.
4. The controls subcontractor shall have in-place facility within 50 miles with technical staff, spare parts inventory for the next five (5) years, and necessary test and diagnostic equipment to support the control systems.
5. The controls subcontractor shall have minimum of three years experience in design and installation of building automation systems similar in performance to those specified in this section. Provide evidence of experience by submitting resumes of the project manager, the local branch manager, project engineer, the application engineering staff, and the electronic technicians who would be involved with the supervision, the engineering, and the installation of the control systems. Training and experience of these personnel shall not be less than three years. Failure to disclose this information will be a ground for disqualification of the supplier.
6. Provide a competent and experienced project manager employed by the controls contractor. The project manager shall be supported as necessary by other contractor employees in order to provide professional engineering, technical and management service for the work. The project manager shall attend scheduled project meetings as required and shall be empowered to make technical, scheduling and related decisions on behalf of the controls contractor.

B. Codes and Standards:

1. All work shall conform to the applicable Codes and Standards.
2. Electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

1.5 PERFORMANCE

A. The system shall conform to the following:

1. Graphic Display: The system shall display up to four (4) graphics on a single screen with a minimum of twenty (20) dynamic points per

graphic. All current data shall be displayed within ten (10) seconds of the request.

2. Graphic Refresh: The system shall update all dynamic points with current data within eight (8) seconds. Data refresh shall be automatic, without operator intervention.
3. Object Command: The maximum time between the command of a binary object by the operator and the reaction by the device shall be two(2) seconds. Analog objects shall start to adjust within two (2) seconds.
4. Object Scan: All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or work-station will be current, within the prior six (6) seconds.
5. Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed (10) seconds.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every (5) seconds. The contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
7. Multiple Alarm Annunciations: All workstations on the network shall receive alarms within five (5) seconds of each other.
8. Performance: Programmable controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every one (1) second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
9. Reporting Accuracy: Listed below are minimum acceptable reporting end-to-end accuracies for all values reported by the specified system:

Measured Variable	Reported Accuracy
Space temperature	$\pm 0.5^{\circ}\text{C}$ ($\pm 1^{\circ}\text{F}$)
Ducted air temperature	$\pm 0.5^{\circ}\text{C}$ [$\pm 1^{\circ}\text{F}$]
Outdoor air temperature	$\pm 1.0^{\circ}\text{C}$ [$\pm 2^{\circ}\text{F}$]
Dew Point	$\pm 1.5^{\circ}\text{C}$ [$\pm 3^{\circ}\text{F}$]
Water temperature	$\pm 0.5^{\circ}\text{C}$ [$\pm 1^{\circ}\text{F}$]
Relative humidity	$\pm 2\%$ RH

Air pressure (ducts)	±25 Pa [±0.1"w.c.]
Air pressure (space)	±0.3 Pa [±0.001"w.c.]
Electrical Power	±0.5% of reading

Note 1: for both absolute and differential pressure

10. Control stability and accuracy: Control sequences shall maintain measured variable at setpoint within the following tolerances:

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.)	0-1.5 kPa (0-6 in. w.g.)
Air Pressure	±3 Pa (±0.01 in. w.g.)	-25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Space Temperature	±1.0°C (±2.0°F)	
Duct Temperature	±1.5°C (±3°F)	
Humidity	±5% RH	

11. Extent of direct digital control: control design shall allow for at least the points indicated on the points lists on the drawings.

1.6 WARRANTY

- A. Labor and materials for control systems shall be warranted for a period as specified under warranty in FAR clause 52.246-21.
- B. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no cost or reduction in service to the owner. The system includes all computer equipment, transmission equipment, and all sensors and control devices.
- C. Controls and instrumentation subcontractor shall be responsible for temporary operations and maintenance of the control systems during the construction period until final commissioning, training of facility operators and acceptance of the project by VA.

1.7 SUBMITTALS

- A. Submit shop drawings in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's literature and data for all components including the following:
 - 1. A wiring diagram for each type of input device and output device including DDC controllers, modems, repeaters, etc. Diagram shall show how the device is wired and powered, showing typical connections at the digital controllers and each power supply, as well as the device itself. Show for all field connected devices, including but not limited to, control relays, motor starters,

electric or electronic actuators, and temperature pressure, flow and humidity sensors and transmitters.

2. A diagram of each terminal strip, including digital controller terminal strips, terminal strip location, termination numbers and the associated point names.
3. Control dampers and control valves schedule, including the size and pressure drop.
4. Catalog cut sheets of all equipment used. This includes, but is not limited to software (by manufacturer and by third parties), DDC controllers, panels, peripherals, airflow measuring stations and associated components, and auxiliary control devices such as sensors, actuators, and control dampers. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted. Each submitted piece of literature and drawings should clearly reference the specification and/or drawings that it supposed to represent.
5. Sequence of operations for each HVAC system and the associated control diagrams. Equipment and control labels shall correspond to those shown on the drawings.
6. Color prints of proposed graphics with a list of points for display.
7. Furnish a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet-compliant device.
8. Schematic wiring diagrams for all control, communication and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.
9. An instrumentation list for each controlled system. Each element of the controlled system shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.
10. Riser diagrams of wiring between central control unit and all control panels.
11. Scaled plan drawings showing routing of LAN and locations of control panels, controllers, routers, gateways, ECC, and larger controlled devices.

12. Construction details for all installed conduit, cabling, raceway, cabinets, and similar. Construction details of all penetrations and their protection.

13. Quantities of submitted items may be reviewed but are the responsibility of the contractor administered by this section of the technical specifications.

C. Product Certificates: Compliance with Article, QUALITY ASSURANCE.

D. Licenses: Provide licenses for all software residing on and used by the controls systems and transfer these licenses to the owner prior to completion.

E. As Built Control Drawings:

1. Furnish three (3) copies of as-built drawings for each control system. The documents shall be submitted for approval prior to final completion.
2. Furnish one (1) stick set of applicable control system prints for each mechanical system for wall mounting. The documents shall be submitted for approval prior to final completion.
3. Furnish one (1) CD-ROM in CAD DWG format for the drawings noted in subparagraphs above. CAD version utilized must be compatible with version currently used at the Fargo VA Medical Center.

F. Operation and Maintenance (O/M) Manuals):

1. Submit in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS. Provide hardcopy and PDF version on CD or DVD.
2. Include the following documentation:
 - a. General description and specifications for all components, including logging on/off, alarm handling, producing trend reports, overriding computer control, and changing set points and other variables.
 - b. Detailed illustrations of all the control systems specified for ease of maintenance and repair/replacement procedures, and complete calibration procedures.
 - c. One copy of the final version of all software provided including operating systems, programming language, operator workstation software, and graphics software.
 - d. Complete troubleshooting procedures and guidelines for all systems.
 - e. Complete operating instructions for all systems.

- f. Recommended preventive maintenance procedures for all system components including a schedule of tasks for inspection, cleaning and calibration. Provide a list of recommended spare parts needed to minimize downtime.
 - g. Training Manuals: Submit the course outline and training material to the Owner for approval three (3) weeks prior to the training to VA facility personnel. These persons will be responsible for maintaining and the operation of the control systems, including programming. The Owner reserves the right to modify any or all of the course outline and training material.
 - h. Licenses, guaranty, and other pertaining documents for all equipment and systems.
- G. Submit performance report to VA Project Engineer prior to final inspection.

1.8 INSTRUCTIONS

- A. Instructions to VA operations personnel: Perform in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS, and as noted below.
1. Training shall comprise of on the job training during start-up, checkout period, and performance test period. VA facilities personnel will work with the contractor's installation and test personnel on a daily basis during start-up and checkout period. During the performance test period, controls subcontractor will provide 8 hours of instructions, given in multiple training sessions (each no longer than four hours in length), to the VA facilities personnel.
 2. The O/M Manuals shall contain approved submittals as outlined in Article 1.7, SUBMITTALS. The controls subcontractor will review the manual contents with VA facilities personnel during second phase of training.
 3. Training shall be given by direct employees of the controls system subcontractor.

1.9 PROJECT CONDITIONS (ENVIRONMENTAL CONDITIONS OF OPERATION)

- A. The ECC and peripheral devices and system support equipment shall be designed to operate in ambient condition of 20 to 35°C (65 to 90°F) at a relative humidity of 20 to 80% non-condensing.
- B. All electronic equipment shall operate properly with power fluctuations of plus 10 percent to minus 15 percent of nominal supply voltage.

C. Sensors and controlling devices shall be designed to operate in the environment, which they are sensing or controlling.

1.10 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 (ASHRAE):
Standard 135-10.....BACNET Building Automation and Control Networks

C. American Society of Mechanical Engineers (ASME):

B16.18-01.....Cast Copper Alloy Solder Joint Pressure Fittings.
B16.22-01.....Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

D. American Society of Testing Materials (ASTM):

B32-08.....Standard Specification for Solder Metal
B88-09.....Standard Specifications for Seamless Copper Water Tube
B88M-09.....Standard Specification for Seamless Copper Water Tube (Metric)
B280-08.....Standard Specification for Seamless Copper Tube for Air-Conditioning and Refrigeration Field Service
D2737-03.....Standard Specification for Polyethylene (PE) Plastic Tubing

E. Federal Communication Commission (FCC):

Rules and Regulations Title 47 Chapter 1-2001 Part 15: Radio Frequency Devices.

F. Institute of Electrical and Electronic Engineers (IEEE):

802.3-11.....Information Technology-Telecommunications and Information Exchange between Systems-Local and Metropolitan Area Networks- Specific Requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access method and Physical Layer Specifications

G. National Fire Protection Association (NFPA):

70-11.....National Electric Code
90A-09.....Standard for Installation of Air-Conditioning and Ventilation Systems

H. Underwriter Laboratories Inc (UL):

94-10.....Tests for Flammability of Plastic Materials for Parts and Devices and Appliances
294-10.....Access Control System Units
486A/486B-10.....Wire Connectors

555S-11.....Standard for Smoke Dampers
 916-10.....Energy Management Equipment
 1076-10.....Proprietary Burglar Alarm Units and Systems

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 25 installations. Spare parts shall be available for at least five years after completion of this contract.

2.2 CONTROLS SYSTEM ARCHITECTURE

A. General

1. The controls systems shall consist of multiple nodes and associated equipment connected by industry standard digital and communication network arrangements.
2. The building controllers and principal communications network equipment shall be standard products of recognized major manufacturers available through normal PC and computer vendor channels - not "Clones" assembled by a third-party subcontractor.
3. The networks shall, at minimum, comprise, as necessary, the following:
 - a. Active processing BACnet-compliant building controllers connected to other BACNet-compliant controllers together with their power supplies and associated equipment.
 - b. Addressable elements, sensors, transducers and end devices.
 - c. Third-party equipment interfaces and gateways as described and required by the contract documents.
 - d. Other components required for a complete and working control systems as specified.

- B. The specifications for the individual elements and component subsystems shall be minimum requirements and shall be augmented as necessary by the contractor to achieve both compliance with all applicable codes, standards and to meet all requirements of the contract documents.

C. Network Architecture

1. The controls communication network shall utilize BACnet communications protocol operating over a standard Ethernet LAN and operate at a minimum speed of 100 Mb/sec.

2. The networks shall utilize only copper and optical fiber communication media as appropriate and shall comply with applicable codes, ordinances and regulations.

D. Third Party Interfaces:

1. The contractor administered by this section of the technical specifications shall include necessary hardware, equipment, software and programming to allow data communications between the controls systems and building systems supplied by other trades.
2. Other manufacturers and contractors supplying other associated systems and equipment shall provide their necessary hardware, software and start-up at their cost and shall cooperate fully with the contractor administered by this Section of the technical specifications in a timely manner and at their cost to ensure complete functional integration.

E. Servers:

1. Provide data storage server(s) to archive historical data including trends, alarm and event histories and transaction logs. Include any additional servers as needed for system expansion.
2. Equip these server(s) with the same software tool set that is located in the BACnet building controllers for system configuration and custom logic definition and color graphic configuration or provide upgrade to all at no extra cost.
3. Access to all information on the data storage server(s) shall be through the same browser functionality used to access individual nodes. When logged onto a server the operator will be able to also interact with any other controller on the control system as required for the functional operation of the controls systems. The contractor administered by this Section of the technical specifications shall provide all necessary digital processor programmable data storage server(s).
4. These server(s) shall be utilized for controls systems application configuration, for archiving, reporting and trending of data, for operator transaction archiving and reporting, for network information management, for alarm annunciation, for operator interface tasks, for controls application management and similar. These server(s) shall utilize IT industry standard data base platforms which utilize a database declarative language designed for

managing data in relational database management systems (RDBMS) such as SQL.

2.3 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135-2008, BACnet.

1. The data link/physical layer protocol (for communication) acceptable to the VA throughout its facilities is Ethernet (ISO 8802-3) and BACnet/IP.

B. Each controller shall have a communication port for connection to an operator interface.

C. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, reports, system software, and custom programs shall be viewable and editable from each internetwork controller.
2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute specified control system operation. An authorized operator shall be able to edit cross-controller links by typing a standard object address.

D. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring. Expansion shall not require operator interface hardware additions or software revisions.

E. ECCs and Controllers with real-time clocks shall use the BACnet Time Synchronization service. The system shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight savings and standard time as applicable. After power outages, the system components shall automatically restart. Attempts to restart equipment shall occur 3 times. After that time, the attempts shall cease and a critical alarm shall be generated. Only 1 alarm shall be submitted for all equipment that fails to re-start.

2.4 ENGINEERING CONTROL CENTER (ECC)

- A. The controls contractor shall utilize one of the existing Operator's Workstation in the Engineering Shop. If the software currently installed on the workstation does not match the controls contractor's software, new software shall be provided. Any workstation upgrades to the existing computer hardware or software shall be completed by this contractor at this time if required.
- B. The ECC shall reside on a high-speed network with controllers as shown on system drawings. The ECC and each standard browser connected to server shall be able to access all system information.
- C. ECC and controllers shall communicate using BACnet protocol. ECC and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ASHRAE/ANSI 135-2008, BACnet Annex J. After power outages, the system components shall automatically restart. Refer to paragraph 2.3.E above.
- D. Hardware: ECC shall conform to the BACnet Advanced Workstation (B-AWS) Profile and shall be BTL-Listed as a B-AWS device.
- E. ECC shall be commercial standard with supporting 32- or 64-bit hardware (as required by the direct-digital control system software) and software enterprise server. Internet Explorer v11.0 SP1 or higher, Windows Script Hosting version 5.6 or higher, Windows Message Queuing, Windows Internet Information Services (IIS) v5.0 or higher, minimum 2.8 GHz processor, minimum 8GB DDR3 SDRAM (minimum 1333 Mhz) memory, 512 MB video card, and 16 speed high density DVD-RW+/- optical drive.
- F. The hard drive shall be at the minimum 1 TB 7200 rpm SATA hard drive with 16 MB cache, and shall have sufficient memory to store:
- G. All required operator workstation software
- H. A DDC database at least twice the size of the delivered system database
- I. One year of trend data based on the points specified to be trended at their specified trend intervals.
- J. Real-time clock:
- K. Accuracy: Plus or minus 1 minute per month.
- L. Time Keeping Format: 24-hour time format including seconds, minutes, hours, date, day, and month; automatic reset by software.
- M. Clock shall function for one year without power.
- N. Provide automatic time correction once every 24 hours by synchronizing clock with the Time Service Department of the U.S. Naval Observatory.

- O. Serial ports: Four USB ports and two RS-232-F serial ports for general use, with additional ports as required. Data transmission rates shall be selectable under program control.
- P. Parallel port: Enhanced.
- Q. Sound card: For playback and recording of digital WAV sound files associated with audible warning and alarm functions.
- R. Color monitor: PC compatible, widescreen, not less than 22 inches, LCD type, with a minimum resolution of 1280 by 1024 pixels, non-interlaced, and a maximum dot pitch of 0.28 mm.
- S. Keyboard: Minimum of 64 characters, standard ASCII character set based on ANSI INCITS 154. Wireless keyboard are not approved unless they meet FIPS-140 encryption.
- T. Mouse: Standard, compatible with installed software.
- U. Removable disk storage: Include the following, each with appropriate controller:
 - 1. Minimum 1 TB removable hard disk, maximum average access time of 10 ms.
- V. Network interface card (NIC): integrated 10-100-1000 Base-TX Ethernet NIC with an RJ45 connector or a 100Base-FX Ethernet NIC with an SC/ST connector.
- W. Cable modem: 42.88 MBit/s, DOCSIS 2.0 Certified, also backwards compatible with DOCSIS 1.1/1.0 standards. Provide Ethernet or USB connectivity.
- X. Optical modem: full duplex link, for use on 10 GBase-R single-mode and multi-mode fiber with a XENPAK module.
- Y. Audible Alarm: Manufacturer's standard.
- Z. RS-232 ASCII Interface
- AA. ASCII interface shall allow RS-232 connections to be made between a meter or circuit monitor operating as the host PC and any equipment that will accept RS-232 ASCII command strings, such as local display panels, and alarm transmitters.
- BB. Pager System Interface: Alarms shall be able to activate a pager system with customized message for each input alarm.
- CC. Alarm System Interface: RS-232 output shall be capable of transmitting alarms from other monitoring and alarm systems to workstation software.
- DD. Cables: provide Plenum-Type, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic

insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

EE. NFPA 70, Type CMP.

FF. Flame Resistance: NFPA 262, Flame Test.

GG. Self-contained uninterruptible power supply (UPS):

HH. Size: Provide a minimum of six hours of operation of ECC equipment, including two hours of alarm printer operation.

II. Batteries: Sealed, valve regulated, recombinant, lead calcium.

JJ. Accessories:

1. Transient voltage suppression.
2. Input-harmonics reduction.
3. Rectifier/charger.
4. Battery disconnect device.
5. Static bypass transfer switch.
6. Internal maintenance bypass/isolation switch.
7. External maintenance bypass/isolation switch.
8. Output isolation transformer.
9. Remote UPS monitoring.
10. Battery monitoring.
11. Remote battery monitoring.

KK. ECC Software:

1. Provide for automatic system database save and restore on the ECC's hard disk a copy of the current database of each controller. This database shall be updated whenever a change is made in any system panel. In the event of a database loss in a building management panel, the ECC shall automatically restore the database for that panel. This capability may be disabled by the operator.
2. Provide for manual database save and restore. An operator with proper clearance shall be able to save the database from any system panel. The operator also shall be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
3. Provide a method of configuring the system. This shall allow for future system changes or additions by users with proper clearance.
4. Operating System. Furnish a concurrent multi-tasking operating system. The operating system also shall support the use of other common software applications. Acceptable operating systems are

- Windows System 7, Linux, and UNIX. Verify operating system preference with owner and IT department before making a selection.
5. System Graphics. The operator workstation software shall be graphically oriented. The system shall allow display of up to 10 graphic screens at once for comparison and monitoring of system status. Provide a method for the operator to easily move between graphic displays and change the size and location of graphic displays on the screen. The system graphics shall be able to be modified while on-line. An operator with the proper password level shall be able to add, delete, or change dynamic objects on a graphic. Dynamic objects shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation by shifting image files based on the status of the object.
 6. Custom Graphics: Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in industry standard formats such as PCX, TIFF, and GEM. The graphics generation package also shall provide the capability of capturing or converting graphics from other programs such as Designer or AutoCAD.
 7. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.
 8. The Controls Systems Operator Interfaces shall be user friendly, readily understood and shall make maximum use of colors, graphics, icons, embedded images, animation, text based information and data visualization techniques to enhance and simplify the use and understanding of the displays by authorized users at the ECC. The operating system shall be Windows 8 or better, and shall support the third party software.
 9. Provide graphical user software, which shall minimize the use of keyboard through the use of the mouse and "point and click" approach to menu selection.

10. The software shall provide a multi-tasking type environment that will allow the user to run several applications simultaneously. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able automatically export data to and work in Microsoft Word, Excel, and other Windows based software programs, while concurrently on-line system alarms and monitoring information.
11. On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
12. User access shall be protected by a flexible and owner re-definable software-based password access protection. Password protection shall be multi-level and partition able to accommodate the varied access requirements of the different user groups to which individual users may be assigned. Provide the means to define unique access privileges for each individual authorized user. Provide the means to on-line manage password access control under the control of a project specific master password. Provide an audit trail of all user activity on the controls systems including all actions and changes.
13. The system shall be completely field-programmable from the common operator's keyboard thus allowing hard disk storage of all data automatically. All programs for the CUs shall be able to be downloaded from the hard disk. The software shall provide the following functionality as a minimum:
 - a. Point database editing, storage and downloading of controller databases.
 - b. Scheduling and override of building environmental control systems.
 - c. Collection and analysis of historical data.
 - d. Alarm reporting, routing, messaging, and acknowledgement.
 - e. Definition and construction of dynamic color graphic displays.
 - f. Real-time graphical viewing and control of environment.
 - g. Scheduling trend reports.
 - h. Program editing.
 - i. Operating activity log and system security.
 - j. Transfer data to third party software.

14. Provide functionality such that using the least amount of steps to initiate the desired event may perform any of the following simultaneously:
 - a. Dynamic color graphics and graphic control.
 - b. Alarm management.
 - c. Event scheduling.
 - d. Dynamic trend definition and presentation.
 - e. Program and database editing.
 - f. Each operator shall be required to log on to the system with a user name and password to view, edit or delete the data. System security shall be selectable for each operator, and the password shall be able to restrict the operator's access for viewing and changing the system programs. Each operator shall automatically be logged off the system if no keyboard or mouse activity is detected for a selected time.
15. Graphic Displays:
 - a. The workstation shall allow the operator to access various system schematics and floor plans via a graphical penetration scheme, menu selection, or text based commands. Graphic software shall permit the importing of AutoCAD or scanned pictures in the industry standard format (such as PCX, BMP, GIF, and JPEG) for use in the system.
 - b. System graphics shall be project specific and schematically correct for each system. (ie: coils, fans, dampers located per equipment supplied with project.) Standard system graphics that do not match equipment or system configurations are not acceptable. Operator shall have capability to manually operate the entire system from each graphic screen at the ECC. Each system graphic shall include a button/tab to a display of the applicable sequence of operation.
 - c. Dynamic temperature values, humidity values, flow rates, and status indication shall be shown in their locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh values.
 - d. Color shall be used to indicate status and change in status of the equipment. The state colors shall be user definable.

- e. A clipart library of HVAC equipment, such as chillers, boilers, air handling units, fans, terminal units, pumps, coils, standard ductwork, piping, valves and laboratory symbols shall be provided in the system. The operator shall have the ability to add custom symbols to the clipart library.
 - f. A dynamic display of the site-specific architecture showing status of the controllers, the ECC and network shall be provided.
 - g. The windowing environment of the workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of graphic associated with an alarm to be viewed without interrupting work in progress. The graphic system software shall also have the capability to split screen, half portion of the screen with graphical representation and the other half with sequence of operation of the same HVAC system.
16. Trend reports shall be generated on demand or pre-defined schedule and directed to monitor display, printers or disk. As a minimum, the system shall allow the operator to easily obtain the following types of reports:
- a. A general list of all selected points in the network.
 - b. List of all points in the alarm.
 - c. List of all points in the override status.
 - d. List of all disabled points.
 - e. List of all points currently locked out.
 - f. List of user accounts and password access levels.
 - g. List of weekly schedules.
 - h. List of holiday programming.
 - i. List of limits and dead bands.
 - j. Custom reports.
 - k. System diagnostic reports, including, list of digital controllers on the network.
 - l. List of programs.
17. Weather Reports
- a. Weather Data Report: Provide a monthly report showing the daily minimum, maximum, and average outdoor air temperature, as well as the number of heating and cooling degree-days for each day. Provide an annual (12-month) report showing the minimum, maximum,

and average outdoor air temperature for the month, as well as the number of heating and cooling degree-days for the month.

18. Scheduling and Override:

- a. Provide override access through menu selection from the graphical interface and through a function key.
- b. Provide a calendar type format for time-of-day scheduling and overrides of building control systems. Schedules reside in the ECC. The digital controllers shall ensure equipment time scheduling when the ECC is off-line. The ECC shall not be required to execute time scheduling. Provide the following spreadsheet graphics as a minimum:
 - 1) Weekly schedules.
 - 2) Zone schedules, minimum of 100 zones.
 - 3) Scheduling up to 365 days in advance.
 - 4) Scheduled reports to print at workstation.

19. Collection and Analysis of Historical Data:

- a. Provide trending capabilities that will allow the operator to monitor and store records of system activity over an extended period of time. Points may be trended automatically on time based intervals or change of value, both of which shall be user definable. The trend interval could be five (5) minutes to 120 hours. Trend data may be stored on hard disk for future diagnostic and reporting. Additionally trend data may be archived to network drives or removable disk media for off-site retrieval.
- b. Reports may be customized to include individual points or predefined groups of at least six points. Provide additional functionality to allow pre-defined groups of up to 250 trended points to be easily accessible by other industry standard word processing and spreadsheet packages. The reports shall be time and date stamped and shall contain a report title and the name of the facility.
- c. System shall have the set up to generate spreadsheet reports to track energy usage and cost based on weekly or monthly interval, equipment run times, equipment efficiency, and/or building environmental conditions.
- d. Provide additional functionality that will allow the operator to view real time trend data on trend graph displays. A minimum of 20 points may be graphed regardless of whether they have been

predefined for trending. In addition, the user may pause the graph and take snapshots of the screens to be stored on the workstation disk for future reference and trend analysis. Exact point values may be viewed and the graph may be printed. Operator shall be able to command points directly on the trend plot by double clicking on the point.

20. Alarm Management:

- a. Alarm routing shall allow the operator to send alarm notification to selected printers or operator workstation based on time of day, alarm severity, or point type.
- b. Alarm notification shall be provided via two alarm icons, to distinguish between routine, maintenance type alarms and critical alarms. The critical alarms shall display on the screen at the time of its occurrence, while others shall display by clicking on their icon.
- c. Alarm display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message in English language. The operator shall be able to sort out the alarms.
- d. Alarm messages shall be customized for each point to display detailed instructions to the operator regarding actions to take in the event of an alarm.
- e. An operator with proper security level access may acknowledge and clear the alarm. All that have not been cleared shall be archived at workstation disk.

LL. Remote Communications:

1. The Engineering Control Center described in paragraph 2.4 shall be accessed locally on site. Remote access to the system shall not be allowed.

2.5 BACNET PROTOCOL ANALYZER

- A. For ease of troubleshooting and maintenance, provide a BACnet protocol analyzer. Provide its associated fittings, cables and appurtenances, for connection to the communications network. The BACnet protocol analyzer shall be able to, at a minimum: capture and store to a file all data traffic on all network levels; measure bandwidth usage; filter out (ignore) selected traffic.

2.6 NETWORK AND DEVICE NAMING CONVENTION

A. Network Numbers

1. BACnet network numbers shall be based on a "facility code, network" concept. The "facility code" is the VAMC's or VA campus' assigned numeric value assigned to a specific facility or building. The "network" typically corresponds to a "floor" or other logical configuration within the building. BACnet allows 65535 network numbers per BACnet internet work.
2. The network numbers are thus formed as follows: "Net #" = "FFFNN" where:
 - a. FFF = Facility code (see below)
 - b. NN = 00-99 This allows up to 100 networks per facility or building

B. Device Instances

1. BACnet allows 4194305 unique device instances per BACnet internet work. Using Agency's unique device instances are formed as follows: "Dev #" = "FFFNDD" where
 - a. FFF and N are as above and
 - b. DD = 00-99, this allows up to 100 devices per network.
2. Note Special cases, where the network architecture of limiting device numbering to DD causes excessive subnet works. The device number can be expanded to DDD and the network number N can become a single digit. In NO case shall the network number N and the device number D exceed 4 digits.
3. Facility code assignments:
4. 000-400 Building/facility number
5. Note that some facilities have a facility code with an alphabetic suffix to denote wings, related structures, etc. The suffix will be ignored. Network numbers for facility codes above 400 will be assigned in the range 000-399.

C. Device Names

1. Name the control devices based on facility name, location within a facility, the system or systems that the device monitors and/or controls, or the area served. The intent of the device naming is to be easily recognized. Names can be up to 254 characters in length, without embedded spaces. Provide the shortest descriptive, but unambiguous, name. For example, in building #123 prefix the number with a "B" followed by the building number, if there is only one

chilled water pump "CHWP-1", a valid name would be "B123.CHWP.1.STARTSTOP". If there are two pumps designated "CHWP-1", one in a basement mechanical room (Room 0001) and one in a penthouse mechanical room (Room PH01), the names could be "B123.R0001.CHWP.1.STARTSTOP" or "B123.RPH01.CHWP.1.STARTSTOP". In the case of unitary controllers, for example a VAV box controller, a name might be "B123.R101.VAV". These names should be used for the value of the "Object_Name" property of the BACnet Device objects of the controllers involved so that the BACnet name and the EMCS name are the same.

2.7 BACNET DEVICES

- A. All BACnet Devices - controllers, gateways, routers, actuators and sensors shall conform to BACnet device profiles and shall be BACnet Testing Laboratories (BTL) -listed as conforming to those device profiles. Protocol Implementation Conformance Statements (PICSs), describing the BACnet capabilities of the devices shall be published and available of the devices through links in the BTL website.
 - 1. BACnet Building Controllers, historically referred to as NACs, shall conform to the BACnet B-BC Device Profile, and shall be BTL-Listed as conforming to the B-BC Device Profile. The Device's PICS shall be submitted.
 - 2. BACnet Advanced Application Controllers shall conform to the BACnet B-AAC Device Profile, and shall be BTL-Listed as conforming to the B-AAC Device Profile. The Device's PICS shall be submitted.
 - 3. BACnet Application Specific Controllers shall conform to the BACnet B-ASC Device Profile, and shall be BTL-Listed as conforming to the B-ASC Device Profile. The Device's PICS shall be submitted.
 - 4. BACnet Smart Actuators shall conform to the BACnet B-SA Device Profile, and shall be BTL-Listed as conforming to the B-SA Device Profile. The Device's PICS shall be submitted.
 - 5. BACnet Smart Sensors shall conform to the BACnet B-SS Device Profile, and shall be BTL-Listed as conforming to the B-SS Device Profile. The Device's PICS shall be submitted.
 - 6. BACnet routers and gateways shall conform to the BACnet B-OTH Device Profile, and shall be BTL-Listed as conforming to the B-OTH Device Profile. The Device's PICS shall be submitted.

2.8 CONTROLLERS

A. General: Provide an adequate number of BTL-Listed B-BC building controllers and an adequate number of BTL-Listed B-AAC advanced application controllers to achieve the performance specified in the Part 1 Article on "System Performance." Each of these controllers shall meet the following requirements.

1. The controller shall have sufficient memory to support its operating system, database, and programming requirements.
2. The building controller shall share data with the ECC and the other networked building controllers. The advanced application controller shall share data with its building controller and the other networked advanced application controllers.
3. The operating system of the controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
4. Controllers that perform scheduling shall have a real-time clock.
5. The controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
 - a. assume a predetermined failure mode, and generate an alarm notification.
6. The controller shall communicate with other BACnet devices on the internetwork using the BACnet Read (Execute and Initiate) and Write (Execute and Initiate) Property services.
7. Communication.
 - a. Each controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol for its communications. Each building controller also shall perform BACnet routing if connected to a network of custom application and application specific controllers.
 - b. The controller shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable operator's terminal.
8. Keypad. A local keypad and display shall be provided for each controller. The keypad shall be provided for interrogating and editing data. Provide a system security password shall be available to prevent unauthorized use of the keypad and display.

9. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
 10. Memory. The controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
 11. The controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Controller operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
- B. Provide BTL-Listed B-ASC application specific controllers for each piece of equipment for which they are constructed. Application specific controllers shall communicate with other BACnet devices on the internetwork using the BACnet Read (Execute) Property service.
1. Each B-ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.
 2. Each B-ASC will contain sufficient I/O capacity to control the target system.
 3. Communication.
 - a. Each controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol for its communications. Each building controller also shall perform BACnet routing if connected to a network of custom application and application specific controllers.
 4. Serviceability: Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
 5. Memory: The application specific controller shall use nonvolatile memory and maintain all BIOS and programming information in the event of a power loss.
 6. Immunity to power and noise: Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

7. Transformer: Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type.

C. Direct Digital Controller Software

1. The software programs specified in this section shall be commercially available, concurrent, multi-tasking operating system and support the use of software application that operates under Microsoft Windows.
2. All points shall be identified by up to 30-character point name and 16-character point descriptor. The same names shall be used at the ECC.
3. All control functions shall execute within the stand-alone control units via DDC algorithms. The VA shall be able to customize control strategies and sequences of operations defining the appropriate control loop algorithms and choosing the optimum loop parameters.
4. All controllers shall be capable of being programmed to utilize stored default values for assured fail-safe operation of critical processes. Default values shall be invoked upon sensor failure or, if the primary value is normally provided by the central or another CU, or by loss of bus communication. Individual application software packages shall be structured to assume a fail-safe condition upon loss of input sensors. Loss of an input sensor shall result in output of a sensor-failed message at the ECC. Each ACU and RCU shall have capability for local readouts of all functions. The UCUs shall be read remotely.
5. All DDC control loops shall be able to utilize any of the following control modes:
 - a. Two position (on-off, slow-fast) control.
 - b. Proportional control.
 - c. Proportional plus integral (PI) control.
 - d. Proportional plus integral plus derivative (PID) control. All PID programs shall automatically invoke integral wind up prevention routines whenever the controlled unit is off, under manual control of an automation system or time initiated program.
 - e. Automatic tuning of control loops.
6. System Security: Operator access shall be secured using individual password and operator's name. Passwords shall restrict the operator to the level of object, applications, and system functions assigned

to him. A minimum of six (6) levels of security for operator access shall be provided.

7. Application Software: The controllers shall provide the following programs as a minimum for the purpose of optimizing energy consumption while maintaining comfortable environment for occupants. All application software shall reside and run in the system digital controllers. Editing of the application shall occur at the ECC or via a portable operator's terminal, when it is necessary, to access directly the programmable unit.

- a. Power Demand Limiting (PDL): Power demand limiting program shall monitor the building power consumption and limit the consumption of electricity to prevent peak demand charges. PDL shall continuously track the electricity consumption from a pulse input generated at the kilowatt-hour/demand electric meter. PDL shall sample the meter data to continuously forecast the electric demand likely to be used during successive time intervals. If the forecast demand indicates that electricity usage will likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads. Once the demand load has met, loads that have been shed shall be restored and returned to normal mode. Control system shall be capable of demand limiting by resetting the HVAC system set points to reduce load while maintaining indoor air quality.

- b. Economizer: An economizer program shall be provided for VAV systems. This program shall control the position of air handler relief, return, and outdoors dampers. If the outdoor air dry bulb temperature falls below changeover set point the energy control center will modulate the dampers to provide 100 percent outdoor air. The operator shall be able to override the economizer cycle and return to minimum outdoor air operation at any time.

- c. Night Setback/Morning Warm up Control: The system shall provide the ability to automatically adjust set points for this mode of operation.

- d. Optimum Start/Stop (OSS): Optimum start/stop program shall automatically be coordinated with event scheduling. The OSS program shall start HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone

condition by the time of occupancy, and it shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period and still maintain desired comfort conditions. The OSS program shall consider both outside weather conditions and inside zone conditions. The program shall automatically assign longer lead times for weekend and holiday shutdowns. The program shall poll all zones served by the associated AHU and shall select the warmest and coolest zones. These shall be used in the start time calculation. It shall be possible to assign occupancy start times on a per air handler unit basis. The program shall meet the local code requirements for minimum outdoor air while the building is occupied. Modification of assigned occupancy start/stop times shall be possible via the ECC.

- e. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or a group of points according to a stored time. This program shall provide the capability to individually command a point or group of points. When points are assigned to one common load group it shall be possible to assign variable time advances/delays between each successive start or stop within that group. Scheduling shall be calendar based and advance schedules may be defined up to one year in advance. Advance schedule shall override the day-to-day schedule. The operator shall be able to define the following information:
 - 1) Time, day.
 - 2) Commands such as on, off, auto.
 - 3) Time delays between successive commands.
 - 4) Manual overriding of each schedule.
 - 5) Allow operator intervention.
- f. Alarm Reporting: The operator shall be able to determine the action to be taken in the event of an alarm. Alarms shall be routed to the ECC based on time and events. An alarm shall be able to start programs, login the event, print and display the messages. The system shall allow the operator to prioritize the alarms to minimize nuisance reporting and to speed operator's response to critical alarms. A minimum of six (6) priority levels of alarms shall be provided for each point.

g. Maintenance Management (PM): The program shall monitor equipment status and generate maintenance messages based upon the operators defined equipment run time, starts, and/or calendar date limits. A preventative maintenance alarm shall be printed indicating maintenance requirements based on pre-defined run time. Each preventive message shall include point description, limit criteria and preventative maintenance instruction assigned to that limit. A minimum of 480-character PM shall be provided for each component of units such as air handling units.

- 1) Chilled water Plant Operation: Refer to section 23 64 10 for BACnet points to be obtained from the modular chiller plant.

2.9 CONTROL CABLES

A. General:

1. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments. Comply with Section 26 05 26.
2. Cable conductors to provide protection against induction in circuits. Crosstalk attenuation within the system shall be in excess of -80 dB throughout the frequency ranges specified.
3. Minimize the radiation of RF noise generated by the system equipment so as not to interfere with any audio, video, data, computer main distribution frame (MDF), telephone customer service unit (CSU), and electronic private branch exchange (EPBX) equipment the system may service.
4. The as-installed drawings shall identify each cable as labeled, used cable, and bad cable pairs.
5. Label system's cables on each end. Test and certify cables in writing to the VA before conducting proof-of-performance testing. Minimum cable test requirements are for impedance compliance, inductance, capacitance, signal level compliance, opens, shorts, cross talk, noise, and distortion, and split pairs on all cables in the frequency ranges used. Make available all cable installation and test records at demonstration to the VA. All changes (used pair, failed pair, etc.) shall be posted in these records as the change occurs.
6. Power wiring shall not be run in conduit with communications trunk wiring or signal or control wiring operating at 100 volts or less.

- B. Analogue control cabling shall be not less than No. 18 AWG solid, with thermoplastic insulated conductors as specified in Section 26 05 21.
- C. Copper digital communication cable between the ECC and the B-BC and B-AAC controllers shall be 100BASE-TX Ethernet, Category 6e, not less than minimum 24 American Wire Gauge (AWG) solid, Shielded Twisted Pair (STP) or Unshielded Twisted Pair (UTP), with thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, as specified in Section 27 10 05.
 - 1. Other types of media commonly used within IEEE Std 802.3 LANs (e.g., 10Base-T and 10Base-2) shall be used only in cases to interconnect with existing media.
- D. Optical digital communication fiber, if used, shall be multimode or singlemode fiber, 62.5/125 micron for multimode or 10/125 micron for singlemode micron with SC or ST connectors as specified in TIA-568-C.1. Terminations, patch panels, and other hardware shall be compatible with the specified fiber and shall be as specified in Section 27 10 05. Fiber-optic cable shall be suitable for use with the 100Base-FX or the 100Base-SX standard (as applicable) as defined in IEEE Std 802.3.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Examine project plans for control devices and equipment locations; and report any discrepancies, conflicts, or omissions to Project VA Engineer for resolution before proceeding for installation.
2. Install equipment, piping, wiring/conduit parallel to or at right angles to building lines.
3. Install all equipment and piping in readily accessible locations. Do not run conduit concealed under insulation or inside ducts.
4. Mount control devices and conduit located on ducts and apparatus with external insulation on standoff support to avoid interference with insulation.
5. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
6. Run wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing.
7. Install equipment level and plum.

B. Electrical Wiring Installation:

1. All wiring cabling shall be installed in conduits. Install conduits and wiring in accordance with Specification Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS. Conduits carrying control wiring and cabling shall be dedicated to the control wiring and cabling: these conduits shall not carry power wiring. Provide plastic end sleeves at all conduit terminations to protect wiring from burrs.
2. Install analog signal and communication cables in conduit and in accordance with Specification Section 26 05 21. Install digital communication cables in conduit and in accordance with Specification Section 27 10 05, Computer Network and Telephone Wiring System.
3. Install conduit and wiring between operator workstation(s), digital controllers, electrical panels, indicating devices, instrumentation, miscellaneous alarm points, thermostats, and relays as shown on the drawings or as required under this section.
4. Install all electrical work required for a fully functional system and not shown on electrical plans or required by electrical specifications. Where low voltage (less than 50 volt) power is required, provide suitable Class B transformers.
5. Install all system components in accordance with local Building Code and National Electric Code.
 - a. Splices: Splices in shielded and coaxial cables shall consist of terminations and the use of shielded cable couplers. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties.
 - b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 300 mm (12 inches) long. Equipment for fiber optics system shall be rack mounted, as applicable, in ventilated, self-supporting, code gauge steel enclosure. Cables shall be supported for minimum sag.
 - c. Cable Runs: Keep cable runs as short as possible. Allow extra length for connecting to the terminal board. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.
 - d. Use vinyl tape, sleeves, or grommets to protect cables from vibration at points where they pass around sharp corners, through walls, panel cabinets, etc.

6. Conceal cables, except in mechanical rooms and areas where other conduits and piping are exposed.
7. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
8. Grounding: ground electrical systems per manufacturer's written requirements for proper and safe operation.

C. Install Sensors and Controls:

1. All control components required to be installed outside of the chiller plant building enclosure shall be furnished by the enclosure manufacturer but completed by this contractor including all wiring, conduit, and accessories. Provide connection to chiller plant controls system in coordination with manufacturer.
2. Temperature Sensors:
 - a. Install all sensors and instrumentation according to manufacturer's written instructions. Temperature sensor locations shall be readily accessible, permitting quick replacement and servicing of them without special skills and tools.
 - b. Calibrate sensors to accuracy specified, if not factory calibrated.
 - c. Use of sensors shall be limited to its duty, e.g., duct sensor shall not be used in lieu of room sensor.
 - d. Install room sensors permanently supported on wall frame. They shall be mounted at 1.5 meter (5.0 feet) above the finished floor.
 - e. Mount sensors rigidly and adequately for the environment within which the sensor operates. Separate extended-bulb sensors from contact with metal casings and coils using insulated standoffs.
 - f. Sensors used in mixing plenum, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
 - g. All pipe mounted temperature sensors shall be installed in wells.
 - h. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor reading.
 - i. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting

or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.

2. Pressure Sensors:

- a. Install duct static pressure sensor tips facing directly downstream of airflow.
- b. Install high-pressure side of the differential switch between the pump discharge and the check valve.
- c. Install snubbers and isolation valves on steam pressure sensing devices.

3. Actuators:

- a. Mount and link damper and valve actuators according to manufacturer's written instructions.
- b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed position.
- c. Check operation of valve/actuator combination to confirm that actuator modulates valve smoothly in both open and closed position.

4. Flow Switches:

- a. Install flow switch according to manufacturer's written instructions.
- b. Mount flow switch a minimum of 5 pipe diameters up stream and 5 pipe diameters downstream or 600 mm (2 feet) whichever is greater, from fittings and other obstructions.
- c. Assure correct flow direction and alignment.
- d. Mount in horizontal piping-flow switch on top of the pipe.

D. Installation of network:

1. Ethernet:

- a. The network shall employ Ethernet LAN architecture, as defined by IEEE 802.3. The Network Interface shall be fully Internet Protocol (IP) compliant allowing connection to currently installed IEEE 802.3, Compliant Ethernet Networks.
- b. The network shall directly support connectivity to a variety of cabling types. As a minimum provide the following connectivity: 100 Base TX (Category 6e cabling) for the communications between the ECC and the B-BC and the B-AAC controllers.

2. Third party interfaces: Contractor shall integrate real-time data from building systems by other trades and databases originating from other manufacturers as specified and required to make the system work as one system.

E. Installation of digital controllers and programming:

1. Provide a separate digital control panel for each major piece of equipment, such as chiller, pumping unit etc. Points used for control loop reset such as outdoor air, outdoor humidity, or space temperature could be located on any of the remote control units.
2. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25 percent of available memory free for future use.
3. System point names shall be modular in design, permitting easy operator interface without the use of a written point index.
4. Provide software programming for the applications intended for the systems specified, and adhere to the strategy algorithms provided.
5. Provide graphics for each piece of equipment and floor plan in the building. This includes each chiller, cooling tower, fan, pumping unit etc. These graphics shall show all points dynamically as specified in the point list.

3.2 SYSTEM VALIDATION AND DEMONSTRATION

- A. As part of final system acceptance, a system demonstration is required (see below). Prior to start of this demonstration, the contractor is to perform a complete validation of all aspects of the controls and instrumentation system.

B. Validation

1. Prepare and submit for approval a validation test plan including test procedures for the performance verification tests. Test Plan shall address all specified functions of the ECC and all specified sequences of operation. Explain in detail actions and expected results used to demonstrate compliance with the requirements of this specification. Explain the method for simulating the necessary conditions of operation used to demonstrate performance of the system. Test plan shall include a test check list to be used by the Installer's agent to check and initial that each test has been successfully completed. Deliver test plan documentation for the performance verification tests to the owner's representative 30 days prior to start of performance verification tests. Provide draft

copy of operation and maintenance manual with performance verification test.

2. After approval of the validation test plan, installer shall carry out all tests and procedures therein. Installer shall completely check out, calibrate, and test all connected hardware and software to insure that system performs in accordance with approved specifications and sequences of operation submitted. Installer shall complete and submit Test Check List and Calibration Report. The Calibration Report shall include the status of all new control equipment in order to verify that every component is operating within its specified range.

C. Demonstration

1. System operation and calibration to be demonstrated by the installer in the presence of the Architect or VA's representative on random samples of equipment as dictated by the Architect or VA's representative. Should random sampling indicate improper commissioning, the owner reserves the right to subsequently witness complete calibration of the system at no addition cost to the VA.
2. Demonstrate to authorities that all required safeties and life safety functions are fully functional and complete.
3. Make accessible, personnel to provide necessary adjustments and corrections to systems as directed by balancing agency.
4. The following witnessed demonstrations of field control equipment shall be included (All demonstrations shall be carefully coordinated with the VA in order to minimize disruptions to the hospital and its staff. Demonstrations shall be completed during seasonal months when units are operational. (For instance, chillers shall be demonstrated during cooling months.)
 - a. Observe HVAC systems in shut down condition. Check dampers and valves for normal position.
 - b. Test application software for its ability to communicate with digital controllers, operator workstation, and uploading and downloading of control programs.
 - c. Demonstrate the software ability to edit the control program off-line.
 - d. Demonstrate reporting of alarm conditions for each alarm and ensure that these alarms are received at the assigned location, including operator workstations.

- e. Demonstrate ability of software program to function for the intended applications-trend reports, change in status etc.
 - f. Demonstrate via graphed trends to show the sequence of operation is executed in correct manner, and that the HVAC systems operate properly through the complete sequence of operation, e.g., seasonal change, occupied/unoccupied mode, and warm-up condition.
 - g. Demonstrate hardware interlocks and safeties functions, and that the control systems perform the correct sequence of operation after power loss and resumption of power loss.
 - h. Prepare and deliver to the VA graphed trends of all control loops to demonstrate that each control loop is stable and the set points are maintained.
 - i. Demonstrate that each control loop responds to set point adjustment and stabilizes within one (1) minute. Control loop trend data shall be instantaneous and the time between data points shall not be greater than one (1) minute.
5. Witnessed demonstration of ECC functions shall consist of:
- a. Running each specified report showing a list of all points being obtained from the chiller plant.
 - b. Display and demonstrate each data entry to show site specific customizing capability. Demonstrate parameter changes.
 - c. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
 - d. Execute digital and analog commands in graphic mode.
 - e. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs (6 loops minimum).
 - f. Demonstrate EMS performance via trend logs and command trace.
 - g. Demonstrate scan, update, and alarm responsiveness.
 - h. Demonstrate spreadsheet/curve plot software, and its integration with database.
 - i. Demonstrate on-line user guide, and help function and mail facility.
 - j. Demonstrate digital system configuration graphics with interactive upline and downline load, and demonstrate specified diagnostics.
 - k. Demonstrate multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.

1. Demonstrate class programming with point options of beep duration, beep rate, alarm archiving, and color banding.

----- END -----

**SECTION 23 21 13
HYDRONIC PIPING**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Water piping to connect HVAC equipment, including the following:
 - 1. Chilled water, condenser water, and drain piping.
 - 2. Glycol-water piping.
 - 3. Factory prefabricated (preinsulated) chilled water piping for underground service.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 31 20 00, EARTHWORK: Excavation and backfill.
- D. Section 03 30 00, CAST-IN-PLACE CONCRETE.
- E. 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.
- F. Section 23 21 23, HYDRONIC PUMPS: Pumps.
- G. Section 23 07 11, HVAC INSULATION: Piping insulation.
- H. Section 23 25 00, HVAC WATER TREATMENT: Water treatment for open and closed systems.
- I. Section 23 21 13, HYDRONIC PIPING: Underground chilled water piping.
- J. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Temperature and pressure sensors and valve operators.
- K. Section 23 64 10, MODULAR CHILLER PLANT

1.3 QUALITY ASSURANCE

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION, which includes welding qualifications.
- B. Design Working Pressure for Preinsulated Chilled Water Piping: 861 kPa (125 psig).
- C. 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.
- D. On Site Supervision of Underground Preinsulated Chilled Water Piping Installation:
 - 1. Provide services of a factory trained representative of the pipe manufacturer for a minimum of three days, to include pre installation, installation and testing periods.

2. Representative's daily written reports to the VA Project Engineer:

Present the original of each report on the day it is prepared and forward a copy to the manufacturer's main office. The report shall be signed by the manufacturer's representative. The report shall state whether or not the condition and quality of the materials used and the installation of the system is in accordance with the plans, specifications, and published standards of the manufacturer, and is satisfactory in all respects. If anything connected with the installation is unsatisfactory, the report shall state that corrective action has been taken or shall contain the manufacturer's recommendations for corrective action. The report shall cover any condition that could result in an unsatisfactory installation. The representative shall take prompt action to return to the factory all damaged and defective material, and shall order prompt replacement of such material.

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 equipment supports.
2. Pipe and tubing, with specification, class or type, and schedule.
3. Pipe fittings, including miscellaneous adapters and special fittings.
4. Flanges, gaskets and bolting.
5. Grooved joint couplings and fittings.
6. Valves of all types.
7. Strainers.
8. All specified hydronic system components.
9. Water flow measuring devices.
10. Gages.
11. Thermometers and test wells.

C. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:

1. Air separators.
2. Expansion tanks.

D. Manufacturer's certificates for underground preinsulated chilled water piping:

1. That the field representative for the factory insulated pipe installation is technically qualified and experienced in installation of the manufacturer's system and is qualified to provide the required site reports.
 2. Upon completion of the work and before final acceptance, the Contractor shall deliver a notarized statement, signed by a principal officer of both the manufacturing firm and the contracting firm, stating that the installation is satisfactory and in accordance with the plans, specifications, and manufacturer's standards.
- E. 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.
- F. Coordination Drawings: Refer to Article, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- G. As-Built Piping Diagrams: Provide drawing as follows for chilled water, condenser water, and other piping systems and equipment.
1. One wall-mounted stick file with complete set of prints. Mount stick file in the chiller plant or control room along with control diagram stick file.
 2. One complete set of reproducible mylar drawings in the same size as contract documents.
 3. One complete set of drawings in electronic format (Autocad version compatible with the version currently in use at the Fargo VA Medical Center).

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 Mechanical Engineers (ASME):
- B1.20.1-83.....Pipe Threads, General Purpose (Inch)
 - B16.1-98.....Cast Iron Pipe Flanges and Flanged Fittings
 - B16.3-98.....Malleable Iron Threaded Fittings
 - B16.4-98.....Gray Iron Threaded Fittings
 - B16.5-03.....Pipe Flanges and Flanged Fittings
 - B16.9-03.....Factory-Made Wrought Buttwelding Fittings
 - B16.11-05.....Forged Fittings, Socket-Welding and Threaded

- B16.14-91.....Ferrous Pipe Plugs, Bushings, and Locknuts with
Pipe Threads
- B16.22-01.....Wrought Copper and Copper Alloy Solder-Joint
Pressure Fittings
- B16.23-02.....Cast Copper Alloy Solder Joint Drainage
Fittings
- B16.24-01.....Cast Copper Alloy Pipe Flanges and Flanged
Fittings, Class 150, 300, 400, 600, 900, 1500
and 2500
- B16.39-98.....Malleable Iron Threaded Pipe Unions, Classes
150, 250, and 300
- B16.42-98.....Ductile Iron Pipe Flanges and Flanged Fittings:
Classes 150 and 300
- B31.1-01.....Power Piping
- B31.9-04.....Building Services Piping
- B40.100-05.....Pressure Gauges and Gauge Attachments
- C. American National Standards Institute, Inc. (ANSI):
- B16.1 00.....Cast Iron Pipe Flanges and Flanged Fittings,
Class 25, 125 and 250
- B16.3 00.....Malleable Iron Threaded Fittings Classes 150
and 300
- B16.5 03.....Pipe Flanges and Flanged Fittings NPS ½ through
NPS 24
- B16.9 03.....Factory Made Wrought Butt Welding Fittings
- B16.11 01.....Forged Fittings, Socket Welding and Threaded
- B16.14 91.....Ferrous Pipe Plugs, Bushings and Locknuts with
Pipe Threads
- B16.18-01.....Cast Copper Alloy Solder joint Pressure
fittings
- B16.22 00.....Wrought Copper and Bronze Solder Joint Pressure
Fittings
- B16.24 01.....Cast Copper Alloy Pipe Fittings and Flanged
Fittings: Class 150, 300, 400, 600, 900, 1500
and 2500
- B31.1 01.....Power Piping
- D. American Society for Testing and Materials (ASTM):
- A47/A47M-99 (2004).....Ferritic Malleable Iron Castings

A53/A53M-06.....Standard Specification for Pipe, Steel, Black
 and Hot-Dipped, Zinc-Coated, Welded and
 Seamless
 A106/A106M-06.....Standard Specification for Seamless Carbon
 Steel Pipe for High-Temperature Service
 A126-04.....Standard Specification for Gray Iron Castings
 for Valves, Flanges, and Pipe Fittings
 A181/A181M-01.....Standard Specification for Carbon Steel
 Forgings, for General-Purpose Piping
 A183-03.....Standard Specification for Carbon Steel Track
 Bolts and Nuts
 A216/A216M-04 Standard Specification for Steel Castings,
 Carbon, Suitable for Fusion Welding, for High
 Temperature Service
 A234/A234M 04 Piping Fittings of Wrought Carbon Steel and
 Alloy Steel for Moderate and High Temperature
 Service
 A307-04 Standard Specification for Carbon Steel Bolts
 and Studs, 60,000 PSI Tensile Strength
 A536-84 (2004) Standard Specification for Ductile Iron Castings
 A 615/A 615M-04 Deformed and Plain Carbon Steel Bars for
 Concrete Reinforcement
 A653/A 653M-04 Steel Sheet, Zinc-Coated (Galvanized) or Zinc-
 Iron Alloy Coated (Galvannealed) By the Hot-Dip
 Process
 B32-04 Standard Specification for Solder Metal
 B61-02 Standard Specification for Steam or Valve Bronze
 Castings
 B62-02 Standard Specification for Composition Bronze or
 Ounce Metal Castings
 B88-03 Standard Specification for Seamless Copper Water
 Tube
 B209 04 Aluminum and Aluminum Alloy Sheet and Plate
 C177 97 Standard Test Method for Steady State Heat Flux
 Measurements and Thermal Transmission Properties
 by Means of the Guarded Hot Plate Apparatus
 C478-03 Precast Reinforced Concrete Manhole Sections

- C533 03 Calcium Silicate Block and Pipe Thermal
Insulation
- C552 03 Cellular Glass Thermal Insulation
- C591-01 Unfaced Preformed Rigid Cellular
Polyisocyanurate Thermal Insulation
- E. American Water Works Association (AWWA):
- C110/03.....Ductile Iron and Grey Iron Fittings for Water
- C203 00.....Coal Tar Protective Coatings and Linings for
Steel Water Pipe Lines Enamel and Tape Hot
Applied
- F. American Welding Society (AWS):
- A5.8/A5.8M-04.....Specification for Filler Metals for Brazing and
Braze Welding
- B2.1-02.....Standard Welding Procedure Specification
- G. Copper Development Association, Inc. (CDA):
- CDA A4015-95.....Copper Tube Handbook
- H. Expansion Joint Manufacturer's Association, Inc. (EJMA):
- EMJA-2003.....Expansion Joint Manufacturer's Association
Standards, Eighth Edition
- I. Manufacturers Standardization Society (MSS) of the Valve and Fitting
Industry, Inc.:
- SP-70-06.....Gray Iron Gate Valves, Flanged and Threaded
Ends
- SP-71-05.....Gray Iron Swing Check Valves, Flanged and
Threaded Ends
- SP-72-99.....Ball Valves with Flanged or Butt-Welding Ends
for General Service
- SP-78-05.....Cast Iron Plug Valves, Flanged and Threaded
Ends
- SP-80-03.....Bronze Gate, Globe, Angle and Check Valves
- SP-85-02.....Cast Iron Globe and Angle Valves, Flanged and
Threaded Ends
- J. Tubular Exchanger Manufacturers Association: TEMA 8th Edition, 2000
- K. Sheet Metal and Air Conditioning Contractors National Association
(SMACNA):
- HVAC Duct Construction Standards, 2nd Edition 1997

1.6 SPARE PARTS

- A. For mechanical pressed sealed fittings provide tools required for each pipe size used at the facility.

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 AND STEAM GENERATION.

2.2 PIPE AND TUBING

- A. Chilled Water (above ground), Condenser Water (above ground), and Glycol-Water Piping:
 - 1. Steel: ASTM A53 Grade B, seamless or ERW, Schedule 40.
 - 2. All condenser water piping shall be Schedule 10 welded stainless steel with all stainless steel fittings.
 - 3. Copper water tube option: ASTM B88, Type K or L, hard drawn.
 - 4. Chilled water piping underground: Factory prefabricated (preinsulated chilled water piping).
- B. Cooling Coil Condensate Drain Piping:
 - 1. From air handling units: Copper water tube, ASTM B88 or Type M.
- C. Chemical Feed Piping for Condenser Water Treatment: Chlorinated polyvinyl chloride (CPVC), Schedule 80, ASTM F441.
- 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. 65 mm (2-1/2 inches) and Larger: Welded or flanged joints. Mechanical couplings and fittings are optional for water piping only.
 - 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.
- B. 50 mm (2 inches) and Smaller: Screwed or welded. Mechanical couplings are optional for water piping only.

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.

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. Mechanical Pipe Couplings and Fittings: May be used, 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.

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 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. Solder Joint:

1. 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. Contractor's Option: Mechanical press sealed fittings, double pressed type, NSF 50/61 approved, with EPDM (ethylene propylene diene monomer) non-toxic synthetic rubber sealing elements for up to 65 mm (2-1/2 inch) and below are optional for above ground water piping only.
3. 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.

2.5 FITTINGS FOR PLASTIC PIPING

A. Chemical feed piping for condenser water treatment: Chlorinated polyvinyl chloride (CPVC), Schedule 80, ASTM F439.

2.6 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).

2.7 SCREWED JOINTS

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

2.8 VALVES

- A. Asbestos packing shall not be allowed.
- B. All valves of the same type shall be products of a single manufacturer. Provide gate and globe valves with packing that can be replaced with the valve under full working pressure.
- C. Provide chain operators for valves 100 mm (4 inches) and larger when the centerline is located 2400 mm (8 feet) or more above the floor or operating platform.
- D. Gate Valves:
 - 1. 50 mm (2 inches) and smaller: MSS-SP80, Bronze, 1034 kPa (150 lb.), wedge disc, rising stem, union bonnet.
 - 2. 65 mm (2 1/2 inches) and larger: Flanged, outside screw and yoke.
 - a. MSS-SP 70, iron body, bronze mounted, 861 kPa (125 psig) wedge disc.
- E. 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 piping. Check valves incorporating a balancing feature may be used.

1. Body: Cast iron, ASTM A126, Class B, or steel, ASTM A216, Class WCB, or ductile iron, ASTM 536, flanged, grooved, or wafer type.
2. Seat, disc and spring: 18-8 stainless steel, or bronze, ASTM B62.
Seats may be elastomer material.

F. Butterfly Valves: May be used in lieu of gate valves in water service except for direct buried pipe. Butterfly valves shall only be allowed to be used for piping larger than 6". Provide stem extension to allow 50 mm (2 inches) of pipe insulation without interfering with valve operation.

1. MSS-SP 67, flange lug type (for end of line service) or grooved end rated 1205 kPa (175 psig) working pressure at 93 degrees C (200 degrees F).
 - 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.
 - c. Actuators: Field interchangeable. Valves for balancing service shall have adjustable memory stop to limit open position.
 - 1) Valves 150 mm (6 inches) and larger: Enclosed worm gear with handwheel, and where required, chain-wheel operator.

G. Ball Valves: Brass or bronze body with chrome-plated ball with full port and Teflon seat at 2760 kPa (400 psig) working pressure rating. Screwed or solder connections. Provide stem extension to allow operation without interfering with pipe insulation.

H. Combination Strainer Ball Valve: combination ball valve, wye-strainer and union with pressure/temperature test ports. 20 mesh stainless steel strainer.

1. The ball valve shall have teflon packing, brass packing nut and blowout-proof stem, larger diameter plated ball and a full size steel handle with vinyl grip.
2. Valves shall be provided with stem extensions as required for insulation thickness applied.

I. Water Flow Balancing Valves: For flow regulation and shut-off. Valves shall be line size rather than reduced to control valve size and be one of the following types.

1. Ball valve as specified herein with memory stop.
2. Eccentric plug valve: Iron body, bronze or nickel-plated iron plug, bronze bearings, adjustable memory stop, operating lever, rated 861 kPa (125 psig) and 121 degrees C (250 degrees F).

J. Automatic Balancing Control Valves: Factory calibrated to maintain constant flow (plus or minus five percent) over system pressure fluctuations of at least 10 times the minimum required for control. Provide standard pressure taps and four sets of capacity charts. Valves shall be line size and be one of the following designs:

1. Gray iron (ASTM A126) or brass body rated 1205 kPa (175 psig) at 93 degrees C (200 degrees F), with stainless steel piston and spring.
2. Brass or ferrous body designed for 2067 kPa (300 psig) service at 121 degrees C (250 degrees F), with corrosion resistant, tamper proof, self-cleaning piston/spring assembly that is easily removable for inspection or replacement.
3. Provide a metal identification tag with chain for each valve, factory marked with the zone identification, valve model number, and rate flow in GPM; "O" ring style union, ball valve, lever handle operator and combination pressure/temperature test port.
4. The manufacturer, for a period of one year from shipment of valves, shall exchange up to 10 percent of the internal flow cartridges at no charge, if flow changes on terminal units are made.
5. Valves shall be provided with stem extension and port extensions as required for insulation thickness applied.
6. Combination assemblies containing ball type shut-off valves, unions, flow regulators, strainers with blowdown valves and pressure temperature ports shall be acceptable.
7. Provide a readout kit including flow meter, probes, hoses, flow charts 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. Venturi Type: Bronze, steel, or cast iron with bronze throat, with valved pressure sensing taps upstream and at the throat.

C. 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.

D. Flow Measuring Device Identification:

1. Metal tag attached by chain to the device.
2. Include meter or equipment number, manufacturer's name, meter model, flow rate factor and design flow rate in l/m (gpm).

2.10 STRAINERS

- A. Basket or Y Type. Tee type is acceptable for water service.
- B. 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.
- C. 100 mm (4 inches) and larger: 3.2 mm (0.125 inch) diameter perforations.
- D. Suction Diffusers: Specified in Section 23 21 23, HYDRONIC PUMPS.

2.11 HYDRONIC SYSTEM COMPONENTS

- A. Tangential Air Separator: ASME Pressure Vessel Code construction for 861 kPa (125 psig) working pressure, flanged tangential inlet and outlet connection, internal perforated stainless steel air collector tube designed to direct release air into expansion tank, bottom blowdown connection. If scheduled on the drawings, provide a removable stainless steel strainer element having 5 mm (3/16 inch) perforations and free area of not less than five times the cross-sectional area of connecting piping.
- B. Closed Expansion Tank: ASME Pressure Vessel Code construction for 861 kPa (125 psig) working pressure, steel, rust-proof coated. Provide tapped openings for drain (bottom) and plugged vent (top). Provide Form No. U-1.
 1. Vertical floor-mounted expansion tank: Provide system or drain connection (bottom) and air charging (top) tappings. Provide ball valve and necessary adapters for charging system. Tank support shall consist of floor mounted base ring with drain access opening or four angle iron legs with base plates.
- C. Pressure Relief Valve: Bronze or iron body and bronze or stainless steel trim, with testing lever. Comply with ASME Code for Pressure Vessels, Section 8, and bear ASME stamp.

D. Automatic Air Vent Valves: Cast iron or semi-steel body, 1034 kPa (150 psig) working pressure, stainless steel float, valve, valve seat and mechanism, minimum 15 mm (1/2 inch) water connection and 6 mm (1/4 inch) air outlet. Pipe air outlet to drain.

2.12 WATER FILTERS AND POT CHEMICAL FEEDERS

A. See section 23 25 00, HVAC WATER TREATMENT, Article 2.2, CHEMICAL TREATMENT FOR CLOSED LOOP SYSTEMS.

2.13 GAGES, PRESSURE AND COMPOUND

A. ASME B40.100, Accuracy Grade 1A, (pressure, vacuum, or compound for air, oil or water), initial mid-scale accuracy 1 percent of scale (Qualify grade), metal or phenolic case, 115 mm (4-1/2 inches) in diameter, 6 mm (1/4 inch) NPT bottom connection, white dial with black graduations and pointer, clear glass or acrylic plastic window, suitable for board mounting. Provide red "set hand" to indicate normal working pressure.

B. Provide brass lever handle union cock. Provide brass/bronze pressure snubber for gages in water service.

C. Range of Gages: Provide range equal to at least 130 percent of normal operating range.

2.14 THERMOMETERS

A. 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 may be slightly greater than shown to meet manufacturer's standard. Required ranges in degrees C (F):

Chilled Water and Glycol- Water 0 to 38 degrees C (32-100 degrees F)
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2.15 FIRESTOPPING MATERIAL

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.16 FACTORY PREFABRICATED (PREINSULATED) CHILLED WATER PIPING

A. Factory Prefabricated (Preinsulated) chilled water piping for underground service shall be equal to Perma-Pipe Xtru-Therm.

B. Inner Carrier Pipe:

1. Steel pipe: ASTM A53 black steel. Pipe up through 300 mm (12 inch) diameter shall be standard weight. Wall thickness for pipe larger than 300 mm (12 inch) diameter shall be not less than 10 mm (0.375 inch). Pipe larger than 50 mm (2 inches) shall be joined by welding.

C. Outer Casing: Outer casing shall be galvanized sheet metal, polyvinylchloride, polyethylene or reinforced thermosetting resin pipe as specified below:

1. Metal jacket (Above ground only): Spiral wound galvanized (G90) steel sheet, 0.70 mm (24 gage) minimum thickness, conforming to SMACNA HVAC Duct Construction Standards. Provide sheet metal covers for joints and fittings permanently attached by bands and rivets. Seal all lap seams in metal covers and weatherproof with silicone sealant or flexible polyurethane sealant strips. Shape covers to allow for insulation of mechanical coupling joints if used.
2. High Density Polyethylene (HDPE): Shall conform to ASTM D 3350, Type III, Class C, Category 3 or 4, Grade P 34 with thickness as follows:

Casing Diameter mm (inches)	Minimum Thickness (in mils)
200 (8) and smaller	100
225 to 500 (9 to 20)	120
525 to 550 (21 to 22)	165
575 to 600 (23 to 24)	200

Sizes larger than those shown above shall be approved in accordance with the Article, SUBMITTALS.

D. Factory Applied Insulation:

1. Foam insulation for prefabricated insulated pipe and fittings shall be polyurethane foam having a density not less than 32 kcm (2 pcf).
 - a. Polyurethane foam shall conform to ASTM 591, Type II, formed for conduit, density not less than 32 kg/cubic meter (2 pcf).
 - b. The insulation "k" factor shall not exceed the numerical value of 0.025 W/(m.k) (0.17 Btu-inch/h. square feet degree F) at 24

degrees C (75 degrees F) mean temperature in accordance with ASTM C177.

2. Insulation thickness for carrier pipe 75 mm (3 inches) nominal diameter and smaller: Not less than 18 mm (0.70 inch) or the standard manufactured thickness exceeding 18 mm (0.70 inch).
3. Insulation thickness for carrier pipe larger than 75 mm (3 inches) nominal diameter: 38 mm (1-1/2 inches).
4. All fittings of the insulated piping system shall be prefabricated and pre-insulated.
5. The polyurethane foam shall completely fill the annular space between the carrier pipe and the casing. Manufacturer shall certify that the insulated pipe is free of insulation voids and describe quality control procedure followed to meet this requirement.

E. Field Applied Insulation:

1. Insulation between fittings and straight pipe and other piping system accessories shall be cellular glass conforming to ASTM C552, calcium silicate conforming to ASTM C533 or polyurethane matching the pipe insulation. Insulation shall be premolded, precut or job fabricated to fit and shall be removable and reusable. Thickness shall match adjacent piping.
2. Buried fittings and accessories shall be factory fabricated and may have field foamed polyurethane insulation to match adjacent piping and shall be protected with a covering matching the pipe casing. Shrink sleeves shall be provided over casing connection joints.

F. End Seals:

1. General: Each preinsulated section of piping shall have a complete sealing of the insulation to provide permanent water and vapor seal at each end of the preinsulated section of piping. Preinsulated sections of piping modified in the field shall be provided with an end seal which is equivalent to the end seals furnished with the preinsulated section of piping. Provide complete sealing of the insulation at each end of each preinsulated conduit section by one of the following methods:
 - a. Carrying the outer casing over tapered pipe insulation ends and extending it to the carrier pipe. Provide sufficient surface bonding area between the casing and the carrier pipe to ensure a permanent water and vapor-resistant seal.

- b. Using specially designed prefabricated caps made of the same material and not less than the same thickness as the casing. Provide sufficient surface bonding area between the cap, and both the casing and carrier pipe, to ensure permanent water and vapor-resistant seal.
 - c. Using rubber ring gaskets designed and dimensioned to fit in the annular space between the casing and carrier pipe in such a manner as to ensure a permanent water and vapor-resistant seal.
 - d. Using shrink sleeves that shall be either heat shrinkable high temperature rubber or polyethylene material that can be bound to the carrier pipes and casing to ensure a permanent water and vapor-resistant seal.
2. Factory casing and end seal testing and certification:
- a. Testing and certification procedures by an independent testing laboratory shall demonstrate that casings and end seals are capable of resisting penetration of water into the casing and insulation at 60 kPa (20 feet) of head pressure, measured above the highest point of the test sample, subjected over the entire surface of an 2.5 m (8-feet) test sample of prefabricated pipe for not less than 48 hours. Test shall use 24 degrees C (75 degree F) water for chilled water service, while the sample is either buried or encased in dry bedding sand with a minimum of 305 mm (12 inches) of sand all around sample. The carrier pipe size in the test section shall be 75 mm (3 inches) in diameter and shall be restrained during the test period. The insulation thickness shall not exceed the maximum thickness provided for the piping in the project.
 - b. Test results for Federal Agency Committee on Underground Heat Distribution System, or similar results may be substituted.

G. Joints:

- 1. Welded joints: Welded joints between sections of pipe and between pipe and fittings shall be provided. Branch connections shall be made with either welding tees or forged branch outlet fittings attached to the main and reinforced against external strains.

2.17 BURIED UTILITY WARNING TAPE

- A. Tape shall be 0.1 mm (0.004 inch) thick, 150 mm (6 inches) wide, yellow polyethylene with a ferrous metallic core, acid and alkali-resistant and shall have a minimum strength of 12,000 kPa (1750 psig) lengthwise

and 10,300 kPa (1500 psig) crosswise with an elongation factor of 350 percent. Provide bold black letters on the tape identifying the type of system. Tape color and lettering shall be unaffected by moisture and other substances contained in the backfill material.

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 convertors and other 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.
- 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.

- 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 air vent at all piping system high points and drain valves at all low points.
- 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. 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.
- 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 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 INSTALLATION OF PREINSULATED CHILLED WATER PIPING

- A. Handling and Storage: Handle and store conduits, pipes, and all accessories to ensure complete installation in a sound undamaged condition. Unloading, tacking, moving, and storing of materials shall be in strict accordance with the manufacturer's requirements. Take special care to ensure that materials which have exceeded their specified shelf life are not used in the installation of the system. Before installation all materials shall be inspected for defects.

Materials found to be defective before or after installation shall be repaired or replaced with sound material, with no additional expense to the Government.

B. Installation of Piping Systems:

1. Piping system furnished shall be installed in accordance with the piping system manufacturer's instructions. Piping shall be installed without springing or forcing other than what has been calculated for thermal expansion and contraction. Pipe ends shall have burrs removed by reaming and shall be installed to permit free expansion and contraction without damage to joints or hangers. Nonmetallic pipe cut in the field shall be machined to fit couplings or joints and shall be coated or treated to match standard factory coated ends. Copper tubing shall not be installed in the same trench with ferrous piping materials. When nonferrous metallic pipe (e.g., copper tubing) crosses any ferrous piping material, a minimum vertical separation of 300 mm (12 inches) shall be maintained between pipes. Connections between different types of pipe and accessories shall be made with transition fittings approved by the manufacturer of the piping system.
2. Pitching of horizontal piping: Horizontal piping shall be pitched at a grade not less than 25 mm (1 inch) in 12 m (40 feet) toward the drain points unless otherwise indicated.
3. Install vacuum and air relief valves, as required, for filling and draining of the system.

C. Pipe Sleeves:

1. Pipe shall be continuous through sleeves. Set in place before concrete is poured.
2. Seal between sleeve and core opening with modular mechanical type link seal.
3. Provide where water lines pass through retaining walls and foundation walls.

D. Cutting of Prefabricated Conduit Sections: Prefabricated conduit sections shall be cut in strict accordance with the manufacturer's recommendations and standards. The cut section shall be treated as required to result in the cut section being identical in every respect to a standard conduit section produced at the factory.

E. Field Casing Closures: Field insulation and encasement of joints shall be accomplished after the visual and pressure tests specified are

completed. Field insulation and encasement shall be in accordance with the manufacturer's written instructions. Thickness dimensions of the insulation and casing materials shall not be less than those of the adjoining prefabricated section. Insulating material may be foamed in place polyurethane or premolded polyurethane foam sections. Care should be taken to ensure that field closures are made under conditions of temperature and cleanliness required to produce a sound continuous vapor barrier. A standard polyethylene heat shrink sleeve shall be installed over the casing and shall have a 150 mm (6-inch minimum) overlap at each end.

F. Insulation and Encasement of Pipe Accessories: Flanges, couplings, unions, valves, fittings, and other pipe accessories, unless otherwise shown or approved, shall be insulated with removable factory premolded, prefabricated or field fabricated insulation. For accessories buried underground, the casing material and thickness shall be identical to that of the adjoining casing material and thickness shall be identical to that of the adjoining casing except that for polyethylene casing larger than 300 mm (12-inch) size, the casing material over fittings shall be reinforced thermosetting resin (RTRP).

G. Trenching and Backfilling: Trench bottoms for underground prefabricated conduit systems shall be smooth and free of sharp objects, stones, and debris that could puncture the casing. Where this is a problem, the trench should be over excavated and stabilized by using sand, fine dirt, or similar material. Partial backfilling is required immediately after installation of the pipe. Selected backfill shall be tamped in not more than 150 mm (6 inch) layers under and around the conduit to a height of not less than 150 mm (6-inch) above the top of the casing. During this process, joints shall be left exposed for visual inspection during field tests.

H. Open Ends: Open ends of pipe lines and equipment shall be properly capped or plugged during installation to keep dirt and other foreign matter out of the system.

I. Vapor Barrier: Install materials to provide and preserve the integrity of the vapor barrier.

3.4 LEAK TESTING ABOVEGROUND AND UNDERGROUND PIPING

A. Inspect all joints and connections for leaks and workmanship and make corrections as necessary, to the satisfaction of the VA Project

Engineer. Tests may be either of those below, or a combination, as approved by the VA Project Engineer.

- B. An operating test at design pressure.
- 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.

3.5 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. Backflow preventer shall be required for the connection to the domestic cold water. Both the backflow preventer and the connection point location shall be approved by the Chief Engineer prior to work.
 - 2. 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 VA Project Engineer.
 - 3. 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.

4. 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.

3.6 TESTING UNDERGROUND PREINSULATED CHILLED WATER PIPING

A. First Hydrostatic Test:

1. All distribution piping shall be tested hydrostatically, before backfilling, with the joints of the water carrier pipe exposed. Installation of thrust blocks prior or after hydrostatic testing shall be as recommended by the pipe manufacturer's installation instructions.
2. Each test cycle shall consist of a 10 minute period at 1034 kPa (150 psig) followed by a 5 minute period at a pressure less than 345 kPa (50 psig). The next cycle shall begin immediately following the completion of the previous cycle. Pressure rise and drop shall not exceed 690 kPa (100 psig) per minute. The pressure gage shall be located and the pressure measured at the opposite end of the system from where the pressure is applied. After completion of the hydrostatic pressure cycling the first hydrostatic pressure test may be performed.

- #### **B. Final Hydrostatic Test:** After successful completion of the first hydrostatic test, the system shall be pressurized to 1-1/2 times the working pressure up to 1034 kPa (150 psig). This pressure shall be held for a minimum of 4 hours. The method of pressurizing the piping system is to disconnect it from the system prior to the start of the 4-hour pressure holding period. If the pressure cannot be held for the specified length of time, the cause of the pressure loss shall be determined, corrected, and all the tests be repeated.

- C. Repair joints, replace damaged or porous pipe and fittings and repeat the test without additional cost to the Government until the system can be demonstrated to have no leakage.

3.7 WATER TREATMENT

- A. Install water treatment equipment and provide water treatment system piping.
- B. Close and fill system as soon as possible after final flushing to minimize corrosion.
- C. Charge systems with chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.
- D. Utilize this activity, by arrangement with the VA Project Engineer, for instructing VA operating personnel.

3.8 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

- A. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Adjust red set hand on pressure gages to normal working pressure.

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SECTION 23 21 23
HYDRONIC PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Hydronic pumps for Heating, Ventilating and Air Conditioning.

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.
- D. Section 23 21 13, HYDRONIC PIPING.
- E. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- F. Section 23 64 10, MODULAR CHILLER PLANT
- G. Section 26 29 11, MOTOR CONTROLLERS.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- B. Design Criteria:
 - 1. Pumps design and manufacturer shall conform to Hydraulic Institute Standards.
 - 2. Pump sizes, capacities, pressures, operating characteristics and efficiency shall be as scheduled.
 - 3. Head-capacity curves shall slope up to maximum head at shut-off. Curves shall be relatively flat for closed systems. Select pumps near the midrange of the curve, so the design capacity falls to the left of the best efficiency point, to allow a cushion for the usual drift to the right in operation, without approaching the pump curve end point and possible cavitation and unstable operation. Select pumps for open systems so that required net positive suction head (NPSHR) does not exceed the net positive head available (NPSHA).
 - 4. Pump Driver: Furnish with pump. Size shall be non-overloading at any point on the head-capacity curve including one pump operation in a parallel or series pumping installation.
 - 5. Provide all pumps with motors, impellers, drive assemblies, bearings, coupling guard and other accessories specified. Statically and dynamically balance all rotating parts.
 - 6. Furnish each pump and motor with a nameplate giving the manufacturers name, serial number of pump, capacity in GPM and head in feet at

design condition, horsepower, voltage, frequency, speed and full load current and motor efficiency.

7. Test all pumps before shipment. The manufacturer shall certify all pump ratings.
8. After completion of balancing, provide replacement of impellers or trim impellers to provide specified flow at actual pumping head, as installed.

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. Pumps and accessories.
 2. Motors and drives.
 3. Variable speed motor controllers.
- C. Manufacturer's installation, maintenance and operating instructions, in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- D. Characteristic Curves: Head-capacity, efficiency-capacity, brake horsepower-capacity, and NPSHR-capacity for each pump and for combined pumps in parallel or series service. Identify pump and show fluid pumped, specific gravity, pump speed and curves plotted from zero flow to maximum for the impeller being furnished and at least the maximum diameter impeller that can be used with the casing.

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 Iron and Steel Institute (AISI):

AISI 1045.....Cold Drawn Carbon Steel Bar, Type 1045

AISI 416.....Type 416 Stainless Steel
- C. American National Standards Institute (ANSI):

ANSI B15.1-00(R2008)..... Safety Standard for Mechanical Power Transmission Apparatus

ANSI B16.1-05.....Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800
- D. American Society for Testing and Materials (ASTM):

A48-03 (2008).....Standard Specification for Gray Iron Castings
 B62-2009.....Standard Specification for Composition Bronze or
 Ounce Metal Castings

E. Maintenance and Operating Manuals in accordance with Section 01 00 00,
 General Requirements.

1.6 DEFINITIONS

- A. Capacity: Liters per second (L/s) (Gallons per minute (GPM) of the fluid pumped.
- B. Head: Total dynamic head in kPa (feet) of the fluid pumped.
- C. Flat head-capacity curve: Where the shutoff head is less than 1.16 times the head at the best efficiency point.

1.7 SPARE MATERIALS

- A. Furnish one spare seal and casing gasket for each pump to the VA Project Engineer.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL PUMPS, BRONZE FITTED

A. General:

1. Provide pumps that will operate continuously without overheating bearings or motors at every condition of operation on the pump curve, or produce noise audible outside the room or space in which installed.
2. Provide pumps of size, type and capacity as indicated, complete with electric motor and drive assembly, unless otherwise indicated.
 Design pump casings for the indicated working pressure and factory test at 1½ times the designed pressure.
3. Provide pumps of the same type, the product of a single manufacturer, with pump parts of the same size and type interchangeable.
4. General Construction Requirements
 - a. Balance: Rotating parts, statically and dynamically.
 - b. Construction: To permit servicing without breaking piping or motor connections.
 - c. Pump Motors: Provide high efficiency motors, inverter duty for variable speed service. Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT. Motors shall be Open Drip Proof and operate at 1750 rpm unless noted otherwise.
 - d. Heating pumps shall be suitable for handling water to 225°F.

- e. Provide coupling guards that meet ANSI B15.1, Section 8 and OSHA requirements.
- f. Pump Connections: Flanged.
- g. Pump shall be factory tested.
- h. Performance: As scheduled on the contract drawings.

5. Variable Speed Pumps:

- a. The pumps shall be the type shown on the drawings and specified herein flex coupled to an open drip-proof motor.
- b. Variable Speed Motor Controllers: Refer to Section 26 29 11, MOTOR CONTROLLERS and to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION paragraph, Variable Speed Motor Controllers. Furnish controllers with pumps and motors.
- c. Pump operation and speed control shall be as shown on the drawings.

B. Base Mounted Pumps:

- 1. Designed for disassembling for service or repair without disturbing the piping or removing the motor.
- 2. Impeller Wear Rings: Bronze.
- 3. Shaft Coupling: Non-lubricated steel flexible type or spacer type with coupling guard, ANSI B15.1, bolted to the baseplate.
- 4. Bearings (Double-Suction pumps): Regreaseable ball or roller type.
- 5. Provide lip seal and slinger outboard of each bearing.
- 6. Base: Cast iron or fabricated steel for common mounting to a concrete base.
- 7. All pump seals shall be suitable for use with water and/or a solution up to 50% Glycol and water. The seals shall be rated to handle the following items as a minimum standard:

dissolved solids	25,000 ppm
undissolved solids	40 ppm
silica content	20 ppm

- 8. Provide line sized shut-off valve and suction strainer, maintain manufacturer recommended straight pipe length on pump suction (with blow down valve). Contractor option: Provide suction diffuser as follows:
 - a. Body: Cast iron with steel inlet vanes and combination diffuser-strainer-orifice cylinder with 5 mm (3/16-inch) diameter

openings for pump protection. Provide taps for strainer blowdown and gage connections.

- b. Provide adjustable foot support for suction piping.
- c. Strainer free area: Not less than five times the suction piping.
- d. Provide disposable start-up strainer.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Follow manufacturer's written instructions for pump mounting and start-up. Access/Service space around pumps shall not be less than minimum space recommended by pumps manufacturer.
- B. Provide drains for bases and seals for base mounted pumps, piped to and discharging into floor drains.
- C. Coordinate location of thermometer and pressure gauges as per Section 23 21 13, HYDRONIC PIPING.

3.2 START-UP

- A. Verify that the piping system has been flushed, cleaned and filled.
- B. Lubricate pumps before start-up.
- C. Prime the pump, vent all air from the casing and verify that the rotation is correct. To avoid damage to mechanical seals, never start or run the pump in dry condition.
- D. Verify that correct size heaters-motor over-load devices are installed for each pump controller unit.
- E. Field modifications to the bearings and or impeller (including trimming) are not permitted. If the pump does not meet the specified vibration tolerance send the pump back to the manufacturer for a replacement pump. All modifications to the pump shall be performed at the factory.
- F. Ensure the disposable strainer is free of debris prior to testing and balancing of the hydronic system.
- G. After several days of operation, replace the disposable start-up strainer with a regular strainer in the suction diffuser.

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**SECTION 23 25 00
HVAC WATER TREATMENT**

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies cleaning and treatment of circulating HVAC water systems, including the following.

1. Cleaning compounds.
2. Chemical treatment for closed loop heat transfer systems.
3. Chemical treatment for open loop systems.
4. Glycol-water heat transfer systems.

1.2 RELATED WORK

- A. Test requirements and instructions on use of equipment/system: Section 01 00 00, GENERAL REQUIREMENTS.
- B. 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.
- C. Piping and valves: Section 23 21 13, HYDRONIC PIPING.
- D. Section 23 64 10, MODULAR CHILLER PLANT

1.3 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Technical Services: Provide the services of an experienced water treatment chemical engineer or technical representative to direct flushing, cleaning, pre-treatment, training, debugging, and acceptance testing operations; direct and perform chemical limit control during construction period and monitor systems for a period of 12 months after acceptance, including not less than 2 service calls and written status reports. During this period perform monthly tests of the cooling tower for Legionella pneumophila and submit reports stating Legionella bacteria count per millimeter. These tests shall be conducted in a certified laboratory and not by a technician in the field. Minimum service during construction/start-up shall be 4 hours. Provide sufficient chemicals for treatment and testing during the warranty period.
- C. Field Quality Control and Certified Laboratory Reports: During the one year guarantee period, the water treatment laboratory shall provide not less than 12 reports based on on-site periodic visits, as stated in paragraph 1.3.B, sample taking and testing, and review with VA

personnel, of water treatment control for the previous period. In addition to field tests, the water treatment laboratory shall provide certified laboratory test reports. These monitoring reports shall assess chemical treatment accuracy, scale formation, fouling and corrosion control, and shall contain instructions for the correction of any out-of-control condition.

D. The water treatment supplier shall:

1. Obtain water samples from the site and furnish a laboratory analysis of the make-up water supply with submittal.
2. Review the make-up water analysis to ensure compatibility with the water treatment program.
3. Propose water treatment methods and chemicals required to maximize water efficiency, minimize material handling and storage while minimizing scale, corrosion and biological growth. Submit all of the above with shop drawings and other required submittals.

E. Log Forms: Provide one year supply of preprinted water treatment test log forms.

F. Chemicals: Chemicals shall be non-toxic approved by local authorities and meeting applicable EPA requirements.

G. Water Treatment Contractor shall specialize in the manufacturing and assembly of water treatment formulations and equipment systems with a minimum of ten (10) years documented experience. Water Treatment Company shall have local representatives, full time service personnel, and water analysis 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 including:

1. Cleaning compounds and recommended procedures for their use.
2. Chemical treatment for closed systems, including installation and operating instructions.
3. Chemical treatment for open loop systems, including installation and operating instructions.
4. Glycol-water system materials, equipment, and installation.

C. Water analysis verification.

D. Provide a system cleaning plan for flushing, treating, and testing HVAC piping. Plan shall include a marked-up drawing to indicate the location of cleaning work.

E. Materials Safety Data Sheet for all proposed chemical compounds, based on U.S. Department of Labor Form No. L5B-005-4.

F. Maintenance and operating instructions in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

1.5 APPLICABLE PUBLICATIONS

A. The publication 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 Fire Protection Association (NFPA):
70-05.....National Electric Code (NEC)

PART 2 - PRODUCTS

2.1 CLEANING COMPOUNDS

A. Alkaline phosphate or non-phosphate detergent/surfactant/specific to remove organic soil, hydrocarbons, flux, pipe mill varnish, pipe compounds, iron oxide, and like deleterious substances, with or without inhibitor, suitable for system wetted metals without deleterious effects.

B. All chemicals to be acceptable for discharge to sanitary sewer.

C. Refer to Section 23 21 13, HYDRONIC PIPING PART 3, for flushing and cleaning procedures.

2.2 CHEMICAL TREATMENT FOR CLOSED LOOP SYSTEMS

A. Inhibitor: Provide sodium nitrite/borate, molybdate-based inhibitor or other approved proprietary compound suitable for make-up quality and make-up rate and which will prevent bacteria/corrosion problems or mechanical seal failure due to excessive total dissolved solids. Shot feed manually. Maintain inhibitor residual as determined by water treatment laboratory, taking into consideration residual and temperature effect on pump mechanical seals.

B. pH Control: Inhibitor formulation shall include adequate buffer to maintain pH range of 8.0 to 10.5.

C. Performance: Protect various wetted, coupled, materials of construction including ferrous, and red and yellow metals. Maintain system essentially free of scale, corrosion, and fouling. Corrosion rate of following metals shall not exceed specified mills per year penetration; ferrous, 0-2; brass, 0-1; copper, 0-1. Inhibitor shall be stable at equipment skin surface temperatures and bulk water temperatures of not less than 121 degrees C (250 degrees F) and 52 degrees C (125 degrees

Fahrenheit) respectively. Heat exchanger fouling and capacity reduction shall not exceed that allowed by fouling factor 0.0005.

D. Pot Feeder: By-pass type, complete with necessary shut off valves, drain and air release valves, and system connections, for introducing chemicals into system, cast iron or steel tank with funnel or large opening on top for easy chemical addition. Feeders shall be 18.9 L (five gallon) minimum capacity at 860 kPa (125 psig) minimum working pressure.

E. Sidestream Water Filter for Closed Loop Systems: Stainless steel housing, and polypropylene filter media with stainless steel core. Provide 2 stacked filters with extended housing. Filter media shall be compatible with antifreeze and water treatment chemicals used in the system. Replaceable filter cartridges for sediment removal service with minimum 20 micrometer particulate at 98 percent efficiency for approximately five (5) percent of system design flow rate. Filter cartridge shall have a maximum pressure drop of 13.8 kPa (2 psig) at design flow rate when clean, and maximum pressure drop of 172 kPa (25 psig) when dirty. A constant flow rate valve shall be provided in the piping to the filter. Inlet and outlet pressure gauges shall be provided to monitor filter condition.

2.3 CHEMICAL TREATMENT FOR OPEN LOOP SYSTEM

A. Open hydronic systems including evaporative cooling water shall have the following water qualities:

1. pH: Maintain a value within 7.0 to 9.0 for all systems.
2. Calcium: Maintain a value greater than 50ppm (as CaCO₃) in the recirculating water for all systems.
3. Total Aerobic Plate Count: Maintain a maximum value of 10,000 CFU/ml or less.
4. Soluble Copper: Maintain a maximum value of 0.25 PPM or less.

B. MANUAL CHEMICAL-FEED EQUIPMENT

1. Bypass Feeders for closed hydronic system (if applicable): Steel, with corrosion-resistant exterior coating, minimum 3.5-inch (89-mm) fill opening in the top, and NPS ¾-inch (DN 20) inlet and top side outlet.
 - a. Minimum working pressure: 150 psig (1035 kPa.)
 - b. Minimum Capacity: 2.0 gallons (7.6L)
2. Granular or solid chemistry inhibitor feeders for open hydronic system: Shall operate and feed inhibitor chemical into the

recirculating water only when the main recirculating water pump is in operation.

- a. Feeders shall be designed to hold a minimum of a thirty-day supply of corrosion and scale inhibitor.
 - b. No chemical feed pumps shall be accepted as part of a solid chemical feed system.
 - c. Feeders and interconnecting piping shall be pre-mounted to allow a single field supply and return connection for each skid.
 - d. Feeders shall be rated to handle a working pressure of 125psig (862 kPA.)
 - e. Potable water shall not be utilized to make down any solids or liquid chemicals.
3. Granular or Solid Chemistry Biocide Feeders: Shall operate and feed biocide into the recirculating water only when the main recirculating water pump is in operation.
- a. Feeders shall be designed to hold a minimum of a thirty-day supply of biocide.
 - b. No chemical feed pumps shall be accepted as part of a solid chemical feed system.
 - c. Feeders and interconnecting piping shall be pre-mounted to allow a single field supply and return connection for each skid.
 - d. Feeders shall be rated to handle a working pressure of 125 psig (862 kPA).
 - e. Potable water shall not be utilized to make down any solids or liquid chemicals.

C. AUTOMATIC CHEMICAL-FEED EQUIPMENT

1. Conductivity controller: Microprocessor driven controller shall provide linear, temperature compensated measurements directly in micromhos from zero (0) to ten-thousand (10,000) with one percent (1%) accuracy. Incorporate LED display in a NEMA 4X enclosure.
 - a. Digital display and touch pad for inputs.
 - b. Quick release conductivity probe with sample stream manifold.
 - c. Evaporative cooling systems using more than 20 pounds of solid or 100 pounds of liquid scale and corrosion inhibitor per month must use real-time direct control of the scale and corrosion inhibitor. Scale and corrosion inhibitor control is independent of conductivity, mechanical failures, overflowing towers, pH, evaporation, blowdown, meters or timers.

- 1) Inhibitor probe of PVC construction, with 4 - 20mA Output.
- d. Sample port for collecting and testing re-circulating water samples shall be installed near the controller.
- e. One inlet/outlet shut off valve for easy removal of probes for inspection and maintenance.
- f. Hand-Off-Auto capability for bleed valve.
 - 1) Motorized ball valve with spring return shall be supplied for bleed control. Pilot operated solenoid valves shall not be accepted for bleed.
- g. Hand-Off-Auto capability for any timer or chemical feed relays.
- h. Sixty-day data acquisition shall be available via a USB port for download.
- i. Pre-bleed and bleed lockout timers shall be available.
- j. Controller programming shall ensure that liquid chemical injection pumps are energized only when the system condenser pump is operating.
- 2. Liquid chemical injection pumps: Self-priming, positive displacement, rated for intended chemical with minimum twenty-percent (20%) safety factor for feed rate and temperature.
 - a. Both stroke and speed control shall be individually adjustable.
 - b. NEMA 4X enclosure.
 - c. Rated discharge pressure shall be at least 125 psig (862 kPa).
 - d. All chemical injection tubing shall be installed within secondary containment.
 - e. Liquid chemical feed stations shall be pre-mounted to allow a single supply and return connection for the conductivity probe manifold, liquid inhibitor injection and non-oxidizing biocide injection (if applicable).
 - f. Liquid chemical feed stations require the installation of a PVC ball check valve after all controller probes and prior to the chemical injection point.
 - g. Liquid oxidizing biocide and liquid inhibitor shall be fed via separate return lines from the chemical injection point back to the re-circulating water system.
 - h. Pumps used for liquid oxidizing biocides shall be equipped to eliminate gas-lock conditions automatically.

- i. All liquid chemical injection points require an injection check valve at the point of addition into the re-circulating water system.

D. CHEMICALS

1. Chemicals shall be as recommended by the water treatment system manufacturer that are compatible with the evaporative cooling equipment and system piping and can attain the water quality specified in 'Performance Criteria.'
 - a. Chromates or zinc shall not be used.
 - b. Scale and corrosion inhibitors shall be non-hazardous to humans and animals for the intended use and for general storage and handling as required for the application.
 - c. Evaporative cooling systems using more than 20 pounds of solid or 100 pounds of liquid scale and corrosion inhibitor per month must use a scale and corrosion inhibitor formulated with an inert tracer dye that is detectable by the inhibitor probe (Section 2.3 A. 3 a.).
 - d. If the scale and corrosion inhibitor is in liquid form it should be supplied in a concentration that will not exceed a 120 ppm feed rate as product.
 - e. If the scale and corrosion inhibitor is provided as a solid it must be supplied in solid pellet form for safe handling of the chemical.
 - f. For ease of transport and storage the weight per container of solid product must be equal to or less than 25 pounds.
 - g. Phosphates are allowed as permitted by EPA and local authorities.
 - h. Two alternating biocides must be supplied along with dedicated feed and control equipment.
 - i. Biocides shall be properly registered for the intended application.
 - j. The feed system shall be sized to ensure sufficient quantity of each recommended chemical is available to provide thirty-days of continuous condenser water operation.
 - k. The water treatment vendor shall not rely on site operators for the handling or feeding of chemicals nor the proper disposal of chemical drums, pails or other packaging.
 - l. Chemical replenishment for one (1) year of system operation shall be calculated based on cycles of concentration attainable using

the site makeup water analysis noted in 'Submittals'. Document the amount of replenishment inhibitor and biocide chemistry which is included in the quoted price for the first year operation.

E. CHEMICAL CONTAINMENT

1. New containment systems are required for all liquid chemical products.
 - a. Containment system shall be fabricated from high-density opaque polyethylene or another material which is specifically selected as appropriate for the chemical to be contained.
 - b. Minimum 110 percent containment capacity for each chemical to be contained.
 - c. All liquid chemical inventories, whether opened or unopened, must be stored within containment systems suitable for each individual product.
 - d. Liquid chemical storage tanks with containment shall be sized to fit through a standard door way and safely transported by two people.

F. WATER TREATMENT SYSTEM SUPPLIER SITE SERVICES

1. The following services shall be the responsibility of, and supervised by, the water treatment system supplier. Supplier shall coordinate installation and startup with the mechanical contractor.
 - a. Location and proper installation of liquid chemical containment.
 - b. Location and proper installation, including mounting, of any controllers, chemical injection pumps, timers and valves.
 - c. Location and proper installation of any field tapping of the condenser water system required to install water treatment system.
 - d. All heat trace and insulation required to protect the water treatment system from freezing.
 - e. If the treatment system is to be installed outside of the mechanical room, a storage shed must be used which includes fans and or heaters to maintain the appropriate climate to prevent freezing and or excessive heat that could jeopardize the treatment chemicals or treatment system operation.
2. The water treatment system supplier shall be on-site for start-up and commissioning including the following:
 - a. Start and configure conductivity controller.

- b. Verify proper operation of motorized ball valve installed for bleed.
- c. Perform field tests on makeup water to verify that quality is consistent with laboratory analysis (Section 1.6 A. 1).
- d. Load, prime and start chemical inhibitor feed.
- e. Load, prime and start biocide feed.

G. CHEMICAL TREATMENT TEST EQUIPMENT

1. Testing equipment: Test kits and test equipment shall be available for maintaining control of program standards in the water systems. Test kits will include the following:
 - a. Reagents and apparatus for determination of corrosion inhibitor level in the condenser water systems.
 - b. Reagents and apparatus for determination of pH, M- alkalinity, free and total chlorine, and calcium hardness.
 - c. Dip-slides for determination of microbiological colony population and biocide effectiveness.

H. Sidestream Separator:

1. Provide sidestream separator for removal of specific unwanted solids from the pumped condenser water system which shall be accomplished with a centrifugal-action vortex separator.
2. In a single pass through the separator, given solids with a specific gravity of 2.6 and water at 1.0, performance is expected to be 98% of 74 microns and larger. Additionally, particles finer in size, heavier by specific gravity and some lighter by specific gravity will also be removed, resulting in an appreciable aggregate removal of particles (up to 75%) as fine as 5 microns.
3. In a recirculating system, 98% performance is predictable to as fine as 40 microns (given solids with a specific gravity of 2.6), with correspondingly higher aggregate performance percentages (up to 90%) of solids as fine as 5 microns.
4. Separator performance must be supported by published independent test results from a recognized and identified test agency. Standard test protocol of upstream injection, downstream capture and separator purge recovery is allowed with 50-200 mesh particles to enable effective, repeatable results. Single-pass test performance must not be less than 95% removal. Model tested must be of the same flow-design series as specified unit.

5. A tangential inlet and mutually tangential internal accelerating slots shall be employed to promote the proper velocity necessary for the removal of the separable solids. The internal accelerating slots shall be spiral-cut for optimum flow transfer, laminar action and particle influence into the separation barrel. The separator's internal vortex shall allow this process to occur without wear to the accelerating slots.
6. Separated particle matter shall spiral downward along the perimeter of the inner separation barrel, in a manner which does not promote wear of the separation barrel, and into the solids collection chamber, located below the vortex deflector plate.
7. To ensure maximum particle removal characteristics, the separator shall incorporate a vortex-induced pressure relief line, drawing specific pressure and fluid from the separator's solids collection chamber via the outlet flow's vortex/venturi effect, thereby efficiently encouraging solids into the collection chamber without requiring a continuous underflow or excessive system fluid loss.
8. System fluid shall exit the separator by following the center vortex in the separation barrel and spiral upward to the separator outlet.
9. Evacuation of separated solids shall be accomplished automatically, employing a dedicated solid-state controller in a NEMA 4 housing. Available for worldwide single-phase voltages of 24VAC to 250VAC. Programming options to include a purge frequency range of every 60 seconds to every 23 hours, 59 minutes. Purge duration options range from 10 seconds to 59 minutes, 59 seconds. Non-volatile memory. Meets CSA requirements. This controller shall automatically operate using the following technique:
 - a. Motorized Ball Valve - An electrically-actuated valve shall be programmed at appropriate intervals and duration in order to efficiently and regularly purge solids from the separator's collection chamber. Valve ball shall be stainless steel with sealant seat. Valve shall be sized to match unit size.
 - b. Provide all wiring and conduit required for controller and valve.
10. Separated solids shall be continuously purged under controlled flow into a solids recovery vessel equipped with two 10-micron fiberfelt solids collection bag. Solids collection capacity: 732 cubic inches (12 liters). Excess liquid shall pass through the bag and return to

- system flow via the separator's integral Vortube, eliminating any need for piping return flow to the system pump's suction line.
- a. Solids recovery vessels shall be constructed of 304 stainless steel with epoxy coated carbon steel lid. Vessel shall include one stainless steel basket, felt bags, and air relief valve.
 - b. Solids recovery system also shall include manual isolation valves for use when servicing the collection bag; sightglass for verification of flow through the vessel; annunciator for indicating when the collector bag needs cleaning/replacement; flow control orifice to minimize fluid volume/velocity through the vessel and collector bag; clamps, tubing and specialty piping for completing the system assembly.
11. The separator and its accessories shall be packaged as a complete system, with all componentry from a single source. In addition to the equipment already specified, the system shall also include pressure gauges with petcock valves for both the inlet and outlet of the separator and an isolation valve at the purge outlet for servicing of the automatic valve as necessary without interrupting system flow.
 12. A connection spool shall also be included for installation on the separator's outlet to properly facilitate the separator's internal access feature.
 13. Separator Design Information:
 - a. Vertical profile.
 - b. Inlet & outlet shall be connections, size: 4".
 - c. Purge outlet shall be threaded with screw-on flange, size: 3/4".
 - d. The separator shall operate within a flow range of: 200-325 gpm.
 - e. Pressure loss shall be between 3-12 psi (.2 - .8 bar), remaining constant, varying only when the flow rate changes.
 14. The separator shall feature the following access capabilities for either inspection or the removal of unusual solids/debris:
 - a. An upper-chamber full-size grooved coupling, allowing complete access to the inlet chamber, acceleration slots and internal separation barrel
 - b. A 1/2-inch inspection/drain, located at the lowest point of the upper chamber
 15. The separator shall be constructed of A-36, A-53B or equivalent quality carbon steel, minimum thickness of .25 inches (6.35 mm).

Maximum operating pressure shall be 150 psi (10.3 bar), unless specified otherwise. Paint coating shall be acrylic urethane, spray-on, gloss black.

2.4 GLYCOL-WATER SYSTEM

- A. Propylene glycol shall be inhibited with 1.75 percent dipotassium phosphate. Do not use automotive anti-freeze because the inhibitors used are not needed and can cause sludge precipitate that interferes with heat transfer.
- B. Provide required amount of glycol to obtain the percent by volume for glycol-water systems as follows and to provide one-half tank reserve supply: 30% propylene-glycol for chilled water systems.
- C. Pot Feeder Make-up Unit: By pass type for chemical treatment, schedule 3.5 mm (10 gauge) heads, 20 mm (3/4-inch) system connections and large neck opening for chemical addition. Feeders shall be five gallon minimum size.
- D. Glycol-Water Make-up System:
 - 1. Glycol-Water Storage Tank: Self supporting polyethylene, minimum 90 mil thickness, with removable cover or black steel with 90 mil polyethylene insert. Capacity shall be 213 L (55 gallons), with approximate diameter of 584 mm (23 inches) and height of 914 mm (36 inches). Reinforced threaded pipe connections shall be provided for all connections. Provide identification for tank showing name of the contents. Provide glycol spill protection drum platform suitable for the glycol tank. Containment platform shall be high-density polyethylene.
- E. Glycol Fill Pump:
 - 1. Pump shall be portable sprinkler/utility pump, suitable for pumping a glycol solution. Pump capacity to be 3.0 G.P.M. at 40 psi discharge pressure with 10 ft of suction lift. Pump motor to be 1/2 H.P., 120 volt, single phase. Provide cord and plug. Provide flexible connection hoses for pump inlet and discharge.

2.5 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Delivery and Storage: Deliver all chemicals in manufacturer's sealed shipping containers. Store in designated space and protect from deleterious exposure and hazardous spills.

- B. Install equipment furnished by the chemical treatment supplier and charge systems according to the manufacturer's instructions and as directed by the technical representative.
- C. Refer to Section 23 21 13 HYDRONIC PIPING for chemical treatment piping, installed as follows:
1. Provide a by-pass line around water meters and bleed off piping assembly. Provide ball valves to allow for bypassing, isolation, and servicing of components.
 2. Provide Schedule 80 PVC piping for corrosion monitor rack per manufacturer's installation instructions. Provide PVC ball valves to isolate and service rack.
 3. Provide installation supervision, start-up and operating instruction by manufacturer's technical representative.
 4. Mechanical contractor will supply two taps with isolation valves on the high pressure side of the main re-circulating water pumps along with associated piping to supply condenser water to the chemical treatment skids.
 5. Mechanical Contractor will supply and connect piping from each tap to supply the inlet of each treatment system.
 6. Mechanical contractor will supply two taps with isolation valves on the low pressure side of the main re-circulating water pumps along with associated piping to return treated water from the chemical treatment skids.
 7. Mechanical Contractor will supply and connect piping from these low pressure taps to the outlet of each treatment system.
 8. Additional taps, if required, will be the responsibility of the water treatment vendor.
 9. Mechanical contractor will supply and connect drain piping from the treatment skids to a sanitary drain. The drain piping shall be piped for gravity drainage.
 10. Mechanical contractor will pipe the two way motorized bleed valve to a sanitary drain connection that is capable of handling the estimated blow down flow. The contractor will test drain prior to ensure drain will handle the amount of water that is released during each controlled blow down.
 11. Water treatment vendor shall be responsible for installing probes, sensing equipment and chemical feed pumps.

- D. Before adding cleaning chemical to the closed system, all air handling coils and fan coil units should be isolated by closing the inlet and outlet valves and opening the bypass valves. This is done to prevent dirt and solids from lodging the coils.
- E. Do not valve in or operate system pumps until after system has been cleaned.
- F. After chemical cleaning is satisfactorily completed, open the inlet and outlet valves to each coil and close the by-pass valves. Also, clean all strainers.
- G. Engage a factory-authorized service representative to perform startup service.
- H. Inspect field-assembled components and equipment installation, including piping. Report results in writing.
- I. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before initiating water-treatment system.
- J. Immediately following completion and verification of flushing, certification records covering the cleaning shall be submitted to the mechanical contractor. Records shall include system volume, cleaner concentration, circulation time, and final chemical reading. Each system shall be chemically treated as provided elsewhere in this specification.
- K. Place water-treatment system into operation during the preliminary phase of systems' startup procedures.
- L. Provide water treatment services, for a period of 1-year from start-up of the cooling system, which will include:
 - 1. Installation and system start-up procedure recommendations.
 - 2. Initial water analysis and recommendations.
 - 3. Training of operating personnel on proper feeding and control techniques.
 - 4. Routine field service and consultation meetings.
 - 5. Log sheets and record forms.
 - 6. Any required laboratory and technical assistance.
- M. Perform tests and report results in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
- N. After cleaning is complete, and water PH is acceptable to manufacturer of water treatment chemical, add manufacturer-recommended amount of chemicals to systems.

O. Instruct VA personnel in system maintenance and operation in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

P. Training shall include procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.

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SECTION 23 31 00
HVAC DUCTS AND CASINGS AND BLOWER COIL UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Ductwork and accessories for HVAC including the following:

1. Supply air outside air, and exhaust 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.

1.2 RELATED WORK

- A. General Mechanical Requirements: Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. Noise Level Requirements: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- C. Duct Insulation: Section 23 07 11, HVAC INSULATION
- D. Exhaust Air Fans: Section 23 34 00, HVAC FANS.
- E. Duct Mounted Instrumentation: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- F. Testing and Balancing of Air Flows: Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
- G. MODULAR CHILLER PLANT: Section 23 64 10.

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 as specified.

E. Duct accessories exposed to the air stream, such as dampers of all types and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

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. Sealants and gaskets.

c. Access doors.

2. Round and flat oval duct construction details:

a. Manufacturer's details for duct fittings.

b. Sealants and gaskets.

c. Access sections.

d. Installation instructions.

3. Volume dampers, back draft dampers.

4. Upper hanger attachments.

5. Motor Operated Damper

6. Flexible connections.

7. COMMON WORK RESULTS FOR HVAC.

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
- 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
- F. Underwriters Laboratories, Inc. (UL):
- 181-08.....Factory-Made Air Ducts and Air Connectors
- 555-06Standard for Fire 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.
- a. All fresh air intake and exhaust air ductwork between louver/hood and air handling unit shall have all joints sealed watertight.

Sealant shall be equal to Sikaflex 15LM polyurethane elastomeric sealant or equal.

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:

> 75 mm to 100 mm (3 inch to 4 inch)

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.

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 VA Project Engineer.

F. 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.

G. Duct Hangers and Supports: Refer to SMACNA Standards Section IV. Avoid use of trapeze hangers for round duct.

2.3 DUCT ACCESS DOORS, PANELS AND SECTIONS

A. Provide access doors, sized and located for maintenance work, upstream, in the following locations:

1. Each automatic 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. For rectangular ducts: Refer to SMACNA HVAC Duct Construction Standards (Figure 2-12).

2. For round and flat oval duct: Refer to SMACNA HVAC duct Construction Standards (Figure 2-11).

2.4 FLEXIBLE DUCT CONNECTIONS

A. Where duct connections are made to exhaust fans, install a non-combustible flexible connection of 822 g (29 ounce) neoprene coated fiberglass fabric approximately 150 mm (6 inches) wide. 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.

2.5 MOTOR OPERATED DAMPER

- A. Provide a motorized damper and actuator for the exhaust and intake system.
- B. Damper frame shall be insulated with styrofoam on four sides and be thermally broken by means of polyurethane resin pockets complete with thermal cuts. Blades shall be extruded aluminum, internally insulated with expanded polyurethane foam and shall be thermally broken. Damper blades shall be permanently secured to blade shaft. Blade shaft shall mount to frame with double bearing allowing rod to rotate while outer bearing remains fixed. Blade and frame seals shall be of extruded silicone and be secured in an integral slot within the aluminum extrusion. Dampers shall be not more than 48 inches in length between bearings. Modulating dampers shall be of the opposed blade type. Dampers when closed shall be guaranteed by the manufacturer not to leak in excess of 5 cfm per square foot at 4 inches water gauge static pressure and -40° F. Dampers shall be installed with operators having sufficient power to limit leakage to the rate specified. Dampers shall have channel frames, and all parts of dampers shall be minimum of 0.075" thickness extruded aluminum.
- C. Electronic damper operators: Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.

2.6 BLOWER COIL UNIT

- A. All units shall be furnished in size, capacity and with accessories as scheduled and herein specified. All units shall be furnished with fan section, fans, fan motor, filter box with filter frame, adjustable V-belt drive and belt guard.
- B. Manufacturer shall provide unit arranged for draw-through application. Unit layout and configuration shall be as defined in project plans and schedule. Blow-through is only acceptable when consideration is given to capturing downstream moisture carryover. Considerations include downstream moisture eliminators and/or extended blank modules with condensate drain pans.
- C. Unit Casing Insulation - High density, foil-faced. Interior surface of unit casing shall be acoustically and thermally lined. Insulation shall have a minimum R-Value of 4 and shall be UL Listed. The insulation shall comply with NFPA-90A and B requirements.

- D. Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil are as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.
- E. Drain Pan(s) shall be constructed of corrosion resistant, type 304 stainless steel. Units with cooling coils shall have drain pans under complete cooling coil section that extend beyond the air-leaving side of the coil to ensure capture of all condensate in section. Pipe to nearest trench drain.
- F. All motors and drives shall be factory-installed and run tested. All motors shall be installed on a slide base to permit adjustment of belt tension. Slide base shall be designed to accept all motor sizes offered by the air-handler manufacturer for that fan size to allow a motor change in the future, should airflow requirements change. Fan sections without factory-installed motors shall have motors field installed by the contractor. The contractor shall be responsible for all costs associated with installation of motor and drive, alignment of sheaves and belts, run testing of the motor, and balancing of the assembly at no additional cost to the owner.
- G. Motors shall be open drip-proof with permanently sealed ball bearings.

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. Control Damper Installation:

1. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.
2. Assemble multiple sections dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.
3. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.
4. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.

E. 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 VA Project 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 (including all supply and exhaust ductwork) included in this project.
- 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 VA Project Engineer and the Test and Balance agency. The Test and Balance agency shall measure and record duct leakage and report to the VA Project 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 VA Project 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)

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

3.4 OPERATING AND PERFORMANCE TESTS

- A. 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.
- D. Section 26 29 11, MOTOR CONTROLLERS.
- E. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- F. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- G. Section 23 64 10, MODULAR CHILLER PLANT

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 and power ventilators 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 and power ventilators shall comply with the following standards:
 - 1. Testing and Rating: AMCA 210.
 - 2. Sound Rating: AMCA 300.
- E. Performance Criteria:
 - 1. The fan schedule shows cubic meters per minute (CFM) and design static pressure. Scheduled fan motors, 0.37 kW (1/2 horsepower) and larger, are sized for design cubic meters per minute (CFM) at 110 percent design static pressure, but not to exceed 185 Pa (3/4-inch) additional pressure.
 - 2. Provide fans and motors capable of stable operation at design conditions and at 110 percent pressure as stated above.
 - 3. Lower than design pressure drop of approved individual components may allow use of a smaller fan motor and still provide the safety factor. When submitted as a deviation a smaller motor may be approved in the interest of energy conservation. The contractor shall be responsible for making necessary changes to the electrical system.
 - 4. Select fan operating point as follows:
 - a. Forward curved and axial fans: Right hand side of peak pressure point.

b. Airfoil, backward inclined or tubular: Near the peak of static efficiency.

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

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. Centrifugal fans, motors, drives, accessories and coatings.
3. In-line centrifugal fans.

C. Certified sound power levels for each fan.

D. Motor ratings types, electrical characteristics and accessories.

E. Belt guards.

F. Maintenance and Operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

G. Certified fan performance curves for each fan showing cubic meters per minute (CFM) versus static pressure, efficiency, and horsepower for design point of operation and at 110 percent of design static pressure. Include product application data to indicate the effect of capacity control devices such as inlet vane dampers on flow, pressure and kW (horsepower).

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. Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA):

9-00.....Load Ratings and Fatigue Life for Ball Bearings

C. Air Movement and Control Association International, Inc. (AMCA):

99-86.....Standards Handbook

210-01.....Laboratory Methods of Testing Fans for
Aerodynamic Performance Rating

261-98.....Directory of Products Licensed to bear the AMCA
Certified Ratings Seal - Published Annually

300-96.....Reverberant Room Method for Sound Testing of
Fans

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

B117-03.....Standard Practice for Operating Salt Spray (Fog)
Apparatus

- D1735-02.....Standard Practice for Testing Water Resistance
of Coatings Using Water Fog Apparatus
- D3359-02.....Standard Test Methods for Measuring Adhesion by
Tape Test
- G152-01.....Standard Practice for Operating Open Flame
Carbon Arc Light Apparatus for Exposure of Non-
Metallic Materials
- G153-01.....Standard Practice for Operating Enclosed Carbon
Arc Light Apparatus for Exposure of Non-Metallic
Materials

E. Underwriters Laboratories, Inc. (UL):

- 181-96.....Factory Made Air Ducts and Air Connectors

PART 2 - PRODUCTS

2.1 CENTRIFUGAL FANS

- A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE. Record factory vibration test results on the fan or furnish to the Contractor.
- B. Construction: Wheel diameters and outlet areas shall be in accordance with AMCA standards.
1. Housing: Low carbon steel, arc welded throughout, braced and supported by structural channel or angle iron to prevent vibration or pulsation, flanged outlet, inlet fully streamlined. Provide lifting clips, and casing drain. Provide manufacturer's standard access door. Provide 12.5 mm (1/2") wire mesh screens for fan inlets without duct connections.
 2. Wheel: Steel plate with die formed blades welded or riveted in place, factory balanced statically and dynamically.
 3. Shaft: Designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fans class.
 4. Bearings: Heavy duty ball or roller type sized to produce a B10 life of not less than 40,000 hours, and an average fatigue life of 200,000 hours. Extend filled lubrication tubes for interior bearings or ducted units to outside of housing.
 5. Belts: Oil resistant, non-sparking and non-static. Furnish one additional complete set of belts for each belt-driven fan.
 6. Belt Drives: Factory installed with final alignment belt adjustment made after installation.
 7. Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15HP, fixed pitch for use with motors larger than 15HP.

Select pulleys, so that pitch adjustment is at the middle of the adjustment range at fan design conditions.

8. Motor, adjustable motor base, drive and guard: Furnish from factory with fan. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION for specifications. Provide protective sheet metal enclosure for fans located outdoors.
9. Furnish variable speed fan motor controllers where shown on the drawings. Refer to Section, MOTOR STARTERS. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION for controller/motor combination requirements.

C. In-line Centrifugal or Mixed Flow In-line Fans: In addition to the requirements of paragraphs A and B, provide inlet and outlet flanges, insulated housing, extended lube lines, spring isolated hangers, welded steel air straightening vanes, bolted access door and arrangement 1, 4 or 9 supports as required.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install fan, motor and drive in accordance with manufacturer's instructions.
- B. Align fan and motor sheaves to allow belts to run true and straight.

3.2 PRE-OPERATION MAINTENANCE

- A. Lubricate bearings, pulleys, belts 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 proper operation of motor, drive system and fan wheel.
- B. Check vibration and correct as necessary for air balance work.

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SECTION 23 64 00
PACKAGED WATER CHILLERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Centrifugal, water-cooled chillers, complete with accessories.

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.
- D. Section 23 21 23, HYDRONIC PUMPS.
- E. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- F. Section 23 21 13, HYDRONIC PIPING.
- G. Section 23 31 00, HVAC DUCTS and CASINGS
- H. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- I. Section 23 64 10, MODULAR CHILLER PLANT
- J. Section 26 29 11, MOTOR CONTROLLERS.
- K. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS
- L. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.3 DEFINITION

- A. Engineering Control Center (ECC): The centralized control point for the intelligent control network. The ECC comprises of personal computer and connected devices to form a single workstation.
- B. BACNET: Building Automation Control Network Protocol, ASHRAE Standard 135.
- C. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.
- D. FTT-10: Echelon Transmitter-Free Topology Transceiver.

1.4 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION, and comply with the following.
- B. Refer to PART 3 herein after and Section 01 00 00, GENERAL REQUIREMENTS for test performance.
- C. Comply with AHRI requirements for testing and certification of the chillers.

- D. Refer to paragraph, WARRANTY, Section 00 72 00, GENERAL CONDITIONS, except as noted below:
 - 1. Provide a 4-year chiller, motor, and compressor warranty to include materials, parts and labor.
- E. Refer to OSHA 29 CFR 1910.95(a) and (b) for Occupational Noise Exposure Standard
- F. Refer to ASHRAE Standard 15, Safety Standard for Refrigeration System, for refrigerant vapor detectors and monitor.
- G. Chiller manufacturer shall coordinate unit size with chiller plant enclosure manufacturer. Chiller shall fit in footprint indicated on drawings in order to maintain access space between chillers and building footprint size. Chillers requiring larger footprint than indicated on drawings shall not be acceptable.

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):
 - 370-01.....Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
 - 495-1999 (R2002).....Refrigerant Liquid Receivers
 - 550/590-03.....Standard for Water Chilling Packages Using the Vapor Compression Cycle
- C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
 - ANSI/ASHRAE-15-2007....Safety Standard for Mechanical Refrigeration Systems
 - GDL 3-1996.....Guidelines for Reducing Emission of Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems
- D. American Society of Mechanical Engineers (ASME):
 - 2007ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels - Division 1"
- E. American Society of Testing Materials (ASTM):
 - C 534/ C 534M-2008.....Preformed, Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
 - C 612-04.....Mineral-fiber Block and Board Thermal Insulation
- F. National Electrical Manufacturing Association (NEMA):
 - 250-2008.....Enclosures for Electrical Equipment (1000 Volts Maximum)

G. National Fire Protection Association (NFPA):

70-2008.....National Electrical Code

H. Underwriters Laboratories, Inc. (UL):

1995-2005..... Heating and Cooling Equipment

1.6 SUBMITTALS

A. Submit in accordance with Specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Manufacturer's Literature and Data.

1. Centrifugal water chillers, including motor starters, control panels, and vibration isolators, and remote condenser data shall include the following:

- a. Rated capacity.
- b. Pressure drop.
- c. Efficiency at full load and part load WITHOUT applying any tolerance indicated in the AHRI 550/590/Standard.
- d. Refrigerant
- e. Accessories.
- f. Installation instructions.
- g. Start up procedures.
- h. Wiring diagrams, including factory-installed and field-installed wiring.
- i. Sound/Noise data report. Manufacturer shall provide sound ratings. Noise warning labels shall be posted on equipment.
- j. Refrigerant vapor detectors and monitors.
- k. Dimensioned plan and elevation view, including required clearances, and location of all field piping and electrical connections.
- l. Summaries of all auxiliary utility requirements such as: electricity, water, air, etc. Summary shall indicate quality and quantity of each required utility.
- m. Diagram of control system indicating points for field interface and field connection. Diagram shall fully depict field and factory wiring.
- n. Manufacturer's certified performance data at full load plus IPLV or NPLV.

C. Maintenance and operating manuals for each piece of equipment in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

D. Run test report for all chillers.

- E. Chillers shall be delivered to the job site completely assembled and charged with refrigerant R134a and be shipped on skids with a weather resistant cover.
- F. Product Certificate: Signed by chiller manufacturer certifying that chillers furnished comply with AHRI requirements. The test report shall include calibrated curves, calibration records, and data sheets for the instrumentation used in factory tests.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL WATER-COOLED CHILLERS

- A. Provide and install as shown on the plans a factory assembled, charged, and tested water-cooled packaged centrifugal chiller. Chillers shall have no more than two oil-free, magnetic bearing, semi-hermetic centrifugal compressors (no exceptions). Each compressor shall have an integrated variable-frequency drive operating in concert with inlet guide vanes for optimized full and part load efficiency. On two-compressor units, the evaporator and condenser refrigerant sides and the expansion valve shall be common and the chiller shall be capable of running on one compressor with the other compressor or any of its auxiliaries inoperable or removed.
- B. General: Provide a complete water-cooled, semihermetic oil-free centrifugal compressor water chiller as specified herein. The unit shall be provided according to standards indicated above. In general, unit shall consist of one or two magnetic bearing, completely oil-free centrifugal compressors, refrigerant, condenser and evaporator, and control systems including integrated variable frequency drive, operating controls and equipment protection controls. Chillers shall be charged with refrigerant HFC-134a. If manufacturer offers a chiller using any HCFC refrigerant, manufacturer shall provide, in writing, documentation signed by an officer of the company assuring refrigerant availability and price schedule for a 20-year period.
- C. The entire chiller system, including all pressure vessels, shall remain above atmospheric pressure during all operating conditions and during shut down to ensure that non-condensables and moisture do not contaminate the refrigerant and chiller system. If any portion of the chiller system is below atmospheric pressure during either operation or shut down, the manufacturer shall include, at no charge:
 - 1. A 20-year purge maintenance agreement that provides parts, labor, and all preventative maintenance required by the manufacturer's operating and maintenance instructions.

2. A complete purge system capable of removing non-condensables and moisture during operation and shut-down.
 3. The manufacturer shall also include at no charge for a period of 20 years an annual oil and refrigerant analysis report to identify chiller contamination due to vacuum leaks. If the analysis identifies water, acid, or other contaminant levels higher than specified by the manufacturer, the oil and/or refrigerant must be replaced or returned to the manufacturer's original specification at no cost to the owner.
 4. The manufacturer shall include a factory-installed and wired system that will enable service personnel to readily elevate the vessel pressure during shutdown to facilitate leak testing.
- D. Performance: Refer to chiller performance rating.
- E. Acoustics: Sound pressure for the unit shall not exceed the levels scheduled on the drawings. Provide the necessary acoustic treatment to chiller as required. Sound data shall be measured in dB according to AHRI Standard 575 and shall include overall dBA.
- F. Compressors:
1. The unit shall utilize magnetic bearing, oil-free, semihermetic centrifugal compressors. The compressor drive train shall be capable of coming to a controlled, safe stop in the event of a power failure.
 2. The motor shall be of the semi-hermetic type, of sufficient size to efficiently fulfill compressor horsepower requirements. It shall be liquid refrigerant cooled with internal thermal sensing devices in the stator windings. The motor shall be designed for variable frequency drive operation.
 3. If the compressor design requires a shaft seal to contain the refrigerant, the manufacturer shall supply a 20 year parts and labor warranty on the shaft seal and a lifetime refrigerant replacement warranty if a seal failure leads to refrigerant loss, or the chiller manufacturer shall assume all costs to supply and install a self contained air conditioning system in the mechanical space sized to handle the maximum heat output of the open drive motor. The energy required to operate this air conditioning system shall be added to the chiller power at all rating points for energy evaluation purposes.
 4. If the compressor/motor uses any form of antifriction bearing (roller, ball, etc), the chiller manufacturer shall provide the following at no additional charge:

- a. A 20-year bearing warranty and all preventative maintenance as specified by the manufacturer's published maintenance instructions.
 - b. At start up, a three-axis vibration analysis and written report to establish bearing condition baseline.
 - c. An annual three-axis vibration analysis and written report indicating bearing condition.
5. The chiller shall be equipped with an integrated Variable Frequency Drive (VFD) to automatically regulate compressor speed in response to cooling load and the compressor pressure lift requirement. Movable inlet guide vanes and variable compressor speed, shall provide unloading. The chiller controls shall coordinate compressor speed and guide vane position to optimize chiller efficiency.
 6. Each compressor circuit shall be equipped with a line reactor to help protect against incoming power surges and help reduce harmonic distortion.
 7. The chiller shall be equipped with a factory-mounted and wired 460V passive harmonic filter guaranteed to meet the IEEE Standard 519 at an Isc/ IL ratio greater than 20.
- G. Evaporator and Condenser:
1. The evaporator and condenser shall be separate vessels of the shell-and-tube type, designed, constructed, tested and stamped according to the requirements of the ASME Code, Section VIII. Regardless of the operating pressure, the refrigerant side of each vessel will bear the ASME stamp indicating compliance with the code and indicating a test pressure of 1.1 times the working pressure, but not less than 100 psig. The tubes shall be individually replaceable and secured to the intermediate supports without rolling or expanding to facilitate replacement if required.
 2. The evaporator shall be flooded type with copper tubes rolled into carbon steel tubesheets. The evaporator shall have left-hand connections when looking at the unit control panel. The evaporator shall be equipped with marine water boxes with removable covers and vent and drain connections. Water connections shall be grooved suitable for Victaulic couplings. The heads shall be carbon steel and the tubesheets shall be carbon steel. The wall copper tubes shall be 0.025 in.
 3. The condenser shall have tubes rolled into carbon steel. The condenser shall have left-hand connections when looking at the unit control panel. The condenser shall be equipped with marine water

- boxes with removable covers and vent and drain connections. Water connections shall be grooved suitable for Victaulic couplings. The heads shall be carbon steel and the tubesheets shall be carbon steel. The wall copper tubes shall be 0.025 in.
4. An electronic expansion valve shall control refrigerant flow to the evaporator. Fixed orifice devices or float controls with hot gas bypass are not acceptable because of inefficient control at low load conditions. The liquid line shall have moisture indicating sight glass.
 5. Re-seating type spring loaded pressure relief valves according to ASHRAE-15 safety code shall be furnished. The evaporator shall be provided with single or multiple valves. The condenser shall be provided with dual relief valves equipped with a transfer valve so one relief valve can be removed for testing or replacement without loss of refrigerant or removal of refrigerant from the condenser. Rupture disks are not acceptable. If rupture disks are required on negative pressure units to prevent air and moisture ingress, then factory mounted spring loaded pressure relief valves shall be provided in series with the rupture disks to contain the remaining refrigerant in the event of vessel over-pressurization. The space between the rupture disk and the relief valve shall include a suitable telltale indicator integrated into the chiller control system to alert the operator that a potential safety issue exists in the pressure relief system.
 6. The evaporator vessel, including water heads, suction line, and any other component or part of a component subject to condensing moisture shall be insulated with UL recognized 3/4 inch closed cell insulation. All joints and seams shall be carefully sealed to form a vapor barrier.
 7. The evaporator waterbox shall be insulated with UL recognized 3/4 inch closed cell insulation. All joints and seams shall be carefully sealed to form a vapor barrier.
 8. Provide factory-mounted and wired, thermal-dispersion water flow switches on each vessel to prevent unit operation with no or low water flow. Paddle and pressure differential type switches are not acceptable due to high rates of failure and false indications from these types of flow indicators.

H. Vibration Isolation

1. Provide neoprene waffle-type vibration isolators for each corner of the unit.

I. Power Connections

1. The power connection shall be: Dual Point Disconnect Switch. Provide disconnect switch for each dual point power connection.

J. Chiller Control

1. The unit shall have a microprocessor-based control system consisting of a 15-inch VGA touch-screen operator interface and a unit controller.
2. The touch-screen shall display the unit operating parameters, accept setpoint changes (multi-level password protected) and be capable of resetting faults and alarms. The following parameters shall be displayed on the home screen and also as trend curves on the trend screen:
 - a. Entering and leaving chilled water temperatures
 - b. Entering and leaving condenser water temperatures
 - c. Evaporator saturated refrigerant pressure
 - d. Condenser saturated refrigerant pressure
 - e. Percent of 100% speed (per compressor)
 - f. % of rated load amps for entire unit
3. In addition to the trended items above, all other important real-time operating parameters shall also be shown on the touch-screen. These items shall be displayed on a chiller graphic showing each component. At a minimum, the following critical areas must be monitored:
 - a. Compressor actual speed, maximum speed, percent speed
 - b. Liquid line temperature
 - c. Chilled water setpoint
 - d. Compressor and unit state and input and output digital and analog values
4. A fault history shall be displayed using an easy to decipher, color coded set of messages that are date and time stamped. Time interval scale shall be user selectable as 20 mins, 2 hours, or 8 hours. The alarm history shall be downloadable from the unit's USB port. An operating and maintenance manual specific for the unit shall be viewable on the screen.
5. All setpoints shall be viewable and changeable (multi-level password protected) on the touch screen and include setpoint description and range of set values.
6. Automatic corrective action to reduce unnecessary cycling shall be accomplished through preemptive control of low evaporator or high discharge pressure conditions to keep the unit operating through abnormal transient conditions.

7. Chiller plant optimization software for multiple chillers shall be provided including automatic control of: at least five (5) chillers, evaporator and condenser pumps (primary and standby), up to 3 stages of cooling tower fan cycling control and a tower modulating bypass valve or cooling tower fan variable frequency drives.
8. The chiller shall be capable of automatic control of: evaporator and condenser pumps (primary and standby), up to 3 stages of cooling tower fan cycling control and a tower modulating bypass valve or cooling tower fan variable frequency drive.
9. The factory mounted controller(s) shall support operation on a network via BACnet® w/IP Ethernet as specified by the successful Building Automation System (BAS) supplier.
10. The information communicated between the BAS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list.
11. All communication from the chiller unit controller as specified in the points list shall be via standard BACnet objects. Proprietary BACnet objects shall not be allowed. BACnet communications shall conform to the BACnet protocol (ANSI/ASHRAE135-2001). A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided along with the unit submittal.
12. The chiller shall be equipped with the capability to restart and reach full load quickly in the event of a power interruption. The compressor shall be capable of restarting within 43 seconds after power is restored and shall reach 80% load within 120 seconds. Chillers not able to restart or load within this time frame shall include a properly sized thermal storage tank to maintain temperature stability in the system.

K. Optional Items

1. The following optional items shall be furnished:
 - a. Shipping Bag w/ no Standard Wood Skidding
 - b. Pumpout unit, with or without storage vessel
 - c. Refrigerant monitor
 - d. To ensure quick and trouble free start up and commissioning, each chiller shall pass a full battery of factory tests. These tests will include the verification of operating and compressor controls to ensure full unit functionality and manufacturing integrity. Any deviation from stringent factory quality standards shall be remedied prior to shipment.

- e. Certifications: ETL/CETL Approval. Certified to AHRI 550/590. Meets ASHRAE 90.1 2010 Standard.
- f. Harmonic filter(s) to work in conjunction with the line reactor to further minimize harmonic distortion.

2.2 REFRIGERANT MONITORING AND SAFETY EQUIPMENT

- A. General: Provide refrigerant monitoring sensor/alarm system and safety equipment as specified here. Refrigerant sensor and alarm system shall comply with ASHRAE Standard 15. The refrigerant monitoring system will be provided by the chiller manufacturer and shall be interfaced with the DDC control system.
- B. Refrigerant monitor shall continuously display the specific gas (refrigerant used) concentration; shall be capable of indicating, alarming and shutting down equipment; and automatically activating ventilation system. On leak detection by refrigerant sensor(s), the following shall occur:
 - 1. Activate machinery (chiller) room ventilation.
 - 2. Activate visual and audio alarm inside and outside of machinery room, with beacon light(s) and horn sounds equipment room and outside equipment room door(s).
 - 3. Notify Engineering Control Center (ECC) of the alarm condition.
- C. Refrigerant monitor shall be capable of detecting concentration of 1 part per million (ppm) for low-level detection and for insuring the safety of operators. It shall be supplied factory-calibrated for the apparent refrigerant.
- D. Monitor design and construction shall be compatible with temperature, humidity, barometric pressure, and voltage fluctuations of the machinery room operating environment.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, piping and electrical to verify actual locations and sizes before chiller installation and other conditions that might affect chiller performance, maintenance, and operation. Equipment locations shown on drawings are approximate. Determine exact locations before proceeding with installation.

3.2 EQUIPMENT INSTALLATION

- A. Install chiller on concrete base with isolation pads or vibration isolators.
 - 1. Charge the chiller with refrigerant, if not factory charged.
 - 2. Install accessories and any other equipment furnished loose by the manufacturer, including remote starter, remote control panel, and remote flow switches, according to the manufacturer written instructions and electrical requirements.
 - 3. Chillers shall be installed in a manner as to provide easy access for tube pull and removal of compressor and motors etc. Also arrange piping to allow for dismantling to permit head removal and tube cleaning.
- B. Install refrigerant monitoring and safety equipment in accordance with ASHRAE Standard 15. Refer to 23 64 10 for more information.
- C. Install thermometers and gages as recommended by the manufacturer and/or as shown on drawings.
- D. Piping Connections:
 - 1. Make piping connections to the chiller for chilled water, condenser water, and other connections as necessary for proper operation and maintenance of the equipment.
 - 2. Make equipment connections with flanges and couplings for easy removal and replacement of equipment from the equipment room.
 - 3. Extend vent piping from the relief valve to the outside.

3.3 STARTUP AND TESTING

- A. Engage manufacturer's factory-trained representative to perform startup and testing service. Provide for as long a time as is necessary to ensure proper operation of the unit, but in no case for less than two full working days. During the period of start-up, the start-up technician shall instruct the owner's representative in proper care and operation of the unit.
- B. Inspect, equipment installation, including field-assembled components, and piping and electrical connections.
- C. After complete installation startup checks, according to the manufacturers written instructions, do the following to demonstrate to the VA that the equipment operate and perform as intended.

1. Check refrigerant charge is sufficient and chiller has been tested for refrigerant leak.
2. Check bearing lubrication and oil levels.
3. Verify proper motor rotation.
4. Verify pumps associated with chillers are installed and operational.
5. Verify thermometers and gages are installed.
6. Verify purge system, if installed, is functional and relief piping is routed outdoor.
7. Operate chiller for run-in-period in accordance with the manufacturer's instruction and observe its performance.
8. Check and record refrigerant pressure, water flow, water temperature, and power consumption of the chiller.
9. Test and adjust all controls and safeties. Replace or correct all malfunctioning controls, safeties and equipment as soon as possible to avoid any delay in the use of the equipment.
10. Prepare a written report outlining the results of tests and inspections, and submit it to the VA.

- D. Engage manufacturer's certified factory trained representative to provide training for 16 hours for the VA maintenance and operational personnel to adjust, operate and maintain equipment.

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 specifications 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 64 10
MODULAR CHILLER PLANT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General description.
2. Manufacturers.
3. Qualifications.
4. Performance testing.
5. Mechanical equipment.
6. Electrical and controls equipment.
7. Project execution.

B. Related Work:

1. Section 23 05 11 COMMON WORK RESULTS FOR HVAC
2. Section 23 05 12 GENERAL MOTOR REQUIREMENTS FOR HVAC.
3. Section 23 05 41 NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
4. Section 23 07 11 HVAC INSULATION.
5. Section 23 09 23 DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
6. Section 23 21 13 HYDRONIC PIPING.
7. Section 23 21 23 HYDRONIC PUMPS.
8. Section 23 25 00 HVAC WATER TREATMENT.
9. Section 23 31 00 HVAC DUCTS AND CASINGS AND BLOWER COIL UNITS.
10. Section 23 34 00 HVAC FANS.
11. Section 23 64 00 PACKAGED WATER CHILLERS.
12. Section 23 65 00 COOLING TOWERS.
13. Section 26 05 11 REQUIREMENTS FOR ELECTRICAL INSTALLATIONS
14. Section 26 05 19 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.
15. Section 26 05 26 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
16. Section 26 27 26 WIRING DEVICES.
17. Section 26 29 11 MOTOR CONTROLLERS

C. References:

1. AHRI - Air-Conditioning, Heating, and Refrigeration Institute.
2. AISC - American Institute of Steel Construction.
3. ANSI - American National Standards Institute.
4. ASCE - American Society of Civil Engineers.
5. ASHRAE - American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

6. ASME - American Society of Mechanical Engineers.
7. ASTM - American Society for Testing and Materials.
8. ETL - Electrical Testing Laboratories.
9. Hydraulic Institute.
10. IBC - International Building Code.
11. IEEE - Institute of Electrical and Electronics Engineers.
12. NEC - National Electrical Code.
13. NEMA - National Electrical Manufacturers Association.
14. NIST - National Institute of Standards and Technology.
15. OSHA - Occupational Safety and Health Administration.
16. Department of Veteran Affairs Design Instructions

1.2 GENERAL DESCRIPTION

- A. Provide a factory assembled modular central plant as specified herein and according to plan drawings. The modular central plant shall be no smaller or larger than shown on plan drawings.
- B. The modular central plant after assembly shall require the following connections for the chilled water portion:
 1. Chilled water suction and discharge pipe connections.
 2. Cooling tower water suction and discharge pipe connections.
 3. Make-up water connection.
 4. Electrical power connection(s).
 5. Terminal contacts to field mounted devices and building automation system (BAS).

1.3 MODULAR CENTRAL PLANT COMPONENTS

- A. The modular central plant's chilled water portion shall consist of the following components: Outdoor equipment enclosure (to include exit doors, landings, stairs, and hand rails, required to reach grade from enclosure), structural base, chillers, cooling tower(s), chilled water pumps/motors, condenser water pumps/motors, controls, valves, and all necessary piping and components as listed in the specification for a complete system.

1.4 MODULAR CENTRAL PLANT DESIGN CONDITIONS

- A. Chiller Plant:
 1. Total cooling load at present: 2,000 tons, 5 chillers at 400 tons each.
 2. Total cooling load in future: 400 tons, 1 additional chiller at 400 tons each.

3. Chilled water system: 5610 GPM at present, 105 pump TDH (system includes one redundant pump).
4. Condenser water system: 7200 GPM at present, 80 pump TDH (system includes one redundant pump).

1.5 MANUFACTURER

- A. Subject to compliance with the specification, provide a complete modular central plant by one of the following manufacturers or approved equals:
 1. Systecon Inc. (www.systecon.com).
- B. All manufacturer's shall match the unit modular chiller size shown on the drawings as well as all the components shown within in order to bid the project. Chiller enclosures that are larger or smaller than the footprint shown on plan shall not be acceptable.

1.6 QUALIFICATIONS

- A. The modular central plant manufacturer shall be listed by ETL or UL as an approved manufacturer of factory assembled modular central plants. The equipment shall bear the listing and label before shipment from the factory. The listing must cover the entire modular central plant as assembled. An individual listing for components is unacceptable.
- B. The modular central plant manufacturer must be the manufacturer of the controls and control panel used for the system. The control panel shall be listed by UL as an approved manufacturer of industrial control panels. Upon request from the engineer, the manufacturer shall furnish proof of listing. Use of commercial grade controllers from the building automation contractor is not acceptable.
- C. The modular central plant manufacturer shall have a quality assurance program. The manufacturer shall provide documentation of this program in the submittal. The manufacturer shall provide a description of the performance test procedure. The manufacturer shall provide current (within last 9 months) independent testing certifying the performance test stand is NIST traceable.
- D. The modular central plant manufacturer shall have a minimum of fifteen (15) years of manufacturing and application experience.
- E. The modular central plant manufacturer shall provide all mechanical drawings in a three-dimensional format. The use of 3D design software is required to ensure the design adequately provides for maintenance and angle clearance. Provide drawings of 3D model in pdf format for review during the shop drawing process.

1.7 PERFORMANCE TESTING

A. Factory Performance Test Standards

1. Field performance testing of the modular central plant is not acceptable.
2. Factory performance test reports to be provided to the owner, consulting engineer, commissioning agent, installing contractor and equipment representative.
3. The entire testing facility shall be independently certified and traceable to NIST or ASME PTC 18.1 calibration procedures. Certification shall be kept on file for inspection. Hydraulic Institute standards shall be followed for the calibration procedures of all testing instrumentation.
4. Prior to factory assembly of the modular central plant, each pump or pumping system shall be performance tested as per 1.7B.
5. After factory assembly of the modular central plant, the entire system shall be hydrostatically tested with water to 150 PSIG for ANSI class 150 for a minimum of thirty (30) minutes.
6. The performance test stand must have a tank that will limit the water temperature rise from the beginning to the end of the test to 10 degrees F. Flow test data must be provided showing the tank temperature.
7. As a minimum requirement, the following test equipment must be utilized and shall be within the following accuracies:
 - a. Flow meter: $\pm 4\%$ of rated flow, 0 to full range.
 - b. Pressure gauges and sensors: $\pm 2\%$ based upon independent dead weight test.
 - c. Tachometer: $\pm 1\%$ of rated speed, 0 to full range.
 - d. Multimeter: for readings of supply voltage, input amperage, input kilowatts, and power factor $\pm 1\%$ of selected reading, 0 to full range.

B. Pumping System Factory Performance Test

1. Prior to testing of the complete modular central plant, the manufacturer shall perform a factory efficiency test for each constant speed pump and each variable speed pumping system at 25%, 50%, 75% and 100% of the design flow of the pump or pumping system.
2. Flow, system total dynamic head, kW and efficiency to be recorded for each of the above percentages of design system flow.

3. As part of the test procedure, the manufacturer shall demonstrate the transition points at which standby variable speed pump(s) are added and subtracted to achieve optimum system efficiency.
4. The control system for each pump set shall be tested and all sequences and alarms shall be simulated.

C. Functional System Load Factory Performance Test

1. Prior to shipment, the complete system (including the chillers and the pumping systems) shall be assembled and tested at the factory by the modular central plant manufacturer.
2. The complete system shall be piped to a certified test stand. The test stand shall be capable of supplying an air conditioning load sufficient to operate the modular plant system for a minimum of thirty (30) minutes.
3. All equipment shall be operated under load and be fully energized.
4. Instrumentation to measure flow, pressure and temperature shall be provided in order to determine that all equipment is operating properly and within range.
5. The pumping systems shall be tested as specified herein in 1.7B.
6. The control systems shall be tested and all sequences and alarms shall be simulated.
7. A complete description of operations as submitted shall be reviewed point by point to ensure that the system operates as specified.
8. The pumps shall be water balanced to provide the specified flows.
9. The testing shall measure kilowatts and power factor for each pump and chiller.
10. A qualified representative of the chiller manufacturer shall start up and operate the chillers, recording a log of operating pressure and temperatures.
11. All chiller compressors shall be operated.

1.8 SUBMITTALS

A. Submittals shall include the following as a minimum:

1. Title page with job name, location, and equipment title.
2. Table of contents with document index.
3. System design information sheet.
4. Description of system operation.
5. Modular central plant general arrangement and dimensioned drawings.
6. Modular central plant schematic showing all pipe sizes, location of reducers, components, specialties, and instrumentation.

7. Structural Shop Drawings: clearly indicate profiles, sizes, spacing, and locations of structural members, connections, attachments, openings, fasteners, cambers and loads. Indicate welded connections using standard AWS welding symbols. Indicate net weld lengths. Indicating framing anchor bolt settings, sizes, and locations from datum. Indicate wall and roof system dimensions, panel layout, general construction details, anchorages, and method of anchorage, method of installation and overall dimensions. Stamped by a professional engineer registered in the state of North Dakota.
 8. Structural Design Calculations, indicating code used, design loads, and sample calculations, stamped by a professional engineer registered in the state of North Dakota.
 9. Electrical power and control wiring drawings.
 10. Pump(s) material and construction drawing(s).
 11. Pump(s) performance curve showing design point.
 12. A predictive pumping energy analysis showing system efficiency and kW.
 13. Complete chiller submittal.
 14. Complete cooling tower submittal.
 15. Complete variable frequency drive(s) submittal.
 16. Catalog information on valves, strainers, and control components.
 17. Name and address of factory trained service company.
 18. Performance test procedure and performance test stand drawing.
- B. Provide electronic download of submittal for approval as well as 2 hardcopy bound sets.
- C. Submittals that are generic and not specifically designed to meet the requirements of this section are not acceptable.
- D. Submittal shall be assembled in an organized manner with proper index.
- E. If the submittal is rejected for the same reasons more than once, upon the third submission the manufacturer shall pay the VA \$1000.00 for each instance for their service before the third or subsequent submittal is reviewed.

1.9 OPERATION AND MAINTENANCE MANUALS

- A. Operation and Maintenance (O&M) Manuals shall include the following as a minimum:
1. Title page with job name, location, and equipment title.
 2. Table of contents with document index.
 3. System design information sheet.

4. Description of system operation.
 5. Modular central plant general arrangement and dimensioned drawings.
 6. Modular central plant schematic showing all pipe sizes, location of reducers, components, specialties, and instrumentation.
 7. Electrical power and control wiring drawings.
 8. Bill of material.
 9. Modular central plant component's operation and maintenance instructions.
- B. Provide electronic download of operation and maintenance manual as well as 2 hardcopy bound sets.
- C. Operation and maintenance manuals that are generic and not specifically designed to meet the requirements of this section are not acceptable.
- D. Operation and maintenance manuals shall be assembled in an organized manner with proper index.

PART 2 - PRODUCTS

2.1 MECHANICAL

A. Outdoor Equipment Enclosure

1. Outdoor equipment enclosure shall include all accessory items necessary for a complete functioning structure to include but not be limited to the following: building identification sign, floor, wall and roof panels, structural framing, roof insulation and epdm roofing, flashing, gutter and downspouts (field installed), louvers, doors and hardware, roof access ladder, personnel door access steps, landings and handrails. Items where applicable must meet OSHA and NFPA 101 requirements, latest editions. All elements must also meet or exceed applicable local code and VA guidelines.
2. A pre-insulated architectural metal panel outdoor equipment enclosure shall be provided as specified below. The enclosure size and color, quantity and location of doors, louvers, and miscellaneous fixtures shall be as shown on submitted general arrangement drawing. The interior of multiple enclosure modules shall be open and provide continuous clearance between components. Doorways or partitions between modules are not acceptable.
3. Enclosure construction and materials
 - a. Outdoor equipment enclosure shall be fabricated as a single assembly or in separate shipping sections as required for shipping or installation purposes. Each section shall include

- means by which the unit is to be lifted and include a label indicating proper lifting instructions.
- b. The enclosure manufacturer 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 sections are assembled to meet manufacturer's recommendations and requirements noted on the drawings.
 - c. All dissimilar materials shall be properly isolated. All floor, wall, and roof deflections shall be less than 1"/360" span including internal compartment pressures. Structures are to be designed for: Wind- Basic wind speed of 120 mph, Risk Category IV, exposure B. Snow: Ground Snow of 50 psf and roof snow load of 42 psf, with Importance Category of IV, $C_e=1.0$, $C_t=1.0$, and $I=1.2$. Live load of 150 psf. Roof shall be slant type and slope a minimum of 1/8" per foot.
 - d. Wall construction to consist of flat insulated stucco embossed architectural metal wall panel.
 - e. Roll-formed exterior and interior steel sheet faces chemically bonded to continuously foamed-in-place polyurethane core; laminated panels are not acceptable.
 - f. Exterior Face: G-90 galvanized stucco embossed painted steel, minimum Grade 33 and/or AZ-50 Aluminum-Zinc stucco embossed painted steel, minimum Grade 33 in 22ga (0.0312").
 - g. Interior Face: G-90 galvanized unembossed painted steel, minimum Grade 33 and/or AZ-50 Aluminum-Zinc unembossed painted steel, minimum Grade 33 in 22ga (0.0312").
 - h. Wall, Floor, & Roof Core Insulation: Foamed In Place, Non-CFC, FM Class I approved, polyurethane. Minimum R value required to be 20. The enclosure shall not contain any exposed insulation. Foil backed or rigid board exposed "stick-on" insulation shall not be acceptable. The entire inside perimeter of the enclosure base shall be insulated to the same level as the walls.
 - i. Exterior Finish: Exterior face sheet shall be treated with a nominal 0.2 mil (5 microns) base primer, followed by a nominal 0.7 mil (17.5 microns) finish coat of full strength PVF2

- fluoropolymer in manufacturer's standard colors. Provide color chart for selection during shop drawings.
- j. Interior Finish: The interior face sheet shall be a nominal 0.2 mil (5 microns) primer followed by a nominal 0.7 mil (17.5 microns) polyester coating in USDA compliant Blizzard White.
 - k. Panels shall be fastened to heavy gauge formed steel structure.
 - l. Where any system pipe exits the side of the enclosure, provide an escutcheon plate consisting of a top plate with bent overlap lip covering the bottom plate with exact cut out for pipe. All penetrations shall be factory installed and sealed. See sealing requirements in section 07 92 00, Joint Sealants.
 - m. Structural Tests: The design load/deflection criteria shall be verified from tests per ASTM E 72 "Air Bag Method" using a 20 psf (.96 kPa) simulated wind load. A deflection limit of L/180 shall apply to wall panel.
 - n. Thermal Transmission: Testing in accordance with ASTM C 518, "measurement of steady state thermal transmission", the panels shall provide a K-factor of .140 btu/sf/hr/deg. F at 75° F (24° C) mean temperature (air films are not included).
 - o. Vapor Barrier:
 - 1) Air Infiltration: Air infiltration shall not exceed .06 cfm per square foot of wall area when tested per ASTM E 283 at a static pressure of 12.0 psf (.576 kPa).
 - 2) Static Water Penetration: There shall be no uncontrolled water penetration through the panel joints at a static pressure of 20.0 psf (.96 kPa) when tested per ASTM E 331.
 - 3) Dynamic Water Penetration: There shall be no uncontrolled water penetration through the panel joints when subjected to a 95 mph (153kph) slipstream airflow and application of water for a 15 minute period in accordance with AAMA 501.1.
 - p. Fire
 - 1) Surface Burning Characteristics: The insulated core shall have been tested in accordance with ASTM E 84 and CAN/ULC S102 for surface burning characteristics. The core shall have a maximum flame spread of 25 and a maximum smoke developed rating of 450.
 - 2) Factory Mutual Research Corporation (FMRC) Standard 4880, 50' (15.24 m) High Corner Test for Unlimited Height Structures:

The panel assembly shall not support a self-propagating fire which reaches any of the limits of the 50' (15.24 m) high corner test structure as evidenced by flaming or material damage of the ceiling of the assembly. Note: Approval is applicable to structures of unlimited height.

- 3) Factory Mutual Research Corporation (FMRC) Standard 4881, Standard for Class 1 Exterior Wall Systems. Note: Panels to be installed per Factory Mutual guidelines for required listings.

q. Bond Strength

- 1) Fatigue Test: The panel shall withstand deflection cycling at L/180 to two (2) million alternate cycles with no evidence of delamination, core cracking or permanent bowing.
- 2) Freeze/Heat Cycling: The panel shall exhibit no delamination, surface blistering or permanent bowing when subjected to cyclic temperature extremes of -20° F (-28° C) to +180° F (+82° C) for twenty-one (21) eight hour cycles.
- 3) Humidity Test: The panel shall exhibit no delamination or metal corrosion at interface when subjected to a +140° F (+60° C) temperature and 100% relative humidity for a total of 1200 hours.
- 4) Autoclave Test: The panel shall exhibit no delamination of the foam core from metal skins when exposed to 2 psi (.122 kg/sq. cm) pressure at a temperature of +212° F (+100° C) for a total of 2½ hours.

4. Doors

- a. Exterior doors shall be of the same color and material as the enclosure. All doors shall conform to ASTM Standards C236, E283-91, and E331-86. Each door shall have a .080-6063-T5 extruded aluminum frame with mitered and welded corners, 304 stainless steel continuous hinge, and extruded EPDM gasket in the door frame.
- b. Single doors shall be 40" wide by 84" high and shall be equipped with a heavy duty closer/holder. Each door shall also be equipped with a panic exit device with rigid outside lever, night latch function, key retracts latch bolt. Core shall be Best 7-pin core to match existing Fargo VA system. Cores shall be provided with the enclosure, but pinned by the owner. Provide pinning materials to the owner. Provide window on door as noted on the drawings.

- c. Double doors shall be 72" wide by 84" high. Double doors shall be arranged side by side with removable center divider. Each door shall be equipped with a heavy duty closer/holder. Each door shall also be equipped with a lever handle lockset, storeroom function, outside lever rigid, key retracts latch bolt, inside lever always free. Core shall be Best 7-pin core to match existing Fargo VA system. Cores shall be provided with enclosure, but pinned by the owner. Provide pinning materials to the owner. Required personnel exit doors shall be provided with galvanized steel landings, treads, and handrails as required to reach grade from the enclosure.
 - d. Provide metal grate landing steps and steel pipe handrail for each door location and as shown on the drawings. Conform to NFPA 101 latest edition.
5. Modular Central Plant HVAC Unit
- a. Self-contained, ceiling-mounted HVAC unit(s) shall be provided to condition the interior space of the plant. Unit(s) shall be factory assembled, pre-charged, pre-wired, tested and ready to operate. Each unit shall provide ventilation, and air-conditioning.
 - b. The plant manufacturer shall provide calculations to determine appropriate plant loads, with HVAC units designed to maintain a maximum indoor temperature of 75 degrees F and minimum indoor temperature of 60 degrees F. Outdoor summer design conditions shall be 93 degrees dry bulb/73 degrees wet bulb. Outdoor winter design conditions is -30 degrees.
 - c. Acceptable Manufacturer: Larkin or Approved Equal.
 - d. Provide thermostat for cooling unit. Thermostats shall have capability of being adjusted to eliminate null or dead band. Wall mounted thermostats shall have setpoint range and temperature display and external adjustment:
 - e. Electronic Thermostats: Solid-state, microprocessor based, programmable to daily, weekend, and holiday schedules.
6. Ventilation Louvers
- a. Two (2) framed louvers shall be provided for the forced draft ventilation system. The louvers shall be of the type and size shown the drawings. One louver shall be for the intake air and

the other for exhaust air. All louvers shall be installed in an accessible, non-restricted location.

- b. The intake louver shall be provided with a motor operated shutter and #4 galvanized hardware screen with 1/2" x 1/2" bird-screen on inside of louver.
- c. The exhaust louver shall be provided with a plenum, motor operated fan, automatic shutter, and with 1/2" x 1/2" bird-screen on inside of louver. The exhaust louver components shall be zinc-coated steel. The ventilation fan shall be of a capacity to maintain adequate cooling and ventilation for the locale in which the equipment is to operate.
- d. Louvers shall have a minimum of 50% free area and bear the AMCA Certified Ratings Program Seal for air performance and water penetration. The louver shall have a maximum intake water penetration rate of 0.01 ounces/ft² at a velocity of 600 FPM. The louver shall have a maximum static pressure drop of 0.06 in W.G. at a velocity of 600 FPM.
- e. Frames, blades, and mullions (sliding interlocking type); 2 mm (0.078-inch) thick extruded 6063-T5 or -T52 aluminum. Blades to be drainable type and have reinforcing bosses.

7. Refrigerant Monitoring and Removal

- a. Follow minimum standards for refrigeration systems as required by ANSI/ASHRAE Standard 15 paying special attention to requirements for air monitoring, ventilation, self-contained breathing apparatus, and leak detection to assure the safety of personnel.
- b. Install proper outside exhaust of chiller refrigerant relief device and purge unit(s). Route exhaust to the exterior of the building and away from all air intakes in compliance with ANSI/ASHRAE 15.
- c. Install a refrigerant monitor that can be calibrated for appropriate refrigerant. Unit shall be capable of detecting concentrations of minimum parts per million (ppm) for low level leak detection to assure the safety of personnel.
- d. Install suitable audible and visual alarms that activate well below the Acceptable Exposure Level (AEL) of the specific refrigerant to alert persons inside and outside of the equipment room that a refrigerant leak condition exists.
- e. Acceptable Manufacturer: Honeywell, Model 301 or Approved Equal.

8. Electrical and Lighting

- a. Refer to electrical drawing E3 and electrical specifications for responsibility of system electrical devices and wiring.

9. EPDM Roof Membrane

- a. The modular central plant manufacturer shall provide a 60-mil black EPDM roof membrane system to cover the roof.
- b. The EPDM roof membrane system shall include a color coordinated steel drip edge.
- c. The EPDM roof membrane system shall include wood blocking and polyisocyanurate insulation provided by the contractor, to provide a taper of 1/8" per foot. Minimum R-value of roof insulation shall be 25.
- d. The modular central plant manufacturer shall hire a local roofing contractor to furnish and install the EPDM roof membrane system at the job site.
- e. Roof shall be sloped to permit rain drainage to one side of the building enclosure. Exterior downspouts shall be provided from roof to permit drainage to grade level.

B. Structural Base

1. A pre-engineered structural steel base shall be provided by the modular central plant manufacturer to support all equipment and facilitate lifting, shipping, and the proper installation of the plant. All major equipment, including chillers and pumps shall be supported directly with structural steel underneath the floor. All equipment shall be welded to the floor. Bolting equipment is not acceptable.
2. Structural base shall be supported on a maximum of 24" centers to the structural intermediate support channels. Structural base shall be lifted with a maximum of 4 lifting lugs. Structural base shall not deflect more than the allowable strain at the allowable design stress or 1/360th of the length of the base, whichever is less. Floor decking shall be provided and be made from solid welded ¼" hot rolled steel diamond plate sheets. Floor decking shall be continuously welded. Floor decking shall be turned upward at the perimeter a minimum of 2" to provide for proper containment. Base shall be insulated around the perimeter of the enclosure to the same requirements for wall insulation listed in previous paragraph.

3. Provide access hatch for connection of sanitary sewer line below equipment enclosure as shown on plan. Access door to hatch shall be minimum 1/4" thick steel and the same type as described above and flush with surface of the floor. Door shall include continuous steel hinge on one side with stainless steel pin. Provide removable hinge pin to allow removal of panel. Door handle shall be recessed steel handle with concealed hinge. If hatch cannot completely open, provide means to lock open to prevent accidental closing of hatch. Intermediate structural floor supports shall be provided for framing of access door from below the floor.
4. Drains shall be specifically located at major equipment throughout the plant. All drains shall be collected in the base and brought out through the base channel to a single location near the main building sewer line. Trough drains to be provided at both ends of chiller(s) as well as other locations noted on plan. Drains to have sloped bottoms and stainless steel or epoxy lined steel construction. Removable galvanized steel gratings to be mounted flush with finished floor.
5. The base shall be bolted to the concrete slab on site by the installing contractor. Follow enclosure manufacturer instructions for bolt sizes and locations. Provide bolting plan during shop drawings for review.

C. Chillers

1. Chillers shall be provided by the modular central plant manufacturer.
2. Refer to Section 23 64 00 CENTRIFUGAL WATER CHILLERS.
3. Chillers shall be restrained for shipment with welded anchoring to floor and tie downs to prevent load shifting.
4. Chillers shall be provided with hinged water box covers on evaporator and condenser for ease of maintenance and tube pull on non connection end.
5. Chillers shall be factory insulated by the chiller manufacturer.
6. Chillers shall be isolated from floor using chiller manufacturer provided amp pad.
7. Chillers shall be provided with a thermal displacement flow detection device.
8. Chillers shall be provided with ball valves with plugs or caps for drain and vent connections.

D. Cooling Towers

1. Cooling tower(s) shall be furnished by the modular central plant manufacturer but installed by the mechanical contractor.
2. Refer to Section 23 65 00 COOLING TOWERS.

E. Pump(s) and Motor(s)

1. Chilled water pumps and motors shall be provided by the modular central plant manufacturer.
2. Condenser water pumps and motors shall be provided by the modular central plant manufacturer.
3. Refer to Section 23 21 23 HYDRONIC PUMPS.
4. Refer to Section 23 05 12 GENERAL MOTOR REQUIREMENTS FOR HVAC.

F. Pipe, Manual Valves, Fittings, and Hydronic Specialties

1. All pipe, manual valves, fittings, and hydronic specialties as shown on the bid drawings within the boundaries of the plant enclosure shall be provided by the modular central plant manufacturer. Piping serving the cooling towers shall be stubbed out of the building, sealed, and capped by the chiller plant manufacturer.
2. All pipe, manual valves, and fittings as shown on the bid drawings between the capped lines stubbed out of the plant enclosure and the cooling tower(s) shall be by the mechanical contractor. Piping shall ship loose in sections.
3. Refer to Section 23 21 13 HYDRONIC PIPING.
4. Pipe shall be fabricated welded steel headers using manufactured fittings conforming to ASME Section 9 Code B.31.1, 150# ANSI class. Pipe shall be sized for a maximum velocity of 10 feet/second and maximum head loss of 8.5 feet per 100 feet of pipe. Branch piping shall be sized for the design capacity of each component.
5. Grooved couplings shall be limited to connections between modules, chiller evaporator and condenser connections, and connections through enclosure walls. A modular central plant assembled entirely of grooved couplings is unacceptable.
6. All pipe inside the plant shall be supported from the structural base and be independent of component connections. Pipe shall be isolated from supports using a non-metallic spacer. Pipe welded directly to supports is unacceptable.

G. Actuated Control Valves

1. The modular central plant manufacturer shall provide automatic, two-way, modulating, control valves with electric actuator for the following functions, at a minimum:
 - a. Chiller evaporator isolation.
 - b. Chiller condenser isolation.
 - c. Cooling tower isolation.
 - d. Cooling tower bypass.
 - e. Make-up water to cooling towers.
2. All valves indicated above shall be provided as an integral part of the modular central plant. All valves shall be designed for quarter turn operation. Three-way assemblies shall consist of two butterfly valves with integral linkage and tee. All butterfly valve shall be constructed with a ductile iron lug body, EPDM seat, stainless steel disc, 416 stainless steel shaft, and copper and brass bushings. The actuator shall be mounted on a bracket, which is coupled to the valve shaft. The actuators for two position operation shall have a split phase capacitor AC reversing motor with 25% duty. The actuators for modulating operation shall have a split phase capacitor AC reversing motor with 100% duty. Actuators shall be housed in an aluminum Nema 4 enclosure with integral 115 VAC condensate heater. Two-position valve actuators shall have end switches. All valves shall be provided with position indication displays on HMI (human machine interface).

H. Filtration

1. Filtration equipment for the cooling towers shall be provided by the modular central plant manufacturer and shall be mounted inside of the plant enclosure.
2. Refer to Section 23 25 00 HVAC WATER TREATMENT.

I. Water Treatment

1. Water treatment equipment for the condenser water system shall be provided by the modular central plant manufacturer and shall be mounted inside of the plant enclosure.
2. Refer to Section 23 25 00 HVAC WATER TREATMENT.
3. The installing contractor (and not the plant manufacturer) is responsible for providing any water treatment chemicals or any routine testing of the water quality.

J. Piping Insulation

1. The modular central plant manufacturer shall provide and install piping insulation with service jacket for all chilled water system components which are included within the interior of the plant enclosure. Components include pumps, piping, valves, fittings, and air separators.
2. Refer to Section 23 07 11 HVAC INSULATION.
3. All piping insulation required for piping that will be installed exterior to the plant enclosure shall be provided and installed by the installing contractor.

K. Fit and Finish

1. Paint: All exposed steel components shall be cleaned, degreased and painted with a rust preventive primer, and shall be painted the same color as the base. The structural base, exposed steel, pipe, pumps, motors, and valves shall be painted with a consistent color and two-part epoxy. All other major equipment shall be in original condition and not painted. Provide touch up paint as part of the shipment.
2. Tagging: All mechanical components, electrical devices (including switches and receptacles), transmitters, and control devices shall be tagged. Provide phenolic name tags with chains for all control valves and transmitters. Provide type tagging in circuit breaker panels (refer to Division 26 for VA requirements). Tagging to be the same as shown on the submitted flow diagram. Refer to 23 05 11 for additional valve labels required.
3. Pipe marking: All pipe shall be marked with pipe markers to indicate type of fluid and flow direction. Markers to have 2 inch letters with colored background. Locate marker before and after major components. Use different colors for each system. Refer to specification section 09 91 00 for more information on pipe labeling.
4. Caution markers: Provide caution markers for all hazards. Markers to include shock hazards and burn hazards. Provide tagging on exterior doors for refrigerant and hearing protection. Provide flash label for electrical equipment as per Division 26 specifications.
5. Conduit and Pipe: All horizontal conduit and pipe shall be installed level. All vertical conduit and pipe shall be installed vertical. Pipe and conduit shall be arranged not to impede access. Pipe and conduit to be arranged so that it does not become a trip hazard or hazard for bumping your head.

2.2 ELECTRICAL

A. Electrical Distribution

1. Refer to electrical drawing E3 and electrical specifications for responsibility of system electrical devices and wiring.
2. Provide flash label for electrical panels and switchgear as per Division 26 specifications.
3. Chiller(s) to be fed with individual (dual point) power feeds.
4. Power Supply: Refer to electrical drawings for specific voltage and phase.
5. Refer to electrical plans and specifications for required devices, electrical equipment, wiring, conduit, lighting, and all accessories required for complete system including required installation methods.

B. Variable Frequency Drives

1. The modular central plant manufacturer shall provide a variable frequency drive for each chilled water pump, condenser water pump, cooling tower fan.
2. Refer to Section 26 29 11 MOTOR CONTROLLERS
3. Provide with adjustable frequency, which employ a pulse width modulated inverter.
4. To insure safety of the equipment, the VFD shall include these protective features and options:
 - a. NEMA 1 enclosure.
 - b. Static instantaneous over-current and over-voltage trip.
 - c. Static over-speed (over-frequency) protection.
 - d. Line or fuse loss and under-voltage protection.
 - e. Power unit over-temperature protection.
 - f. Motor inverse time overload protection.
 - g. Input line reactor or DC choke. AC or DC sized for a minimum of 1-½% impedance.
 - h. Ammeter.
 - i. Speed meter.
 - j. Automatic restart after power failure or minor drive fault. The drive shall attempt a minimum of two restarts before a complete drive shut-down.
 - k. Power on light.
 - l. Manual speed potentiometer or control capability through the keypad.

- m. Hand/Off/Automatic Switch or Manual/Automatic Switch with start/stop pushbutton.
- n. VFD fault light and reset.
- o. The drive shall include built in diagnostics. Diagnostics shall be annunciated through the alpha numeric keypad. The drive shall be listed UL, ETL and/or CSA.
- p. All drive information shall be transmitted to the BAS through an interface with the master control panel. Multiple BAS connections are not acceptable.

2.3 CONTROLS

A. Hardware

1. All controls hardware required for the operation of the modular central plant to be provided by the modular central plant manufacturer regardless if they located inside or outside of the chiller enclosure. Refer to specification 23 09 23 for additional controls information.
2. The central plant control enclosure to conform to NEMA 1 type construction.
3. Control panel to be UL 508A listed under _{cUL_{US}}.
4. The modular central plant control panel to include:
 - a. Disconnect switch.
 - b. Control circuit transformer 480/120 with primary and secondary fuses.
 - c. System Local-Off-Remote selection.
 - d. System Initialized indication.
 - e. Run indication for each pump and chiller.
 - f. Pump failure alarm indication and reset.
 - g. Lead selector for manual alternation of each pump set.
 - h. Lead selector for manual alternation of chillers.
 - i. Open-close-auto switch for each control valve.
 - j. Position indication for each control valve.
 - k. Failure alarm indication for each control valve.
 - l. Chiller failure alarm indication with cut-off.
 - m. Programmable Logic Controller (PLC).
 - n. Human Machine Interface (HMI).
 - o. Interface controls for variable frequency drives.
5. Programmable Logic Controller (PLC).
 - a. Manufacturer: Siemens Industry Demand Flow or approved equal.

- b. Memory: Expandable to 64K.
 - c. PLC to have built in communication for peer-to-peer, DH 485, device net or RS232.
 - d. I/O points: 4096.
 - e. Provide built in security with multiple levels of passwords.
 - f. PLC is to be mounted in the cabinet to avoid accidental damage. Damage to the HMI shall not affect the operation of the PLC.
 - g. Individual remote I/O panels to be provided for each equipment module.
 - h. Commercial grade DDC systems are not acceptable.
6. All analog and digital inputs and outputs to be supplied with compatible programmable logic controller interface (either individually or in clustered groups).
7. Human Machine Interface (HMI)
- a. The operator display to be provided in a single integrated graphic display screen with a separate processor for the controls.
 - b. The HMI to be suitable for mounting in the door of a NEMA 1 enclosure so that it will maintain the enclosure's NEMA 1 rating.
 - c. Mount at a suitable height to assure proper visibility and easy access by the operator.
 - d. Display shall be a 15" color STN display and a resistive touch screen rated for at least 5,000,000 touches.
 - e. The HMI includes the following:
 - 1) CPU: Minimum 5x86/133 MHz.
 - 2) System memory: Minimum 8 MB.
 - 3) Storage Memory: All memory storage shall be local. Flash drives shall not be allowed. Rotating media devices and mechanical hard drives are not acceptable.
 - 4) Serial ports: Total 2, with at least one (1) port configurable for RS232/422/486.
 - 5) Ethernet port: NE 2000 compatible, 10 MBPS / 10 Base-T with RJ45 connector.
 - 6) Expansion Slots: Minimum one (1) PC/104 slot
 - f. The HMI will be provided with a full color graphic display. A separate screen shot will be provided for the following:
 - 1) Master screen.
 - 2) Chilled water schematic.

- 3) Chilled water pumps.
- 4) Chillers.
- g. Each screen will have a touch button to relocate the screen to any of the main screens. On each screen the touching of the individual component will take you to a component screen. The component screens to consist of:
 - 1) Chillers.
 - 2) Pumps.
 - 3) Valves.
- h. The master screen will display the active tons, kW, flow and kW/ton.
- i. All screens shots to be provided digitally to the building automation for their use in monitoring the controls.
- 8. Control components
 - a. Differential Pressure Transmitters
 - 1) Provide complete, self-contained, variable capacitance type differential pressure transmitters.
 - 2) The following are to be remote mounted by mechanical contractor:
 - a) Air-Cooled Chiller Mounted Outside
 - 3) The following are to be mounted inside the plant:
 - a) Chiller chilled water (across evaporator)
 - b) Chiller Pumps and Condenser Pumps
 - 4) Wiring terminals and electronics to be in separate compartments, so the electronics remain sealed during installation.
 - 5) Provide reverse polarity protection to keep wiring mishaps from damaging the transmitter.
 - 6) Wiring Manufacturer: Belden 9320 or approved equal, two wire, shielded twisted cable between the control system and the transmitters, and installed separate from any conduit containing AC circuit wiring.
 - 7) Design range shall be as required by system. External zero and span adjustments, over-pressure to 2,000 PSI, and no humidity effects.
 - 8) Internal mechanical linkages are not allowed in the transmitter(s).
 - 9) Range: 0 to 4" H2O to 0 to 642" H2O

- 10) Accuracy: $\pm 0.075\%$ of calibrated span from 1:1 to 15:1 turndown
 - 11) Turndown: 100:1
 - 12) Stability $\pm 0.15\%$ of URL over a 36-month period.
 - 13) Connection Type: $\frac{1}{4}$ " or $\frac{1}{2}$ " NPT
 - 14) Wetted parts: Including flanges, drains, and vent valves:
316L sst
 - 15) Diaphragm material: 316 L stainless steel
 - 16) Fill fluid: Silicone Oil DC200
 - 17) Gasket material: PTFE
 - 18) Stainless steel bolts and nuts
 - 19) NEMA 4X Enclosure
 - 20) Power: 10.5 to 42 v dc
 - 21) Output: Two wire 4-20mA dc
- b. Turbine Type Flow Meters
- 1) Provide dual electrode, insertion type flow meter(s) for the chilled water system. Refer to control diagram for location.
 - 2) Manufacturer: Onicon F-3500 or approved equal.
 - 3) Wiring Manufacturer: Belden 9320 or approved equal, two wire, shielded twisted cable between the control system and the transmitters, and installed separate from any conduit containing AC circuit wiring. Provide NEMA 4 aluminum enclosure for wiring and electronics.
 - 4) Provide 15 straight pipe diameters for installation as per manufacturer's instructions. Provide additional straight pipe diameters as necessary.
 - 5) Provide hot tap installation, in order to be both insertable and removable through a ball valve when the pipe is under pressure.
 - 6) Flow meter shall be complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. The flow meter shall be hand-insertable up to 400 psi.
 - 7) The flow meter shall have insertion electromagnetic flow meter with dual-electrode design and continuous auto-zero function combined to improve accuracy..
 - 8) Wetted metal components shall be nickel-plated brass. The maximum operating temperature shall be 300 degree F peak.

Each flow meter shall be individually wet-calibrated against a primary volumetric standard that is accurate to within 0.1% and traceable to National Institutes of Standards and Technology. The manufacturer's certificate of calibration shall be provided with each flow meter. Accuracy shall be within $\pm 1.0\%$ of rate at the calibrated velocity. The flow meter shall include integral analog output(s), 4-20 mA, 0-10V, or 0-5V.

- 9) Provide BTU meter equal to Onicon System-10 BTU meter for energy management. Meter shall be remote mounted from the flow meter. Provide additional wiring and conduit as required for remote mounting. BTU meter shall be capable of sending an output signal to the building automation system.
- 10) The flow meter shall be covered by the manufacturer's two year warranty.

c. Water Temperature Sensors

- 1) Provide self-contained RTD type smart sensor temperature transmitters. Refer to controls drawings for location and quantity.
- 2) Power input and current output (4-20mA) through the same pair of low voltage wires.
- 3) Each transmitter head to be explosion proof.
- 4) Temperature Probe: Provide a platinum, wire wound, sensing element in a 316SS sheath, spring loaded, and inserted into a $\frac{3}{4}$ " NPT stainless steel thermowell with explosion proof process fittings and connection head. The thermowell to penetrate one-half the pipe diameter.
- 5) Element: 100 ohm @ 0 deg C Platinum
- 6) Temp Coefficient Range: .00385 Ohms/Ohm/deg. C
- 7) Range: -45 to 260 deg C / -58 to 500 deg F
- 8) Length: 55" max
- 9) OD: $\frac{1}{4}$ "
- 10) Sheath: 316SS
- 11) Construction: 2 or 4 wire single or dual
- 12) Lead Wire: 22 gage stranded silver plated Copper
- 13) Factory certification: Match RTD to Transmitter
- 14) Factory calibration point: 32°F
- 15) Accuracy at calibration point: $\pm 0.1^\circ\text{F}$

d. Water Temperature Transmitters

- 1) Universal use as transmitter for resistance thermometer, thermoelement, Ω or mV signal
- 2) As field indicator for any 4 to 20 mA signals
- 3) Die cast aluminum or stainless steel two-chamber enclosure
- 4) Output: 4-20 mA, 2 wire
- 5) Aux power supply: 24 V +/- 1 %
- 6) Load: 500 Ω
- 7) Storage Temperature: 23 C (73.4 F)
- 8) Error in Output: < 0.1% of span
- 9) Factory certification: Match Transmitter to RTD

e. Pressure Transmitters

- 1) Provide across any device that has a pressure drop including chiller barrels, pumps and suction diffusers. Pressure to be displayed after compensation for elevation.
- 2) Manufacturer and Product: Dwyer Model 626-12 or approved equal.

f. Outdoor Wetbulb Temperature Transmitter

- 1) Provide one wetbulb temperature transmitter with radiation shield.
- 2) Manufacturer: Vaisala Model HMT330 or approved equal.
- 3) Wiring Manufacturer: Belden 9320 or approved equal, two wire, shielded twisted cable between the control system and the transmitters, and installed separate from any conduit containing AC circuit wiring.
- 4) Power input and current output (4-20mA) through the same pair of low voltage wires.
- 5) The humidity range shall be 0-100% RH. The temperature range shall be up to up to 356 Deg F.
- 6) The accuracy of the temperature transmitter shall be +/-0.36 Deg F at 68 Deg F. The accuracy of the analog output shall be +/-0.05% of full scale at 68 Deg F.
- 7) Temperature transmitter shall be field installed outdoors and wired by the temperature controls contractor.

g. Current Switches: Current operated switches shall be self powered, solid state with adjustable trip current as well as status, power, and relay command status LED indication. The

switches shall be selected to match the current of the application and output requirements of the DDC systems.

h. Control Valves

- 1) Valves shall be rated for a minimum of 150 percent of system operating pressure at the valve location but not less than 900 kPa (125 psig).
- 2) Valves 50 mm (2 inches) and smaller shall be bronze body with threaded or flare connections.
- 3) Valves 60 mm (2 1/2 inches) and larger shall be bronze or iron body with flanged connections.
- 4) Brass or bronze seats except for valves controlling media above 100 degrees C (210 degrees F), which shall have stainless steel seats.
- 5) Flow characteristics shall be three way modulating valves - globe pattern (position versus flow relation shall be linear relation for steam or equal percentage for water flow control), two-way modulating valves - globe pattern. (position versus flow relation shall be linear for steam and equal percentage for water flow control), or two-way 2-position (valves shall be ball or gate).
- 6) Maximum pressure drop for modulating valves shall be greater of 10 feet of water or the pressure drop through the apparatus. Maximum pressure drop for two position valves shall be line size.

i. Damper and Valve Operators and Relays

- 1) Fail Safe Operation: Control valves and dampers shall provide "fail safe" operation in either the normally open or normally closed position as required for freeze, moisture, and smoke or fire protection.
- 2) Spring Ranges: Range as required for system sequencing and to provide tight shut-off.
- 3) Electronic operator shall provide full modulating control of dampers and valves. A linkage and pushrod shall be furnished for mounting the actuator on the damper frame internally in the duct or externally in the duct or externally on the duct wall, or shall be furnished with a direct-coupled design. Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator

heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque. Minimum valve close-off pressure shall be equal to the system pump's dead-head pressure, minimum 50 psig for valves smaller than 4 inches.

- 4) Electronic damper operators: Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.

B. Control Sequencing

1. All controls sequencing of pumps, water-cooled chillers, air cooled chiller, and cooling towers required for the operation of the modular central plant to be provided by the modular central plant manufacturer.
2. Refer to Section 23 09 23 DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
3. Demand Flow Chiller Optimization:

- a. The goal of demand flow is to allow the BAS to provide a chilled water plant operational strategy that optimizes total system energy and performance by synchronously operating its five subsystems (chiller, chilled water pumps, condenser water pumps, cooling tower fans, and air side equipment) along a dynamic system efficiency curve relative to the current environmental/load condition. The demand flow optimization and control system utilizes the demand flow panel - a controller providing all the demand flow variable speed and critical system parameter algorithms.

b. Demand Flow Control Strategy

- 1) Sequencing of chillers: Demand flow equipment sequencing is based on which chiller is the most efficient over a period of time. This is determined by totaling kWh and ton hours for each chiller and calculating kW/ton. This chiller becomes the lead chiller. If all chillers are found to be similar, chiller

sequencing is based on runtime hours. The chiller with the less runtime becomes the lead.

2) Speed Control of Variable Condenser Pumps and Tower Fans:

Conventional cooling tower control involves delivering a specific condenser water temperature to the chillers and is usually delivered with constant speed pumps. In contrast demand flow uses a patented demand based control methodology. The demand flow panel continually polls critical system parameters in order to determine the optimum condenser water system differential pressure. The controller dictates the speed of the condenser pump variable frequency drives and tower fans to maintain the lowest yet safest allowable refrigerant enthalpy leading into the evaporator on all operating chillers based on current load conditions while maintaining system efficiency targets.

3) System Control of Chilled Water Distribution Pumping: Chilled

water distribution pumps are usually operated to maintain a specific distribution differential pressure. The demand flow panel continually polls the pre determined critical system parameters and determines the optimum chilled water system differential pressure necessary to meet current load requirements while maintaining pre defined system efficiency targets. The demand flow algorithms are sent continually to the BAS.

4) Equipment Protection: At all times, the chillers and other

system components are operated well within their manufacturer's recommended limits. The demand flow control software accomplishes this by continuously monitoring key parameters, such as chilled & condenser water flows, rates of flow changes and entering/leaving condenser water temperatures. Operation is strictly limited to ensure these parameters remain within the range recommended by the manufacturer for the specific chiller to which the control is applied. The automatic safety shutdown circuit on each chiller is also entirely functional so that the chiller fail safe protection is undiminished.

5) Water BTU Measurement:

- a) Provide supply and return temperature sensors and for "Delta-T" calculation of BTU consumption in locations noted on the control drawings. Monitor total accumulated BTUs, current BTUs, monthly total BTUs, and yearly total BTUs for each location specified or shown. Flow measurement will be determined by a differential pressure drop across the chiller barrels.
 - b) Provide isolation valve kit to allow removal and servicing of meter while system is operating.
 - c) All devices associated with the BTU measurement serving the chilled water system shall be suitable for the extreme environmental conditions. The devices shall properly operate with the specified accuracy and shall not be affected by the media, or by the environment that includes but not limited to low temperatures (10°F), temperature fluctuations and condensation. Control panel enclosures and electronics shall meet the aforementioned requirements or located strategically to ensure proper operation.
- 6) Performance Measurement & Verification: Instantaneous tonnage and real time power draw (kW) of each component of the chilled water plant will be recorded. These values will be used to calculate an average monthly kW/ton. This actual monthly average kW/ton for the plant will be subtracted from the monthly baseline kW/ton to calculate the monthly kW/ton reduction. The BAS system will trend and display actual sub metered data and web - based sub metering will be used to create and communicate actual average monthly kW/ton. The stipulated annual reduction in chiller plant kW/ton will be reported monthly through the BAS on a monthly and end of year basis.
- 7) Commissioning: Sequencing and equipment failure tests are performed according to the engineer's specification by the commissioning agent. During test events and normal day to day system operation, demand flow shall regain control of the plant and will return to demand flow mode within 15 minutes of the testing or sequencing event.
- 8) Individual Equipment Performance: The calculated plant efficiency assumes that all selected and installed equipment

operates at the performance levels stated in the equipment submittals. If the installed equipment does not operate per submittal specifications then the baseline would be adjusted to represent actual equipment performance.

c. Chiller Manager (Continuation of Controls Sequence from Sheet H8.

1) Chilled Water System - Chiller Manager - Run Conditions:

- a) The chilled water system shall be enabled to run whenever:
 - i. A definable number of chilled water coils need cooling
 - ii. To prevent short cycling, the chiller manager shall run for and be off for minimum adjustable times (both user definable).
 - iii. Each chiller shall run subject to its own internal safeties and controls.

2) Chiller Staging

- a) This section refers to the staging and sequencing of each chiller "train". The sequence of operation for each individual chiller and its associated support equipment (such as pumps) are not included in this section.
- b) The controller shall determine the facility cooling load and shall stage the chillers on in sequence to meet rising cooling demand and rising main CHWS temperature where:
- c) Load (in tons refrigeration) = $[(\text{CHWR temp (degrees F)} - \text{CHWS temp (degrees F)}) \times \text{flow (gpm)}] / 24$
- d) Load (in kW refrigeration) = $[(\text{CHWR temp (degrees C)} - \text{CHWS temp (degrees C)}) \times \text{flow (liters/min)}] / 14.36$
- e) Units shall be converted as required to reflect actual system of units used (metric or English) including glycol.
- f) Main CHWS temperature is measured at a point leaving the chiller plant and entering the facility. This point shall be downstream and common to all chillers.
- g) Chiller load and unload will be based on the following parameters:
 - i. % Chiller Operating power after adjustments by chiller onboard controller for Chiller Current Limit. This value will vary depending on the ambient conditions.

- ii. Chilled water supply temp above or below setpoint by 2 degrees F (adjustable)
- h) The controller shall determine the facility cooling load from:
 - i. CHWS flow (main CHWS leaving chiller plant)
 - ii. CHWS temperature (main CHWS leaving chiller plant)
 - iii. CHWR temperature (main CHWR returning to chiller plant)
- i) The controller shall operate chillers, pumps, and cooling towers based on the following parameters:
 - i. Chilled water and condenser water pump speeds are varied to meet cooling load and chiller flow requirements in a repeatable and predictable manner.
 - ii. Chillers are operated to meet cooling load in a repeatable and predictable manner based on available cooling from cooling towers and cooling load from the building.
 - iii. Cooling towers are operated to meet cooling load in a repeatable and predictable manner based on ambient conditions and load from the chillers.
 - iv. Plant operation will not increase energy use of air handlers.
 - v. Plant operation will not increase chilled water setpoint above current setpoint unless the chillers are at minimum chilled water flow conditions.
 - vi. Plant operation will NOT operate chillers outside of published manufacturer engineering parameters.
- j) Use of BACnet MS/TP gateway for chiller communication is required to meet the point requirements herein and in the Point Summary.
- k) The lead chiller train shall run anytime the chiller manager is enabled. Additional chillers shall stage on to meet load conditions. To prevent short cycling, there shall be a user definable (adj.) delay between stages, and each stage shall have a user definable (adj.) minimum runtime.
- l) A service bypass switch shall be installed on the user interface to allow a service technician to put the

individual chiller into standard operating mode for maintenance.

- m) The chiller staging order shall be user definable. The designated lead chiller (user definable) shall rotate upon one of the following conditions (user selectable):
 - i. manually through a software switch
 - ii. if chiller runtime (adj.) is exceeded
 - iii. monthly
- n) Each chiller shall run subject to its own internal safeties and controls. On failure of any chiller, the failed chiller shall be "removed" from operation and the next available piece of equipment as defined by the user shall be staged on in its place.
- o) Alarms shall be provided as follows:
 - i. Chiller 1 Failure: Commanded on, but the status is off.
 - ii. Chiller 2 Failure: Commanded on, but the status is off.
 - iii. Chiller 3 Failure: Commanded on, but the status is off.
 - iv. Chiller 4 Failure: Commanded on, but the status is off.
 - v. Chiller 5 Failure: Commanded on, but the status is off.
 - vi. Chiller 6 Failure: Commanded on, but the status is off.
 - vii. High Main Chilled Water Supply Temp: If the main chilled water supply temperature is greater 56°F (adj.).
 - viii. Low Main Chilled Water Supply Temp: If the main chilled water supply temperature is less than 38°F (adj.).
 - ix. High Main Chilled Water Return Temp: If the main chilled water return temperature is > than 68°F (adj.).
 - x. Low Main Chilled Water Return Temp: If the main chilled water return temperature is less than 47°F (adj.).

C. Communications

1. Modular central plant shall included full integration of all components to single BAS interface of the protocol. Options include BACnet MS/TP, BACnet Ethernet, or BACnet IP (coordinate with on site controls contractor).
2. The communication interface shall be native to the existing building management system. The installation of the communication cabling to the main building shall be included by the on-site controls contractor.
3. The communication interface shall transmit and receive the following points:
 - a. Transmit:
 - 1) Chilled Water System Request to Start/Stop (Digital)
 - 2) Chilled Water Supply Temperature
 - 3) Enable/Disable Individual Chillers
 - b. Receive:
 - 1) Equipment on/off status (Each pump, chiller, tower) (Digital)
 - 2) Equipment failure alarms (Each pump, chiller, tower) (Digital)
 - 3) Valve failure alarm (Each control valve)(Digital)
 - 4) Valve position (Each 2-way control valve)(Digital)
 - 5) Valve position (Each modulating control valve)(Analog)
 - 6) Pump speed (Each pump)(Analog)
 - 7) Pump suction pressure (Each pump)(Analog)
 - 8) Pump discharge pressure (Each pump)(Analog)
 - 9) Suction header pressure (Each connection)(Analog)
 - 10) Discharge header pressure (Each connection)(Analog)
 - 11) Chilled water system and individual chiller flow (Analog)
 - 12) Chilled water system zone differential pressure (Analog)
 - 13) Chiller evaporator differential pressure (Analog)
 - 14) Chilled water system supply temperature (Analog)
 - 15) Chilled water system return temperature (Analog)
 - 16) Condenser water system flow (Analog)
 - 17) Condenser water system zone differential pressure (Analog)
 - 18) Chiller condenser differential pressure (Analog)
 - 19) Condenser water system supply temperature (Analog)
 - 20) Condenser water system return temperature (Analog)
 - 21) Chiller inlet temperature (Analog)
 - 22) Chiller outlet temperature (Analog)

- 23) Chiller inlet pressure (Analog)
- 24) Chiller outlet pressure (Analog)
- 25) Wire-to-water efficiency (Each variable speed pump set)
(Analog)
- 26) Chilled water system KW (Analog)
- 27) Chilled water system KW/Ton (Analog)

PART 3 - EXECUTION

3.1 DELIVERY OF EQUIPMENT

A. Prior to Shipment:

- 1. Manufacturer is required to disassemble modular central plant into subassembly form. Subassemblies shall be authorized by the engineer. Manufacturer is required to weatherize subassemblies for shipment. This shall include exterior equipment and exposed sections of the subassemblies. Manufacturer is required to completely drain system of water and remove drain plugs where the possibility of freeze damage may exist.

B. Upon Delivery at Jobsite:

- 1. Reassembly of the modular central plant is the responsibility of the installing contractor. Reassembly of the subassemblies shall be coordinated between the manufacturer and installation contractor, with the manufacturer providing a technician for supervision. Installation contractor shall comply with the manufacturer's instructions for rigging, unloading, and transporting equipment.

3.2 INSTALLATION

- A. All equipment, piping, controls, electrical systems, and accessories for a complete chiller plant system as shown on the drawings and in the specifications shall be provided by either the manufacturer or the contractor as listed below. No change orders shall be allowed for lack of coordination of between the supplier and contractor.

B. Responsibilities of the Manufacturer:

- 1. Provide detailed instruction manual on the reassembly of the modular central plant.
- 2. Provide two (2) visits for the supervision of the installation of the modular central plant.
- 3. Inspect installed modular central plant including field assembled components and connections.

C. Responsibilities of the Installation Contractor:

1. Install the modular central plant in accordance with the manufacturer's instructions.
2. Receive and inspect the interior and exterior of the modular central plant and report damage accordingly.
3. Provide temporary protection of individual enclosure and equipment sections from the elements before roofing and final section connections can be finalized.
4. Hoist and rig all subassemblies into final locations.
5. Reassemble equipment sections including reconnections at the section splits for the base, house enclosure, and piping. Caulking and sealing as required.
6. Level and shim structural base as needed per manufacturer's recommendations.
7. Supply and install all roof finishing materials including caulking and sundry items needed to complete modular central plant installation.
8. Realign and level all equipment within recommended tolerances including pumps and motors.
9. Check and tighten all mechanical connections that may have vibrated loose during shipment.
10. Reconnect all internal electrical power and control conduit between subassemblies as required.
11. Install equipment accessories that are shipped loose from the manufacturer.
12. Install control instrumentation that is shipped loose from the manufacturer. This may include pressure transmitters, temperature transmitters, flow meters, and the associated wiring for each device.
13. Install all field connections to the modular central plant. This shall include all system, electric, domestic water, drainage, and control connections.
14. Reassemble and install cooling towers and outdoor piping, electrical, and control wiring.
15. Provide and install all outdoor piping and valves required for the cooling tower between the modular central plant and the cooling towers.
16. Provide and install all piping, supports, controls, wiring, valves, and accessories for relocated air-cooled chiller.

17. Provide and install all required power and control wiring and conduit between the modular central plant and the cooling towers.
18. Install safety disconnect switches near the cooling tower fan motors.
19. Touch-up and paint scratches and minor dents that may occur during hoisting and rigging.
20. Flush and fill each system.
21. Obtain all pertinent inspections/tests outlined in the remainder of the specifications prior to start-up of modular central plant.

3.3 DEMONSTRATION

- A. Commissioning and Start-up: Manufacturer to provide two (2) visits for commissioning and start-up. Each visit will require a minimum of three (3) days on-site. Installation contractor to complete and sign off on all items listed on the start-up request form. Commissioning shall include final checkout, adjustment, and start-up of the complete system.
- B. Training: Manufacturer or representative will provide a minimum of forty (40) hours of training for the owner's personnel on the operation and maintenance of the modular central plant (training shall be split up into multiple sessions as coordinated with the owner). Chiller manufacturer's representative will provide eight (8) hours of training for the owner's personnel on the operation and maintenance of the chiller. Chiller manufacturer's representative shall advise owner of upcoming O&M sessions two (2) weeks in advance.

3.4 WARRANTY

- A. Manufacturer shall provide parts and labor warranty coverage for all components for a period of 12 months from start-up which is the date of the final inspection/commissioning for the fully operational chiller plant system.

END OF SECTION

SECTION 23 65 00
COOLING TOWERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Packaged, induced draft, open circuit cooling tower, complete with fill, fan, inlet louvers and associated accessories and equipment.

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 item.
- B. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- C. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT: Requirements for vibration isolation.
- D. Section 23 21 13, HYDRONIC PIPING: Requirements for water piping and fittings.
- E. Section 23 25 00, HVAC WATER TREATMENT: Requirements for condenser water treatment.
- F. Section 23 64 10, MODULAR CHILLER PLANT.
- G. Section 23 31 00, HVAC DUCTS and CASINGS: Requirements for sheet metal ductwork.
- H. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.

1.3 QUALITY ASSURANCE

- A. Refer to Article, QUALITY ASSURANCE, in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. Design Criteria:
 - 1. Design to withstand _____Pa (____ psf) wind load.
 - 2. Free water drift loss shall not be greater than five hundredths of one percent (0.005) of the water circulated to tower.
 - 3. Sound levels at 1.5 meters (5 feet) and 15 meters (50 feet) in any direction from the tower shall not exceed 83dB (A) and 72dB (A), respectively. Select "low Noise" model cooling towers. Provide sound attenuators if necessary to meet the noise criteria.
- C. Performance Criteria:
 - 1. Manufacturer shall certify that performance of cooling towers will meet contract requirements, stating entering air wet bulb temperature, entering and leaving condenser water temperatures, water flow rates, fan kW (horsepower). Certification shall be made at the time of submittal.

2. Cooling Technology Institute (CTI) Certified Towers: These towers shall have been tested, rated, and certified in accordance with Cooling Technology Institute (CTI) Standard 201, and shall bear the CTI certification label, and shall be listed in the CTI directory of certified cooling towers.
3. The alignment and balancing of the fans, motors and drive shaft as installed shall operate within the vibration tolerance specified in specification Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

1.4 SUBMITTALS

- A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Shop Drawings
 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 2. Include rated capacities, pressure drop, fan performance and rating curves, dimensions, weights, mounting details, front view, side view, equipment and device arrangement.
 3. Certified drawings of the cooling tower, sound data, recommended steel support indicating weight loadings, wiring diagrams, installation instructions, operation and maintenance instructions, and thermal performance guarantee by the manufacturer.
 4. Include electrical rating, detail wiring for power, signals and controls.
 5. Sound curves and characteristics of sound attenuators if required to meet the noise criteria.
- C. Certification:
 1. Submit four copies of performance curves, for CTI certified cooling towers, showing compliance with actual conditions specified, to the VA Project Engineer two weeks prior to delivery of the equipment. Reports shall include:
 - a. Test and certify cooling tower thermal performance according to CTI Standard 201.
 - b. Test and certify cooling tower sound performance according to CTI ATC-128.
 2. Two weeks prior to final inspection, submit four copies of the following to the VA Project Engineer:
 - a. Certification by the manufacturer that the cooling towers conform to the requirements of the drawings and specifications.

- b. Certification by the Contractor that the cooling towers have been installed, adjusted, and tested.
- 3. Warranty:
 - a. Motor/Drive System: Five (5) year comprehensive warranty against materials and workmanship including motor, fan, bearings, mechanical support, sheaves, bushings and belt.
 - b. Unit: One (1) year from start-up, which is the date of the final inspection/commissioning for the fully operational chiller plant system.
 - c. Unit: Five (5) year comprehensive warranty against materials and workmanship for complete unit from start-up.

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 National Standard Institute (ANSI/ASSE)
A10.18-2007.....Safety Requirements for Temporary Floors, Holes,
Wall Openings, Stairways and Other Unprotected
Edges in Construction and Demolition Operations
- C. American Society of Mechanical Engineers (ASME):
PTC 23-03.....Performance Test Codes on Atmospheric Water
Cooling Equipment
- D. American Society for Testing Materials (ASTM):
A385-08.....Standard Practice for Providing High-Quality
Zinc Coatings (Hot-Dip)
B117-07a.....Standard Practice for Operating Salt Spray (Fog)
Apparatus
B209-07.....Standard Specification for Aluminum and
Aluminum-Alloy Sheet and Plate
E84-08a.....Standard Test Method for Surface Burning
Characteristics of Building Materials
- E. Cooling Technology Institute (CTI):
ATC-105-00.....Acceptance Test Code for Water-Cooling Towers
(CTI Code Tower Standard Specifications)
201-02 (Rev. 04).....Standard for Certification of Water Cooling
Tower Thermal Performance (CTI Code Tower
Standard Specifications)
- F. National Electrical Manufacturers Association (NEMA):
MG 1-2006 Includes.....Motors and Generators (ANSI)

250-03.....Enclosures for Electrical Equipment (1000 Volts
Maximum)

G. National Fire Protection Association (NFPA):

70-08.....National Electrical Code

PART 2 - PRODUCTS

2.1 INDUCED DRAFT OPEN CIRCUIT COOLING TOWER:

A. Cooling tower shall be a factory assembled, induced draft, counter-flow type with a vertical discharge configuration. Factory assembled and tested, induced draft counterflow cooling tower complete with fill, fan, louvers, accessories, and rigging supports.

B. Materials

1. Base Bid: Provide optional Type 304 and/or 316 Stainless Steel as specified under Deduct Alternate. Refer to Specification Section 01 00 00 General Requirements for more information.
2. Under Deduct alternate, provide galvanized Sheet Steel complying with ASTM A 653/A 653M and having G-235 designation (except for basin material which shall remain stainless steel under Deduct Alternate).

C. Fan(s):

1. Type and Material: Axial propeller, individually adjustable wide chord blade extruded aluminum installed in a closely fitted cowl with venturi air inlet for maximum efficiency, covered with a heavy gauge hot dipped Galvanized fan guard.
2. Maximum sound pressure level of 83_dB(A) measured at 5 feet above the fan discharge during full speed operation in accordance with CTI Standard ATC-128.
3. Super low sound fan incorporating wide chord blade design (capable of 9 dB(A) to 15 dB(A) reduction in sound).

D. Water Distribution System: Non-corrosive materials.

1. Evenly distribute water over fill material with pressurized spray tree.
 - a. Pipes: Schedule 40 PVC, Non-corrosive Materials
 - b. Nozzles: Non-clogging, ABS Plastic, threaded into branch piping.
2. Maximum pressure at inlet shall be 45 psig.
3. Provide water silencers for reduction of sound up to 4 to 7 dB(A).

E. Collection Basin Material: Type 304 Stainless Steel:

1. Removable stainless-steel strainer with openings smaller than nozzle orifices.
2. Joints: Bolted and sealed watertight or welded.
3. Overflow, makeup and side drain connections.

4. Oversized outlet for maximum flow conditions. Outlet size shall match piping size shown on plan.
 5. Flume plate between cells (for multiple-cell units) or Equalizer connection (for multiple-cooling-tower system). All basins in the cooling tower shall be directly connected so that water level is even among all cells.
- F. Casing: Galvanized Steel (Deduct Alternate) or Type 304 Stainless Steel (Base bid):
1. Casing panels shall totally encase the fill media to protect the fill from damage due to direct atmospheric contact.
 2. Fasteners: Corrosion resistance equal to or better than materials being fastened.
 3. Joints: Sealed watertight.
 4. Welded Connections: Continuous and watertight
- G. Fill Media: PVC; resistant to rot, decay and biological attack; formed, crossfluted bonded together for strength and durability in block format for easy removal and replacement; suitable for use as a working surface; self extinguishing with flame spread rating of 5 per ASTM E84-81a; able to withstand continuous operating temperature of 130°F; and fabricated, formed and installed by the manufacturer to ensure water breaks up into droplets.
- H. Drift Eliminators: Same material as Fill. 0.001% drift rate.
- I. Air Inlet Louver Screens: Formed PVC mounted in G-235 galvanized (Deduct Alternate) (or Type 316 stainless - Base Bid) steel frames for easy removal; designed "Sight Tight" to completely block direct sunlight from entering and water from splashing out of the cooling tower. Provide louver access door with quick release mechanism.
- J. Water Level Control: Plastic float with an adjustable linkage. Includes 5-probe electronic water level control package (ground, low level alarm, low level fill, high level fill, high level alarm) along with 2 water level sensors capable of 0-10 vDC signal to temperature controls.
- K. Electric Basin Heating:
1. Electric immersion heater sized for operation down to zero degrees outside air temperature. Package shall include thermostat and low-water protection device, and heater power contactors.
- L. Motors and Drives
1. Enclosure Type: TEAO or TEFC
 2. Motor Speed: VFD Duty, inverter capable, premium efficient.
 3. Drive: Power Band Belt designed for 150% of the motor nameplate HP.

- a. Belt: Mutli-groove, solid back V-belt type neoprene reinforced with polyester cord.
 - b. Sheaves: Aluminum alloy if located inside the airstream.
 - c. Bearings: Heavy duty, self-aligning pillow block bearings with lubrication lines extended to side access door. Minimum L10 life for bearings shall be 75,000 hours. Provide extended grease lines and fittings.
 - d. Vibration Cutout Switch: Mechanical switch to de- energize fan motors if excessive vibration in NEMA 4 enclosure.
4. Cooling tower shall be compliant with efficiency standards outlined in ASHRAE 90.1-2010.

M. Maintenance Access

- 1. Internal Working/Service Platforms: Provide a complete internal working platform and ladder system for service of all drive components. A suitable working platform may be constructed of the fill media for counter-flow cooling towers. Provide a platform to include access to all cooling towers that are installed adjacent to each other. Refer to plans for platform layout.
- 2. Handrails/Grabrails: Galvanized steel pipe complying with 29 CFR 1910.23. If access to fan deck is required, supply a perimeter handrail with ladder from grade to fan deck.
- 3. Ladders: Aluminum, with grabrail, vertical complying with 29 CFR 1910.27.

2.2 CONTROL PANEL

- A. Provide factory furnished control panel for each cooling tower.
- B. Control panel shall be a factory pre-wired NEMA 250 Type 3 - Drip-proof type enclosure, containing:
 - 1. Unfused disconnect switch.
 - 2. Fan motor variable speed drives/motor starters.
 - 3. Interlocks and relays.
 - 4. Pilot lights and push buttons.
 - 5. Refer to 23 64 10 for more information on cooling tower and condenser water system points that will be obtained from the modular chiller plant to be monitored by the building DDC system.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cooling tower according to equipment manufacturer's written instruction.
- B. Install cooling towers plumb, level and anchored on structure provided. Coordinate steel structure with cooling tower mounting requirements.

- C. Install vibration controls according to manufacturer's recommendations.
- D. Install anchor bolts to elevations required for proper attachment to supported equipment.
- E. Maintain manufacturer's recommended clearances for service and maintenance.
- F. Piping:
 - 1. Install piping, including flanges or union adjacent to cooling towers to allow for service and maintenance.
 - 2. Install flexible pipe connectors at connections to cooling towers mounted on vibration isolators.
 - 3. Install shutoff/balancing valves at cooling tower inlet connections.
 - 4. Install piping adjacent to cooling towers to allow service and maintenance.
 - 5. Provide drain piping with valve at cooling tower drain connections and at low points in piping.
 - 6. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.
 - 7. Domestic Water Piping: Comply with applicable requirements in Section 22 11 00, FACILITY WATER DISTRIBUTION. Connect to water-level control with shutoff valve and union, flange, or mechanical coupling at each connection.
 - 8. Supply and Return Piping: Comply with applicable requirements in Section 23 21 13, HYDRONIC PIPING. Connect to entering cooling tower connections with shutoff valve/balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve. Connect to leaving cooling tower connection with shutoff valve. Make connections to cooling tower with a union or mechanical coupling .
 - 9. Equalizer Piping: Piping requirements to match supply and return piping. Connect an equalizer pipe, full size of cooling tower connection, between tower cells. Connect to cooling tower with shutoff valve.
- G. Electrical Wiring: Install electrical devices, components and accessories furnished loose by manufacturer, including remote flow switches and variable frequency drives.

3.2 FIELD QUALITY CONTROL

- A. Provide the services of an independent testing and inspection agency to perform the field tests and inspections of non-CTI certified cooling towers, 700 kW (200 tons) and larger, according to ASME PTC-23 "Performance Test Code on Cooling Tower Equipment". Submit qualification

of the independent testing agency to the VA Project two weeks prior to the inspection for approval.

- B. If the cooling tower does not meet the specified performance, the Contractor shall make the tower corrections necessary to bring the tower into compliance with the specified performance including replacing the tower if necessary. Additional tests will be required until the tower meets the specified performance. Costs for the tower corrections or replacement, and tests shall be borne by the Contractor.

3.3 STARTUP AND TESTING

- A. Provide the services of a factory-authorized and qualified representative to perform start up service.
- B. Clean entire unit including basin.
- C. Inspect field-assembled components and equipment installation, including piping and electrical connections.
- D. Verify that accessories are properly installed.
- E. Obtain and review performance curves and tables.
- F. Perform startup checks, according to manufacturer's written instructions, and as noted below:
 - 1. Check clearances for airflow and tower servicing.
 - 2. Check for vibration isolation and structural support.
 - 3. Verify fan rotation for correct direction and for vibration or binding and correct problems.
 - 4. Adjust belts to proper alignment and tension.
 - 5. Lubricate rotating parts and bearings.
 - 6. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
 - 7. Check vibration switch setting. Verify operation.
 - 8. Verify operation of basin heater and control.
 - 9. Operate equipment controls and safeties.
 - 10. Verify that tower discharge is high enough and it does not recirculate into HVAC air intakes. Recommend corrective action.
- G. Adjust water level for operating level and balance condenser water flow to each tower inlet.
- H. Check water treatment water system, including blow down for proper operation of the tower. Check makeup water-level control and valve.
- I. Start cooling tower, including condenser water pumps and verify the tower operation.
- J. Prepare and submit a written report of startup and inspection service to the VA Project Engineer.

K. Replace defective and malfunctioning units.

3.4 TRAINING:

A. Furnish the services of a competent, factory-trained engineer or technician for a 40-hour period for instructing VA personnel in operation and maintenance of the equipment, including review of the operation and maintenance manual, on a date requested by the VA Project Engineer (and in separate 8-hour periods as coordinated with owner). Coordinate this training with that of the chiller, if furnished together.

3.5 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 specifications 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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