

SECTION 22 05 11
COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section shall apply to all sections of Division 22.
- B. Definitions:
 - 1. Exposed: Piping and equipment exposed to view in finished rooms.
 - 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 05 50 00, METAL FABRICATIONS.
- D. Section 07 60 00, FLASHING AND SHEET METAL: Flashing for Wall and Roof Penetrations.
- E. Section 07 92 00, JOINT SEALANTS.
- F. Section 09 91 00, PAINTING.
- G. Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION.
- H. Section 23 09 23, DIRECT DIGITAL CONTROLS FOR HVAC.
- I. 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.
 - 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. Names, mail and e-

- mail addresses and phone numbers of service organizations providing service shall be submitted for project record and inserted into the operations and maintenance manual.
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 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. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the COR prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.
- C. Execution (Installation, Construction) Quality:
1. All items shall be applied and installed in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract drawings and specifications shall be referred to the COR for resolution. Written hard copies or computer files of manufacturer's installation

instructions shall be provided to the COR at least two weeks prior to commencing installation of any item.

D. Guaranty: Warranty of Construction, FAR clause 52.246-21.

E. Plumbing Systems: IPC, International Plumbing Code.

1.4 SUBMITTALS

A. Submittals shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 05 11, COMMON WORK RESULTS FOR PLUMBING", with applicable paragraph identification.

C. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements.

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, lists of previous installations for selected items of equipment shall be provided. Contact persons who will serve as references, with telephone numbers and e-mail addresses shall be submitted with the references.

G. Manufacturer's Literature and Data: Manufacturer's literature shall be submitted under the pertinent section rather than under this section.

1. Equipment and materials identification.

2. Fire stopping materials.

3. Wall, floor, and ceiling plates.

H. 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. Listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment shall be provided.

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. Damaged equipment shall be replaced with an identical unit as determined and directed by the COR. Such replacement shall be at no additional cost to the Government.
3. Interiors of new equipment and piping systems shall be protected against entry of foreign matter. Both inside and outside shall be cleaned before painting or placing equipment in operation.
4. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.

B. Cleanliness of Piping and Equipment Systems:

1. Care shall be exercised in the storage and handling of equipment and piping material to be incorporated in the work. Debris arising from cutting, threading and welding of piping shall be removed.
2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.
3. The interior of all tanks shall be cleaned prior to delivery and beneficial use by the Government. All piping shall be tested in accordance with the specifications and the International Plumbing Code (IPC), latest edition. All filters, strainers, fixture faucets shall be flushed of debris prior to final acceptance.
4. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below shall form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
Boiler and Pressure Vessel Code (BPVC):

- SEC IX-2007.....Boiler and Pressure Vessel Code; Section IX,
Welding and Brazing Qualifications.
- C. American Society for Testing and Materials (ASTM):
- A36/A36M-2008.....Standard Specification for Carbon Structural
Steel
- A575-96 (R 2007).....Standard Specification for Steel Bars, Carbon,
Merchant Quality, M-Grades R (2002)
- E84-2005.....Standard Test Method for Surface Burning
Characteristics of Building Materials
- E119-2008a.....Standard Test Methods for Fire Tests of
Building Construction and Materials
- D. Manufacturers Standardization Society (MSS) of the Valve and Fittings
Industry, Inc:
- SP-58-02.....Pipe Hangers and Supports-Materials, Design and
Manufacture
- SP 69-2003 (R 2004).....Pipe Hangers and Supports-Selection and
Application
- E. National Electrical Manufacturers Association (NEMA):
- MG1-2003, Rev. 1-2007...Motors and Generators
- F. International Code Council, (ICC):
- IBC-06, (R 2007).....International Building Code
- IPC-06, (R 2007).....International Plumbing Code

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

- A. STANDARDIZATION OF COMPONENTS SHALL BE MAXIMIZED TO REDUCE SPARE PART requirements.
- B. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for final assembled unit.
1. All components of an assembled unit need not be products of same manufacturer.
 2. Constituent parts that are alike shall be products of a single manufacturer.
 3. Components shall be compatible with each other and with the total assembly for intended service.
 4. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.

- C. Components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.
- D. Major items of equipment, which serve the same function, shall be the same make and model

2.2 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

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

2.4 CONTROL WIRING

- A. All material and equipment furnished and installation methods shall conform to the requirements of Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. All electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems shall be provided.

2.5 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Use symbols, nomenclature and equipment numbers specified, shown on the drawings, or 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 3/16-inch high of brass with black-filled letters, or rigid black plastic with white letters specified in Section 09 91 00, PAINTING shall be permanently fastened to the equipment. Unit components such as water heaters, tanks, coils, filters, fans, etc. shall be identified.
- C. Control Items: All temperature, pressure, and controllers shall be labeled and the component's function identified. Identify and label each item as they appear on the control diagrams.
- D. Valve Tags and Lists:
 - 1. Plumbing: All valves shall be provided with valve tags and listed on a valve list (Fixture stops not included).

2. Valve tags: Engraved black filled numbers and letters not less than 1/2-inch high for number designation, and not less than 1/4-inch for service designation on 19 gage, 1-1/2 inches round brass disc, attached with brass "S" hook or brass chain.
3. Valve lists: Valve lists shall be created using a word processing program and printed on plastic coated cards. The plastic coated valve list card(s), sized 8-1/2 inches by 11 inches shall show valve tag number, valve function and area of control for each service or system. The valve list shall be in a punched 3-ring binder notebook. A copy of the valve list shall be mounted in picture frames for mounting to a wall.
4. A detailed plan for each floor of the building indicating the location and valve number for each valve shall be provided. Each valve location shall be identified with a color coded sticker or thumb tack in ceiling.

2.6 GALVANIZED REPAIR COMPOUND

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

2.7 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 International Building Code (IBC), latest edition, and SECTION 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. Submittals based on the International Building Code (IBC), latest edition, SECTION 13 05 41 requirements, 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. The Support system of suspended equipment over 500 pounds shall be submitted for approval of the COR in all cases. See these specifications for lateral force design requirements.
- 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.
 2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 4 inches thick when approved by the COR for each job condition.

3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 4 inches thick when approved by the COR for each job condition.
- 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 7/8-inch outside diameter.
- E. For Attachment to Wood Construction: Wood screws or lag bolts.
- F. 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 1-1/2 inches minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.
- G. Multiple (Trapeze) Hangers: Galvanized, cold formed, lipped steel channel horizontal member, not less than 1-5/8 inches by 1-5/8 inches, No. 12 gage, designed to accept special spring held, hardened steel nuts. Trapeze hangers are not permitted for steam supply and condensate piping.
 1. Allowable hanger load: Manufacturers rating less 200 pounds.
 2. Guide individual pipes on the horizontal member of every other trapeze hanger with 1/4-inch U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 1/2-inch galvanized steel bands, or insulated calcium silicate shield for insulated piping at each hanger.
- H. Pipe Hangers and Supports: (MSS SP-58), use hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or insulated calcium silicate shields. Provide Type 40 insulation shield or insulated calcium silicate shield at all other types of supports and hangers including those for insulated piping.
 1. General Types (MSS SP-58):
 - a. Standard clevis hanger: Type 1; provide locknut.
 - b. Riser clamps: Type 8.
 - c. Wall brackets: Types 31, 32 or 33.
 - d. Roller supports: Type 41, 43, 44 and 46.
 - e. Saddle support: Type 36, 37 or 38.
 - f. Turnbuckle: Types 13 or 15.

g. U-bolt clamp: Type 24.

h. Copper Tube:

- 1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with isolation tape to prevent electrolysis.
- 2) For vertical runs use epoxy painted or plastic coated riser clamps.
- 3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.

2.8 PIPE PENETRATIONS

- A. Pipe penetration sleeves shall be installed for all pipe other than rectangular blocked out floor openings for risers in mechanical bays.
- B. Pipe penetration sleeve materials shall comply with all fire stopping requirements for each penetration.
- C. To prevent accidental liquid spills from passing to a lower level, provide the following:
 1. For sleeves: Extend sleeve 1 inch above finished floor and provide sealant for watertight joint.
 2. For blocked out floor openings: Provide 1-1/2 inch angle set in silicone adhesive around opening.
 3. For drilled penetrations: Provide 1-1/2 inch angle ring or square set in silicone adhesive around penetration.
- C. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of COR.
- D. Sheet metal, plastic, or moisture resistant fiber sleeves shall be provided for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.
- E. Sleeve clearance through floors, walls, partitions, and beam flanges shall be 1 inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation plus 1 inch in diameter. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.

F. Sealant and Adhesives: Shall be as specified in Section 07 92 00, JOINT SEALANTS.

2.9 ASBESTOS

Materials containing asbestos are not permitted.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

- A. Location of piping, sleeves, inserts, hangers, and equipment, access provisions shall be coordinated with the work of all trades. Piping, sleeves, inserts, hangers, and equipment shall be located clear of windows, doors, openings, light outlets, and other services and utilities. Equipment layout drawings shall be prepared to coordinate proper location and personnel access of all facilities. The drawings shall be submitted for review. Manufacturer's published recommendations shall be followed for installation methods not otherwise specified.
- B. Operating Personnel Access and Observation Provisions: All equipment and systems shall be arranged to provide clear view and easy access, without use of portable ladders, for maintenance 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. Maintenance and operating space and access provisions that are shown on the drawings shall not be changed nor reduced.
- C. Structural systems necessary for pipe and equipment support shall be coordinated 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. Holes through concrete and masonry shall be cut by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by COR where working area space is limited.
 - 2. Holes shall be located to avoid interference with structural members such as beams or grade beams. Holes shall be laid out in advance and drilling done only after approval by COR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to COR for approval.

3. Waterproof membrane shall not be penetrated. Pipe floor penetration block outs shall be provided outside the extents of the waterproof membrane.
- 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. Protection and Cleaning:
1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the COR. Damaged or defective items in the opinion of the COR, shall be replaced.
 2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Pipe openings, equipment, and plumbing fixtures shall be tightly covered against dirt or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.
- I. Concrete and Grout: Concrete and shrink compensating grout 3000 psi minimum. shall be used for all pad or floor mounted equipment. Gages, thermometers, valves and other devices shall be installed with due regard for ease in reading or operating and maintaining said devices. Thermometers and gages shall be located and positioned to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.
- J. Interconnection of Controls and Instruments: Electrical interconnection is generally not shown but shall be provided. Comply with NFPA-70.
- K. Many plumbing systems interface with the HVAC control system. See the HVAC control points list and section 23 09 23 DIRECT DIGITAL CONTROLS FOR HVAC
- 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 cause the least interfere with normal operation of the facility.
- M. Work in Animal Research Areas: Seal all pipe penetrations with silicone sealant to prevent entrance of insects.
- N. Work in bathrooms, restrooms, housekeeping closets: All pipe penetrations behind escutcheons shall be sealed with plumber's putty.
- O. Switchgear Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints.
- P. 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 electrical conduit, motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

3.2 TEMPORARY PIPING AND EQUIPMENT

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

3.3 RIGGING

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

3.4 PIPE AND EQUIPMENT SUPPORTS

- A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Holes shall be drilled or burned in structural steel ONLY with the prior written approval of the COR.
- B. The use of chain pipe supports, wire or strap hangers; wood for blocking, stays and bracing, or hangers suspended from piping above shall not be permitted. Rusty products shall be replaced.
- C. Hanger rods shall be used that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. A minimum of 1/2-inch clearance between pipe or piping covering and adjacent work shall be provided.
- D. For horizontal and vertical plumbing pipe supports, refer to the International Plumbing Code (IPC), 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. Tubing and capillary systems shall be supported in channel troughs.

F. Floor Supports:

1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Concrete bases and structural systems shall be anchored and doweled to resist forces under operating and seismic conditions (if applicable) without excessive displacement or structural failure.
2. Bases and supports shall not be located and installed until equipment mounted thereon has been approved. Bases shall be sized to match equipment mounted thereon plus 2 inch excess on all edges. Structural drawings shall be reviewed for additional requirements. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top, and shall be suitable for painting.
3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a grout material to permit alignment and realignment.

3.5 LUBRICATION

- A. All equipment and devices requiring lubrication shall be lubricated prior to initial operation. All devices and equipment shall be field checked for proper lubrication.

3.6 PLUMBING SYSTEMS DEMOLITION

- A. Rigging access, other than indicated on the drawings, shall be provided after approval for structural integrity by the COR. Such access shall be provided without additional cost or time to the Government. Where work is in an operating plant, approved protection from dust and debris shall be provided at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.
- B. In an operating plant, cleanliness and safety shall be maintained. The plant shall be kept in an operating condition. Government personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and plant operation. Work shall be confined to the immediate area concerned; maintain cleanliness and wet down

demolished materials to eliminate dust. Dust and debris shall not be permitted to accumulate in the area to the detriment of plant operation. All flame cutting shall be performed to maintain the fire safety integrity of this plant. Adequate fire extinguishing facilities shall be available at all times. All work shall be performed in accordance with recognized fire protection standards. Inspections will be made by personnel of the VA Medical Center, and the Contractor shall follow all directives of the COR with regard to rigging, safety, fire safety, and maintenance of operations.

- C. Unless specified otherwise, all piping, wiring, conduit, and other devices associated with the equipment not re-used in the new work shall be completely removed from Government property. This includes all concrete equipment pads, pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. All openings shall be sealed after removal of equipment, pipes, ducts, and other penetrations in roof, walls, floors, in an approved manner and in accordance with plans and specifications where specifically covered. Structural integrity of the building system shall be maintained. Reference shall also be made to the drawings and specifications of the other disciplines in the project for additional facilities to be demolished or handled.
- D. All valves including gate, globe, ball, butterfly and check, all pressure gages and thermometers with wells shall remain Government property and shall be removed and delivered to COR and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these plans and specifications. Such material shall be removed from Government property expeditiously and shall not be allowed to accumulate.

3.7 CLEANING AND PAINTING

- A. Prior to final inspection and acceptance of the plant and facilities for beneficial use by the Government, the plant facilities, equipment and systems shall be thoroughly cleaned and painted. Refer to Section 09 91 00, PAINTING.
- B. In addition, the following special conditions apply:
 - 1. Cleaning shall be thorough. Solvents, cleaning materials and methods recommended by the manufacturers shall be used for the specific tasks. All rust shall be removed prior to painting and from surfaces

- to remain unpainted. Scratches, scuffs, and abrasions shall be repaired prior to applying prime and finish coats.
2. The following Material And Equipment shall NOT be painted::
 - a. Motors, controllers, control switches, and safety switches.
 - b. Control and interlock devices.
 - c. Regulators.
 - d. Pressure reducing valves.
 - e. Control valves and thermostatic elements.
 - f. Lubrication devices and grease fittings.
 - g. Copper, brass, aluminum, stainless steel and bronze surfaces.
 - h. Valve stems and rotating shafts.
 - i. Pressure gages and thermometers.
 - j. Glass.
 - k. Name plates.
 3. Control and instrument panels shall be cleaned and damaged surfaces repaired. Touch-up painting shall be made with matching paint obtained from manufacturer or computer matched.
 4. Pumps, motors, steel and cast iron bases, and coupling guards shall be cleaned, and shall be touched-up with the same color as utilized by the pump manufacturer
 5. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats.
 6. The final result shall be a smooth, even-colored, even-textured factory finish on all items. The entire piece of equipment shall be repainted, if necessary, to achieve this.

3.8 IDENTIFICATION SIGNS

- A. Laminated plastic signs, with engraved lettering not less than 3/16-inch high, shall be provided that designates equipment function, 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 shall be placed on factory built equipment.
- C. Pipe Identification: Refer to Section 09 91 00, PAINTING.

3.9 STARTUP AND TEMPORARY OPERATION

- A. Start up of equipment shall be performed as described in the equipment specifications. Temporary use of equipment is specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.

3.10 OPERATING AND PERFORMANCE TESTS

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

3.11 OPERATION AND MAINTENANCE MANUALS

- A. Provide four bound copies. The Operations and maintenance manuals shall be delivered to COR not less than 30 days prior to completion of a phase or final inspection.
- B. All new and temporary equipment and all elements of each assembly shall be included.
- C. Data sheet on each device listing model, size, capacity, pressure, and other information shall be included.
- D. Manufacturer's installation, maintenance, repair, and operation instructions for each device shall be included. Assembly drawings and parts lists shall also be included. A summary of operating precautions and reasons for precautions shall be included in the Operations and Maintenance Manual.
- E. Schematic diagrams and wiring diagrams of all control systems corrected to include all field modifications shall be included.
- F. Set points of all interlock devices shall be listed.

3.12 INSTRUCTIONS TO VA PERSONNEL

Instructions shall be provided in accordance with Article, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS.

- - - E N D - - -

SECTION 22 08 00

COMMISSIONING OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section apply to all sections of Division 22.
- 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) appointed by the Department of Veterans Affairs will manage the commissioning process.

1.2 RELATED WORK

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

1.3 SUMMARY

- A. This Section includes requirements for commissioning plumbing systems, subsystems and equipment. This Section supplements the general requirements specified in Section 01 91 00 General Commissioning Requirements.
- B. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more 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 22 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 22, is required in cooperation with the VA and the Commissioning Agent.
- B. The Plumbing systems commissioning will include the systems listed in Section 01 19 00 General Commissioning Requirements:

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 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 the Building Plumbing Systems will require inspection of individual elements of the Plumbing construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00 and the Commissioning Plan to schedule inspections as required to support the commissioning process.

3.2 PRE-FUNCTIONAL CHECKLISTS

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

sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

- A. Contractor tests as required by other sections of Division 22 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING:

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

3.5 TRAINING OF VA PERSONNEL

- A. Training of the VA operation and maintenance personnel is required in cooperation with the Resident Engineer and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Section 01 19 00. The instruction shall be scheduled in coordination with the Resident Engineer after submission and approval of formal training plans. Refer to Section 01 91 00

GENERAL COMMISSIONING REQUIREMENTS and Division 22 Sections for
additional Contractor training requirements.

----- **END** -----

SECTION 22 35 00
DOMESTIC WATER HEAT EXCHANGERS

PART 1 - GENERAL

1.1 DESCRIPTION:

This section describes the requirements for domestic hot water heat exchangers including thermometers and all necessary accessories, connections and equipment.

1.2 RELATED WORK:

- A. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

1.3 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. Indirect Fired Water Heaters.
 - 2. Pressure and Temperature Relief Valves.
 - 3. Vacuum Breakers.
- B. Equipment components in contact with potable water shall meet NSF compliance requirements in document NSF 61, "Drinking Water System Components - Health Effects.

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):
 - Z21.22-00/4.4A-00.....Relief Valves for Hot Water Supply systems
- C. American Society of Mechanical Engineers (ASME):
 - B1.20.1-01.....Pipe Threads, General Purpose
 - B16.5-03.....Pipe Flanges and Flanged Fittings, NPS ½ through NPS 24
 - PTC 25.3-02.....Pressure Relief Devices

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.

PART 2 - PRODUCTS

2.1 INDIRECT FIRED DOMESTIC WATER HEATERS

- A. A packaged hot water storage tank with integral hot water heating coil shall be provided with size and capacity as scheduled on the drawings.
- B. The storage tank shall be constructed of welded stainless steel type 316L with a working pressure of 150 psig, tested to 300 psi. Hot and cold water taps into the tank shall be welded stainless steel NPT fittings.
- C. The storage tank shall have a stainless steel temperature sensor well located at the middle of the tank.
- D. The storage tank shall be completely insulated on top, bottom, and sides with a minimum 2 inch thick urethane foam insulation system in compliance with ASHRAE 90.1-2010, with a durable plastic jacket.
- E. The heat exchanger coils shall be constructed from finned 90/10 cupronickel and fabricated in a helix wound for hot water heating at the bottom of the tank, with NPT taps at the bottom sides of the tank. The pressure rating shall be equal to or greater than 150 psig.
- F. The temperature controls shall be based upon an adjustable temperature transmitter that operates a control valve and is capable of maintaining outlet water temperature within 2°C (4°F) of setting. Refer to control drawings.

- G. Provide a relief valve that is ASME rated and stamped for combination temperature and pressure relief valve. The relief valve shall have a total relieving capacity at least as great as heat input. The pressure setting shall be less than the working pressure rating of the heat exchanger minus 10 percent.
- H. Provide a vacuum breaker rated for the cold water inlet pipe size and tank capacity.

2.2 THERMOMETERS:

- A. Thermometers shall be rigid stem, dial type with a stainless steel case. The thermometer shall be back connected, BI-metal or gas actuated, with circular dial 3 1/2 inches in diameter graduated from 40 to 210°F, with two-degree graduations guaranteed accurate within one scale division. The thermometer shall be mounted in a brass NPA thermometer well in a tee in the piping.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. The water heaters shall be installed on concrete bases as indicated on the drawings.
- B. The water heaters shall be installed level and plumb.
- C. Water heaters shall be installed and connected in accordance with manufacturer's written instructions.
- D. All pressure and temperature relief valves discharge shall be piped with copper pipe the full size of the relief valve to nearby floor drains.
- E. Thermometers shall be installed on water heater outlet piping.
- F. The control thermostats shall be set for a maximum setting of 140°F.
- G. Install the vacuum breaker on the cold water inlet pipe to the storage tank.

3.2 LEAKAGE TEST:

- A. Before piping connections are made, the water heaters shall be tested at a hydrostatic pressure of 200 psig. Any failed test shall be corrected and the water heater shall be retested at no additional cost to the VA.

3.3 PERFORMANCE TEST:

- A. Ensure that all of the remote water outlets will have a minimum of 120°F and a maximum of 130°F water flow at all times. If necessary,

make all correction to balance the return water system or reset the
thermostat to make the system comply with design requirements.

- - - E N D - - -

**SECTION 22 40 00
PLUMBING FIXTURES**

PART 1 - GENERAL

1.1 DESCRIPTION

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.
- C. SECTION 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
Requirements for commissioning, systems readiness checklist, and training.

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
A112.19.3-2001(R2008)...Stainless Steel Plumbing Fixtures (Designed for
Residential Use)
- C. American Society for Testing and Materials (ASTM):
A276-2010Stainless and Heat-Resisting Steel Bars and
Shapes
WW-P-541-E/GENPlumbing Fixtures with Amendment 1
- D. National Association of Architectural Metal Manufacturers (NAAMM):
NAAMM AMP 500-505
Metal Finishes Manual (1988)

- E. 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. National Sanitation Foundation (NSF)/American National Standards
Institute (ANSI):
61-2009Drinking Water System Components-Health Effects
- 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 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.

2.2 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 COR.
- C. Supply from stops not integral with faucet shall be chrome plated copper flexible tubing or flexible stainless steel with inner core of non-toxic polymer.
- D. Supply pipe from wall to valve stop shall be rigid threaded IPS copper alloy pipe, i.e. red brass pipe nipple, chrome plated where exposed.

2.3 ESCUTCHEONS

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

2.4 EMERGENCY FIXTURES

- A. (P-707) Emergency Shower and Eye and Face Wash (Free Standing):
1. Shower Head: Polished chrome plated, 8 inches in diameter, install head 84 inches above floor. Equip with stay-open ball valve, chrome plated. Operate valve with 24 inches 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 1/2 inch stainless steel stay open ball valve operated by stainless steel push flag handle. Mount eye and face wash spray heads 42 inches above finished floor, with barrier free access.
 3. Shower head and emergency eye and face wash shall be mounted to stainless steel stanchion with floor flange. Pipe discharge to direct waste to nearby floor drain. Paint stanchion same color as room interior.
- B. Thermostatic Valve:
1. Installation: Provide emergency thermostatic mixing valve installed in-line in water supply to emergency shower with minimum 20 GPM capacity at a pressure drop of 30 psi.
 2. Valves: Type T/P combination temperature and pressure balancing for emergency shower. Valve body shall be suitable copper alloy. Internal parts shall be copper, nickel alloy, CRS, or thermoplastic material. Valve inlets shall be 1 inch IPS and outlet shall be 1-1/4 inch IPS. Provide external screwdriver check stops and strainers. Valve shall provide a minimum of 20 gpm at 30 psi inlet pressure. Water supply temperature shall be adjustable from 65-95 degrees F, initially set at 85 degrees F.
 3. Thermometer: Stainless steel, 2 1/2 inches dial type with range from 30 to 140 degrees F.

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, or floor. Mounting bolts and nuts shall be stainless steel or chrome plated brass.
- C. Toggle Bolts: For hollow masonry units, finished or unfinished.
- D. Expansion Bolts: For brick or concrete or other solid masonry. Shall be 1/4 inch diameter bolts, and to extend at least 3 inches into masonry

and be fitted with loose tubing or sleeves extending into masonry. Wood plugs, fiber plugs, lead or other soft metal shields are prohibited.

- E. Power Set Fasteners: May be used for concrete walls, shall be 1/4 inch threaded studs, and shall extend at least 1-1/4 inches into wall.
- F. Tightly cover and protect fixtures and equipment against dirt, water and chemical or mechanical injury.
- G. Provide tempered water supply to combination emergency shower/eye wash station.

3.2 CLEANING

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

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00 - COMMISSIONING OF PLUMBING SYSTEMS for all inspection, startup, 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 22 08 00 - COMMISSIONING OF PLUMBING SYSTEMS and related sections for contractor responsibilities for system commissioning.

- - - E N D - - -

SECTION 23 05 10
COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section apply to all sections of Division 23 related to boiler plant and steam generation.
- B. Definitions:
 - 1. Exposed: Piping, ductwork, and equipment exposed to view in finished rooms.
 - 2. Option or optional: Contractor's choice of an alternate material or method.
 - 3. RE: COR

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 05 50 00, METAL FABRICATIONS.
- D. Section 07 84 00, FIRESTOPPING.
- E. Section 07 60 00, FLASHING AND SHEET METAL: Flashing for Wall and Roof Penetrations.
- F. Section 07 92 00, JOINT SEALANTS.
- G. Section 09 91 00, PAINTING.
- H. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- I. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION.
- J. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC.
- K. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
- L. Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION.
- M. Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
- N. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- O. Section 23 11 23, FACILITY NATURAL-GAS PIPING.
- P. Section 23 51 00, BREECHINGS, CHIMNEYS, and STACKS.
- Q. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.
- R. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS
- S. Section 26 29 11, MOTOR CONTROLLERS.

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.
- D. Products Criteria:
 - 1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years (or longer as specified elsewhere). The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other specification sections for any exceptions and/or additional requirements.
 - 2. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT, for quality assurance requirements for boiler plant computer workstation software.
 - 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. 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 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.

E. Equipment Service Organizations:

1. Engine, generator, heat recovery steam generator, chiller, controls, and associated equipment: Service organizations, authorized and trained by the manufacturers of the equipment supplied, shall be located within 100 miles of the project. These organizations shall come to the site and provide acceptable service to restore CHP plant 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.
 - a. Submit names, mail and e-mail addresses and phone numbers of service personnel and organizations providing service under these conditions for (as applicable to the project): engine, boiler control systems, heat recovery steam generator, pumps, generators, critical instrumentation, computer workstation and programming.

F. 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 COR for resolution. Provide written hard copies or computer files of manufacturer's installation instructions to the COR 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. 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 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.

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

1.4 SUBMITTALS

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

have each reviewed drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.

- E. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient installation. Final review and approvals will be made only by groups.
- F. Submittal "Groups" for CHP plant work are defined in the following checklist:
 - 1. Group I (CHP Controls and Boiler Plant Controls and Instrumentation): Engine control system, gas piping, flow measuring systems, heat recovery steam generator (HRSG), fluid coolers, instruments and accessories, computer workstation and software, instrumentation, tools, chemical treatment.
 - 2. Group II (HVAC Systems): Evaporative cooling units, fans, duct silencers, diffusers and grills chiller, cooling tower, chemical treatment.
 - 3. Group III (Heat Recovery Systems): Heat exchangers, pumps, hydronic piping and specialties, steam piping and specialties, instrumentation, insulation.
- G. Ungrouped submittal items, which may be submitted individually, include, but are not limited to:
 - 1. Seismic calculations and drawings indicating equipment and piping anchoring, reinforcement and bracing.
 - 2. DDC Controls, control valves, dampers, and associated equipment.
- H. Layout Drawings:
 - 1. For areas requiring coordination between multiple trades and systems, prepare and submit coordination drawings. The drawings shall include plan views, elevations and sections of all affected systems and shall be on a scale of not less than 1:32 (3/8-inch equal to one foot). Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings shall clearly show locations and adequate clearance for all equipment, piping, valves, control panels and other items. Show the access means for all items requiring access for operations and maintenance. Provide detailed layout drawings of all piping and duct systems.

2. Do not install equipment foundations, equipment or piping until layout drawings have been approved.
- I. 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 COR.
 2. Submit electric motor data and variable speed drive data with the driven equipment.
 3. Equipment and materials identification.
 4. Fire-stopping materials.
 5. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.
 6. Wall, floor, and ceiling plates.
- J. 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.
- K. Engine-Generator Set Maintenance Data and Operating Instructions:
 1. Refer to section 48 20 10: Natural Gas Fueled Combined Heat and Power Facility General Requirements.
- L. Provide copies of approved HVAC, heat recovery system, and controls equipment submittals to the Testing, Adjusting and Balancing Subcontractor.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning, Heating and Refrigeration Institute (AHRI):
430-2009.....Central Station Air-Handling Units
- C. American National Standard Institute (ANSI):
B31.1-2007.....Power Piping
- D. Rubber Manufacturers Association (ANSI/RMA):
IP-20-2007.....Specifications for Drives Using Classical
V-Belts and Sheaves

- IP-21-2009.....Specifications for Drives Using Double-V
(Hexagonal) Belts
- IP-22-2007.....Specifications for Drives Using Narrow V-Belts
and Sheaves
- E. Air Movement and Control Association (AMCA):
- 410-96.....Recommended Safety Practices for Air Moving
Devices
- F. American Society of Mechanical Engineers (ASME):
- Boiler and Pressure Vessel Code (BPVC):
- Section I-2007.....Power Boilers
- Section IX-2007.....Welding and Brazing Qualifications
- Code for Pressure Piping:
- B31.1-2007.....Power Piping
- G. American Society for Testing and Materials (ASTM):
- A36/A36M-08.....Standard Specification for Carbon Structural
Steel
- A575-96(2007).....Standard Specification for Steel Bars, Carbon,
Merchant Quality, M-Grades
- E84-10.....Standard Test Method for Surface Burning
Characteristics of Building Materials
- E119-09c.....Standard Test Methods for Fire Tests of
Building Construction and Materials
- H. Manufacturers Standardization Society (MSS) of the Valve and Fittings
Industry, Inc:
- SP-58-2009.....Pipe Hangers and Supports-Materials, Design and
Manufacture, Selection, Application, and
Installation
- SP 69-2003.....Pipe Hangers and Supports-Selection and
Application
- SP 127-2001.....Bracing for Piping Systems, Seismic - Wind -
Dynamic, Design, Selection, Application
- I. National Electrical Manufacturers Association (NEMA):
- MG-1-2009.....Motors and Generators
- J. National Fire Protection Association (NFPA):
- 31-06.....Standard for Installation of Oil-Burning
Equipment
- 54-09.....National Fuel Gas Code
- 70-08.....National Electrical Code

85-07.....Boiler and Combustion Systems Hazards Code

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

101-09.....Life Safety Code

1.6 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage.
2. Place damaged equipment in first class, new operating condition; or, replace same as determined and directed by the 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. HRSG shall be left clean following final internal inspection by Government insurance representative or inspector.
5. 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 BOILER PLANT

- A. Plant Operation: Government employees will be continuously operating and managing all plant facilities, including temporary facilities, that serve the steam and condensate requirements of the medical center.
- B. Maintenance of Steam Supply and Condensate Return Service: Schedule all work to permit continuous steam and condensate service at pressures and

flow rates as required by the medical center. At all times there shall be one spare boiler available and one spare pump for each service available, in addition to those required for serving the load demand. The spare boiler and pumps must be capable of handling the loads that may be imposed if the operating boiler or pump fails.

- C. Steam and Condensate Service Interruptions: Limited steam and condensate service interruptions, as required for interconnections of new and existing systems, will be permitted by the COR during periods when the steam demands are not critical to the operation of the medical center. These non-critical periods are limited to between 8 pm and 5 am during the non-heating season. Provide at least one week advance notice to the COR.
- D. Phasing of Work: Comply with all requirements shown on drawings or specified.
- E. Plant Working Environment: Maintain the architectural and structural integrity of the plant building and the working environment at all times. Maintain the interior of plant at 65 degrees F minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. No storm water or ground water leakage permitted. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA.
- F. Acceptance of Work for Government Operation: As new facilities are made available for operation and these facilities are of beneficial use to the Government, inspections will be made and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After correction of deficiencies as necessary for beneficial use, the Contracting Officer will process necessary acceptance and the equipment will then be under the control and operation of Government personnel.

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

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

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

2.2 COMPATIBILITY OF RELATED EQUIPMENT

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

2.3 LIFTING ATTACHMENTS

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 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 AND STEAM GENERATION EQUIPMENT; Section 26 29 11, MOTOR CONTROLLERS; and, Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide energy efficient premium efficiency type motors as scheduled.

2.5 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. pumps shall be product of a single manufacturer.
- C. Motors shall be premium efficiency, inverter-duty 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 unless specified otherwise under individual equipment specifications.
- 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.

2.6 BOILER PLANT CONTROLS AND INSTRUMENTATION, COMPUTER WORKSTATION

- A. Provide, and place into proper operation, complete systems as specified in Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT. Furnish all hardware, software and programming to properly accomplish specified functions.
- B. Electronic Systems: Provide complete, protected power supplies as specified. Power supplies shall protect computers, controls, instruments and accessories from damage due to spikes, surges, transients, and overloads in the incoming power supply. Provide all interconnections between elements of the system. Entire installation shall conform to NFPA 70.

2.7 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Use symbols, nomenclature and equipment numbers specified, shown on the drawings and shown in the maintenance manuals. In addition, provide bar code identification nameplate for all equipment which will allow the

equipment identification code to be scanned into the system for maintenance and inventory tracking. Identification for piping is specified in Section 09 91 00, PAINTING.

- B. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 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 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. CHP and Heat Recovery Systems: Provide for all valves.
 - 2. Valve tags: Engraved black filled numbers and letters not less than 1/2-inch high for number designation, and not less than 1/4-inch for service designation on 19 gage 1-1/2 inches round brass disc, attached with brass "S" hook or brass chain.
 - 3. Valve lists: Typed or printed plastic coated card(s), sized 8-1/2 inches by 11 inches showing tag number, valve function and area of control, for each service or system. Punch sheets for a 3-ring notebook. Also provide valve lists in electronic spreadsheet format.
 - 4. Provide detailed plan for each floor of the building indicating the location and valve number for each valve. Identify location of each valve with a color coded thumb tack in ceiling.

2.8 FIRESTOPPING

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

2.9 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 Hangers and Supports: Refer to Section 23 21 13, HYDRONIC PIPING.

C. Supports for Roof Mounted Items:

1. Equipment: Refer to requirements indicated on structural drawings. Where not specified elsewhere, provide equipment rails fabricated galvanized steel, minimum 18 gauge, with integral baseplate, continuous welded corner seams, factory installed 2 by 4 treated wood nailer, 18 gauge galvanized steel counter flashing cap with screws, built-in cant strip, minimum height 11 inches. For surface insulated roof deck, provide raised cant strip to start at the upper surface of the insulation.
2. Pipe/duct pedestals: Provide a galvanized Unistrut channel welded to U-shaped mounting brackets which are secured to side of rail with galvanized lag bolts.

D. 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.

E. Attachment to Concrete Building Construction:

1. Concrete insert: MSS SP-58, Type 18.
2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than four inches thick when approved by the COR for each job condition.
3. Power-driven fasteners: Permitted in existing concrete or masonry not less than four inches thick when approved by the COR for each job condition.

F. Attachment to Steel Building Construction:

1. Welded attachment: MSS SP-58, Type 22.
2. Beam clamps: MSS SP-58, Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 7/8-inch outside diameter.

G. Attachment to existing structure: Support from existing floor/roof frame.

H. 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 1-1/2 inches minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.

I. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 1-5/8

inches by 1-5/8 inches, 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 200 pounds.
2. Guide individual pipes on the horizontal member of every other trapeze hanger with 1/4-inch U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 1/2-inch galvanized steel bands, or preinsulated calcium silicate shield for insulated piping at each hanger.

J. Supports for Piping Systems:

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

3. High and Medium Pressure Steam (MSS SP-58):
 - a. Provide eye rod or Type 17 eye nut near the upper attachment.
 - b. Piping 2 inches and larger: Type 43 roller hanger. For roller hangers requiring seismic bracing provide a Type 1 clevis hanger with Type 41 roller attached by flat side bars.
 - c. Piping with Vertical Expansion and Contraction:
 - 1) Movement up to 3/4-inch: Type 51 or 52 variable spring unit with integral turn buckle and load indicator.
 - 2) Movement more than 3/4-inch: Type 54 or 55 constant support unit with integral adjusting nut, turn buckle and travel position indicator.
4. Converter and Expansion Tank Hangers: May be Type 1 sized for the shell diameter. Insulation where required will cover the hangers.
- M. Pre-insulated Calcium Silicate Shields:
 1. Provide 360 degree water resistant high density 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 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.
- N. Seismic Restraint of Piping and Ductwork: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. Comply with MSS SP-127.

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 one inch above finished floor and provide sealant for watertight joint.
 - 2. For blocked out floor openings: Provide 1-1/2 inch angle set in silicone adhesive around opening.
 - 3. For drilled penetrations: Provide 1-1/2 inch angle ring or square set in silicone adhesive around penetration.
- C. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of COR.
- D. Sheet Metal, Plastic, or Moisture-resistant Fiber Sleeves: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.
- E. Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.
- F. Galvanized Steel or an alternate Black Iron Pipe with asphalt coating Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, connect sleeve with floor plate.
- G. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.
- H. Sleeves are not required for wall hydrants for fire department connections or in drywall construction, unless through fire rated walls.
- I. Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.

J. Sealant and Adhesives: Shall be as specified in Section 07 92 00, JOINT SEALANTS.

2.12 PENETRATIONS

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

2.13 SPECIAL TOOLS AND LUBRICANTS

- A. Furnish, and turn over to the COR, tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.
- B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.
- C. Refrigerant Tools: Provide system charging/Evacuation equipment, gauges, fittings, and tools required for maintenance of furnished equipment.
- D. Tool Containers: Hardwood or metal, permanently identified for intended service and mounted, or located, where directed by the COR.
- E. Lubricants: For grease lubricated equipment, provide a minimum of one pound of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.14 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 3/32-inch for floor plates. For wall and ceiling plates, not less than 0.025-inch for up to 3-inch pipe, 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.

2.15 ASBESTOS

Materials containing asbestos are not permitted.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

- A. Coordinate location of piping, sleeves, inserts, hangers, ductwork and equipment. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Prepare equipment layout drawings to coordinate proper location and personnel access of all facilities. Submit the coordination 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. Boiler Control Panel Locations: Locate and orient panels in existing boiler control room so that operating personnel standing in front of boilers can view the control switches and displays on the panel face.
- D. Boiler and Economizer Access Platforms: Arrange piping and equipment to allow access by a person standing on the platforms to all valves located above the boilers, to boiler manways located on top of the boilers, and to all economizer valves and access panels.
- E. Equipment and Piping Support: Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations to permit proper installation.
- F. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.
- G. 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 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 COR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to COR for approval.
 3. Do not penetrate membrane waterproofing.
- H. Interconnection of Instrumentation or Control Devices: Generally, electrical and pneumatic interconnections are not shown but must be provided.
- I. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.
- J. Electrical Interconnection of Controls and Instruments: These are 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.
- K. Protection and Cleaning:
1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the COR. Damaged or defective items, in the opinion of the COR, shall be replaced.
 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.
- L. Concrete and Grout: Use concrete and shrink compensating grout 3000 psi minimum.
- M. Install gages, thermometers, valves and other devices with for ease of 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.

N. Install steam piping expansion joints per manufacturer's recommendations.

O. 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. Plant Operation: Government employees will be continuously operating and managing all plant facilities, including temporary facilities, that serve the steam and condensate requirements of the medical center.
4. Maintenance of Steam Supply and Condensate Return Service: Schedule all work to permit continuous steam and condensate service at pressures and flow rates as required by the medical center. At all times there shall be one spare boiler available and one spare pump for each service available, in addition to those required for serving the load demand. The spare boiler and pumps must be capable of handling the loads that may be imposed if the operating boiler or pump fails.
5. Steam and Condensate Service Interruptions: Limited steam and condensate service interruptions, as required for interconnections of new and existing systems, will be permitted by the COR during periods when the steam demands are not critical to the operation of the medical center. These non-critical periods are limited to between 8 pm and 5 am during the non-heating season. Provide at least one week advance notice to the COR.
6. Phasing of Work: Comply with all requirements shown on drawings or specified.
7. Plant Working Environment: Maintain the architectural and structural integrity of the plant building and the working environment at all times. Maintain the interior of plant at 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.
8. 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.
9. 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 COR. Locate openings that will least effect structural slabs, columns, ribs or beams. Refer to the COR for determination of proper design for openings through structural sections and opening layouts approval, prior to cutting or drilling into structure. After COR's approval, carefully cut opening through construction no larger than absolutely necessary for the required installation.
- P. Switchgear/Electrical Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints. Installation of piping, ductwork, leak protection apparatus or other installations foreign to the electrical installation shall be located in the space equal to the width and depth of the equipment and extending from to a height of 6 ft. above the equipment or to ceiling structure, whichever is lower (NFPA 70).
- Q. 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 may require temporary installation or relocation of equipment and piping.
- B. The Contractor shall provide all required facilities in accordance with the requirements of phased construction and maintenance of service. All piping and equipment shall be properly supported, sloped to drain, operate without excessive stress, and shall be insulated where injury can occur to personnel by contact with operating facilities. The requirements of Paragraph 3.1 apply.
- C. Temporary facilities and piping shall be completely removed and any openings in structures sealed. Provide necessary blind flanges and caps to seal open piping remaining in service.

3.3 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. Upon request, the Government will check structure adequacy and advise Contractor of recommended restrictions.
- 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 COR 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. Drill or burn holes in structural steel only with the prior approval of the COR.
- 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 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, air-separators, and other heavy components. Provide a support on each leg at changes of direction. Supports shall not interfere with expansion compensation devices or loops.
- E. HVAC Vertical Pipe Supports:
 - 1. Up to 6-inch pipe, 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. Additional supports for heavy equipment are indicated on the structural drawings.
 - 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, and as indicated on the structural drawings. Anchor and dowel concrete bases and structural systems to resist forces under operating and

- seismic conditions (if applicable) 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 2 inch excess on all edges. Foundations shall have horizontal dimensions that exceed equipment base frame dimensions by at least 6 inches on all sides. Refer to structural drawings. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top, and shall be suitable for painting.
 3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a granular material to permit alignment and realignment.
 4. For seismic anchoring, refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

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 COR. Such access shall be provided without additional cost or time to the Government. Where work is in an operating plant, provide approved protection from dust and debris at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.
- B. In an operating facility, maintain the operation, cleanliness and safety. Government personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and plant operation. Confine the work to the immediate area concerned; maintain cleanliness and wet down demolished materials to eliminate dust. Do not permit debris to accumulate in the area to the detriment of plant operation. Perform all flame cutting to maintain the fire safety integrity of this plant. Adequate fire extinguishing facilities shall be available at all times. Perform all work in accordance with recognized fire protection standards. Inspection will be made by personnel of the VA Medical Center, and Contractor shall follow all directives of the RE or COR 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 COR and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these plans and specifications, and dispose of properly. Such material shall be removed from Government property expeditiously and shall not be allowed to accumulate.
- E. Disposal of equipment that handled infectious waste including the Rotoclave, grinder, conveyer, and other equipment that handled infectious waste shall be thoroughly cleaned and disinfected before removal and disposed of properly, such that any remnants of infectious waste have been destroyed and do not contaminate equipment or pathways used for demolition and transport.
- F. After demolition and removal of equipment, the generator room shall be thoroughly cleaned before installation of new equipment and a system is started. The floors and walls around the equipment and pathways used for handling infectious waste shall be cleaned with a suitable disinfectant by cleaning personnel equipped with appropriate personal protection equipment, respirators, etc. After disinfection, the room shall be flushed and wiped down with clean water, and allowed to thoroughly dry. The entire generator room shall be vacuumed with a HEPA rated vacuum to remove dirt and dust from remaining surfaces, including walls, bar joists, electrical wiring and cabinets, pipes, etc.

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 and painted. Refer to Section 09 91 00, PAINTING.
- B. In addition, the following special conditions apply:

1. Cleaning shall be thorough. Use solvents, cleaning materials and methods recommended by the manufacturers for the specific tasks. Remove all rust prior to painting and from surfaces to remain unpainted. Repair scratches, scuffs, and abrasions prior to applying prime and finish coats.
2. Material And Equipment Not To Be Painted Includes:
 - a. Motors, controllers, control switches, and safety switches.
 - b. Control and interlock devices.
 - c. Regulators.
 - d. Pressure reducing valves.
 - e. Control valves and thermostatic elements.
 - f. Lubrication devices and grease fittings.
 - g. Copper, brass, aluminum, stainless steel and bronze surfaces.
 - h. Valve stems and rotating shafts.
 - i. Pressure gauges and thermometers.
 - j. Glass.
 - k. Name plates.
3. Control and instrument panels shall be cleaned; damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.
4. Pumps, motors, steel and cast iron bases, and coupling guards shall be cleaned, and shall be touched-up with the same color as utilized by the pump manufacturer
5. Engine, Fuel Trains and Accessories, Chiller, Pumps, Air Separators, Expansion Tanks, etc.: Retain manufacturer's factory finish. Touch up or recoat as necessary to provide smooth, even-colored and even-textured finish.
6. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats.
7. Paint shall withstand the following temperatures without peeling or discoloration:
 - a. Engine exhaust stack and breeching -- 200 degrees F on insulation jacket surface and 1000 degrees F on metal surface of stacks and breeching.
 - b. Condensate and feedwater -- 100 degrees F on insulation jacket surface and 250 degrees F on metal pipe surface.
 - c. Steam -- 125 degrees F on insulation jacket surface and 375 degrees F on metal pipe surface.

8. 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.

3.7 IDENTIFICATION SIGNS

- A. Provide laminated plastic signs, with engraved lettering not less than 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. Boiler Control and Instrumentation Panels: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT
- D. 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 that require periodic greasing with lubrication fittings or devices.
- C. Provide adequate lubricants for one year of service of the engine-generator set. Refer to section 48 20 10 and the genset manufacturer's lubrication instructions.
- C. 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

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 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

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

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

PART 1 - GENERAL

1.1 DESCRIPTION:

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

1.2 RELATED WORK:

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements common to more than one Section of Division 26.
- B. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS: Starters, control and protection for motors.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION.
- E. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.
- F. Section 23 21 23, HYDRONIC PUMPS.
- G. Section 23 34 00, HVAC FANS.
- H. Section 23 64 00, PACKAGED WATER CHILLERS.
- I. Section 23 65 00, COOLING TOWERS.
- J. Section 23 74 13, PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS.

1.3 SUBMITTALS:

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Shop Drawings:
 - 1. Provide documentation to demonstrate compliance with drawings and specifications.
 - 2. Include electrical ratings, efficiency, bearing data, power factor, frame size, dimensions, mounting details, materials, horsepower, voltage, phase, speed (RPM), enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.
- C. Manuals:
 - 1. Submit simultaneously with the shop drawings, companion copies of complete installation, maintenance and operating manuals, including technical data sheets and application data.

- D. Certification: Two weeks prior to final inspection, unless otherwise noted, submit four copies of the following certification to the COR:
 - 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. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. National Electrical Manufacturers Association (NEMA):
 - MG 1-2006 Rev. 1 2009 ..Motors and Generators
 - MG 2-2001 Rev. 1 2007...Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators
- C. National Fire Protection Association (NFPA):
 - 70-2008.....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, LOW-VOLTAGE MOTOR STARTERS; 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 shall be 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.
- E. Voltage ratings shall be as follows:
 - 1. Single phase:
 - a. Motors connected to 120-volt systems: 115 volts.
 - b. Motors connected to 208-volt systems: 200 volts.
 - c. Motors connected to 240 volt or 480 volt systems: 230/460 volts, dual connection.
 - 2. Three phase:
 - a. Motors connected to 208-volt systems: 200 volts.
 - b. Motors, less than 100 HP, connected to 240 volt or 480 volt systems: 208-230/460 volts, dual connection.
- F. Number of phases shall be as scheduled on the drawings, or if not indicated as follows:
 - 1. Motors, less than 1/2 HP: Single phase.
 - 2. Motors, 1/2 HP and larger: 3 phase.
 - 3. Exceptions:
 - a. Hermetically sealed motors.
 - b. Motors for equipment assemblies, less than 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 104°F environment, where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation. If the motors exceed 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 160 degrees F shall be stranded copper with Teflon FEP insulation with jacket. This includes wiring on the boilers.
 - b. Other wiring at boilers and to control panels shall be NFPA 70 designation THWN.
 - c. Provide shielded conductors or wiring in separate conduits for all instrumentation and control systems where recommended by manufacturer of equipment.
4. Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.

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

Minimum Premium Efficiencies Open Drip-Proof				Minimum Premium Efficiencies Totally Enclosed Fan-Cooled			
Rating HP	1200 RPM	1800 RPM	3600 RPM	Rating HP	1200 RPM	1800 RPM	3600 RPM
1	82.5%	85.5%	77.0%	1	82.5%	85.5%	77.0%
1.5	86.5%	86.5%	84.0%	1.5	87.5%	86.5%	84.0%
2	87.5%	86.5%	85.5%	2	88.5%	86.5%	85.5%
3	88.5%	89.5%	85.5%	3	89.5%	89.5%	86.5%
5	89.5%	89.5%	86.5%	5	89.5%	89.5%	88.5%
7.5	90.2%	91.0%	88.5%	7.5	91.0%	91.7%	89.5%
10	91.7%	91.7%	89.5%	10	91.0%	91.7%	90.2%
15	91.7%	93.0%	90.2%	15	91.7%	92.4%	91.0%
20	92.4%	93.0%	91.0%	20	91.7%	93.0%	91.0%
25	93.0%	93.6%	91.7%	25	93.0%	93.6%	91.7%
30	93.6%	94.1%	91.7%	30	93.0%	93.6%	91.7%
40	94.1%	94.1%	92.4%	40	94.1%	94.1%	92.4%
50	94.1%	94.5%	93.0%	50	94.1%	94.5%	93.0%
60	94.5%	95.0%	93.6%	60	94.5%	95.0%	93.6%
75	94.5%	95.0%	93.6%	75	94.5%	95.4%	93.6%
100	95.0%	95.4%	93.6%	100	95.0%	95.4%	94.1%
125	95.0%	95.4%	94.1%	125	95.0%	95.4%	95.0%

150	95.4%	95.8%	94.1%	150	95.8%	95.8%	95.0%
200	95.4%	95.8%	95.0%	200	95.8%	96.2%	95.4%

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

PART 3 - EXECUTION

3.1 INSTALLATION:

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

3.2 FIELD TESTS

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

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 COR and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.4 COMMISSIONING

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

3.5 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of units.

- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 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, heating hot water and drain piping.
 - 2. Extension of domestic water make-up piping.
 - 3. Glycol-water piping.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic restraints for piping.
- D. 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.
- E. Section 23 21 23, HYDRONIC PUMPS: Pumps.
- F. Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION: Piping insulation.

1.3 QUALITY ASSURANCE

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

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Pipe and 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. Flexible connectors for water service.
 9. Pipe alignment guides.
 10. Expansion joints.
 11. Expansion compensators.
 12. All specified hydronic system components.
 13. Water flow measuring devices.
 14. Gages.
 15. Thermometers and test wells.
 16. Electric heat tracing systems.
 17. Seismic bracing details for piping.
- C. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:
1. Heat Exchangers (Water to Water)
 2. Air separators.
 3. Expansion tanks.
- D. Submit the welder's qualifications in the form of a current (less than one year old) and formal certificate.
- E. As-Built Piping Diagrams: Provide drawing as follows for chilled water, condenser water, glycol for engine cooling, and heating hot water system and other piping systems and equipment.
1. One complete set of reproducible drawings.
 2. One complete set of drawings in electronic Autocad and pdf format.

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. American National Standards Institute, Inc.
- B. American Society of Mechanical Engineers/American National Standards Institute, Inc. (ASME/ANSI):
- B1.20.1-83(R2006).....Pipe Threads, General Purpose (Inch)
- B16.4-06.....Gray Iron Threaded Fittings B16.18-01 Cast
Copper Alloy Solder joint Pressure fittings

- 23 21 13-3

A216/A216M-08.....Standard Specification for Steel Castings,
Carbon, Suitable for Fusion Welding, for High
Temperature Service

A234/A234M-07.....Piping Fittings of Wrought Carbon Steel and
Alloy Steel for Moderate and High Temperature
Service

A307-07.....Standard Specification for Carbon Steel Bolts
and Studs, 60,000 PSI Tensile Strength

A536-84 (2004).....Standard Specification for Ductile Iron
Castings

A615/A615M-08.....Deformed and Plain Carbon Steel Bars for
Concrete Reinforcement

A653/A 653M-08.....Steel Sheet, Zinc-Coated (Galvanized) or Zinc-
Iron Alloy Coated (Galvannealed) By the Hot-Dip
Process

B32-08 Standard Specification for Solder Metal

B62-02.....Standard Specification for Composition Bronze
or Ounce Metal Castings

B88-03.....Standard Specification for Seamless Copper
Water Tube

B209-07.....Aluminum and Aluminum Alloy Sheet and Plate

C177-04Standard Test Method for Steady State Heat Flux
Measurements and Thermal Transmission
Properties by Means of the Guarded Hot Plate
Apparatus

D3350-08.....Polyethylene Plastics Pipe and Fittings
Materials

C591-08.....Unfaced Preformed Rigid Cellular
Polyisocyanurate Thermal Insulation

D1784-08.....Rigid Poly (Vinyl Chloride) (PVC) Compounds and
Chlorinated Poly (Vinyl Chloride) (CPVC)
Compound

D1785-06.....Poly (Vinyl Chloride) (PVC) Plastic Pipe,
Schedules 40, 80 and 120

D2241-05.....Poly (Vinyl Chloride) (PVC) Pressure Rated Pipe
(SDR Series)

- F439-06.....Standard Specification for Chlorinated Poly
(Vinyl Chloride) (CPVC) Plastic Pipe Fittings,
Schedule 80
- F441/F441M-02.....Standard Specification for Chlorinated Poly
(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules
40 and 80
- F477-08.....Elastomeric Seals Gaskets) for Joining Plastic
Pipe
- F2389.....Standard Specification for pressure rated
polypropylene (PP) piping systems
- F. American Water Works Association (AWWA):
- C110-08.....Ductile Iron and Grey Iron Fittings for Water
- C203-02.....Coal Tar Protective Coatings and Linings for
Steel Water Pipe Lines Enamel and Tape Hot
Applied
- G. American Welding Society (AWS):
- B2.1-02.....Standard Welding Procedure Specification
- H. Copper Development Association, Inc. (CDA):
- CDA A4015-06.....Copper Tube Handbook
- I. Expansion Joint Manufacturer's Association, Inc. (EJMA):
- EMJA-2003.....Expansion Joint Manufacturer's Association
Standards, Ninth Edition
- J. Manufacturers Standardization Society (MSS) of the Valve and Fitting
Industry, Inc.:
- SP-67-02a.....Butterfly Valves
- SP-70-06.....Gray Iron Gate Valves, Flanged and Threaded
Ends
- SP-71-05.....Gray Iron Swing Check Valves, Flanged and
Threaded Ends
- SP-80-08.....Bronze Gate, Globe, Angle and Check Valves
- SP-85-02.....Cast Iron Globe and Angle Valves, Flanged and
Threaded Ends
- SP-110-96.....Ball Valves Threaded, Socket-Welding, Solder
Joint, Grooved and Flared Ends
- SP-125-00.....Gray Iron and Ductile Iron In-line, Spring
Loaded, Center-Guided Check Valves

K. National Sanitation Foundation/American National Standards Institute, Inc. (NSF/ANSI):

14-06.....Plastic Piping System Components and Related Materials

50-2009a.....Equipment for Swimming Pools, Spas, Hot Tubs and other Recreational Water Facilities - Evaluation criteria for materials, components, products, equipment and systems for use at recreational water facilities

61-2008.....Drinking Water System Components - Health Effects

L. Tubular Exchanger Manufacturers Association: TEMA 9th Edition, 2007

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, Heating Hot Water, Glycol-Water, and Vent Piping:

1. Steel: ASTM A53 Grade B, seamless or ERW, Schedule 40.

2. Copper water tube option: ASTM B88, Type K or L, hard drawn.

B. Domestic Hot and Cold Water Connections

1. Extension of Domestic Water Make-up Piping and connections to water heaters: ASTM B88, Type K or L, hard drawn copper tubing.

C. Chemical Feed Piping for Condenser Water Treatment: Chlorinated polyvinyl chloride (CPVC), Schedule 80, ASTM F441.

D. Condenser Water Piping

1. Polypropylene-Random (PP-R): ASTM F2389, SDR11, socket welded Aquatherm Blue with UV protection.

2. PVC: ASTM F439-06, Schedule 80, with socket solvent welded fittings.

E. 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. 2 inches and Smaller: Screwed or welded joints.

1. Butt welding: ASME B16.9 with same wall thickness as connecting piping.

2. Forged steel, socket welding or threaded: ASME B16.11.

3. Screwed: 150 pound malleable iron, ASME B16.3. 125 pound cast iron, ASME B16.4, may be used in lieu of malleable iron. Bushing reduction of a single pipe size, or use of close nipples, is not acceptable.
4. Unions: ASME B16.39.
5. Water hose connection adapter: Brass, pipe thread to 3/4 inch garden hose thread, with hose cap nut.
- B. 2-1/2 inches and Larger: Welded or flanged joints. Contractor's option: Grooved mechanical couplings and fittings are recommended but welded piping is also acceptable.
 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 1/8 inch thick full face neoprene gasket suitable for 220 degrees F.
 - 1) Contractor's option: Convuluted, cold formed 150 pound steel flanges, with teflon gaskets, may be used for water service.
 - b. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A307, Grade B.
- C. Welded Branch and Tap Connections: Forged steel weldolets, or branchlets and threadolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 may be used for drain, vent and gage connections.
- D. Grooved Mechanical Pipe Couplings and Fittings (Recommended): Grooved Mechanical Pipe Couplings and Fittings may be used, with cut or roll grooved pipe, in water service up to 230 degrees F in lieu of welded, screwed or flanged connections. All joints must be rigid type.
 1. Grooved mechanical couplings: Malleable iron, ASTM A47 or ductile iron, ASTM A536, fabricated in two or more parts, securely held together by two or more track-head, square, or oval-neck bolts, ASTM A449 and A183.
 2. Gaskets: Rubber product recommended by the coupling manufacturer for the intended service.
 3. Grooved end fittings: Malleable iron, ASTM A47; ductile iron, ASTM A536; or steel, ASTM A53 or A106, designed to accept grooved mechanical couplings. Tap-in type branch connections are acceptable.

2.4 FITTINGS FOR COPPER TUBING

A. Joints:

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

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

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

2.5 FITTINGS FOR PLASTIC PIPING

- A. Schedule 40 and schedule 80 PVC, socket type for solvent welding.
- B. Schedule 40 PVC drain piping: Drainage pattern.
- C. Chemical feed piping for condenser water treatment: Chlorinated polyvinyl chloride (CPVC), Schedule 80, ASTM F439.
- D. PP-R piping: Socket fusion welded.

2.6 DIELECTRIC FITTINGS

- A. Provide where copper tubing and ferrous metal pipe are joined.
- B. 2 inches and Smaller: Threaded dielectric union, ASME B16.39.
- C. 2 1/2 inches and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.
- D. Temperature Rating, 210 degrees F.
- E. Contractor's option: On pipe sizes 2" and smaller, screwed end brass ball valves or dielectric nipples may be used in lieu of dielectric unions.

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 is not acceptable.

- B. All valves of the same type shall be products of a single manufacturer.
- C. Provide chain operators for valves 6 inches and larger when the centerline is located 8 feet or more above the floor or operating platform.

D. Shut-Off Valves

1. Ball Valves (Pipe sizes 2" and smaller): MSS-SP 110, screwed or solder connections, brass or bronze body with chrome-plated ball with full port and Teflon seat at 400 psig working pressure rating. Provide stem extension to allow operation without interfering with pipe insulation.
2. Butterfly Valves (Pipe Sizes 2-1/2" and larger): Provide stem extension to allow 2 inches of pipe insulation without interfering with valve operation. MSS-SP 67, flange lug type or grooved end rated 175 psig working pressure at 200 degrees F. Valves shall be ANSI Leakage Class VI and rated for bubble tight shut-off to full valve pressure rating. Valve shall be rated for dead end service and bi-directional flow capability to full rated pressure. Not permitted for direct buried pipe applications.
 - a. Body: Cast iron, ASTM A126, Class B. Malleable iron, ASTM A47 electro-plated, or ductile iron, ASTM A536, Grade 65-45-12 electro-plated.
 - b. Trim: Bronze, aluminum bronze, or 300 series stainless steel disc, bronze bearings, 316 stainless steel shaft and manufacturer's recommended resilient seat. Resilient seat shall be field replaceable, and fully line the body to completely isolate the body from the product. A phosphate coated steel shaft or stem is acceptable, if the stem is completely isolated from the product.
 - c. Actuators: Field interchangeable. Valves for balancing service shall have adjustable memory stop to limit open position.
 - 1) Valves 6 inches and smaller: Lever actuator with minimum of seven locking positions, except where chain wheel is required.
 - 2) Valves 8 inches and larger: Enclosed worm gear with handwheel, and where required, chain-wheel operator.
 - 3) 3. Gate Valves (Contractor's Option in lieu of Ball or Butterfly Valves):

- a) 2 inches and smaller: MSS-SP 80, Bronze, 150 psig, wedge disc, rising stem, union bonnet.
- b) 2 1/2 inches and larger: Flanged, outside screw and yoke. MSS-SP 70, iron body, bronze mounted, 125 psig wedge disc.

E. Globe and Angle Valves

1. Globe Valves

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

2. Angle Valves:

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

F. Check Valves

1. Swing Check Valves:

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

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

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

G. Water Flow Balancing Valves: For flow regulation and shut-off. Valves shall be line size rather than reduced to control valve size.

1. Ball or Globe style valve.

2. A dual purpose flow balancing valve and adjustable flow meter, with bronze or cast iron body, calibrated position pointer, valved

- pressure taps or quick disconnects with integral check valves and preformed polyurethane insulating enclosure.
3. Provide a readout kit including flow meter, readout probes, hoses, flow charts or calculator, and carrying case.
- H. 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 175 psig at 200 degrees F, with stainless steel piston and spring.
 2. Brass or ferrous body designed for 300 psig service at 250 degrees F, with corrosion resistant, tamper proof, self-cleaning piston/spring assembly that is easily removable for inspection or replacement.
 3. Combination assemblies containing ball type shut-off valves, unions, flow regulators, strainers with blowdown valves and pressure temperature ports shall be acceptable.
 4. Provide a readout kit including flow meter, probes, hoses, flow charts and carrying case.

2.9 STRAINERS

- A. Y Type.
1. Screens: Bronze, monel metal or 18-8 stainless steel, free area not less than 2-1/2 times pipe area, with perforations as follows: 0.045 inch diameter perforations for 4 inches and larger: 0.125 inch diameter perforations.
- B. Suction Diffusers: Specified in Section 23 21 23, HYDRONIC PUMPS.

2.10 FLEXIBLE CONNECTORS FOR WATER SERVICE

- A. Flanged Spool Connector:
1. Single arch or multiple arch type. Tube and cover shall be constructed of chlorobutyl elastomer with full faced integral flanges to provide a tight seal without gaskets. Connectors shall be internally reinforced with high strength synthetic fibers impregnated with rubber or synthetic compounds as recommended by connector manufacturer, and steel reinforcing rings.
 2. Working pressures and temperatures shall be as follows:
 - a. Connector sizes 2 inches to 4 inches, 165psig at 250 degrees F.

- b. Connector sizes 5 inches to 12 inches, 140 psig at 250 degrees F.
- 3. Provide ductile iron retaining rings and control units.

B. Mechanical Pipe Couplings:

See other fittings specified under Part 2, PRODUCTS.

2.11 EXPANSION JOINTS

- A. Factory built devices, inserted in the pipe lines, designed to absorb axial cyclical pipe movement which results from thermal expansion and contraction. This includes factory-built or field-fabricated guides located along the pipe lines to restrain lateral pipe motion and direct the axial pipe movement into the expansion joints.
- B. Manufacturing Quality Assurance: Conform to Expansion Joints Manufacturers Association Standards.
- C. Bellows - Externally Pressurized Type:
 - 1. Multiple corrugations of Type 304 stainless steel.
 - 2. Internal and external guide integral with joint.
 - 3. Design for external pressurization of bellows to eliminate squirm.
 - 4. Groove joint (Victaulic Type) or flanged ends.
 - 5. Smooth internal flow liner of same diameter as adjacent pipes.
 - 6. Conform to the standards of EJMA and ASME B31.1.
 - 7. Threaded connection at bottom, one inch minimum, for drain or drip point.
 - 8. Integral external cover and internal sleeve.
 - 9. Rated for working pressure of 150 psig.
- E. Expansion Compensators:
 - 1. Corrugated bellows, externally pressurized, stainless steel or bronze.
 - 2. Internal guides and anti-torque devices.
 - 3. Threaded ends.
 - 4. External shroud.
 - 5. Smooth internal flow liner of same diameter as adjacent pipes.
 - 6. Conform to standards of EJMA.
 - 7. Rated for working pressure of 150 psig.
- F. Expansion Joint (Contractor's Option): 350 psig maximum working pressure, steel pipe fitting consisting of telescoping body and slip-pipe sections, PTFE modified polyphenylene sulfide coated slide section, with grooved ends, suitable for axial end movement to 3 inch.

- G. Expansion Joint Identification: Provide stamped brass or stainless steel nameplate on each expansion joint listing the manufacturer, the allowable movement, flow direction, design pressure and temperature, date of manufacture, and identifying the expansion joint by the identification number on the contract drawings.
- H. Guides: Provide factory-built guides along the pipe line to permit axial movement only and to restrain lateral and angular movement. Guides must be designed to withstand a minimum of 15 percent of the axial force which will be imposed on the expansion joints and anchors. Field-built guides may be used if detailed on the contract drawings.
- I. Supports: Provide saddle supports and frame or hangers for heat exchanger. Mounting height shall be adjusted to facilitate gravity return of steam condensate. Construct supports from steel, weld joints.

2.12 HYDRONIC SYSTEM COMPONENTS

- A. Plate and Frame Heat Exchanger:
 - 1. Fixed frame with bolted removable corrugated channel plate assembly, ASME code stamped for 150 psig working pressure.
 - 2. Corrugated channel plates shall be type 316 or 304 stainless steel.
 - 3. Channel plate ports to be double gasketed to prevent mixing or cross-contamination of hot side and cold side fluids. Gaskets to be EPDM.
 - 4. Channel plate carrying bars to be carbon steel with zinc yellow chromate finish.
 - 5. Fixed frame plates and moveable pressure plates to be corrosion resistant epoxy painted carbon steel.
 - 6. Piping connections 2.5" and smaller to be carbon steel NPT tappings. Piping connections 3" and larger to be stud port design to accept ANSI flange connections. Connection ports to be integral to the frame or pressure plate.
 - 7. Finished units to be provided with OSHA required, formed aluminum splash guards to enclose exterior channel plate and gasket surfaces.
 - 8. Provide two sets of replacement gaskets and provide one set of wrenches for disassembly of plate type heat exchangers.
 - 9. Performance: As scheduled on drawings.
- B. Air Purger: Cast iron or fabricated steel, 125 psig water working pressure, for in-line installation.

- C. High Efficiency Air Separator: ASME Pressure Vessel Code construction for 125 psig working pressure, flanged inlet and outlet connection, internal stainless steel screen or pall rings to separate air, bottom blowdown connection. Provide Form No. U-1. If scheduled on the drawings, provide a removable stainless steel strainer element having 3/16 inch perforations and free area of not less than five times the cross-sectional area of connecting piping.
- D. Diaphragm or Bladder Type Pre-Pressurized Expansion Tank: ASME Pressure Vessel Code construction for 125 psig working pressure, welded steel shell, rust-proof coated, with a flexible elastomeric diaphragm or bladder suitable for a maximum operating temperature of 240 degrees F. Provide Form No. U-1. Tank shall be equipped with system connection, drain connection, standard air fill valve and be factory pre-charged to a minimum of 12 psig.
- E. Pressure Reducing Valve (Water): Diaphragm or bellows operated, spring loaded type, with minimum adjustable range of 4 psig above and below set point. Bronze, brass or iron body and bronze, brass or stainless steel trim, rated 125 psig working pressure at 225 degrees F.
- F. 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.
- G. Automatic Air Vent Valves (where shown): Cast iron or semi-steel body, 150 psig working pressure, stainless steel float, valve, valve seat and mechanism, minimum 1/2 inch water connection and 1/4 inch air outlet.

2.13 GAGES, PRESSURE AND COMPOUND

- A. ASME B40.100, Accuracy Grade 1A, pressure or compound for air, oil or water), initial mid-scale accuracy 1 percent of scale (Qualify grade), metal or phenolic case, 4-1/2 inches in diameter, 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 or ball valve. 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.
 - 1. For condenser water suction (compound): Minus 30 inches Hg to plus 50 psig.

2.14 PRESSURE/TEMPERATURE TEST PROVISIONS

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

2.15 THERMOMETERS

- A. BIMETALLIC-ACTUATED THERMOMETERS
 - 1. Standard: ASME B40.200.
 - 2. Case: stainless steel with 3-inch nominal diameter.
 - 3. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F and deg C.
 - 4. Connector Type(s): Union joint, rigid back, with unified-inch screw threads.
 - 5. Connector Size: 1/2 inch NPT, with ASME B1.1 screw threads.
 - 6. Stem: 0.25 inch diameter; stainless steel.
 - 7. Window: Clear Polycarbonate.
 - 8. Ring: Stainless steel.
 - 9. Element: Silicone damped Bimetal coil.
 - 10. Pointer: Dark-colored metal.
 - 11. Accuracy: Plus or minus 1 percent of scale range.
 - 12. Scale ranges:
 - a. Chilled Water and Glycol-Water: 32-100 degrees F.
 - b. Hot Water and Glycol-Water: -30-240 degrees F.
- B. LIGHT-ACTIVATED THERMOMETERS

Basis of Subject to compliance with requirements, provide Trerice SX-9 light powered digital thermometer, or comparable

 - 1. Case: Plastic or metal; 7-inch nominal size unless otherwise indicated.
 - 2. Scale(s): Deg F and deg C.
 - 3. Case Form: Adjustable angle.

4. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
5. Stem: Aluminum and of length to suit installation.
6. Design for Thermowell Installation: Bare stem.
7. Display: Digital.
8. Accuracy: Plus or minus 1 deg F.
9. Scale Ranges: 0-240 degrees F.

C. THERMOWELLS

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: Brass.
4. Material for Use with Steel Piping: Brass.
5. Type: Stepped shank unless straight or tapered shank is indicated, with extension neck to clear pipe insulation.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of internal screw thread of thermowell to size of thermometer connection.
12. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.16 FIRESTOPPING MATERIAL

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

2.17 ELECTRICAL HEAT TRACING SYSTEMS

- A. Systems shall meet requirements of the National Electrical Code (NEC), Section 427.
- B. Provide tracing for outdoor piping subject to freezing temperatures (Below 38 degrees F) as follows:
 1. Condenser water piping for cooling towers
 2. Make-up water
 3. Domestic water lines exposed to weather.

- C. Heat tracing shall be provided to the extent shown on the drawings (Floor plans and Elevations).
- D. Electrical Heating Tracing Accessories:
 - 1. Power supply connection fitting and stainless steel mounting brackets. Provide stainless steel worm gear clamp to fasten bracket to pipe.
 - 2. 1/2 inch wide fiberglass reinforced pressure sensitive cloth tape to fasten cable to pipe at 12 inch intervals.
 - 3. Pipe surface temperature control thermostat: Cast aluminum, NEMA 4 (watertight) enclosure, 1/2 inch NPT conduit hub, SPST switch rated 20 amps at 480 volts AC, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature at not less than 34 degrees F.
 - 4. Signs: Manufacturer's standard (NEC Code), stamped "ELECTRIC TRACED" located on the insulation jacket at 10 feet intervals along the pipe on alternating sides.

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.
- D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 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 one inch in 40 feet.
Provide eccentric reducers to keep bottom of sloped piping flat.

- E. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.
- F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted on the drawings.
- G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.
- H. Provide manual or automatic air vent at all piping system high points and drain valves at all low points. Install piping to floor drains from all automatic air vents.
- I. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:
 - 1. Water treatment pot feeders and condenser water treatment systems.
 - 2. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.
- J. Thermometer Wells: In pipes 2-1/2 inches and smaller increase the pipe size to provide free area equal to the upstream pipe area, or install in tee at 90 degree elbow.
- K. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION.
- L. Where copper piping is connected to steel piping, provide dielectric connections.

3.2 PIPE JOINTS

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

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

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

3.3 EXPANSION JOINTS (BELLOWS AND SLIP TYPE)

- A. Anchors and Guides: Provide expansion joints, anchors, and pipe guides as required to minimize stress in piping systems due to thermal expansion. Provide type, quantity and spacing as recommended by manufacturer of expansion joint and as shown. A professional engineer shall verify in writing that anchors and guides are properly designed for forces and moments which will be imposed.
- B. Cold Set: Provide setting of joint travel at installation as recommended by the manufacturer for the ambient temperature during the installation.
- C. Preparation for Service: Remove all apparatus provided to restrain joint during shipping or installation. Representative of manufacturer shall visit the site and verify that installation is proper.
- D. Access: Expansion joints shall be located in readily accessible space. Locate joints to permit access without removing piping or other devices. Allow clear space to permit replacement of joints and to permit access to devices for inspection of all surfaces and for adding.

3.4 SEISMIC BRACING ABOVEGROUND PIPING

Provide in accordance with Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.5 LEAK TESTING ABOVEGROUND PIPING

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

3.6 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Water Piping:
 - 1. Initial flushing: Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system component. Provide temporary piping or hose to bypass coils, control valves, exchangers and other factory cleaned equipment unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place. Isolate or protect clean system components, including pumps and pressure vessels, and remove any component which may be damaged. Open all valves, drains, vents and strainers at all system levels. Remove plugs, caps, spool pieces, and components to facilitate early debris discharge from system. Sectionalize system to obtain debris carrying velocity of 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 COR.
 - 2. Cleaning: 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 6 feet per second. Circulate each section for not less than four hours. Blow-down all strainers, or remove and clean as frequently as necessary. Drain and prepare for final flushing.

3. Final Flushing: Return systems to conditions required by initial flushing after all cleaning solution has been displaced by clean make-up. Flush all dead ends and isolated clean equipment. Gently operate all valves to dislodge any debris in valve body by throttling velocity. Flush for not less than one hour.

3.7 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. Utilize this activity, by arrangement with the COR, for instructing VA operating personnel.

3.8 ELECTRIC HEAT TRACING

- A. Install heat tracing as indicated on the plans and as recommended by the manufacturer.
- B. Coordinate electrical connections.

3.9 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

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

- - - E N D - - -

SECTION 23 21 23
HYDRONIC PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 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 in a parallel or series pumping installation with one pump in operation.
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.

C. Allowable Vibration Tolerance for Pump Units: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

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. 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.

1.4 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 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.

1.5 DEFINITIONS

- A. Capacity: Gallons per minute (GPM) of the fluid pumped.
- B. Head: Total dynamic head in 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.

1.6 SPARE MATERIALS

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

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 and STEAM GENERATION 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, LOW-VOLTAGE MOTOR STARTERS 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. In-Line Type, Base Mounted End Suction or Double Suction Type:
1. Casing and Bearing Housing: Close-grained cast iron, ASTM A48.
 2. Casing Wear Rings: Bronze.
 3. Suction and Discharge: Plain face flange, 125 psig, ANSI B16.1.
 4. Casing Vent: Manual brass cock at high point.
 5. Casing Drain and Gage Taps: 1/2-inch plugged connections minimum size.
 6. Impeller: Bronze, ASTM B62, enclosed type, keyed to shaft.
 7. Shaft: Steel, AISI Type 1045 or stainless steel.
 8. Shaft Seal: Manufacturer's standard mechanical type to suit pressure and temperature and fluid pumped.
 9. Shaft Sleeve: Bronze or stainless steel.
 10. Motor: Furnish with pump. Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.
 11. Base Mounted Pumps:
 - a. Designed for disassembling for service or repair without disturbing the piping or removing the motor.
 - b. Impeller Wear Rings: Bronze.
 - c. Shaft Coupling: Non-lubricated steel flexible type or spacer type with coupling guard, ANSI B15.1, bolted to the baseplate.
 - d. Bearings (Double-Suction pumps): Regreaseable ball or roller type. Provide lip seal and slinger outboard of each bearing.
 - e. Base: Cast iron or fabricated steel for common mounting to a concrete base.
 12. 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 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.

2.2 VERTICAL TURBINE PUMP

- A. Pump Bowls: Close-grained cast iron, flanged and bolted type, reinforced with four ribs (minimum), which are at least one-half the flange metal thickness.

- B. Impellers: Bronze, enclosed type, secured to the shaft with steel tempered keys.
- C. Replaceable Wear Rings: Bronze.
- D. Pump Shaft: AISI Type 416, stainless steel.
- E. Suction Bell: Cast iron, belled to reduce entrance losses.
- F. Suction Strainer: Bronze, basket type, with net open area at least twice the calculated area at the suction bell lip.
- G. Sleeve Bearings: Bronze provided in each bowl and in the suction bell, to be lubricated by the pumped fluid. Suction bell bearing shall be packed permanently with non-soluble grease and fitted with a bronze sand collar.
- H. Discharge Column Pipe: Steel with threaded or flanged connections.
- I. Lineshaft: AISI Type 1045, steel connected through steel threaded couplings. Shaft (and column) sections shall not exceed ten feet in length.
- J. Replaceable Shaft Sleeves: Stainless steel "shrunkfit" on the line-shaft at each bearing location.
- K. Column Connection Bearings: Fluted rubber supported by non-threaded "spider" type retainers butted between the machined faces of the discharge column. "Spider" shall be made of nickel-iron with a minimum brinell of 170.
- L. Surface Discharge Head Assembly: Close-grained cast iron with integral 125 psig flat face flange, ANSI B16.1. Provide two lifting lugs with capacity to support the weight of the entire pump.
Provide steel base plate and hardware for securing the discharge head to the base plate.
- M. Stuffing Box: Manufacturer's standard, two Teflon sealcages, and split type packing gland.
- N. Stuffing Box Bearing Housing: Cast iron, one piece, with bronze sleeve bearings.
- O. Motor: Vertical, hollow shaft type, direct connected.

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 and STEAM GENERATION.
- C. Piping and valves: Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM and CONDENSATE HEATING PIPING.
- D. Cooling Towers and Fluid Coolers: Section 23 65 00, COOLING TOWERS.

1.3 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- 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. The VA Hospital currently uses West Chemical (435) 730-4464 for water treatment of other system on the Salt Lake City Campus. Direct and perform chemical limit control during construction period and monitor systems for a period of 12 months after acceptance, including not less than 6 service calls and written status reports. Emergency calls are not included. 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 6 hours.

- C. Field Quality Control and Certified Laboratory Reports: During the one year guarantee period, the water treatment laboratory shall provide not less than 8 reports (during the cooling season) based upon 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. Log Forms: Provide one year supply of preprinted water treatment test log forms.
- E. Chemicals: Chemicals shall be non-toxic approved by local authorities and meeting applicable EPA requirements.

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. Materials Safety Data Sheet for all proposed chemical compounds, based on U.S. Department of Labor Form No. L5B-005-4.
- E. 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):
70-2008.....National Electric Code (NEC)

- C. American Society for Testing and Materials (ASTM):
F441/F441M-02 (2008) ... Standard Specification for Chlorinated Poly
(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules
40 and 80

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 and Section 23 22 13, STEAM and CONDENSATE HEATING 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 compound suitable for make-up quality and make-up rate and which will cause or enhance 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 250 degrees F and 125 degrees Fahrenheit respectively. Heat exchanger fouling and capacity reduction shall not exceed that allowed by fouling factor 0.0005.

2.3 CHEMICAL TREATMENT FOR OPEN LOOP SYSTEMS

- A. General: Provide the following:
1. A factory-fabricated and tested packaged, self-contained, chemical feed/blow-down monitoring, controlling and alarming system,

containing all except specified or indicated remote components, and requiring only terminal sample stream and chemical piping/tubing connections, remote component electrical connection and power supply.

2. System shall be suitable for a broad spectrum make-up water supply and chemical treatment program. Components, except those specified or indicated otherwise, shall be housed in one or more joined or divided steel enclosures.

B. System Functions:

1. Automatically maintain a predetermined, selectable, total dissolved solids concentration through a continuously monitoring conductivity controller, maintain a predetermined, selectable, scale/corrosion inhibitor and dispersant residual, through a continuously make-up monitoring meter/counter/timer and inhibitor/dispersant ratio controller; achieve a predetermined, selectable, peak concentration of one or two microbiocides as needed on an alternating basis, through a programmable timer controller. De-energize controller or stagger feed chemicals that would degrade or could be incompatible if fed simultaneously.
2. Automatically maintain a predetermined, selectable, pH level through a continuously monitoring pH controller. For systems with make up water alkalinity in excess of 125 PPM or hardness above 300 PPM, provide acid feed limit timer and audible/visual alarm actuated on low pH.

C. Main control panel and accessories:

1. Housed in a NEMA Type 4X enclosure:
 - a. Hinged key lock door with viewing window.
 - b. Hard wire connected to power source.
 - c. Provide minimum of three (3) 115V, 1 Ph, 60 Hz receptacles located on enclosure for electrical connection and control of chemical pumps.
 - d. Prewired for ease of installation.
2. Provide an external combination mounted flow switch with transparent sight tube.
 - a. Disable control outputs upon loss of water flow to prevent chemical feeding.
 - b. Provide complete with 3/4 inch connections and combination conductivity and temperature electrode.

3. Keypad or remote control: Access all measurements and set points through chemical resistant key pad or remote.
 - a. Security code to prevent unauthorized access.
4. Utilize microprocessor technology.
5. Menu driver programs.
6. Liquid crystal display (LCD).
7. Provide temperature corrected measurements by reading water temperature and adjusting conductivity values according to known temperature curve.
 - a. Range: 32-212 deg F with an adjustable high alarm.
8. Provide real-time clock.
9. Conductivity monitor:
 - a. Provide linear measurements of full range.
 - b. Provide two scales for selection of high and low in field to assure accurate measurements.
 - c. Provide increments of 1 microohm/cm with adjustable hysteresis.
 - d. Provide bleed-off control in following manner:
 - 1) Standard operation-controller actuates a bleed off solenoid valve when dissolved solids level is exceeded by trip point.
 - 2) Provide an adjustable bleed limit timer to prevent excessive bleed off.
 - 3) An alarm contact shall close when timer has timed out.
10. Biocide operation:
 - a. Provide a programmable 28 day biocide timer for accurate addition of algaecide.
 - b. Provide a secondary bleed off timer to lower conductivity in system prior to biocide feed.
 - c. Lock out cooling water bleed-off during biocide feed period.
11. Chemical feed control: Provide three timers that are capable of operating in one of following field programmable modes.
 - a. Counter-timer-chemical feed proportioned to make-up water rate.
 - 1) Controller shall send low voltage signal to a contacting head water meter.
 - 2) Low voltage signal will ensure long contact life.
 - 3) Water meter shall read in gallons.
12. Alarms:
 - a. Provide alarm LEDs with silence button for high and low conductivity, 10-60 minute bleed-off, chemical feed limit timers,

and chemical drum level. Provide remote output relay to indicate alarm condition to Building Control System specified under Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

13. Controller operating data history:
 - a. Retain in memory all operating data for following parameters:
 - 1) Standard memory shall allow acquisition and storage of all analog inputs for a one-week period.
 - 2) A three (3) hour minimum, maximum average of all conditions shall be stored for a one-week period.
 - 3) A minute-by-minute account of operating conditions shall be available for latest three-hour period.
14. Electrode: Combination temperature and conductivity type.
 - a. Quick disconnect.
 - b. Supplied in flow switch assembly.
15. Ph monitor:
 - a. Sensor for monitoring purposes only.
 - b. Acid shall not be used to control pH.
- D. Impulse water meter:
 1. General:
 - a. Measure in gallons.
 - b. Sized to meter peak make up rates.
 - c. Equipped with an electrical contacting register.
 - d. Totalize flow at main control panel.
 2. Provide at following locations:
 - a. Cooling tower make up lines.
- E. Provide CPVC injection nozzles, ASTM F441 with corporation stop to inject chemical into main circulating water line.
 1. Pressure rating: 100 PSI
 2. Size: DN20 (3/4 IN) NPT.
 3. Quantity: Three (3).
- F. Provide chemical feed pumps operated by a 115V, 60 cycle, single phase motor.
 1. Provide separate stroke and stroke frequency setting capabilities.
 2. Positive displacement type pump
 - a. Provide with anti-siphon/pressure relief valve installed on pump head which provides anti-siphon protection and aids in priming under pressure.
 - b. Capacity: As determined by Water Treatment Vendor.

- c. Complete with discharge check valves, foot valves, polyethylene suction and discharge tubing.
- 3. Quantity: Provide one pump for each chemical provided.
- G. Bleed-off piping assembly:
 - 1. Inlet shut-off valve.
 - 2. Wye strainer.
 - 3. Strainer blowdown valve.
 - 4. Throttling valve.
 - 5. Brass solenoid valve compatible with main control panel.
 - 6. Assembly shall be sized by Water Treatment Vendor.
- H. Secondary containment double wall chemical drums:
 - 1. Material: Polyethylene.
 - 2. Capacity: 62 or 120 gallons each.
 - 3. Provide one tank for each chemical, as required by chemical treatment contractor.
- I. Provide liquid level switch assemblies with a CPVC bung hole adapter, ASTM F441, to mount directly into 55 GAL chemical drum bung hole.
 - 1. Interface with main control panel.
 - 2. Quantity: Three (3).
- J. Provide test kits for monitoring inhibitor levels, total dissolved solids, chlorides, alkalinity and closed system inhibitors.
- K. Provide one (1) year's supply of chemical treatment including quantity of chemicals necessary to chemically treat system to control scale, corrosion and biological fouling. Provide water treatment products that perform the following:
 - 1. Inhibitor to protect against corrosion and scale formation.
 - 2. Two liquid biocides for prevention of slime, bacteria and algae.
 - 3. Chromate based chemical are unacceptable.
 - 4. Water treatment chemicals to remain stable throughout operating temperature range.
 - 5. Are compatible with pump seals and other elements in the systems.
 - 6. Maintain required pH balance to prevent precipitation and/or breakdown of circulating fluid.
- L. Chemicals: Provide sufficient chemicals for start-up and testing and twelve months operation from date of project acceptance.
 - 1. Scale/corrosion inhibitor: Provide a concentrated liquid organic corrosion/scale/ fouling inhibiting formation without phosphates, chromates, zinc and other materials in excess of allowable, local,

- effluent limits. Feed automatically. Maintain residual as determined by water treatment laboratory.
2. Dispersant: Provide a concentrated liquid organic/polyelectrolyte formulation. Feed automatically. Maintain residual as determined by water treatment laboratory.
 3. pH Control: Depending upon local water conditions, provide 60 or 66 degree Baume technical grade, concentrated sulfuric acid for acidic treatment or sodium hydroxide (NaOH) for basic treatment to maintain pH in the range of 7.0 to 8.0 automatically. Provide one initial 12.5 gallon carboy of acid or base and one spare carboy of acid or base, if required.
 4. Microbiocides: Provide two different, one oxidizing and one non-oxidizing, concentrated algaecide-biocide formations containing no heavy metals and which are effective at maximum encountered pH. Alternate solutions as needed to effectuate selective kill without build-up of immunity. Period treatment with a chlorine releasing agent is permissible within allowable, local, effluent limits. Feed automatically. Develop peak concentration and maintain for minimum period as determined by water treatment laboratory.
 5. All chemicals to be acceptable for discharge to sanitary sewer.
- M. Water Analysis: Confirm raw water analysis or provide analysis if none is furnished:
- Description Year (Avg.)
- Silica (SiO₂) _____
- Iron & Aluminum _____
- Calcium (Ca) _____
- Magnesium (Mg) _____
- Sodium (Na) & Potassium (K) _____
- Carbonate (CO₃) _____
- Bicarbonate (HCO₃) _____
- Sulfate (SO₄) _____
- Chloride (Cl) _____
- Nitrate (NO₃) _____
- Turbidity _____
- pH _____
- Residual Chlorine _____
- Total Alkalinity _____
- Non Carbonate Hardness _____

Total Hardness _____

Dissolved Solids _____

N. Conduct performance test to prove capacity and performance of treatment system.

1. Raw water total hardness, PPM

2. Concentration cycles

3. Raw water, pH

4. System water, pH

5. Chemical solution used

6. Acid solution used

7. Quantity of chemical solution injected into system per cycle

8. Quantity of acid injected into system per cycle

9. Make up water required

10. Waste to drain requirement

O. Chemical Treatment System Piping and Valves

1. Schedule 80 CPVC and fittings. Pipe size shall be 25 mm (1 inch) unless otherwise shown.

2. Ball Valves: CPVC type.

2.4 GLYCOL-WATER SYSTEM

A. Provide coolant in accordance with engine manufacturer's recommendations. Basis of design uses inhibited ethylene glycol. 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: 35 percent for engine cooling system and aftercooler.

2.5 EQUIPMENT AND MATERIALS IDENTIFICATION

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

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. Bleed off water piping with bleed off piping assembly shall be piped from pressure side of circulating water piping to a convenient drain. Bleed off connection to main circulating water piping shall be upstream of chemical injection nozzles.
 3. Provide piping for the flow assembly piping to the main control panel and accessories.
 - a. The inlet piping shall connect to the discharge side of the circulating water pump.
 - b. The outlet piping shall connect to the water piping serving the cooling tower downstream of the heat source.
 - c. Provide inlet Y-strainer and ball valves to isolate and service main control panel and accessories.
 4. Install injection nozzles with corporation stops in the water piping serving the cooling tower downstream of the heat source.
 5. Provide installation supervision, start-up and operating instruction by manufacturer's technical representative.
- D. Before adding cleaning chemical to the closed system, all heat exchangers 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 in 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 HX. Also, clean all strainers.
- G. Perform tests and report results in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
- H. After cleaning is complete, and water PH is acceptable to manufacturer of water treatment chemical, add manufacturer-recommended amount of chemicals to systems.
- I. Instruct VA personnel in system maintenance and operation in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

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SECTION 23 65 00
COOLING TOWERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Packaged, induced draft open circuit cooling tower and forced draft closed circuit fluid cooler as scheduled on the drawings, complete with fill, fan, inlet louvers, sump heaters, level controls, and associated accessories and equipment.

1.2 RELATED WORK

- A. Seismic Restraint for Equipment: Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION: General mechanical requirements and items, which are common to more than one item.
- C. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- D. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT: Requirements for vibration isolation.
- E. Section 23 21 13, HYDRONIC PIPING: Requirements for water piping and fittings.
- F. Section 23 31 00, HVAC DUCTS and CASINGS: Requirements for sheet metal ductwork.
- G. Section 26 29 11, 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 a 30 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 5 feet from in any direction from the tower shall not exceed 75dB (A). Select "low Noise" model cooling towers, where available. Sound levels shall be measured with a Type 1 (precision) system and in full conformance with ATC-128 test code published by the Cooling Technology Institute (CTI). The measurement system shall have a real-time frequency analyzer and separate microphones with an overall tolerance +/- 3 dB. All low sound options shall be CTI

Certified for thermal performance. Provide sound attenuators if necessary to meet the noise criteria.

C. Performance Criteria:

1. Cooling towers shall meet the performance requirements scheduled on the drawings. 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 horsepower, and pump head at base of tower. Certification shall be made at the time of submittal.
2. The thermal ratings of the Cooling 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 fans, motors and drive shaft as installed shall be aligned and balanced at the factory.

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. Include electrical rating, detail wiring for power, signals and controls.
4. Pump characteristic curve for the closed circuit fluid cooler.
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 COR two weeks prior to delivery of the equipment.
2. Two weeks prior to final inspection, submit four copies of the following to the COR:
 - a. Certification from the manufacturer that the cooling tower(s), accessories, and components are suitable for seismic design

category D installations and that the unit will be fully operational after the seismic event at the project site.

- b. Certification by the manufacturer that the cooling towers conform to the requirements of the drawings and specifications.
- c. Certification by the Contractor that the cooling towers have been installed, adjusted, and tested.

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)
ATC-105S-Rev. July 2004.Acceptance Test Code for Closed Circuit 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, cross-flow type with a vertical discharge configuration.
- B. Casing: Heavy gage (minimum 16 gage) Stainless Steel or Fiberglass Reinforced Plastic (FRP) with UV inhibitors.
 - 1. All components of the cooling tower shall be fabricated of series 300 stainless steel: ASTM A666, Type 301L or 304. The tower shall be capable of withstanding water having a chloride content (NaCl) up to 750 ppm; a sulfate content (SO4) up to 1200 ppm; a calcium content (CaCO3) up to 800 ppm; and silica (SiO2) up to 150 ppm. The circulating water shall contain no oil, grease, fatty acids, or organic solvents.
 - 3. Fiberglass Reinforced Plastic: FRP with maximum flame spread rating of five according to ASTM E84 and with UV inhibitors.
 - 4. Fasteners: Stainless steel bolts or tapping screws for assembly. Use stainless steel washers with neoprene backing where required for preventing leaks.
 - 5. Joints and Seams: Sealed watertight.
 - 6. Welded connections: Continuous and watertight.
- C. Framing: Rolled or formed structural stainless steel conforming to ASTM A666, Type 301L or 304.
- D. Louvers:
 - 1. Spaced to minimize air resistance and prevent splash out. Louver materials shall be similar to the casings or may be polyvinyl chloride (PVC) if formed integral with the fill material.
- E. Fill: PVC or FRP, resistant to rot, decay and biological attack; with a maximum flame spread rating of five per ASTM E84 and fabricated, formed and installed by manufacturer to ensure that water breaks up into droplets.
- F. Drift Eliminators: Same as fill material. Effectively trap water droplets entrained in discharge air stream and limit drift loss to less

than 0.005 percent of the total water circulated. Sections shall be assembled into easily removable racks of the same material as the casing. Eliminators can be PVC neoprene honeycomb type.

- G. Hot Water Distribution System: Open basin, flume and troughs, or a pipe system with nozzles spaced for even distribution of water over fill material. Provide access door. System shall be self-draining and non-clogging. Spray nozzles, if used, shall be cleanable stainless steel, bronze or high impact plastic, non-clog, removable type properly spaced for even distribution. Provide cover for entire nozzle area or flume/trough area.
- H. Cold Water Collection Basin: Heavy gauge, stainless steel or FRP with UV inhibitors. Overflow, drain not less than DN (Deutsches Normung) 50 (NPS (Nominal Pipe Size) 2), and a 304 stainless steel strainer assembly with openings smaller than nozzle orifices and with built-in vortex baffling to prevent cavitation and air entrainment in the water basin circulating pump.
- I. Accessories: Make-up water, overflow and drain connections.
- J. Collection Basin Water Level Control: Electronic operated with remote (indoor) mounted slow closing 120V solenoid valve and NEMA MG 1, Type 4x enclosure, water level probes and probe stilling chamber. The control system shall monitor the water level in the cold-water basin to determine level events used for cold-water make-up, high and low alarms or pump shut down. The control panel shall use electromechanical relays providing power for the make-up solenoid and electrical contacts for alarm and pump shutdown control circuits. Probes shall be contained in a vertical stilling chamber to stabilize the water in the cold-water basin. Probes shall have replaceable stainless steel tips and level height shall be field adjustable. Solid state controls with stainless steel electrode probes and relays factory wired to a terminal strip to provide control of makeup and drain valves, low and high level alarms and output for shutoff of pump on low level.
- K. Fans: Heavy duty axial flow type, Gear or direct driven and balanced at the factory after assembly, with cast aluminum or aluminum alloy FRP blades. Fans shall be driven by variable speed motor. The fan drive and moving parts shall be completely enclosed by removable hot dip galvanized or stainless steel screens and panels complying with OSHA regulations. Fan shaft bearings of the self aligning, grease-

lubricated ball or roller bearings with moisture proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 degrees F. Bearings designed for an L-10 life of 50,000 hours and with extended lubrication lines to an easily accessible location outside of the wet air stream. Provide large stainless steel access doors for inspection and cleaning.

L. Motors and drives:

1. The alignment and balancing of the fans, motors and drive shaft as installed shall operate without objectionable noise and vibration, within the vibration limits specified in specification Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
2. In addition to the requirements of specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION, the following shall apply:
 - a. Motors: Totally enclosed or epoxy encapsulated NEMA MG 1. Protect fan, bearings, and appurtenances from damage by weather, corrosion, water spray and grit. Provide motors with severe duty rating with the rotor and stator protected with corrosion-inhibiting epoxy resin, double shielded, vacuum-degassed bearings lubricated with premium moisture-resistant grease suitable for temperatures between minus 20 and plus 300 degrees F, and an internal heater automatically energized when motor is de-energized. Provide an adjustable motor base or other suitable provision for adjusting belt tension as required.
 - b. Fan(s) shall be driven through a gear reducer, a V belt, or direct driven.
 - 1) Gear reducer drive: Specially designed for cooling tower operation, with dynamically balanced drive shaft assembly or shock absorbent flexible coupling requiring no lubrication, cast iron case with readily accessible oil drum and fill, and self-contained oil reservoir sealed against water entrance.
 - 2) V Belt Drive: Fan shall be driven by a one-piece, multi-groove, neoprene/polyester belt, where this is the manufacturer's standard. Belt drives shall be "V" type as specified in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION. Belt driven fan and

motor shafts shall have taper-lock sheaves fabricated from corrosion resistant material.

- c. Motor Controllers: Provide variable speed motors and controllers, as scheduled on the drawings for cooling tower fans. See specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
 - d. Lubrication fittings shall be readily accessible outside the wet air stream. Provide access doors for inspection and cleaning.
 - e. Fans over 60 inches in diameter shall include a vibration cutout switch located in a protected position to effectively monitor fan vibration. Vibration switch shall be solid-state with adjustable time delay in NEMA 250, Type 4 enclosure. It shall stop fan motor and provide an alarm contact under excessive fan vibration. Interface the vibration cut-out switch with the DDC control system to provide an alarm in the event the fans stop due to excessive vibration.
- M. Safety: Provide fan guards, ladders, handrails and platform in conformance with the ANSI A10.18 as follows:
- 1. Fan Guard: Removable fan discharge with a rigid framed screen guard, installed over the fan cylinder.
 - 2. Ladders: Vertical hot-dip galvanized steel or aluminum ladder for each tower located outdoors. Ladders higher than 12 feet shall have safety cage. Ladders shall extend to within one foot of the grade.
 - 3. Hand Railing: Steel or aluminum hand railings not less than 42 inches high around perimeter of each fan-deck, or working surface 12 feet or more above ground, roof or other supporting construction. Handrails shall meet OSHA Standards. Steel hand rails shall be hot dip galvanized after welding, or stainless steel.
 - 4. Platform: Galvanized steel with a bar grating floor.
- N. Electric Basin Heater: Furnish stainless steel electric immersion heater installed in a threaded coupling on the side of the basin and with watertight junction boxes mounted in the basin with sufficient capacity to maintain plus 40 degrees F water in the basin at -10 degrees F ambient. Provide a NEMA Type 4 control panel mounted on the side of each cooling tower cell with magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Provide a water-level probe to monitor cooling

tower water level and de-energize the heater when the water reaches low-level set point. Provide a control-circuit transformer with primary and secondary side fuses, terminal blocks with numbered and color-coded wiring to match wiring diagram, Single-point, field-power connection to a nonfused disconnect switch and heater branch circuiting complying with NFPA 70. Provide a Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquid tight conduit.

2.2 FORCED DRAFT CLOSED CIRCUIT FLUID COOLER

- A. Cooler shall be a factory assembled, forced draft, counter-flow type with a vertical discharge configuration.
- B. Casing: Heavy gage (minimum 16 gage) Stainless Steel or Fiberglass Reinforced Plastic (FRP) with UV inhibitors.
 - 1. Stainless Steel: ASTM A666, Type 304.
 - 2. Fiberglass Reinforced Plastic: FRP with maximum flame spread rating of five according to ASTM E84 and with UV inhibitors.
 - 3. Fasteners: stainless steel bolts or tapping screws for assembly. Use stainless steel washers with neoprene backing where required for preventing leaks.
 - 5. Joints and Seams: Sealed watertight.
 - 6. Welded Connections: Continuous and watertight.
- C. Framing: Rolled or formed structural stainless steel conforming to ASTM A666, Type 304.
- D. Drift Eliminators: Same as fill material. Effectively trap water droplets entrained in discharge air stream and limit drift loss to less than 0.005 percent of the total water circulated. Sections shall be assembled into easily removable racks of the same material as the casing. Eliminators can be PVC neoprene honeycomb type.
- E. Cold Water Collection Basin: Heavy gauge stainless steel or FRP with UV inhibitors. Overflow; drain not less than 2-inches, and a 304 stainless steel strainer assembly with openings smaller than nozzle orifices and with built-in vortex baffling to prevent cavitation and air entrainment in the water basin circulating pump.
- F. Collection Basin Water Level Control: Electronic operated with remote (indoor) mounted slow closing 120V solenoid valve and NEMA MG 1, Type 4x enclosure. Solid state controls with stainless steel electrode probes and relays factory wired to a terminal strip to provide control

of makeup valve, low and high level alarms and output for shutoff of pump on low level.

- G. Cooling Coil Sections: Copper tube with stainless-steel sheet or Stainless-steel tube and sheet, tested at 350 psig air pressure under water. Slope tubes to permit free drainage of fluid. Design and manufacture and test coils according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and bearing ASME "U" stamp. Design coil and casing housing section for easy removal of coil. Coil section shall be of the serpentine design type with coil tubing welded into service pipe connection header. Provide flanged piping connections suitable for field mounting on the vent, supply and return water lines to the coil.

- H. Water Distribution System: Open gravity type or individual removable non-clogging spray nozzle type and specifically designed that each trough or spray nozzle extends the entire length of the cooling coil section to complete wetting of the cooling coil at all times. The unit spray distribution system shall evenly distribute the spray water over the coil, continuously wetting the coil. The spray nozzles shall be made of PVC and are of a large-orifice design to help prevent clogging. The spray nozzle shall distribute the water in a full 360-degree radius for maximum distribution. The internal piping shall be schedule 40 PVC or stainless steel to prevent spray system corrosion. The spray system piping shall extend through the unit casing to allow flushing of the system when needed. The spray nozzles, which shall be attached to the piping with stainless steel clamps, can be inspected or removed through one of the stainless steel access doors.

The re-circulating unit pump shall be a close-coupled, centrifugal type pump that uses a mechanical seal. The pump is specifically sized for the spray system and is located on the unit skid for easy access. The pump motor shall be an ODP, 1 hp motor suitable for service on 460 volts, 3 phase 60-hertz systems.

Provide corrosion resistant hangers and supports designed to resist movement during operation and shipment.

- I. Cooling Water Distribution Circulating Pump: Close coupled bronze fitted or stainless steel centrifugal circulating pump with mechanical seal suitable for outdoor use, suction strainer, and flow balancing valve. A stainless steel anti-vortexing hood shall be provided on pump

suction. Pump shall be completely piped to suction strainer and water distribution system, mounted to drain completely when tower basin is drained. Include a bleed line with valve between pump discharge and overflow pipe. Pump motor shall be wired to factory installed control-starter panel. For pump motor, see specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

1. Spare Pump - Provide a Factory Mounted second pump with motor and riser with Auto Change-Over. The system shall include gate valves and check valves on both risers, and one flow switch in each riser.

J. Fans: Centrifugal double width, double inlet, forward curved blades, belt driven and statically and dynamically balanced at the factory after assembly. Hot-dip galvanized steel centrifugal fans belt driven by variable speed motor. The fan drive and moving parts shall be completely enclosed by removable hot-dip galvanized screens and panels complying with OSHA regulations. Fan shaft bearings of the self aligning, grease-lubricated ball or roller bearings with moisture proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 degrees F. Bearings designed for an L-10 life of 200,000 hours and with extended lubrication lines to an easily accessible location outside of the wet air stream. Provide access doors for inspection and cleaning.

K. Motors and Drives:

1. The alignment and balancing of the fans, motors and drive shaft as installed shall operate without objectionable noise and vibration, within the vibration limits specified in specification Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
2. In addition to the requirements of specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION, the following shall apply:
 - a. Motors: Totally enclosed or epoxy encapsulated NEMA MG 1. Protect fan, bearings, and appurtenances from damage by weather, corrosion, water spray and grit. Provide motors with severe duty rating with the rotor and stator protected with corrosion-inhibiting epoxy resin, double shielded, vacuum-degassed bearings lubricated with premium moisture-resistant grease suitable for temperatures between minus 20 and plus 300 degrees F, and an internal heater automatically energized when motor is de-

- energized. Provide an adjustable stainless steel motor base or other suitable provision for adjusting belt tension.
- b. V Belt Drive: Fan shall be driven by a one-piece, multi-groove, neoprene/polyester belt, where this is the manufacturer's standard. Belt drives shall be "V" type as specified in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION. Belt driven fan and motor shafts shall have taper-lock sheaves fabricated from corrosion resistant material.
 - c. Motor Controllers: Provide variable speed motors and controllers, as scheduled on the drawings for cooling tower fans. See specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
 - d. Lubrication fittings shall be readily accessible outside the wet air stream. Provide access doors for inspection and cleaning.
 - e. 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.
- L. Electric Basin Heater: Furnish stainless steel electric immersion heater installed in a threaded coupling on the side of the basin and with watertight junction boxes mounted in the basin with sufficient capacity to maintain plus 40 degrees F water in the basin at -10 degrees F ambient. Provide a NEMA Type 3R enclosure mounted on the side of the cooler cell with magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Provide a water-level probe to monitor cooler water level and de-energize the heater when the water reaches low-level set point. Provide a control-circuit transformer with primary and secondary side fuses, terminal blocks with numbered and color-coded wiring to match wiring diagram, Single-point, field-power connection to a non-fused disconnect switch and heater branch circuiting complying with NFPA 70. Provide a metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquid tight conduit.
- M. Discharge Hood: Provide tapered, stainless steel discharge hood to direct cooling airflow up and away from the adjacent cooling tower and building.

- N. Safety: Provide fan guards, ladders, handrails and platform in conformance with the ANSI A10.18 as follows:
1. Fan Guard: Removable rigid framed screen guard, installed over the inlet side of the fan.
 2. Ladders: Vertical hot-dip galvanized steel or aluminum ladder for each tower located outdoors. Ladders higher than 12 feet shall have safety cage. Ladders shall extend to within one foot of the grade.
 3. Hand Railing: For units higher than 8 feet above grade, provide galvanized steel platform with a bar grating floor, and steel or aluminum hand railings not less than 42 inches high around perimeter of each fan-deck, or working surface 12 feet or more above ground. Handrails shall meet OSHA Standards.

2.3 CONTROL PANEL

- A. Provide factory furnished control panel for each cooling tower and fluid cooler.
- 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. Provide contacts for remote start/stop and for Engineering Control Center (ECC) interface.

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. Refer to structural drawings and specifications.
- C. Install vibration controls according to manufacturer's recommendations.
- C. Install anchor bolts to elevations required for proper attachment to supported equipment.
- D. Maintain manufacturer's recommended clearances for service and maintenance.
- E. 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: Connect to water-level control with shutoff valve and union, flange, or mechanical coupling at each connection. Pitch piping down to drain at the lowest point. Low point shall be equipped with automatic drain valve controlled by the DDC system that opens when cooling tower sump is emptied.
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, thermometer, plugged tee with pressure gage, and drain connection with valve. Connect to leaving cooling tower connection with shutoff valve. Make connections to cooling tower with a flanged, grooved, or mechanical coupling.
- F. Seismic Restraints: Provide in accordance with Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- G. Electrical Wiring: Install any electrical devices, components and accessories furnished loose by manufacturer, including remote flow switches and variable frequency drives.

3.2 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. Verify proper oil level in gear-drive housing. Fill with oil to proper level.
7. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
8. Check vibration switch setting. Verify operation.
9. Verify operation of basin heater and control.
10. Operate equipment controls and safeties.
11. Verify that tower discharge is high enough and it does not recirculate into HVAC air intakes. Recommend corrective action if necessary.
- 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 COR.
- K. Replace defective and malfunctioning units.

3.3 TRAINING:

- A. Furnish the services of a competent, factory-trained engineer or technician for a 2-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 COR. Coordinate this training with that of the chiller, if furnished together.

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SECTION 482010

NATURAL GAS-FUELED COMBINED HEAT & POWER FACILITY GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the overall scope of supply, basic requirements and minimum level of performance and quality for a natural gas-fueled Combined Heat & Power (CHP) facility.

1.2. RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS: General construction practices.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES: Submittals.
- C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS: General requirements for commissioning.
- D. Section 23 05 93 TAB
- E. Section 23 07 11 INSULATION
- F. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS
- G. Section 23 11 23 NATURAL GAS PIPING
- H. Section 23 21 13 HYDRONIC PIPING
- I. Section 23 51 00, BREECHINGS, CHIMNEYS, AND STACKS
- J. Section 23 65 00, COOLING TOWERS: General requirements for cooling towers and related equipment.
- K. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical installation requirements.
- L. Section 26 05 13, MEDIUM-VOLTAGE CABLES: Requirements for medium-voltage cables, splices, and terminations.
- M. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Requirements for current conductors.
- N. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for grounding.
- O. Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS: Requirements for boxes, conduits, and raceways.
- P. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Requirements for

forming a complete underground raceway system.

- Q. Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS: Requirements for commissioning the electrical system, subsystem, and equipment.
- R. Section 26 12 19, PAD-MOUNTED, LIQUID FILLED, MEDIUM-VOLTAGE TRANSFORMERS: Requirements for pad-mounted transformers.
- S. Section 26 13 13, MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR: Requirements for medium-voltage switchgear.
- T. Section 26 22 00 LOW-VOLTAGE TRANSFORMERS: Requirements for low voltage dry type transformers.
- U. Section 26 24 16, PANELBOARDS.
- V. Section 26 29 11, MOTOR CONTROLLERS.
- W. Section 26 29 21, ENCLOSED SWITCHES AND CIRCUIT BREAKERS.
- X. Section 23 09 11, INSTRUMENTATION AND CONTROL FOR CHP PLANT:
General requirements for plant controls.

1.3. DEFINITIONS

- A. Commissioning Authority: An entity identified by the COR who plans, schedules and coordinates the Commissioning Team to implement the Commissioning Process.
- B. Commissioning Plan: A document prepared and updated by the Commissioning Authority, the Commissioning Plan outlines the organization, schedule, allocation of resources, and documentation requirements of the Commissioning Process.
- C. Commissioning Process: A quality focused process for enhancing the delivery of a project. The Process focuses on verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the design intent. Commissioning is typically abbreviated by "Cx". Commissioning and Cx have the exact same meaning and will be used interchangeably throughout the Contract documents.
- D. Commissioning Team: The team is comprised of the selected leader from each individual company constructing the equipment and/or systems to be commissioned. These individuals through coordinated actions are responsible for implementing the Commissioning Process.

- E. Contractor: General Contractor selected to provide the described CHP facility
- F. Corrective Issue Report (CIR): A report generated by the (Cx) Authority during Performance Testing documenting issues found during the performance of functional and integrated system testing procedures that require follow-up corrective action.
- G. COR: VA Contracting Officer's Technical Representative
- H. Functional Performance Testing (FPT): The process by which specific documents, components, equipment, assemblies, systems, and interfaces among systems are confirmed to comply with the criteria described in the sequence of operation and contract documents.
- I. Integrated Systems Testing (IST): The process by which various systems and their cooperative interaction and operation are confirmed to comply with the sequence of operation and contract documents (e.g. a gas engine, heat recovery hot water generator, and peripheral equipment reacting to a shutdown).
- J. Pre-Functional Checklist (PFC): Documents prepared by the Cx Authority and issued to the Contractor at the commencement of the Construction Phase. The purpose of the Checklist is to verify that appropriate components are on site, correctly installed, functional and ready for Functional Performance Testing.
- K. Provide: Furnish and install, complete and ready for intended use.
- L. Supplier: Entity supplying equipment and/or materials to Contractor
- M. Unless otherwise specified or indicated, electrical and electronics terms used in this document shall be as defined in IEEE 100.

1.4. QUALITY ASSURANCE

- A. The Contractor shall demonstrate that they have successfully installed at least four projects that, in aggregate, equal or exceed the size of the proposed project. References shall be provided for each of these referenced projects.
- B. The Contractor shall have in place a complete and functioning comprehensive Quality Assurance program covering the design, procurement, fabrication, packaging and delivery of the specified systems, equipment and materials. This program shall ensure that the

equipment and materials furnished by the Contractor meet the requirements of contract documents as well as the Contractor's own procedures and processes. Process shall be included in submittals for review and approval by the COR.

- C. The COR shall be given the opportunity to witness all testing.
- D. The COR reserves the right to reject equipment or components which require major modification or alteration to meet contract documents.
- E. Non-conformances to this document and major equipment or component repairs that occur shall be documented and approved by the Commissioning Agent/COR in writing prior to testing and shipment.
- F. Software Quality Assurance (SQA):
 - 1. Establish an SQA plan that addresses software tests normally performed by programmers and tests performed to verify system operation.
 - 2. Perform software tests to benchmark functional evaluations, including the following:
 - a. Conformance to contract requirements.
 - b. Language deviation.
 - c. Error handling.
 - d. Operational speed.
 - e. Maintain a software error log to record occurrence, solution, and corrected resolution.
 - f. Furnish software programming as required to perform functions as specified. Provide annotations in the programming describing functions and changes such that the COR and others in the future can understand the logic so that changes can be readily made.
 - g. Provide software licensed to the Government in perpetuity.

1.5. SUBMITTALS

- A. Submit design documents, shop drawings, product data, and samples in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Contractor shall make all necessary field measurements and

investigations to assure that the equipment and assemblies will fit in the allotted space and meet contract requirements.

- C. 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 from the applicable other manufacturers, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.
- D. Submittals and shop drawings for independent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient installation. Final review and approvals will be made only with their completed groups.
 - 1. Shop Drawing Submittals: Submit Shop Drawings in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Shop Drawings shall be submitted for all products described in subsequent sections of this document. Shop drawings shall include a complete list of equipment and materials proposed for the project. All documents, drawings, and data submitted shall be in the English language, with English (IP) units.
- E. Product Data: Include detailed information for all components and materials of the CHP system including, but not limited to.
 - 1. Genset: Engine and generator performance data, design parameters, thermal output, power output, fuel input, CHP component power requirements, combustion air requirements, ventilation requirements, connection requirements, emission data, emission control data and noise octave band data.
 - 2. Drycoolers for heat shedding from high temperature engine (jacket and oil cooler) cooling loop: Performance data, construction details, dimensional and weight data, noise octave band data.
 - 3. Fluid Coolers for cooling the turbocharged combustion air via the aftercooler, as specified in section 23 65 00.
 - 4. Emission control systems: Oxidation Catalyst, engine low NOx control and tuning.

5. Heat Recovery Steam Generator: Performance data at the exhaust flow rate from the engine, unit size, configuration, construction details, trim controls and exhaust bypass assembly details, noise attenuation octave band data, controls and insulation.
 6. Plate and Frame Heat exchangers: Performance data corrected for the required glycol concentration, construction details, and dimensional data.
 7. Interconnecting piping, connection sizes, connection types, all related devices, control valves, control dampers, instrumentation and fittings connecting items 1 through 6 of this subparagraph F.
 8. CHP package Piping & Instrumentation diagrams including design flows, pressures and temperatures for 100% load, 75% load, 50% load and 25% load. Diagram shall show energy balance of CHP facility components.
 9. Control panel(s), hardware (controllers, sensors, human-machine interfaces, circuit boards, monitors, etc.) and software details to describe control sequences of engine-generator and accessories, all control components, all signals including control, alarms and safety sequences, and interconnection with other control systems as specified. Include dimensional data and clearance and access requirements for all panels.
 10. Wiring diagrams for electrical power and controls wiring with factory installed wiring and field installed wiring clearly described for this installation.
- F. Certificates: Submit technical representative's certification that the installation has been implemented as depicted by the contract documents and where applicable, recommended by the manufacturer.
- G. Manufacturer's Instructions and Operation and Maintenance Documentation:
1. Safety precautions
 2. Operator restart
 3. Startup, shutdown, and post-shutdown procedures
 4. Normal operations
 5. Emergency operations
 6. Environmental conditions

7. Preventive maintenance plan and schedule
8. Troubleshooting guides and diagnostic techniques
9. Wiring and control diagrams
10. Maintenance and repair procedures
11. Removal and replacement instructions
12. Spare parts and supply list
13. Operations and Maintenance submittal data
14. Parts identification
15. Testing equipment and special tool information
16. Warranty information
17. Testing and performance data
18. Contractor information

H. Closeout Submittals:

1. Contractor shall provide four (4) hard copy bound and two (2) compact disc copy sets of the Operations and Maintenance Manuals for all equipment and auxiliaries provided.
2. Provide a complete schedule of normally required inspection, preventative maintenance, predictive maintenance, and overhaul tasks and the outage hours required for all of the equipment and auxiliary systems supplied under the work of this contract, plus replacement parts associated with each task. Provide inspection and maintenance plans required to support the performance and minimum on-line availability specified herein. List requirements by year with a list of recommended spare parts for each through one entire overhaul cycle.
3. Provide a minimum of three (3) licenses/copies of all proprietary software required for installation, testing, tuning, or operation of the equipment, instrumentation, and/or protective devices furnished under this scope.
4. At Contract completion the Contractor shall turn over two (2) neatly marked sets of reproducible record documents representing the "as-built" work to the Commissioning Agent and COR for verification.

1.6. APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this document to the extent referenced. Publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers / American National Standards Institute (ASME/ANSI):
- B16.5-2009 Pipe Flanges and Flanged Fittings
- B16.10-2009 Face to Face and End to End Dimensions of Valves
- B16.34-2009 Valves-Flanged, Threaded, and Welding End
- B31.1-2012 Power Piping
- C. ASME Boiler and Pressure Vessel Code (BPVC):
- Section I-2013 Rules for Construction of Power Boilers
- Section VIII-2013: Rules for Construction of Pressure Vessels
(Div. 1)
- Section IX-2013: Welding and Brazing Qualifications
- D. ASME Performance Test Codes (PTC):
- 46-1996 Overall Plant Performance
- E. American Petroleum Institute (API):
- 614-2008 Lubrication, Shaft-sealing and Oil-Control Systems and Auxiliaries
- 686-2009 Machinery Installation and Installation Design
- F. American Welding Society (AWS):
- QC1-2007 Standard for AWS Certification of Welding Inspectors (2007)
- G. Hydraulic Institute (HI):
- 1.1-1.2-2008 Centrifugal Nomenclature
- H. Institute of Electrical and Electronics Engineers (IEEE):
- 100-2009 IEEE Standards Dictionary: Glossary of Terms and Definitions
- C2-2012 National Electric Safety Code (NESC) 1547-2003 Standard for Interconnecting Distributed Resources with Electric Power

Systems

I. International Code Council (ICC):

IBC-2012 International Building Code

J. International Society of Automation (ISA):

5.1-2009 Instrumentation Symbols and Identification

K. Manufacturers Standardization Society (MSS):

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

L. National Electric Manufacturers Association (NEMA):

Guide to Preparing a Design Proposal for Paralleling Customer
Generation with an Electric Utility

MG 1-2011 Motors and Generators

M. National Fire Protection Association (NFPA):

37-2010 Standard for the Installation and Use of Stationary
 Combustion Engines and Gas Turbines

54-2012 National Fuel Gas Code

70-2011 National Electric Code (NEC)

85-2011 Boiler and Combustion Systems Hazard Code

N. Underwriters Laboratories (UL):

142-2006 Steel Aboveground Tanks for Flammable and Combustible
 Liquids

O. VHA Boiler Plant Safety Device Testing Manual

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide equipment and materials to construct a fully functioning Combined Heat and Power (CHP) facility to provide electricity, hot water, and chilled water to the Salt Lake City, Utah VA hospital, utilizing natural gas as the primary fuel source.
- B. The new plant will burn natural gas fuel in a Combined Heat and Power (CHP) arrangement. The fuel shall be combusted directly in a prime mover which will generate electric power, and the resultant waste heat

from the prime mover will be utilized to generate steam, hot water and chilled water for heating and cooling needs.

- C. A process flow diagram depicting the desired CHP configuration is included in contract plans.

2.2 COMBINED HEAT AND POWER SYSTEM

- A. Natural gas fuel supply system, valves, and interconnecting piping.
- B. One CHP module, including:
 - 1. Natural gas-fueled combustion reciprocating engine-generator set to generate electric power.
 - 2. Heat Recovery Steam Generator to utilize the waste heat from the exhaust gases from the prime mover.
 - 3. An air cooled radiator (dry-cooler) with associated pumps and controls.
 - 4. A closed-circuit evaporative fluid cooler for cooling combustion air after compression in a turbocharger (after cooler).
 - 5. Emissions and pollution control systems including catalyst and all necessary auxiliary equipment and controls.
 - 6. CHP module control panel.
 - 7. Plate and frame heat exchanger to recover heat from engine jacket and oil cooler.
 - 8. Equipment interconnecting piping.
 - 9. All necessary controls and wiring.
 - 10. Exhaust system.
 - 11. Starting System, including air motor, air compressor, and compressed air storage tank with capacity in accordance engine manufacturer's specifications.
 - 12. Lubrication Oil storage tank and automatic feed system.
 - 13. Acoustic enclosure.
- C. Provide interconnecting piping, valves, pipe supports, flexible connections, vibration isolation, insulation, piping specialties, miscellaneous pumps, cable/conduit, interconnecting wiring, instrumentation, and controls as specified herein and otherwise required

to provide complete and functioning plant systems.

D. Shop testing and field testing as specified herein and otherwise required by codes referenced herein.

E. Startup and commissioning of all plant systems provided in this work scope.

F. Operations and maintenance training for all plant systems provided in this work scope.

G. Maintenance service for a five year period following acceptance of the CHP system by the VA.

2.3 PERFORMANCE GUARANTEES

The CHP facility specified herein shall be designed to generate the range of production capacities tabulated below and scheduled on the drawings on a continuous basis.

Genset	100% load
Electrical Power, KW (ISO 8528-1)	2,650
Thermal Output Engine Exhaust MBTU/hr	3,968
Thermal Output Engine Jacket Water MBTU/hr	3,197
Thermal Output Oil Cooler MBTU/hr	1,113
Thermal Output Load Side of Plate and Frame Heat Exchanger MBTU/hr	4,310

Load Side of Plate and Frame Heat Exchanger performance parameters	600 gpm LWT 188 degF EWT 172 degF
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- A. The natural gas fuel consumption for the CHP facility specified herein shall be guaranteed not to exceed the following for the described load conditions at the generated power and heat levels specified earlier, utilizing natural gas with LHV = 1,046BTU/SCF (20,920 BTU/LB) as the basis:

Natural Gas Fuel Consumption of Genset	100% Load	75% Load	50% load
MBTU/hr	22,048	17,137	12,261
CF/hr	20,112	15,662	11,228

- B. The electrical, thermal and overall CHP generator-engine efficiencies shall be guaranteed meet or exceed the following:

Efficiency Genset	100% Load	75% Load	50% load
Electrical Efficiency (%)	42.8	41.2	38.3
Thermal Efficiency (%)	43.6	44.9	46.6
Total Efficiency (%)	86.0	85.9	84.7

- C. Emissions of the noted pollutants for the CHP facility specified herein shall be guaranteed not to exceed the following tables for the described load conditions. If no value for a pollutant is given in the tables below, the emissions shall comply with local, state and federal emission limit requirements.

Emissions at 100% Load

Pollutant	100% load (Leaving Engine- untreated)		After Treatment
	g/BHP-hr	Tons/year (8760 hr/yr)	Tons/year (8760 hr/yr)
NOx (as NO2)	0.49	18.12	18.12
CO	1.37	50.65	5.07
VOC (NMHC)	0.30	11.09	7.76
Particulate PM 2.5	0.01	-	
Particulate PM 10	0.01	-	
Formaldehyde HCHO	0.28	-	

D. Overall noise levels generated by the CHP facility specified herein shall be guaranteed to meet the following maximum noise criteria:

a. Control Room - 56 dBA (NC-50)

b. Offices - 50 dBA (NC-43)

c. 85 dBA in the adjacent generator room area outside of acoustic enclosure.

d. 125 dBA around the unenclosed generators

e. The CHP plant shall not increase the broadband sound level at the property boundary by more than 5 dB(A) above the current existing ambient noise levels. Sound levels shall meet the requirements of the Salt Lake City Code and the following maximum noise criteria:

f. 40 dBA at the south property line.

g. 65 dBA at the public area (parking lot)

h. There shall be no significant tonal sounds at community residents as certified by an acoustical engineering professional.

1. The overall A-weighted sound power level measured 3 feet from the exhaust outlet for the generator-engine's exhaust system shall not exceed 85 dBA.

2. The CHP facility shall not emit any noises or combination of noises which will exceed 55 dBA A-weighted sound power level measured 200 feet from the CHP facility.
3. Outdoor equipment (cooling towers, drycoolers) A-weighted sound power levels shall not exceed 75 dBA measured 3 ft from the equipment. Equipment which exceeds this level shall be provided with acoustic barrier screens.
4. The CHP plant shall not produce any "pure tone" condition. A "pure tone" exists if the sound pressure level, at any given octave band center frequency, exceeds the levels of the two adjacent octave bands by three (3) or more decibels. Submit report of sound pressure levels by octave band with CHP system running at half and full rated electrical output.

2.4 RECIPROCATING ENGINE GENERATOR

- A. The reciprocating engine-generator package shall include all features needed for safe, highly reliable, efficient, long-term operation. The design is based on the requirements of a Caterpillar CG-260-12 12 cylinder turbocharged natural gas fueled nominal 3 MW engine generator set. Design shall be in accordance with good engineering practice, applicable standards, and shall meet the strict demands typical of industrial power plants for safety and reliability, as well as those imposed by VA and all regulatory agencies having jurisdiction in the State of Utah. Engine generator equipment shall be selected from manufacturers who have been routinely engaged in the production of such equipment for a minimum of 10 years.
- B. The reciprocating engine generator packages shall be designed for automated, continuous duty electric power generation over the range of 1325 to 2650 KW at the project site elevation of 4,500 feet above sea level. Load control shall be automated to provide full power except when facility power consumptions is less than genset power production capacity. The genset output shall modulate to prevent export of power back to the utility.
- C. The package shall be furnished with all necessary gas, lube oil, compressed air, and cooling water connections, instrumentation, and controls for completely automated control, monitoring and testing. All connections shall be furnished with valves and fittings.

- D. The package shall be designed for indoor installation with indoor temperatures between 45 degrees F and 100 degrees F. The reciprocating engine generator shall be capable of sustained operation with utility pipeline natural gas fuel at the pressure available (15 psig) at Salt Lake City, Utah VA boiler plant.
- E. The unit shall be synchronized to the existing utility grid. The unit governor response time shall be rapid enough to allow stand-alone operation. Controls and operation shall be suitable for operation in parallel with the utility electrical grid, and as a stand-alone emergency generator.
- F. The reciprocating engine generator package shall be mounted on a structurally isolated reinforced concrete foundation, as indicated on the structural drawings. Foundation shall be designed utilizing dynamic analytical techniques (including evaluation of harmonic characteristics) to ensure that the anchorage is capable of withstanding both live and dead load characteristics as specified by the manufacturer without exceeding manufacturer's limits for displacement and vibration.
- G. The reciprocating engine generator package shall include, but not necessarily be limited to, the following:
 - 1. Engine generator package mounted indoors inside a ventilated acoustic enclosure inside the existing Rotoclave room.
 - 2. The following Design parameters shall be used:
 - a. Location: Salt Lake City, Utah.
 - b. Feet above sea level: 4,500 feet.
 - c. Temperature of ambient plant air for design & performance purposes: 77 degrees F.
 - d. Relative humidity of plant air for design purposes: 60% RH.
 - e. Fuel LHV: 1000 BTU/cubic foot (methane number 80)
 - 3. Electric Generator:
 - a. 12,470 V +/- 10%
 - b. 3 Phase, 4-Wire
 - c. 0.80 power factor
 - d. 60 Hz

- e. 900-1800 RPM (Basis of Design is 900 RPM)
- f. Continuous rated for grid parallel prime power (non-emergency)
- 4. Compressed air engine starting system, including air compressor, compressed air storage tank, and piping with heavy-duty starting motor that automatically engages and releases from engine flywheel.
- 5. Lube oil system, pumps and coolers for engine and generator, suitable for remote mounting, including interconnecting piping, filtering/purification system, thermostatic control valve, and crankcase drain, fresh lube oil storage tank and automatic feed, waste oil drain piping. Lube oil shall be cooled with the engine jacket coolant to recover heat from the lube oil.
- 6. A closed loop, liquid-cooled cooling system with radiator suitable for remote mounting on the roof, interconnecting piping, controls and electric coolant pump with a backup pump that automatically starts upon failure of the lead pump. Coolant shall be a solution of 35 percent (volume) ethylene-glycol-based antifreeze and 65 percent water (or as defined by the engine manufacturer) to provide freeze protection down at least -8 degrees F, with anticorrosion additives as recommended by engine manufacturer. Temperature Control shall be via a thermostatic 3 way control valve that modulates coolant flow to the dry coolers automatically to maintain optimum constant coolant inlet temperature as recommended by engine manufacturer.
- 7. Include Jacket glycol/water heat recovery system designed to transfer heat from the jacket glycol/water cooling loop to the new heating hot water heat recovery loop to be used to drive an absorption chiller, provide hot water heat for building 7, heat domestic hot water, and preheat steam system condensate.
 - a. Plate and frame heat exchanger with capacity, flows, and maximum pressure drops as scheduled on the drawings.
 - b. Expansion tank.
 - c. Temperature control valves, instrumentation, and controls as required to automatically maintain an operator-adjustable hot water set point temperature, as indicated on the drawings.
- 8. Include exhaust heat recovery steam generator (HRSG) that heats feed water from the existing boiler plant deaerators to generate 100 psig

steam, using heat from the engine exhaust gases. System shall include the following as a minimum:

- a. Exhaust Heat Recovery Steam Generator (HRSG)
 - b. Feed water control valve.
 - c. Water level controls.
 - d. Exhaust gas bypass damper and controls.
 - e. Internal circulation pump and VFD.
 - f. Control system for HRSG components with MODBUS interface for connection to the existing Boiler Control system.
 - g. HRSG shall provide a minimum sound attenuation to limit boiler exhaust outlet A- weighted sound power levels to 85 dBA at the discharge.
9. Fuel system for natural gas supply to the engine, including fuel control valves/pressure regulators, solenoid valves, vent valves, filters, gas detection, safeties and controls. Provide vent piping to outside as required.
 10. Interconnecting piping, tubing, and/or flexible hose connections as required between Supplier-furnished oil cooler, heat exchanger, glycol/water connection, gas piping, lube oil, and main package.
 11. Inlet air filter, heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator
 12. Manufacturer's standard stairs, platforms and safety rails (as needed) for maintenance.
 13. Filters for startup and commissioning of the engine, and two (2) complete sets of clean new filters upon turnover of the unit to COR.
 14. Maintain temperature rise of system components within required limits when unit operates at 100 percent of rated load for 2 hours with ambient temperature at top of range of ambient conditions specified herein.
 15. Exhaust piping connecting engine to heat recovery steam generator inlet and outlet to exterior of building, as indicated on the drawings and specified in section 23 51 00 - Breechings, Chimneys, and Stacks. Provide flexible connections and expansion exhaust bellows as recommended by the engine manufacturer and exhaust system manufacturer.

16. Provide muffler/silencer, critical type, sized as recommended by engine manufacturer and selected with the complete exhaust piping system, catalyst, and HRSG to not exceed 80 % of engine manufacturer's maximum backpressure requirements.
17. Insulation and cladding of hot equipment and exhaust system components for heat retention, noise reduction and personnel protection.
18. Personnel protection insulation required for 140 degrees F and above equipment surface temperatures, or as required by applicable codes and standards, whichever temperature is lower.
19. Instruments and equipment required for interface with distribution switchgear such as resistance temperature detectors, potential and current transformers, neutral ground resistor and associated current transformer.
20. Vibration monitoring, condition monitoring, and data management systems.
21. Real-time event recorder with first-out identification and reporting to the operator.
22. Steel base frame.
23. Base plates, shims, alignment/leveling equipment, vibration isolators, and any other mounting hardware required to set and align equipment and minimize transmission of engine vibration to the adjacent slabs and rooms.
24. Safety rails as required in accordance with OSHA standards. All safety ladders, hand rails, gratings, steps, external structural or support members shall be hot dipped galvanized.
25. Control valves, block valves and instrument isolation/root valves as required. Include required instruments and transmitters such as pressure and temperature indicators, resistance temperature detectors and thermometers, potential and current transformers.
26. Painting, suitable for exposure (indoor) and corrosion protection, appropriate for the corrosive effects of a typical power plant environment.
27. Safety guards in accordance with OSHA standards. Safety guards on exposed rotating parts shall be painted "Safety Yellow."

28. Adequately sized and positioned lifting lugs for all furnished equipment.
29. Expansion fittings in engine exhaust pipe to protect engine, heat recovery boiler, catalyst and building structure.
30. Computer-based engine control system including unit governor controls and synchronization controls compatible with local electric utility, meters, gages, alarms and miscellaneous controls, locally mounted in modular enclosure. All control equipment requiring a conditioned space shall be centrally located in a conditioned environment. Control system shall be provided with MODBUS interface for communication with the existing boiler plant control system.

2.5 HEAT RECOVERY STEAM GENERATOR

- A. Provide Heat Recovery Steam Generator (HRSG) as scheduled on the drawings and in accordance with the requirements specified herein. The basis of design unit is Cain Model ESG1-830H16CSS.
- B. The Heat Recovery Steam Generator package shall include all features needed for safe, highly reliable, efficient, long-term operation. Design shall be in accordance with good engineering practice, applicable standards, and shall meet the strict demands typical of industrial power plants for safety and reliability, as well as those imposed by VA and all regulatory agencies having jurisdiction in the State of Utah. HRSG shall be selected from manufacturers who have been routinely engaged in the production of such equipment for a minimum of 10 years.
- C. The HRSG shall use finned water tubes designed to utilize waste heat extracted from the prime mover exhaust stream to generate 100 psig steam (adjustable) for process use. The HRSG manufacturer shall provide a modulating full port bypass assembly to control process hot water temperature by modulating hot exhaust gas flow over the finned tube surfaces.
- D. All pressure parts shall be designed for operating and design pressure ranges corresponding to the equipment being served. The Heat Recovery Steam Generator shall be constructed and stamped in accordance with the most recent edition of the ASME Boiler and Pressure Vessel Code, Section I (Rules of Construction of Power Boilers) and Section VIII Div. 1 (Rules for Construction of Pressure Vessels) as applicable for 150 psig. The HRSG shall be registered with the National Board of Boiler and Pressure Vessel Inspectors. Provide a pressure relief valve sized for

the maximum capacity of the unit, with pipe connection to pipe relief outside.

- E. The HRSG shall be furnished with all necessary engine exhaust gas, drain and water connections, pumps, instrumentation, and controls for completely automated control, monitoring and testing. All connections shall be furnished with valves and fittings. Sample ports shall be provided with pipe caps or blind flanges.
- F. The HRSG package shall be designed for indoor installation. The package shall include, but not necessarily be limited to, the following:
 - 1. All necessary interconnecting ductwork including expansion joints, insulated and lined transition ducts to mate to the prime mover exhaust flange and all necessary gaskets and hardware. HRSG outlet to stack/breeching shall include expansion joint.
 - 2. All valves, relief valves, drains, vents, instrumentation and accessories required by ASME Sections I and VIII and ASME B31.1 as applicable. Exhaust compartment drain shall be accessible and shall have provisions for a drain valve which opens to drain moisture automatically on an adjustable schedule (timer).
 - 3. All HRSG external piping defined to be within the ASME Code Sections I and VIII jurisdictional limits.
 - 4. Ductwork for oxidation catalysts (refer to section on Emissions Control Equipment herein).
 - 5. Stack emissions sampling connections, as indicated on the drawings and in accordance with local, state and EPA requirements.
 - 6. Heat Recovery Hot Water Boiler shall include external exhaust gas bypass, with stainless steel construction and stainless steel, flanged, exhaust gas connections.
 - 7. The HRSG shall have a hinged, full face, gas tight, inspection door providing access to the entire heating surface for inspection, tube removal, and/or cleaning.
 - 8. All necessary instruments including an electronic flue gas by-pass damper actuator, and remote and local pressure monitoring to allow for automatic steam pressure control. Controls shall utilize a Programmable Logic Controller (PLC) with interface capability to the boiler control system and BMS.
 - 9. The HRSG shall include Pressure relief valve, (2) 50-400°F bimetal liquid thermometers; 3" dial; stainless stem with well; ½" NPT, and (2) 200-1000°F bimetal flue gas temperature thermometers; 3"

- dial; stainless stem; ½" NPT
10. Painting, suitable for indoor exposure and corrosion protection, appropriate for the corrosive effects of a typical power plant environment.
 11. Fully packaged system mounted on a common structural steel frame. Steel frame shall be sized to meet specific requirements of this installation.
 12. HRSG shall perform as an exhaust noise muffler. Discharge sounds limited at the exhaust system outlet shall be limited to a maximum (75 dbA @ 10!) to those levels specified in the project noise study (85 dBA A-weighted sound power level).
 13. Steam drum and exhaust heat exchanger shall be completely insulated with minimum 4" thick mineral wool insulation.

2.6 REMOTE COOLING RADIATOR (DRYCOOLER)

- A. The remote mounted radiator shall have horizontal core and vertical air discharge. The radiator shall be suitable for outdoor operation and shall be sized to match the requirements of the engine-generator manufacturer.
- B. The radiators shall be heavy-duty bolted construction with a self-supporting base with mounting holes and lifting lugs.
- C. The radiator tube bundle shall be constructed of seamless round copper tubes with aluminum fins mechanically bonded to the tubes. The radiator coil shall be rated for a minimum design pressure of 150 PSIG and a maximum operating temperature of 250 deg F.
- D. Each radiator shall be equipped with a minimum of two fans. Each radiator fan shall be a high performance airfoil type with low noise blades. The radiator unit sound levels shall not exceed levels scheduled on the drawings. Each fan shall be located in a spun galvanized steel venturi. Each radiator fan shall have an O.S.H.A approved zinc plated steel wire fan guard.
- E. Sound power levels of outdoor equipment shall meet the project sound requirements (A-weighted sound power level of 77 dBA or less)
- F. Each fan shall have direct drive motor with a 1.15 service factor. Multiple fans may also be belt or gear driven from a single motor.
- G. Provide micro-bubble air separator with automatic air vent and bladder type expansion tanks sized to accommodate the thermal expansion of the fluid in the cooling system. While maintaining cooling circuit pressure the expansion tank must be able to accommodate a 15% water system

expansion.

2.7 PLATE AND FRAME HEAT EXCHANGER

- A. Provide plate and frame type heat exchanger as specified in section 23 21 13, complete with gasketed plates supported in a steel frame with vertical and horizontal supports. Provide piping connections for each fluid stream on the same fixed end, permitting the heat exchanger to be opened for inspection, cleaning, replacement or addition of plates without removing the piping.
- B. Plates shall be individually field replaceable AISI 304 or AISI 316 stainless steel herringbone pattern channel corrugated plates.
- C. Gaskets shall be of glue free design and suitable for system fluids, either NBR or EPDM.
- D. The heat exchanger frame shall be constructed using either SA516-70 or A36 material. Entire frame shall be bolted together.
- E. Plate carrying and guiding bar shall be carbon steel/Aluminum up to 8 inch connection and for above 8 inch connection, the surfaces of the carrying and guide bars that come into contact with the plates shall be 304 stainless steel.
- F. Frame shall be primed using a zinc-rich gray universal primer and finish painted.

2.8 FUEL GAS SYSTEM

- A. Provide natural gas fuel piping, valves, and control in accordance with engine manufacturer's requirements and section 23 11 23 - Facility Natural Gas Piping.

2.9 POST-COMBUSTION EMISSIONS CONTROL SYSTEM

- A. Post-combustion emissions control systems shall be provided to ensure that the criteria pollutants at the stack are within the specified permit limitations at all operating conditions. The system shall be provided for each generator module and shall include as minimum the following:
 - 1. NOx Control via Tuning of the engine control system
 - 2. The engine control shall be programmed to provide emissions with no more than 0.50 grams of NOx per brake horsepower hour (bhp-hr).
- B. CO and Non-Methane Hydrocarbon (NMHC) Reduction via Oxidation Catalyst

1. A post-combustion oxidation catalyst CO reduction system shall be provided. The catalyst shall be capable of reducing the combined CO emissions from the prime mover to meet the permit limitations specified herein. The unit shall be complete with:

- a. CO Catalyst Modules. Design life shall not be less than 26,100 operating hours (from first gas-in) or 39 months from delivery, whichever occurs first. Supplier shall provide catalyst life guarantee and replacement schedule based upon year-round base-loaded operation, assume 8,500 hours/year.
- b. Structural frame work for supporting the catalyst overhead in the mechanical room, as indicated on the drawings.

2.10 AFTERCOOLER HEAT REJECTION

- A. Provide a closed-circuit evaporative fluid-cooler (cooling-tower) sized to meet the engine manufacturer's aftercooler cooling requirements, as scheduled on the drawings for the basis of engine, and specified in section 23 65 00 - Cooling Towers.

2.11 ACOUSTIC ENCLOSURE

- A. Provide a factory fabricated acoustic enclosure as indicated on the drawings to reduce sound transmission into the generator room outside the enclosure to approximately 65 dB(A). The enclosure shall reduce noise enough to allow sound pressure in adjacent rooms to be NC30 or less.
- B. The basis of design is IAC Acoustics Moduline Super Noiselock Panels with Noise-Lock Sound Control Doors (STC-51).
- C. The acoustic panel system shall be complete with doors, framing, panels, and trim and safing pieces for pipe and duct penetrations. The panel system shall consist of modular 4 inch thick steel panels with 3/16 inch hot rolled steel solid outer sheets and 22 gage perforated galvanized steel inner sheets, with high density acoustic insulation between the inner and outer walls. The weight of the panels shall be approximately 15 lbs / sq. ft.
- D. Acoustic panels shall be rated for sound blocking acoustic performance with the following transmission loss (TL) and sound transmission class (STC) values:

Frequency	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	STC
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TL	31	34	35	44	54	63	62	68	48
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E. Sound Absorption Coefficient (a) & Noise Reduction Coefficient. (NRC)

Frequency	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	NRC
NRC		0.94	1.19	1.11	1.06	1.03	1.03	1.04	1.1/ 0.95

F. Sound Control Doors shall be constructed with 14 ga. galvanized steel, rated for acoustical performance of STC-51 and is provided with Cam-Lift hinges. The single leaf personnel doors have a clear opening 33" wide x 73 ½" high and the double leaf personnel door has a clear opening 82" wide x 81 ¾" high.

G. Acoustic panel manufacturer shall include layout and approval drawings based on field dimensions provided.

2.12 MECHANICAL GENERAL REQUIREMENTS

A. Provide CHP mechanical and piping systems in general accordance with the applicable portions of the VA Design Manual (Including Energy Center), with Section 23 05 11, COMMON WORK RESULTS HVAC, and Section 23 21 13, Hydronic Piping, and with the requirements specified herein.

B. The design, fabrication, installation and testing of all piping shall conform to the latest edition with all current addenda of ASME B31.1 (Power Piping), and Section I of the ASME Boiler and Pressure Vessel Code (Rules for Construction of Power Boilers) along with all applicable federal, state and local laws.

C. All welding shall be in accordance with the latest edition with all current addenda of Section IX of the ASME Boiler and Pressure Vessel Code.

D. Pipe joints shall be normally welded, flanged, or grooved joint coupling system (Victaulic or approved equal). Threaded joints are permitted only when required to make connections to equipment and shall be in accordance with the requirements and limitations specified in ASME B31.1.

E. Natural gas and compressed air piping shall be blown clean using compressed air. Steam piping shall be blown with steam. All pipe

cleaning procedures shall be designed to meet the cleanliness criteria of the relevant connected equipment manufacturers.

- F. All piping 2 inch NPS in diameter and smaller shall be as specified in 23 21 13 - Hydronic Piping, or schedule 40 at a minimum, whichever is greater.
- G. All cast steel body valves shall have the pressure containing parts constructed of ASTM designation A216 Gr. WCB carbon steel. Gate and globe (rising stem) valves shall be bolted bonnet with pressure temperature rating conforming to ANSI B16.34. Stems shall meet ASTM designation A186 F6 chromium stainless steel. Wedges (gate valves) shall meet ASTM A182 F6 chromium stainless steel on valves from 2" to 6". Sizes 8" and larger may be A216 WCB with forged rings or overlay equal to 182 F6. Seat rings shall be hard faced carbon steel or 13% chromium A182 F6 stainless.
- H. All forged steel body valves shall have the pressure containing parts constructed of ASTM A105, Grade 2 forged carbon steel. Seat and wedges shall meet ASTM A182 F6 chromium stainless steel. Seat rings shall be hard faced. Valves shall conform to ANSI B16.34 pressure temperature rating.
- I. All gate and globe valves 4" and larger shall be drilled and tapped in accordance with MSS SP 45 and equipped with a standard size drain valve and equalizing by-pass valve assembly.
- J. Isolation valves for natural gas service shall be of the ball or plug type. Valves shall be specifically suited for natural gas service and shall conform to the design requirements of API 6D. Valves shall be fire tested in accordance with API 607.
- K. Pipe hangers shall comply with MSS-SP-58. Support spacing for horizontal pipe hangers shall be in accordance with MSS-SP-58 and table 121.5 of ASME B31.1. Horizontal and vertical pipe attachments shall be selected in accordance with MSS-SP-58.
- L. Process piping shall be supported using either shoes or hangers. Supporting these lines directly on steel is not acceptable.
- M. All pipe support hardware (including spring hangers) shall be hot dipped galvanized, unless field welding is required. Repair any damaged galvanized plating with a field applied cold galvanized coating.

- N. Contractor shall provide insulation for piping and equipment for the following purposes as applicable:
1. Reduction of unwanted energy loss or gain to the rooms.
 2. Maintaining safe surface temperatures for the purpose of personnel protection.
 3. Preventing condensation on systems that operate below ambient dew point.
- O. Insulation thickness shall be selected to meet or exceed current ASHRAE 90.1 requirements for thermal resistance, and as indicated on the drawings, whichever is more stringent. Application of all insulation types shall be done in accordance with manufacturer's recommendations. Insulating materials shall be selected from the following approved types as appropriate for the service:
1. Cellular Glass
 2. Mineral Fiber Blanket
- P. Pumps shall be provided where required in the CHP facility as scheduled on the drawings and selected to meet system pressure, temperature, and flow rate requirements for the actual equipment installed. Refer to specification section 23 21 23 Hydronic Pumps.

2.13 ELECTRICAL GENERAL REQUIREMENTS

- A. Provide CHP electrical systems in general accordance with the applicable portions of Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and with the requirements specified herein.
- B. Provide electrical distribution equipment as required for a complete plant operation to include:
1. Generator paralleling control.
 2. Distribution switchgear to tie new cogeneration facility into the existing power distribution infrastructure.
 3. Plant auxiliary power system including transformers, distribution switchboards, motor control centers, and low voltage systems as necessary for a complete and functional CHP system.
 4. Provide critical power systems as required for the plant including life safety equipment.

5. Provide control for stand-alone operation to allow the CHP plant to provide backup power in the event of loss of utility power (Island Mode).
- C. Provide all necessary documentation and studies as required by the supplying electric utility for paralleling the new generation resource to the electric utility.
1. The utility interconnect application for connection with Rocky Mountain Power has been started. Coordinate generator and equipment interconnection requirements and settings with the electric utility.
 2. Comply with all local, regional and national requirements for paralleling the new generation to the utility.
- D. Electrical studies required for safe system operation are underway by other contractors. Study results shall include recommended system settings which optimize selective coordination and allow for safe operation and maintenance of equipment. These results will be presented to the contractor by the COR when available for all are flash labeling. Limit harmonics to less than 5%. The Point of Common Coupling for this evaluation shall be the CHP plant main voltage bus.
- E. Electrical conservation
1. Provide electrical metering of CHP generator system and provide communication interfaces (MODBUS or equal) for energy monitoring and management, as indicated on the control and instrumentation drawings.
- F. Control interface
1. All process equipment shall be configured for operation via the plant boiler control system.
 2. Protective functions and interlocks shall be hardwired.
 3. Control functions for motor controllers shall be hardwired.
- G. Acceptance testing
1. All electrical systems shall be set, evaluated and tested in accordance with NETA ATS recommendations. All materials and combined systems shall be UL listed.
- H. Commissioning

1. Provide support for system commissioning activities.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install the CHP plant components and materials in accordance with this section, applicable codes and standards referenced herein, and the printed instructions of the respective equipment manufacturers. Prior to system start-up, ensure no copper wire remains exposed with the exception of grounding wire in certain circumstances per manufacturer instructions.
- B. Piping installation shall be compliant with ASME Section I and ANSI/ASME B31.1 as applicable.
- C. Wiring Installation: Utilize on site measurements in conjunction with engineering designs to accurately cut wires and layout before making permanent connections. Locate wires out of the way of windows, doors, openings, and other hazards. Ensure wires are free of snags and sharp edges that have the potential to compromise the wire insulation. Installation shall be UL listed.
- D. Instrumentation: Install instruments and sensors as required by the control manufacturers.
- E. Contractor shall coordinate with COR and with equipment manufacturers to schedule on-site manufacturer representation during equipment erection, installation, alignment, and testing.
- F. Equipment-Specific Requirements:
 1. Installation and stamping of all boiler external piping shall be in accordance with Part PG-105 of Section I of the ASME Boiler and Pressure Vessel Code.
 2. Install and align new chilled water, hot water and condenser water pumps in strict accordance with API RP-686. Mechanically chip/roughen concrete to prepare for grout under base plates. Pumps shall be laser aligned. All mechanical seal setting tabs shall be left installed until just prior to startup.

3.2 FIELD QUALITY CONTROL

- A. Field Inspection: Prior to initial operation, inspect the CHP systems

for conformance to drawings, specifications and applicable codes and standards. Inspect the following information on each piece of equipment:

1. Manufacturer's name or trademark
2. Model name or number
3. Certifying agency label and rating. Provide UL and FM approvals for all safety devices.

B. Tests: Provide equipment and apparatus required for performing inspections and tests as specified in applicable codes, standards, and manufacturer's recommendations. Correct defects disclosed by the tests and repeat tests. Conduct testing in the presence of the Commissioning Agent and COR.

1. Operation Tests: Perform tests on electrical systems, in accordance with the manufacturer's written recommendations. On site UL inspection and listing is required. Tests shall include shutdown and restart of entire CHP system.
2. Non-Destructive Examination (NDE): Perform NDE on piping welds and structural welds utilizing inspection techniques as specified in applicable codes and in accordance with equipment manufacturer's written procedures.
3. Heat Recovery Steam Generator Pressure Tests: The completed Heat Recovery Hot Water Boilers shall be hydrostatically tested in accordance with the requirements of Part PG-99, Section I of the ASME Boiler and Pressure Vessel Code. Conduct tests after the equipment is installed and connected for operation and prior to initial firing. An authorized inspector shall witness the hydrostatic test. Correct any deficiencies discovered during the testing, and retest equipment until satisfactory results are achieved and are accepted by the Inspector. Identify and remove any connecting equipment that is not rated for the test pressure. Cap the openings left by the disconnected equipment. Reinstall the equipment after the tests are complete. Internal and external inspections shall be made by a national board inspector at time of delivery, prior to start-up, and after acceptance at contractor's expense.
4. Piping Pressure Tests: Hydrostatically test all new or modified

piping in accordance with the requirements of ASME B31.1 at a test pressure of 1.5 times the design (maximum allowable working) pressure. Where leaks occur, repair pipe and the repeat tests. Remove and replace defective piping and joints.

5. Electrical Testing: All electrical testing shall be completed in accordance with the latest approved version of IEEE 1547, Section 5.0. Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to perform acceptance testing. Report results in writing.
 - a. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.15.1 and 7.22.1 (except for vibration baseline test). Certify compliance with test parameters. Perform all tests stated in the manufacturer's written tests recommendations.
 - b. Provide load banks for testing. For one generator the load bank shall be resistive only, 1.0 power factor and sized to match be largest generator.
 - c. 2-Hour Full Load Test, including verification of all campus electrical demand load following operations.
 - d. System Integrity Tests:
 1. Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation.
 2. Check for air, exhaust, and fluid leaks.
 - e. Exhaust-System Back-Pressure Test:
 1. Generator manufacturer shall provide a pressure tap downstream of the turbo discharge. Connect a manometer with scale exceeding 40" WG and verify that the back pressure at full load is within engine manufacturer's written allowable limits.
 - f. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 20 and 25 percent step-load increases and decreases, and verify that performance is as specified.

6. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
7. Noise Level Tests: Measure A-weighted level of noise emanating from generator set installation, including engine exhaust and cooling-air intake and discharge, as requested by the engineer of record. Test shall be performed at 3:00 AM on a week night, except Friday. Test instruments shall have been calibrated within the last 12 months, traceable to standards of the National Institute for Standards and Technology, and adequate for making positive observation of test results. Make calibration records available for examination on request.
8. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the CHP system is in good operating condition and properly performing the intended functions. System shall be run continuously for minimum (45) calendar days without faults or failures. If a fault or failure occurs, the time period starts over after corrective action has been made.
- B. Perform overall CHP plant performance testing in accordance with ASME PTC 46.

3.4. INSTRUCTION

- A. Provide training, at the VA's facility, for the personnel listed herein so that VA personnel can operate, maintain, change system configurations, and repair the complete CHP system. The engine-generator set will be maintained and repaired under a five year service agreement to be negotiated between the VA and the selected service organization and included in the project budget.

- B. Initial training for Operators shall be conducted in two sessions, one in the morning, and one in the afternoon, to accommodate a multiple shift schedule. Follow-up training shall be conducted approximately one month after the initial training, one in the morning, and one in the afternoon, to be scheduled with VA personnel.
- C. Each training session should be designed to last approximately two hours, including classroom time and observations of the actual installed equipment.
- D. Separate training sessions shall be held for each of the following equipment groups:
 - 1. Engine-Generator Set and associated cooling equipment, combustion air systems, electrical connections, and controls.
 - 2. Hot Water Heat Recovery System and associated heat exchangers, pumps, piping, electrical systems and controls.
 - 3. Absorption Chiller System and associated pumps, piping, electrical systems and controls.
 - 4. Electrical Systems, interconnections, instrumentation, and stand-by power operation.
- E. Prior to project closeout and field acceptance testing, provide training plan and schedule including the following information:
 - 1. List of all classes/courses.
 - 2. Description of each course.
 - 3. Duration of each course.
 - 4. Sequence of courses.
- F. Provide competent, factory authorized personnel to provide instruction to Operations and Maintenance (O&M) personnel. Include sufficient hours of training to provide complete training for operation and maintenance of the equipment and systems.
- G. Provide the name and resume of proposed instructors: instructors must have at least 2 years' experience with training for the designated systems and equipment. Instructor's primary language must be English.
- H. Provide training manual that includes, as a minimum, the following:
 - 1. Course objective.

2. Course outline.
 3. Theory of operation.
 4. Case studies that demonstrate application, operation (including casualty control), troubleshooting, repair and maintenance of equipment.
 5. Notes that supplement and enhance information provided in the manufacturer's operation and maintenance manuals.
 6. Thorough review of applicable drawings, photos, tables, diagrams and schematics.
 7. List of references for further independent study.
- I. VA reserves the right to require Contractor to repeat training classes if not satisfied that objectives are met, at no cost to the VA.
 - J. VA reserves the right to video record the training sessions.
 - K. Provide certification in writing that this training has been accomplished.

3.5. COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and Section 26 08 00 - COMMISSIONING OF ELECTRICAL 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.
- C. Commissioning Agent and COR shall be notified in reasonable time of all test events scheduled by or through the Contractor. Participation by the Commissioning Agent and COR will be at the discretion of the Commissioning Agent and COR.

3.6. CHP SYSTEM WARRANTY

- A. Contractor shall guarantee that all provided material and equipment will be free from defects, workmanship and will remain so for a period of one year from date of final acceptance of the CHP System by the VA. The Contractor shall provide OEM's equipment warranty documents to the

COR that certifies each item of equipment installed conforms to OEM published specifications.

1. During the one year warrantee period, the contractor and the associated manufacturers (as needed) shall make all repairs and adjustments, including parts and labor, at no additional charge to the VA.
2. During the one year warrantee period, contractor and the associated manufacturers (as needed) shall perform all maintenance required by the engine and equipment manufacturers standard maintenance schedules including lubrication oil, parts and labor, at no additional charge to the VA.

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