



VOLUME 2 of 3 – FIRE SUPPRESSION, PLUMBING, HVAC, ELECTRICAL
VA SPECIFICATIONS
FOR
NEW SUBSTANCE ABUSE BUILDING ADDITION TO BUILDING #170
FOR
CENTRAL ARKANSAS VETERANS HEALTHCARE SYSTEM
AT
NORTH LITTLE ROCK, ARKANSAS

CENTRAL ARKANSAS VETERANS HEALTHCARE SYSTEM
CONTRACT #VA256-P-1272
NEW SUBSTANCE ABUSE BUILDING ADDITION TO BUILDING #170

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PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section apply to all sections of Division 21.
- 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. Building Components for Attachment of Hangers: Section 05 31 00, STEEL DECKING, Section 05 36 00, COMPOSITE METAL DECKING.
- D. Section 05 50 00, METAL FABRICATIONS.
- E. Section 07 84 00, FIRESTOPPING.
- F. Flashing for Wall and Roof Penetrations: Section 07 60 00, FLASHING AND SHEET METAL.
- G. Section 07 92 00, JOINT SEALANTS.
- H. Section 09 91 00, PAINTING.
- I. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS
- J. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 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. See other specification sections for any exceptions.
2. Equipment Service: Products shall be supported by a service organization which maintains a complete inventory of repair parts and is located reasonably close to the site.
3. 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.
4. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.
5. 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.
6. Asbestos products or equipment or materials containing asbestos shall not be used.

B. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Resident Engineer prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

C. Guaranty: In GENERAL CONDITIONS.

E. Supports for sprinkler piping shall be in conformance with NFPA 13.

F. Supports for standpipe shall be in conformance with NFPA 14.

1.5 SUBMITTALS

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

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

1. Equipment and materials identification.
2. Fire-stopping materials.
3. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.

4. Wall, floor, and ceiling plates.
- C. Coordination Drawings: Provide detailed layout drawings of all piping systems. Provide details of the following.
 1. Mechanical equipment rooms.
 2. Hangers, inserts, supports, and bracing.
 3. Pipe sleeves.
 4. Equipment penetrations of floors, walls, ceilings, or roofs.
- D. 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.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Except for a specific date given, the issue in effect (including amendments, addenda, revisions, supplements, and errata) on the date the system's submittal is technically approved by VA, shall be enforced.
- B. American Society for Testing and Materials (ASTM):
 - A36/A36M.....Carbon Structural Steel
 - A575.....Steel Bars, Carbon, Merchant Quality, M-Grades R (2002)
 - E84.....Standard Test Method for Burning Characteristics of Building Materials
 - E119.....Standard Test Method for Fire Tests of Building Construction and Materials
- C. National Fire Protection Association (NFPA):
 - 90A.....Installation of Air Conditioning and Ventilating Systems
 - 101Life Safety Code

PART 2 - PRODUCTS

2.1 LIFTING ATTACHMENTS

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

2.2 EQUIPMENT AND MATERIALS IDENTIFICATION

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

2.3 FIRESTOPPING

- A. Section 07 84 00, FIRESTOPPING specifies an effective barrier against the spread of fire, smoke and gases where penetrations occur for piping.

2.4 GALVANIZED REPAIR COMPOUND

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

2.5 PIPE PENETRATIONS

- A. Install sleeves during construction for other than blocked out floor openings for risers in mechanical bays.
- B. To prevent accidental liquid spills from passing to a lower level, provide the following:
 - 1. For sleeves: Extend sleeve 25 mm (one inch) above finished floor and provide sealant for watertight joint.
 - 2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
 - 3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.

- C. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from this requirement must receive prior approval of Resident Engineer.
- D. Sheet Metal, Plastic, or Moisture-resistant Fiber Sleeves: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.
- E. Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.
- F. Galvanized Steel or an alternate Black Iron Pipe with asphalt coating Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, connect sleeve with floor plate.
- G. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.
- H. Sleeves are not required for wall hydrants for fire department connections or in drywall construction.
- I. Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.
- J. Sealant and Adhesives: Shall be as specified in Section 07 92 00, JOINT SEALANTS.

2.6 TOOLS

- A. Furnish, and turn over to the Resident Engineer, special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.
- B. Tool Containers: Hardwood or metal, permanently identified for intended service and mounted, or located, where directed by the Resident Engineer.

2.7 WALL, FLOOR AND CEILING PLATES

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

- C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Use also where insulation ends on exposed water supply pipe drop from overhead. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Coordinate location of piping, sleeves, inserts, hangers, and equipment. Locate piping, sleeves, inserts, hangers, and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Follow manufacturer's published recommendations for installation methods not otherwise specified.
- B. Protection and Cleaning:
1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the Resident Engineer. Damaged or defective items in the opinion of the Resident Engineer shall be replaced.
 2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect equipment against dirt, water chemical, or mechanical injury. At completion of all work thoroughly exposed materials and equipment.
- C. Concrete and Grout: Use concrete and shrink compensating grout 25 MPa (3000 psi) minimum, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.
- D. Install gages, valves, and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position 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.
- E. Work in Existing Building:
1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00 00, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).
 2. As specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will least interfere with normal operation of the facility.

3. Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills, will be permitted only with approval of the Resident Engineer. Locate openings that will least effect structural slabs, columns, ribs or beams. Refer to the Resident Engineer for determination of proper design for openings through structural sections and opening layouts approval, prior to cutting or drilling into structure. After Resident Engineer's approval, carefully cut opening through construction no larger than absolutely necessary for the required installation.
- F. 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.
- G. 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 OPERATING AND PERFORMANCE TESTS

- A. Additional Testing for portions of system in existing Building 170: Prior to hydrostatic testing as required by NFPA 13 for wet systems, it is required that the existing area in Building 170 be pneumatically tested for 2 hours with 50 PSI showing not more than 5 PSI loss in pressure in the 2 hour period as similarly described in NFPA 13 for pneumatic testing requirements for dry systems. The contractor shall isolate each area for testing. If during the isolation process existing grooved couplings are removed, the contractor is required to install new ones in the place of the ones removed for isolation purposes. Properly executed tests certificates are required for "Close Out Documents".
- B. 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 Resident Engineer.
- C. 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.

- D. 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.

3.3 INSTRUCTIONS TO VA PERSONNEL

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

--- E N D ---

SECTION 21 10 00
WATER-BASED FIRE-SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The design and installation of a hydraulically calculated automatic fire sprinkler system complete and ready for operation, for the entire building including the mechanical equipment rooms, elevator machine rooms, elevator shafts, and accessible shafts.
- B. The design and installation of a standpipe system combined with the sprinkler system.
- C. Installation of new sectional valves in the sprinkler/standpipe system feed mains as indicated on the drawings.
- D. Modification of the existing sprinkler and standpipe systems as indicated on the drawings. Size system by pipe schedule in accordance with NFPA 13 and NFPA 14 the latest editions.
- E. Existing piping to be reused, replaced or removed as indicated on the drawings. Removal of piping to include all valves, flow switches, supervisory devices, hangers, supports, and associated fire alarm system conduit and wire.
- F. Replacement of all existing sprinklers, as indicated on the drawings. Work to include all necessary piping modifications, new sprinklers and new sprinkler escutcheons.
- G. Provide access doors or panels where control or drain valves are located behind plaster or gypsum walls or ceilings as necessary to install piping above suspended plaster or gypsum ceilings.
- H. Painting of exposed piping and supports to follow Section 09 91 00, PAINTING.

1.2 RELATED WORK

- A. Treatment of penetrations through rated enclosures: Section 07 84 00, FIRESTOPPING.
- B. Access panels for plaster ceilings: Section 08 31 13, ACCESS DOORS AND FRAMES.
- C. Painting of exposed pipe: Section 09 91 00, PAINTING.
- D. Section 21 05 11, COMMON WORK RESULTS FOR FIRE SUPPRESSION.
- E. Section 28 31 00, FIRE DETECTION AND ALARM.
- F. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 DESIGN CRITERIA

- A. The design, materials, equipment, installation, inspection, and testing of the automatic sprinkler system and standpipe system shall be in accordance with the required advisory provisions of NFPA 13, 14, 25, and 75. Exception to NFPA Fire Codes are as follows:
 - 1. Standpipe system shall be sized to meet volume requirements of NFPA 14 but not pressure requirements.
- B. Base system design hydraulic calculations using the area/density method on the following criteria and in accordance with NFPA 13 latest edition.
 - 1. Sprinkler Protection:
 - a. All patient care, treatment, office, waiting areas, educational areas, and corridors: Light hazard, (0.10 gpm/sq. ft.) over the hydraulically most remote 140 m² (1500 sq. ft.).
 - b. Mechanical Equipment Rooms, Electrical Switchgear Rooms, Electric Closets, Elevator Shafts, Elevator Machine Rooms, and storage rooms between 9 and 23 m² (100 and 250 sq. ft.): Ordinary Hazard, Group 1, 6.1 L/minute/m² (0.15 gpm/sq. ft.) over the hydraulically most remote 140 m² (1500 sq. ft.).
 - c. Clean and soiled linen rooms, trash rooms, clean and soiled utility rooms, laboratories, and storage rooms over 23 m² (250 sq. ft.): Ordinary Group 2, 8.1 L/minute/m² (0.20 gpm/sq. ft.) over the hydraulically most remote 140 m² (1500 sq. ft.).
 - d. Provide sprinklers in accessible shafts per NFPA 13 latest edition.
 - 2. Add water allowance of 15 L/s (250 gpm) for inside and outside hose streams to the sprinkler requirements at the connection to the distribution main.
 - 3. Hydraulic Calculations: The calculated demand including hose stream requirements shall fall no less than 10 percent below the available supply curve.

- 4. Water Supply
 - a. Base sprinkler design on the capacity of the existing fire pump.
- C. For each sprinkler zone provide a control valve, flow switch, self-contained test, drain assembly and pressure gage.
- D. Provide a separate sprinkler valve for each elevator machine room and other areas as required by NFPA 13 latest edition.
- E. Provide a guard for each sprinkler in the janitors' closets, the elevator machine room and sprinklers within 2100 mm (7 ft.) of the floor and other areas as required by NFPA 13.
- F. Locate sprinklers in patient bedrooms assuming all privacy curtains have 13 mm (1/2 in.) openings in mesh extending 450 mm (18 in.) from ceiling.
- G. Seismic Protection: Seismically brace all new and existing piping systems in accordance with NFPA 13 and the International Building Code, of the latest versions.

1.5 QUALIFICATIONS:

- A. Designer's Qualifications: Design work and shop drawings shall be prepared by a licensed engineer practicing in the field of Fire Protection Engineering or a NICET (National Institute for Certification in Engineering Technologies) Level III sprinkler technician.
- B. Installer's Qualifications: The installer shall possess a valid State fire protection contractor's license. The installer shall provide documentation of having successfully completed three projects of similar size and scope.
- C. On-site emergency service within four hours notification.

1.6 SUBMITTALS

- A. Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Sprinkler design shall be done by a certified professional. All plans shall be stamped by qualified P.E.
- C. Emergency service point of contact name and 24 hour emergency telephone number.
- D. Manufacturer's Literature and Data:
 - 1. Pipe and fittings.
 - 2. Valves
 - 3. Drips
 - 4. Sprinklers-each type, temperature and model
 - 5. Inspectors Test Alarm Modules
 - 6. Sprinkler Cabinets
 - 7. Sprinkler Plugs

8. Pressure Gages
 9. Pipe Hangers and Supports
 10. Water Flow Switches
 11. Valve Tamper Switches
 12. Valve Cabinet
- E. Detailed drawings in accordance with NFPA 13 and NFPA 14, the latest editions. Drawings shall be prepared using CADD software stamped by fire protection professional engineer and include all new and existing sprinklers and piping. Use format in use at the VA medical center. Drawings are subject to change during the bidding and construction periods. Any wall and ceiling changes occurring prior to the submittal of contractors shop drawings shall be incorporated into the contractors detailed design at no additional contract cost.
- F. Hydraulic calculations for each sprinkler system in accordance with NFPA 13 latest edition.
- G. Operation and Maintenance Data:
1. Indicating Valves
 2. Water Flow and valve tamper switches
 3. Copy of NFPA 25
- H. Recommended preventive maintenance schedule.

1.7 AS-BUILT DOCUMENTATION

- A. A Mylar as-built drawing and two blueline copies shall be provided for each drawing. One copy of final CADD drawing files shall also be provided on CD, for each drawing.
- B. Four sets of manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- C. Four sets of hydraulic calculations for each sprinkler system updated to include submittal review comments and any changes to the installation which affect the calculations including one electronic set in PDF format.
- D. Four copies of the hydrostatic report and NFPA 13 material and test certificate for each sprinkler system.
- E. Four sets of operation and maintenance data updated to include submittal review comments and any equipment substitutions including one copy of NFPA 25.
- F. Manufacturers literature, hydraulic calculations, reports and operation and maintenance data shall be in a labeled 3-ring binder.

1.8 WARRANTY

- A. All work performed and materials and equipment furnished under this contract shall be free from defects for a period of one year from date of acceptance by the government.

- B. All new piping and equipment incorporated into the new system shall be hydrostatically tested and warranted as new.

1.9 APPLICABLE PUBLICATIONS

- A. 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. Except for a specific date given, the issue in effect (including amendments, addenda, revisions, supplements, and errata) on the date the system's submittal is technically approved by VA, shall be enforced.
- B. National Fire Protection Association (NFPA)
 - 13Installation of Sprinkler Systems
 - 14Installation of Standpipe and Hose Systems
 - 25Inspection, Testing and Maintenance of water Based Fire Protection Systems
 - 70-11National Electrical Code
 - 72National Fire Alarm Code
 - 170Standards for Fire Safety Symbols
 - 291Fire Flow Testing and Marking of Hydrants
- C. Underwriters Laboratories Inc. (UL)
 -Fire Protection Equipment Directory
- D. Factory Mutual Engineering Corporation (FM)
 -Approval Guide
- E. Complete maintenance and inspection service for the new sprinkler systems shall be provided by a factory trained authorized representative of the manufacturer of the major equipment for a period of one year after acceptance of the entire installation by the government.
- F. Contractor shall provide all necessary test equipment, parts and labor to perform required maintenance.
- G. All inspections, testing and maintenance work required by NFPA 25, NFPA 20, NFPA 13, and recommended by the equipment manufacturer shall be provided. Work shall include operation of sprinkler system alarm and supervisory devices.

- H. Maintenance and testing shall be performed on a quarterly basis. A computerized preventive maintenance schedule shall be provided and shall describe the protocol for preventive maintenance of equipment. The schedule shall include a systematic examination, adjustment, and cleaning of all equipment.
- I. Non-included Work: Maintenance service shall not include the performance of any work due to improper use, accidents or negligence for what the contractor is not responsible.
- J. Service and emergency personnel shall report to the Engineering Office or their authorized representative upon arrival at the hospital and again upon the completion of the required work. A copy of the work ticket containing a complete description of work performed and parts replaced shall be provided.
- K. Emergency Service:
 - 1. Normal and overtime emergency call-back service shall consist of an on-site response to calls within four hours of notification.
 - 2. Overtime emergency call-back service shall be limited to minor adjustments and repairs to affect the integrity of the system.
 - 3. The standpipe system and all but a single sprinkler system must be operational before the responding service person leaves the facility.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All devices and equipment shall be Underwriters Laboratories Inc. listed for their intended purpose. All sprinklers shall be Factory Mutual approved.

2.2 PIPING AND FITTINGS

- A. Pipe and fittings from inside face of building 300 mm (12 in.) above finished floor to a distance of approximately 1500 mm (5 ft.) outside building: Ductile Iron, flanged fittings and 316 stainless steel bolting.
- B. Fire Protection water supply within the building up to sprinkler system isolation valves shall be black steel, schedule 10 minimum.
- C. Sprinkler piping downstream of the isolation valve on wet-pipe systems shall be black steel, schedule 10 minimum.
- D. Threaded or flanged fittings shall be ANSI B1 6.3 cast iron, class 125 minimum. Threaded fittings are not permitted on pipe with wall thickness less than schedule 40.
- E. All fittings on galvanized piping shall be galvanized in accordance with ASTM A53.
- F. Slip type or clamp-on type rubber gasketed fittings shall be listed for each piping application.

- G. Sprinkler head connections to branch lines shall be made using a flexible stainless hose assembly with bracketing system as manufactured by FlexHead Industries. Each FlexHead unit comes with a mounting bracket and a 1-piece, leak tested sprinkler drop. The mounting bracket is compatible with any suspended or gypsum board ceiling system. All FlexHead commercial sprinkler connections are Factory Mutual (FM) approved and UL listed and are manufactured in an FM/UL audited facility. The bracket system is made from galvanized sheet metal and is approved and compatible for use with light, medium and heavy load grids (ASTM C635, C636) or gypsum board ceiling systems. These flexible connections are required for seismic reasons. The use of other UL/FM approved devices manufactured by other than FlexHead Industries is acceptable to achieve the seismic requirements for this project.
- H. Piping passing through building seismic joints shall contain a flexible expansion loop designed for seismic movement as manufactured by The Metraflex Company. Flexible loops shall be located at or near the building seismic joint. A vertical support hanger, located within four (4) pipe diameters, shall be installed on each side of the flexible loop. Each hanger shall be transversely and longitudinally braced per local codes. Seismic bracing shall not pass through the building seismic joint and shall not connect or tie together different sides or parts of the building structure. Flexible expansion loops shall be capable of moving in the $\pm X$, $\pm Y$, and $\pm Z$ planes. The flexible expansion loop and the hanger assembly shall be FM tested and approved for use in fire protection piping systems from 1"-12". Sizes 1"-3" shall be FM Approved for 300 psi working pressure at ambient temperature, and sizes 4"-12" shall be FM Approved for 175 psi working pressure. The use of other UL/FM approved devices manufactured by other than The Metraflex Company is acceptable to achieve the seismic requirements for this project.
- I. Piping Materials Standards:
1. Welded and seamless steel pipe – follow ANSI/ASTM A 53
 2. Wrought steel pipe – follow ANSI/ASME B36.10M
 3. Electric resistance welded steel pipe – follow ASTM A 135
 4. Alloy material - follow ASTM B 446
- J. Fitting Materials Standards:
1. Cast iron threaded fitting, Class 125 and 250 - follow ASME B16.4
 2. Cast iron pipe flanges and flanged fittings - follow ASME B16.1
 3. Malleable iron threaded fittings, Class 150 and 300 steel - follow ASME B16.3
 4. Factory made wrought steel butt weld fittings - follow ASME B16.9
 5. Buttwelding ends for pipe, valves, flanges, and fitting - follow ASME B16.25

- K. Pipe Identification – All pipe, including specially listed pipe allowed by NFPA 13, shall be marked continuously along its length by the manufacturer in such a way as to properly identify the type of pipe. Pipe identification shall include the manufacturer's name, model designation, or schedule.

2.3 VALVES

- A. Listed Indicating Valves:
1. Gate: OS&Y, 2400 kPa (350 psi) Water Working Pressure (WWP).
 2. Butterfly: Gear operated, indicating type, 2400 kPa (350 psi) water working pressure (WWP).
Butterfly valves are to be installed in a manner that does not interfere with the operation of any system component.
 3. Ball (inspectors test and drain only): iron body, stainless steel trim, for 2050 kPa (300 psi) service, indicating type.
- B. Check Valves: Swing type, rubber faced or wafer type spring loaded butterfly check valve, 2400 kPa (350 lb.) water working pressure (WWP).
- C. Drain Valves: Threaded bronze angle, globe, ball or butterfly, 4100 kPa (600 psi), Water or gas (WOG) equipped with reducer and hose connection with cap or connected to a drain line.
- D. Self-contained Test and Drain Valve:
1. Ductile iron body with bronze "Drain" and "Test" bonnets. Acrylic sight glass for viewing test flow. Various sized orifice inserts to simulate flow through 14 mm (17/32 in.), 13 mm (1/2 in.), 12 mm (7/16 in.), and 10 mm (3/8 in.) diameter sprinklers, 32 mm (1-1/4 in.) female threaded outlets or 32 mm (1-1/4 in.) one-quarter turn locking lug outlets for plain end pipe (end preparation to be in accordance with manufacturer's recommendation).
- E. Standpipe Fire Department Hose Valve: Globe Valve, Potter-Roemer, Inc. Fig. 4115 2-1/2" rough brass with cap and chain. Hose connection shall match responding fire department requirements. Provide for valves installed in a cabinet a 65 mm (2-1/2 in.) attached cap and chain and a 65 mm x 40 mm (2-1/2 in. x 1-1/2 in.) reducer placed in cabinet.
- F. Roof Hydrant: Potter-Roemer, Inc. Fig. 5840 wall mount 4 x 2-1/2 2-way fire department outlet connection. Cast brass back outlet body with caps and chains. Cast brass round wall plate lettered "Hydrant".
- G. Roof Manifold: Potter-Roemer, Inc. Fig. 5845 free standing 4 x 2-1/2 2-way exposed fire department outlet connection. Cast brass back angle body with male hose threads with caps and chains. 18" long polished brass cover sleeve, and cast brass plate lettered "Hydrant".

2.4 AUTOMATIC BALL DRIPS

- A. Cast brass 20 mm (3/4 in.) in line automatic ball drip with both ends threaded with iron pipe threads.

2.5 SPRINKLERS

- A. Quick response sprinklers shall be standard type except as noted below. The maximum distance from the deflector to finished ceiling shall be 50 mm (2 in.) for pendent sprinklers. Pendent sprinklers in finished areas shall be provided with semi-recessed adjustable screwed escutcheons and installed within the center one-third of their adjustment. The sprinkler shall be installed in the flush position with the element exposed below the ceiling line. At the specified locations, provide the following type of sprinklers. Provide quick response sprinklers in all areas, except where specifically prohibited by their listing or approval, and the following:

LOCATION	TYPE
Mechanical Equipment Rooms, Electrical or Telephone Closets & Electrical Switch Gear Rooms	Quick Response, Upright Pendent Brass [93 °C (200 °F)]
Elevator Shafts & Elevator Machine Rooms	Standard Upright or Sidewall Brass [93 °C (200 °F)]
Exhaust Ducts & Duct Collars	Standard Pendent or Upright (Extra High Temperature [163-191 °C (325-375 °F.)])
All Areas Not Listed Above	Quick Response, Recessed Pendent, Chrome Plated [66-74 °C (150-165 °F)]

- B. Do not use quick response sprinklers in the same sprinkler zone with other sprinklers types. In sprinklered light hazard patient zones that are expanded into fully sprinklered zones, revise the existing system to contain quick response sprinklers.
- C. Sprinklers to be installed as per NFPA 13.

2.6 TOOLS AND REPLACEMENT PARTS

- A. Sprinkler Cabinet:
1. Provide a minimum 5 percent spare sprinklers with escutcheons with a minimum of two of each type/or as required by NFPA-13, whichever is more demanding.
 2. Provide a minimum of two of each type sprinkler wrenches used.
 3. Install cabinets in each building where directed by the Resident Engineer.
 4. Spare sprinklers shall be kept in a cabinet where ambient temperatures do not exceed 100 Deg.
- B. Sprinkler system water flow switch: one of each size provided.

- C. Sprinkler system valve tamper switch: one of each type provided.
- D. Provide two sprinkler plugs attached to multi-section extension poles 2400 mm (8 ft.) minimum.

2.7 IDENTIFICATION SIGNS

- A. Provide for all new and existing sectional valves, riser control valves, system control valves, drain valves, test and drain connections and alarm devices with securely attached identification signs (enamel on metal) in accordance with NFPA 13.

2.8 STANDPIPE HOSE VALVE CABINETS

- A. Standpipe hose valve cabinets: Cabinets shall be 20 gage steel coated with glossy polyester to match wall, with continuous steel hinge with brass pin, recessed type 600 x 600 x 250 mm (24 x 24 x 10 in.). Exception: A smaller dimension for the depth may be used if required by the specific installation, and if approved by the Engineer.

2.9 HANGERS AND EARTHQUAKE BRACING

- A. In accordance with NFPA 13 and 14. Comply with seismic requirements as per NFPA and the International Building Code, of the latest versions.

2.10 WATERFLOW SWITCHES

- A. Integral, mechanical, non-coded, non-accumulative retard type, with two sets of SPDT auxiliary contacts and adjustable from 0 to 90 seconds.
- B. All conduit and wiring connected thereto shall be provided in Section 28 31 00, FIRE DETECTION AND ALARM.

2.11 VALVE SUPERVISORY SWITCHES

- A. Provide each indicating sprinkler and standpipe valve with adequate means for mounting a valve supervisory switch.
- B. Mount switch so as not to interfere with normal operation of the valve and adjust to operate within two revolutions toward the closed position of the valve control, or when the stem is moved no more than one fifth of the distance from its normal position.
- C. The mechanism shall be contained in a weatherproof die cast aluminum housing, which shall provide a 20 mm (3/4 in.) tapped conduit entrance and incorporate the necessary facilities for attachment to the valves.
- D. Switch housing to be finished in red baked enamel.
- E. Supervisory switches for ball and butterfly valves may be integral with the valve.
- F. All conduit and wiring connected thereto shall be provided in Section 28 31 00, FIRE DETECTION AND ALARM.

2.12 WALL, FLOOR AND CEILING PLATES

- A. Exposed piping passing through walls, floors or ceilings shall be provided with chrome colored escutcheon plates.
- B. Comply with NFPA 101 Fire Barrier Penetration codes.

2.13 PRESSURE GAUGE

- A. Provide a 1280 kPa (200 psi) pressure gauge at each flow alarm switch location, at the top of each sprinkler or standpipe riser, and at each main drain connection.

2.14 HANGERS

- A. Hangers shall be designed to support five times the weight of the water filled pipe plus 250 Lb (114Kg) at each point of piping support.
- B. These points of support shall be adequate to support the system.
- C. The spacing between hangers shall not exceed the value given for the type of pipe as indicated in NFPA 13 tables.
- D. Hanger components shall be ferrous.
- E. Detailed calculations shall be submitted, when required by the reviewing Authority, showing stress developed in hangers, piping, fittings and safety factors allowed.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Supervisory Switches: For each indicating sprinkler zone and standpipe system riser control valve, provide a supervisory switch that is connected to the fire alarm system. Standpipe hose valves and test and drain valves shall not be provided with supervisory switches.
- B. Waterflow Switches: For each sprinkler zone and each standpipe riser and where indicated on drawings, provide a waterflow switch. Install waterflow switch and adjacent valves in easily accessible locations.
- C. Sprinkler Zone: Each sprinkler zone shall coincide with each smoke zone. That is to say that a single smoke zone is not to have more than one sprinkler system control valve for that area.
- D. Piping connections:
 - 1. Combined Standpipe and Sprinkler System: Provide standpipe system as required. Start the sprinkler system work for each zone at valve connection to standpipe location at each zone.

E. Drains, Test Pipes and Accessories:

1. Provide a drain at base of risers, drain connection on valved sections, and drains at other locations for complete drainage of the system. Provide valve in drain lines and connect to the central drain riser. Discharge riser outside over splash block, indirectly over standpipe drain connected to storm sewer, or as indicated. The main drain shall be capable of full discharge test without allowing water to flow onto the floor.
2. Provide test pipes in accordance with NFPA 13. Test pipes shall be valved and piped to discharge through proper orifice as specified above for drains.

F. Provide a 1280 kPa (200 psi) pressure gage at each flow alarm switch location, at the top of each sprinkler or standpipe riser, and at each main drain connection.

G. Conceal all piping, except in pipe basements, stairwells and rooms without ceilings.

H. Install new piping and sprinklers aligned with natural building and other sprinklers lines.

I. Locate piping in stairways as near ceiling as possible to prevent tampering by unauthorized personnel. Provide a minimum headroom of 2250 mm (7 ft.-6 in.) for all piping.

J. Piping arrangement shall avoid contact with other piping and equipment and allow clear access to other equipment or devices requiring access or maintenance.

K. Cutout disks, which are created by cutting holes in the walls of pipe for flow switches and non-threaded pipe connections, shall be affixed near to the pipe where the originated. They shall be displayed until final inspection and then removed.

L. Firestopping shall comply with Section 07 84 00, FIRESTOPPING. All holes through stairways, smoke barrier walls, and fire walls shall be sealed on a daily basis.

M. Provide hydraulic design information signage as required by NFPA 13 and 14.

N. Install access doors in ceilings of rooms where above ceiling access is required.

3.2 TEST

A. Automatic Sprinkler System: NFPA 13 and 25.

B. Standpipe and Hose System: NFPA 25.

3.3 INSTRUCTIONS

A. Furnish the services of a competent instructor for not less than two four-hour periods for instructing personnel in the operation and maintenance of the fire pump and sprinkler system, on the dates requested by the RE/COTR.

- - - END - - -

SECTION 21 12 00
FIRE-SUPPRESSION STANDPIPES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Fire-suppression wet standpipes.

1.2 SCOPE OF WORK

- A. Design, installation and testing shall be in accordance with NFPA 14 except for specified exceptions.
- B. Design, materials, equipment and installation, inspection and testing of a complete and ready for operation fire-suppression wet standpipe system as required by NFPA 14.
- C. Modification of the existing standpipe system as indicated on the drawings and as further required by these specifications.
- D. Expansion of the building system fire alarm system to incorporate new system alarms and supervisory devices.
- E. Providing of access panels where control or drain valves are located behind plaster or gypsum walls or ceilings.
- F. Painting of exposed piping and supports to match surrounding background in stairways and red in unfinished areas.

1.3 RELATED WORK

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Section 33 10 00, WATER UTILITIES.
- C. Section 07 84 00, FIRESTOPPING, Treatment of penetrations through rated enclosures.
- D. Section 08 31 13, ACCESS DOORS AND FRAMES: for access panels for plaster or gypsum finishes.
- E. Section 09 91 00, PAINTING.
- F. Section 21 10 00, WATER-BASED FIRE-SUPPRESSION SYSTEMS, for dry sprinklers, fire pumps, etc.
- G. Section 28 31 00, FIRE DETECTION AND ALARM, Connection to fire alarm of flow switches and valve supervisory switches.
- H. Section 21 05 11, COMMON WORK RESULTS FOR FIRE SUPPRESSION, for general mechanical requirements and items, which are common to more than one section.

1.4 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.5 QUALITY ASSURANCE

- A. Designer's Qualifications: Design work and shop drawings shall be prepared by a licensed engineer practicing in the field of Fire Protection Engineering.
- B. Installer Reliability: The installer shall possess a valid State of Arkansas contractor's license. The installer shall provide documentation of having successfully completed three projects of similar size and scope.
- C. Materials and Equipment: All equipment and devices shall be of a make and type listed by UL and approved by FM, or other nationally recognized testing laboratory for the specific purpose for which it is used. All materials, devices, and equipment shall be approved by the VA.
- D. Testing: Materials and Testing Certificate as per NFPA 14. Provide certificates for all parts of the system.

1.6 DESIGN CRITERIA

- A. The design, materials, equipment, installation, and testing of the system shall be in accordance with NFPA 14 the latest edition.
- B. For hydraulic calculations, calculated demand shall not fall less than 10 percent below the water supply curve.
- C. Water Supply: Base water supply on the existing fire pump.
- D. Size standpipes to provide 450 kPa (65 psig) at the most remote connections.
- E. Provide seismic protection for all new and existing systems as required by NFPA 14. Also comply with Section 21 05 11, COMMON WORK RESULTS FOR FIRE SUPPRESSION, for allowable seismic design.

1.7 SUBMITTALS

- A. Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Prepare detailed working drawings that are stamped by a Registered Professional Engineer practicing in the field of Fire Protection Engineering. As Government review is for technical adequacy only, the installer remains responsible for correcting any conflicts with other trades and building construction that arise during installation. Partial submittals will not be accepted. Material submittals shall be approved prior to the purchase or delivery to the job site. Suitably bind submittals in notebooks or binders and provide index referencing the appropriate specification section. Submittals shall include, but not be limited to, the following:
1. Certificates:
 - a. Designer's and Installer's qualifications and documentation of previous work.
 - b. Materials and Testing certificates as specified.
 2. Drawings: Submit detailed 1:100 (1/8 inch) scale (minimum) working drawings conforming to NFPA 14. Include a site plan showing the fire hydrant nearest the fire department connection.
 3. Manufacturers Literature and Data Sheets: All pertinent literature and data for the materials and equipment proposed for the project. Include listing information and installation instructions in data sheets. Clearly identify the item to be used.
 - a. For the existing backflow preventer, provide flow test curves from UL, FM, or the Foundation for Hydraulic Research and Cross-Connection Control to verify pressure loss calculations.
 - b. Provide for materials and equipment proposed for use on the system. Include listing information and installation instructions in data sheets. Where data sheet describes items in addition to that item being submitted, clearly identify proposed item on the sheet.
 4. Calculation Sheets: Submit hydraulic calculations in accordance with NFPA 14.
 5. Final Document Submittals: Provide as-built drawings, testing and maintenance instructions in accordance with the requirements in Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Submittals shall include, but not be limited to, the following:
 - a. One complete set of reproducible as-built drawings showing the installed system with the specific interconnections between the waterflow switch and the fire alarm equipment. One copy of final CADD drawing files shall be provided on CD that are compatible with the VAMC CADD system.

- b. Four sets of complete, simple, understandable, step-by-step, testing instructions giving recommended and required testing frequency of all equipment, methods for testing all equipment, and a complete trouble shooting manual. Provide maintenance instructions on replacing any components of the system including internal parts, periodic cleaning and adjustment of the equipment and components with information as to the address and telephone number of both the manufacturer and the local supplier of each item.
- c. Certificates shall document all parts of the installation.
 - 1. Designer's and Installer's qualifications and documentation of previous work.
 - 2. Materials and Testing certificates as specified.
- d. Instruction Manual: Provide one copy of the instruction manual covering the system in a flexible protective cover and mount in an accessible location adjacent to the riser.

1.8 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. Except for a specific date given, the issue in effect (including amendments, addenda, revisions, supplements, and errata) on the date the system's submittal is technically approved by VA, shall be enforced.
- B. American Society of Mechanical Engineers (ASME):
 - B16.3..... Malleable Iron Threaded Fittings
- C. Factory Mutual Engineering Corporation (FM):
 - Approval Guide
- D. National Fire Protection Association (NFPA):
 - 14 Installation of Standpipe, Private Hydrant and Hose Systems
 - 101 Safety to Life from Fire in Buildings and Structures (Life Safety Code)
 - 170 Fire Safety Symbols
- E. Underwriters Laboratories, Inc. (UL):
 - Fire Protection Equipment Directory
- F. Uniform Building Code

PART 2 PRODUCTS

2.1 GENERAL

- A. All devices and equipment shall be Underwriters Laboratories listed for their intended purpose.

2.2 PIPING & FITTINGS

- A. Shall be in accordance with NFPA 14, black steel, schedule 10 minimum.
- B. Threaded or flanged fittings shall be ANSI B 16.3 cast iron, class 125 minimum. Threaded fitting are not permitted on pipe with wall thickness less than Schedule 40.
- C. Clamp-on fittings with rubber gaskets shall be listed for the piping application.
- D. Plain end pipe, fittings with locking lugs or shear bolts are not permitted. Use nonferrous piping in MRI Scanning Rooms.

2.3 VALVES

- A. Do not use quarter turn ball valves for 50 mm (2 inch) or larger drain valves.
- B. The wet system control valve shall be a listed indicating type valve. Control valve shall be UL Listed and FM Approved for fire protection installations. System control valve shall be rated for normal system pressure but in no case less than 175 PSI. (No Substitutions Allowed).
- C. Listed Indicating Valves:
 - 1. Gate: OS&Y, 1200kPa (175 psig) WOG.
 - 2. Butterfly: Gear operated, indicating type, 1200 kPa (175 psig) WOG.
- D. Check Valves: Swing type, rubber faced or wafer type spring loaded butterfly check valve, 1200 kPa (175 psig) WOG.
- E. Drain Valves: Threaded bronze angle, globe, ball or butterfly, 1000 kPa (150 psig.) WOG equipped with reducer and hose connection with cap or connected to a drain line.
- F. Standpipe Hose Valves: 65 mm (2-1/2 inch) screwed, brass hose angle valve, male hose threads same as local fire protection service, 65 mm (2-1/2 inch) by 40 mm (1-1/2 inch) reducer, and with permanently attached polished brass cap and chain.
- G. Roof Hydrant: Potter-Roemer, Inc. Fig. 5840 wall mount 4 x 2-1/2 2-way fire department outlet connection. Cast brass back outlet body with caps and chains. Cast brass round wall plate lettered "Hydrant".
- H. Roof Manifold: Potter-Roemer, Inc. Fig. 5845 free standing 4 x 2-1/2 2-way exposed fire department outlet connection. Cast brass back angle body with male hose threads with caps and chains. 18" long polished brass cover sleeve, and cast brass plate lettered "Hydrant".
- I. Automatic Ball Drips: Cast brass 20 mm (3/4 inch) in-line automatic ball drip with both ends threaded with iron pipe threads.

2.4 IDENTIFICATION SIGNS/HYDRAULIC PLACARDS

- A. Provide for all new and existing sectional valves, riser control valves, drain valves and alarm devises. The signs shall be in accordance with NFPA 14 and attached securely to each item.
- B. Plastic, steel or aluminum signs with white lettering on a red background with holes for easy attachment. Enter pertinent data for each system on the hydraulic placard.

2.5 STANDPIPE HOSE VALVE CABINETS

- A. Standpipe hose valve cabinets: Cabinets shall be 20 gage steel coated with glossy polyester to match wall, with continuous steel hinge with brass pin, recessed type 600 x 600 x 250 mm (24 x 24 x 10 in.). Exception: A smaller dimension for the depth may be used if required by the specific installation, and if approved by the Engineer.

2.6 VALVE SUPERVISORY SWITCHES:

- A. Provide each indicating standpipe and control valve with adequate means for mounting a valve supervisory switch.
- B. Mount switch so as not to interfere with normal operation of the valve and adjust to operate within two revolutions toward the closed position of the valve control, or when the stem is moved no more than one fifth of the distance from its normal position.
- C. The mechanism shall be contained in a weatherproof die cast aluminum housing, which shall provide a 20 mm (3/4 in.) tapped conduit entrance and incorporate the necessary facilities for attachment to the valves.
- D. Switch housing to be finished in red baked enamel.
- E. Water flow Alarm Switches: Mechanical, non-coded, non-accumulative retard and adjustable from 0 to 60 seconds minimum. Set flow switches at an initial setting between 20 and 30 seconds.
- F. Valve Supervisory Switches for Ball and Butterfly Valves: May be integral with the valve.
- G. All conduit and wiring connected thereto shall be provided in Section 28 31 00, FIRE DETECTION AND ALARM.

2.7 GAUGES

- A. Provide gauges as required by NFPA 14.

2.8 PIPE HANGERS AND SUPPORTS

- A. Supports, hangers, etc., of an approved pattern placement to conform to NFPA 14. System piping shall be substantially supported to the building structure. Materials used in the installation or construction of hangers and supports shall be listed and approved for such application. Hangers or supports not specifically listed for service shall be designed and bear the seal of a professional engineer.

2.9 WALL, FLOOR AND CEILING PLATES

- A. Provide chrome plated steel escutcheon plates for exposed piping passing through walls, floors or ceilings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be accomplished by the licensed contractor. Provide a qualified technician, experienced in the installation and operation of the type of system being installed, to supervise the installation and testing of the system.
- B. Installation of Piping: Accurately cut pipe to measurements established by the installer and work into place without springing or forcing. In any situation where bending of the pipe is required, use a standard pipe-bending template. Install concealed piping in spaces that have finished ceilings. Sidewall heads may need to be utilized. Locate piping in stairways as near to the ceiling as possible to prevent tampering by unauthorized personnel, and to provide a minimum headroom clearance of 2250 mm (seven feet six inches). To prevent an obstruction to egress, provide piping clearances in accordance with NFPA 101.
- C. Welding: Conform to the requirements and recommendations of NFPA 14.
- D. Drains: Pipe drains to discharge at safe points outside of the building or to sight cones attached to drains of adequate size to readily carry the full flow from each drain under maximum pressure. Do not provide a direct drain connection to sewer system or discharge into sinks. Install drips and drains where necessary and required by NFPA 14. Exception: Drains may be piped to adequately sized floor sinks within the building where approved by the RE.
- E. Valve Supervisory Switches: Provide supervisory switches for standpipe control valves. Do not provide standpipe hose valves and test and drain valves with supervisory switches. Do not provide valve supervisory switches on standpipe hose valves, test or drain valves. See Section 28 31 00, FIRE DETECTION AND ALARM for connections.
- F. Waterflow Alarm Switches: Install waterflow switch and adjacent valves in easily accessible locations.

- G. Affix cutout disks, which are created by cutting holes in the walls of pipe for flow switches and non-threaded pipe connections to the respective waterflow switch or pipe connection near to the pipe from where they were cut.
- H. Provide pressure gauge at each water flow alarm switch location, at the top of each standpipe, and at each main drain connection.
- I. Penetrations: Sleeve or core drill concrete and masonry. Provide clearance between pipe and openings as required by NFPA 14. Seal penetrations and clearances in fire rated wall and floor assemblies with listed through-penetration firestop materials in accordance with Section 07 84 00, FIRESTOPPING.
- J. Securely attach identification signs to control valves, drain valves, and test valves. Locate hydraulic placard information signs at each sectional control valve where there is a zone water flow switch.
- K. Interruption of Service: There shall be no interruption of the existing sprinkler protection, water, electric, or fire alarm services without prior permission of the Contracting Officer. Contractor shall develop an interim fire protection program where interruptions involve in occupied spaces. Request in writing at least one (1) week prior to the planned interruption. Any interruption shall be limited to 4 hours for final connections or repairs.
- L. Welding: All welding shall conform to the requirements and recommendations of NFPA 14 latest editions.

3.2 INSPECTION AND TEST

- A. Flushing: Flush newly installed systems prior to performing hydrostatic tests in order to remove any debris which may have been left as well as ensuring piping is unobstructed.
- B. Hydrostatic Testing: Hydrostatically test the system including the fire department connections, as specified in NFPA 14, NFPA 25 and NFPA 13 latest edition, in the presence of the Authority Having Jurisdiction or his designated representative.
- C. Final Inspection and Testing: Test the system in accordance with NFPA 14, NFPA 25 and NFPA 13 latest editions after all necessary corrections have been accomplished. Advise the Authority Having Jurisdiction who will then schedule the final inspection and test. Furnish all instruments, labor and materials required for the tests and provide the services of the installation foreman or other competent representative of the installer to perform the tests. Correct any deficiencies found and retest the system. Include the operation of all features of the systems under normal conditions in the test.

3.3 INSTRUCTIONS

- A. Furnish the services of a competent instructor for not less than two hours for instructing personnel in the operation and maintenance of the system, on the dates requested by the COTR/Resident Engineer.

3.4 WARRANTY

- A. All work performed and materials and equipment furnished under this contract shall be free from defects for a period of one year from date of acceptance by the government.
- B. All new piping and equipment incorporated into the new system shall be hydrostatically tested and warranted as new.

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SECTION 21 13 13
WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 SCOPE OF WORK

- A. Design, installation and testing shall be in accordance with NFPA 13, 2011 except for specified exceptions.
- B. The design and installation of a hydraulically calculated automatic wet system complete and ready for operation, for all portions of Building 172, including the mechanical equipment rooms, telephone rooms, elevator machine rooms, and elevator shafts.
- C. Modification of the existing sprinkler system as indicated on the drawings and as further required by these specifications.

1.2 RELATED WORK

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Section 33 10 00, WATER UTILITIES.
- C. Section 07 84 00, FIRESTOPPING, Treatment of penetrations through rated enclosures.
- D. Section 09 91 00, PAINTING.
- E. Section 21 10 00, WATER-BASED FIRE-SUPPRESSION SYSTEMS, Dry sprinklers, fire pumps, etc.
- F. Section 21 12 00, FIRE-SUPPRESSION STANDPIPES.
- G. Section 28 31 00, FIRE DETECTION AND ALARM, Connection to fire alarm of flow switches, pressure switches and valve supervisory switches.
- H. Section 21 05 11, COMMON WORK RESULTS FOR FIRE SUPPRESSION.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. **Installer Reliability:** The installer shall possess a valid State of Arkansas fire sprinkler contractor's license. The installer shall have been actively and successfully engaged in the installation of commercial automatic sprinkler systems for the past ten years.
- B. **Materials and Equipment:** All equipment and devices shall be of a make and type listed by UL and approved by FM, or other nationally recognized testing laboratory for the specific purpose for which it is used. All materials, devices, and equipment shall be approved by the VA.
- C. **Submittals:** Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Prepare detailed working drawings that are signed by a NICET Level III or Level IV Sprinkler Technician or stamped by a Registered Professional Engineer practicing in the field of Fire Protection Engineering. As Government review is for technical adequacy only, the installer remains responsible for correcting any conflicts with other trades and building construction that arise during installation. Partial submittals will not be accepted. Material submittals shall be approved prior to the purchase or delivery to the job site. Suitably bind submittals in notebooks or binders and provide index referencing the appropriate specification section. Submittals shall include, but not be limited to, the following:
 - 1. **Qualifications:**
 - a. Provide a copy of the installing contractor's fire sprinkler contractor license.
 - b. Provide a copy of the NICET certification for the NICET Level III or Level IV Sprinkler Technician who prepared and signed the detailed working drawings unless the drawings are stamped by a Registered Professional Engineer practicing in the field of Fire Protection Engineering.
 - 2. **Drawings:** Submit detailed 1:100 (1/8 inch) scale (minimum) working drawings conforming to NFPA 13. Include a site plan showing the piping to the water supply test location.
 - 3. **Manufacturers Data Sheets:**
 - a. For existing backflow preventers, provide flow test curves from UL, FM, or the Foundation for Hydraulic Research and Cross-Connection Control to verify pressure loss calculations.
 - b. Provide for materials and equipment proposed for use on the system. Include listing information and installation instructions in data sheets. Where data sheet describes items in addition to that item being submitted, clearly identify proposed item on the sheet.
 - 4. **Calculation Sheets:** Submit hydraulic calculation sheets in tabular form conforming to the requirements and recommendations of NFPA 13.

5. Final Document Submittals: Provide as-built drawings, testing and maintenance instructions in accordance with the requirements in Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Submittals shall include, but not be limited to, the following:
 - a. One complete set of reproducible as-built drawings showing the installed system with the specific interconnections between the waterflow switch or pressure switch and the fire alarm equipment.
 - b. Complete, simple, understandable, step-by-step, testing instructions giving recommended and required testing frequency of all equipment, methods for testing all equipment, and a complete trouble shooting manual. Provide maintenance instructions on replacing any components of the system including internal parts, periodic cleaning and adjustment of the equipment and components with information as to the address and telephone number of both the manufacturer and the local supplier of each item.
 - c. Material and Testing Certificate: Upon completion of the sprinkler system installation or any partial section of the system, including testing and flushing, provide a copy of a completed Material and Testing Certificate as indicated in NFPA 13.
 - d. Certificates shall document all parts of the installation.
 - e. Instruction Manual: Provide one copy of the instruction manual covering the system in a flexible protective cover and mount in an accessible location adjacent to the riser.
- D. Design Basis Information: Provide design, materials, equipment, installation, inspection, and testing of the automatic sprinkler system in accordance with the requirements of NFPA 13. Recommendations in appendices shall be treated as requirements.
 1. Perform hydraulic calculations in accordance with NFPA 13 utilizing the Area/Density method. Do not restrict design area reductions permitted for using quick response sprinklers throughout by the required use of standard response sprinklers in the areas identified in this section.
 2. Sprinkler Protection: To determining spacing and sizing, apply the following coverage classifications:
 - a. Light Hazard Occupancies: Patient care, treatment, and customary access areas.
 - b. Ordinary Hazard Group 1 Occupancies: Storage rooms between 9 and 23 m² (100 and 250 sq. ft.), Mechanical Equipment Rooms, Electrical Switchgear Rooms, Electric Closets, Elevator Machine Rooms, and Elevator Shafts.
 - c. Ordinary Hazard Group 2 Occupancies: Storage rooms over 23 m² (250 sq. ft.), clean and soiled linen rooms, pharmacy and associated storage, and storage areas..

- d. Request clarification from the Government for any hazard classification not identified.
- 3. Hydraulic Calculations: Calculated demand including hose stream requirements shall fall no less than 10 percent below the available water supply curve.
 - a. Base sprinkler design on the capacity of the existing fire pump as identified in Section 21 10 00, WATER-BASED FIRE-SUPPRESSION SYSTEMS.
- 4. Zoning:
 - a. For each sprinkler zone provide a control valve, flow switch and a test and drain assembly with pressure gauge.
 - b. Sprinkler zones shall conform to the smoke barrier zones shown on the drawings.
 - c. Provide seismic protection in accordance with NFPA 13.

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. National Fire Protection Association (NFPA):
 - 13Installation of Sprinkler Systems
 - 101-09Safety to Life from Fire in Buildings and Structures (Life Safety Code)
 - 170Fire Safety Symbols
- C. Underwriters Laboratories, Inc. (UL): Fire Protection Equipment Directory.
- D. Factory Mutual Engineering Corporation (FM): Approval Guide
- E. Uniform Building Code
- F. Foundation for Cross-Connection Control and Hydraulic Research

PART 2 PRODUCTS

2.1 PIPING & FITTINGS

- A. Sprinkler systems in accordance with NFPA 13.

2.2 VALVES

- A. Valves in accordance with NFPA 13.
- B. Do not use quarter turn ball valves for 50 mm (2 inch) or larger drain valves.
- C. The wet system control valve shall be a listed indicating type valve. Control valve shall be UL Listed and FM Approved for fire protection installations. System control valve shall be rated for normal system pressure but in no case less than 175 PSI. (No Substitutions Allowed).
- D. Automatic Ball Drips: Cast brass 20 mm (3/4 inch) in-line automatic ball drip with both ends threaded with iron pipe threads.

2.3 SPRINKLERS

- A. All sprinklers except “institutional” type sprinklers shall be FM approved. Provide quick response sprinklers in all areas, except where specifically prohibited by their listing or approval.
 - 1. Elevator shafts and machine rooms: Standard response sprinklers.
- B. Temperature Ratings: In accordance with NFPA 13, except as follows:
 - 1. Sprinklers in elevator shafts and elevator machine rooms: Intermediate temperature rated.

2.4 SPRINKLER CABINET

- A. Provide sprinkler cabinet with the required number of sprinkler heads of all ratings and types installed, and a sprinkler wrench for each system. Locate adjacent to the riser. Sprinkler heads shall be installed in center of tile or center to center.

2.5 IDENTIFICATION SIGNS/HYDRAULIC PLACARDS

- A. Plastic, steel or aluminum signs with white lettering on a red background with holes for easy attachment. Enter pertinent data for each system on the hydraulic placard.

2.6 SWITCHES

- A. Contain in a weatherproof die cast/red baked enamel, oil resistant, aluminum housing with tamper resistant screws, 13 mm (1/2 inch) conduit entrance and necessary facilities for attachment to the valves. Provide two SPDT switches rated at 2.5 amps at 24 VDC.
- B. Water flow Alarm Switches: Mechanical, non-coded, non-accumulative retard and adjustable from 0 to 60 seconds minimum. Set flow switches at an initial setting between 20 and 30 seconds.
- C. Valve Supervisory Switches for Ball and Butterfly Valves: May be integral with the valve.

2.7 GAUGES

- A. Provide gauges as required by NFPA 13.

2.8 PIPE HANGERS AND SUPPORTS

- A. Supports, hangers, etc., of an approved pattern placement to conform to NFPA 13. System piping shall be substantially supported to the building structure. The installation of hangers and supports shall adhere to the requirements set forth in NFPA 13, Standard for Installation of Sprinkler Systems. Materials used in the installation or construction of hangers and supports shall be listed and approved for such application. Hangers or supports not specifically listed for service shall be designed and bear the seal of a professional engineer.

2.9 WALL, FLOOR AND CEILING PLATES

- A. Provide chrome plated steel escutcheon plates for exposed piping passing through walls, floors or ceilings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be accomplished by the licensed contractor. Provide a qualified technician, experienced in the installation and operation of the type of system being installed, to supervise the installation and testing of the system.
- B. Installation of Piping: Accurately cut pipe to measurements established by the installer and work into place without springing or forcing. In any situation where bending of the pipe is required, use a standard pipe-bending template. Install concealed piping in spaces that have finished ceilings. Where ceiling mounted equipment exists, such as in operating and radiology rooms, install sprinklers so as not to obstruct the movement or operation of the equipment. Sidewall heads may need to be utilized. Locate piping in stairways as near to the ceiling as possible to prevent tampering by unauthorized personnel, and to provide a minimum headroom clearance of 2250 mm (seven feet six inches). To prevent an obstruction to egress, provide piping clearances in accordance with NFPA 101.
- C. Welding: Conform to the requirements and recommendations of NFPA 13.
- D. Drains: Pipe drains to discharge at safe points outside of the building or to sight cones attached to drains of adequate size to readily carry the full flow from each drain under maximum pressure. Do not provide a direct drain connection to sewer system or discharge into sinks. Install drips and drains where necessary and required by NFPA 13. Exception: Drains may be piped to adequately sized floor sinks within the building where approved by the RE.
- E. Supervisory Switches: Provide supervisory switches for sprinkler control valves.
- F. Waterflow Alarm Switches: Install waterflow switch and adjacent valves in easily accessible locations.
- G. Inspector's Test Connection: Install and supply in conformance with NFPA 13, locate in a secured area, and discharge to the exterior of the building.
- H. Affix cutout disks, which are created by cutting holes in the walls of pipe for flow switches and non-threaded pipe connections to the respective waterflow switch or pipe connection near to the pipe from where they were cut.
- I. Sleeves: Provide for pipes passing through masonry or concrete. Provide space between the pipe and the sleeve in accordance with NFPA 13. Seal this space with a UL Listed through penetration fire stop material in accordance with Section 07 84 00, FIRESTOPPING. Where core drilling is used in lieu of sleeves, also seal space. Seal penetrations of walls, floors and ceilings of other types of construction, in accordance with Section 07 84 00, FIRESTOPPING.

- J. Provide pressure gauge at each water flow alarm switch location and at each main drain connection.
- K. Firestopping shall comply with Section 07 84 00, FIRESTOPPING.
- L. Securely attach identification signs to control valves, drain valves, and test valves. Locate hydraulic placard information signs at each sectional control valve where there is a zone water flow switch.
- M. Repairs: Repair damage to the building or equipment resulting from the installation of the sprinkler system by the installer at no additional expense to the Government.
- N. Interruption of Service: There shall be no interruption of the existing sprinkler protection, water, electric, or fire alarm services without prior permission of the Contracting Officer. Contractor shall develop an interim fire protection program where interruptions involve in occupied spaces. Request in writing at least one week prior to the planned interruption.

3.2 INSPECTION AND TEST

- A. Additional Testing for portions of system in existing Building 170: Prior to hydrostatic testing as required by NFPA 13 for wet systems, it is required that the existing area in Building 170 be pneumatically tested for 2 hours with 50 PSI showing not more than 5 PSI loss in pressure in the 2 hour period as similarly described in NFPA 13 for pneumatic testing requirements for dry systems. The contractor shall isolate each area for testing. If during the isolation process existing grooved couplings are removed, the contractor is required to install new ones in the place of the ones removed for isolation purposes. Properly executed tests certificates are required for "Close Out Documents".
- B. Preliminary Testing: Flush newly installed systems prior to performing hydrostatic tests in order to remove any debris which may have been left as well as ensuring piping is unobstructed. Hydrostatically test system, including the fire department connections, as specified in NFPA 13, in the presence of the Contracting Officers Technical Representative (COTR) or his designated representative. Test and flush underground water line prior to performing these hydrostatic tests.

- C. Final Inspection and Testing: Subject system to tests in accordance with NFPA 13, and when all necessary corrections have been accomplished, advises COTR/Resident Engineer to schedule a final inspection and test. Connection to the fire alarm system shall have been in service for at least ten days prior to the final inspection, with adjustments made to prevent false alarms. Furnish all instruments, labor and materials required for the tests and provide the services of the installation foreman or other competent representative of the installer to perform the tests. Correct deficiencies and retest system as necessary, prior to the final acceptance. Include the operation of all features of the systems under normal operations in test.

3.3 INSTRUCTIONS

- A. Furnish the services of a competent instructor for not less than two hours for instructing personnel in the operation and maintenance of the system, on the dates requested by the COTR/Resident Engineer.

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SECTION 22 05 11
COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section 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 31 20 00, EARTH MOVING: Excavation and Backfill.
- D. Section 03 30 00, CAST-IN-PLACE CONCRETE: Concrete and Grout.
- E. Section 05 50 00, METAL FABRICATIONS.
- F. Section 07 84 00, FIRESTOPPING.
- G. Section 07 60 00, FLASHING AND SHEET METAL: Flashing for Wall and Roof Penetrations.
- H. Section 07 92 00, JOINT SEALANTS.
- I. Section 09 91 00, PAINTING.
- J. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- K. Section 23 07 11, HVAC INSULATION.
- L. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- M. Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 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 160 km (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 under these conditions for (as applicable to the project): pumps, critical instrumentation, computer workstation and programming 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 Resident Engineer (RE)/Contracting Officers Technical Representative (COTR).
5. **Multiple Units:** When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.
6. **Assembled Units:** Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.
7. **Nameplates:** Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
8. Asbestos products or equipment or materials containing asbestos shall not be used.

- B. Welding: Before any welding is performed, contractor shall submit a certificate certifying that welders comply with the following requirements:
1. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualifications".
 2. Comply with provisions of ASME B31 series "Code for Pressure Piping".
 3. Certify that each welder has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.
 4. All welds shall be stamped according to the provisions of the American Welding Society.
- C. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Resident Engineer prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.
- D. Execution (Installation, Construction) Quality:
1. 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 RE/COTR for resolution. Written hard copies or computer files of manufacturer's installation instructions shall be provided to the RE/COTR at least two weeks prior to commencing installation of any item.
 2. Complete layout drawings shall be required by Paragraph, SUBMITTALS. Construction work shall not start on any system until the layout drawings have been approved.
- E. Guaranty: Warranty of Construction, FAR clause 52.246-21.
- F. Plumbing Systems: IPC, International Plumbing Code.

1.5 SUBMITTALS

- A. Submittals shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Submittals for individual systems and equipment assemblies which consist of more than one item or component shall be made for the system or assembly as a whole. Partial submittals will not be considered for approval.
1. Mark the submittals, "SUBMITTED UNDER SECTION_____".
 2. Submittals shall be marked to show specification reference including the section and paragraph numbers.
 3. Submit each section separately.

- 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. Electric motor data and variable speed drive data shall be submitted with the driven equipment.
 - 2. Equipment and materials identification.
 - 3. Fire stopping materials.
 - 4. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.
 - 5. Wall, floor, and ceiling plates.
- H. Coordination Drawings: Complete consolidated and coordinated layout drawings shall be submitted for all new systems, and for existing systems that are in the same areas. The drawings shall include plan views, elevations and sections of all systems and shall be on a scale of not less than 1:32 (3/8-inch equal to one foot). Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings shall clearly show the proposed location and adequate clearance for all equipment, piping, pumps, valves and other items. All valves, trap primer valves, water hammer arrestors, strainers, and equipment requiring service shall be provided with an access door sized for the complete removal of plumbing device, component, or equipment. Equipment foundations shall not be installed until equipment or piping until layout drawings have been approved. Detailed layout drawings shall be provided for all piping systems. In addition, details of the following shall be provided.
 - 1. Mechanical equipment rooms.

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

I. Maintenance Data and Operating Instructions:

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

1.6 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage.
2. Damaged equipment shall be replaced with an identical unit as determined and directed by the RE/COTR. 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 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 SAFETY GUARDS

- A. Pump shafts and couplings shall be fully guarded by a sheet steel guard, covering coupling and shaft but not bearings. Material shall be minimum 16-gage sheet steel; ends shall be braked and drilled and attached to pump base with minimum of four 6 mm (1/4-inch) bolts. Reinforce guard as necessary to prevent side play forcing guard onto couplings.
- B. All Equipment shall have moving parts protected from personal injury.

2.4 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.

2.5 ELECTRIC MOTORS, MOTOR CONTROL, CONTROL WIRING

- A. All material and equipment furnished and installation methods shall conform to the requirements of Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT; and, Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). All electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems shall be provided. Premium efficient motors shall be provided. Unless otherwise specified for a particular application, electric motors shall have the following requirements.
- B. 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, and controls and interlocks on factory assembled and wired devices shall be in accordance with the requirements of this specification.
 3. Wire and cable materials specified in the electrical division of the specifications shall be modified as follows:
 - a. Wiring material located where temperatures can exceed 71° C (160° 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. Shielded conductors or wiring in separate conduits for all instrumentation and control systems shall be provided where recommended by manufacturer of equipment.
 4. Motor sizes shall be selected 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-ready” per NEMA Standard, MG1, Part 31.4.4.2.
- C. Motor Efficiency and Power Factor: All motors, when specified as “high efficiency or Premium Efficiency” by the project specifications on driven equipment, shall conform to efficiency and power factor requirements in Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT, with no consideration of annual service hours. Motor manufacturers generally define these efficiency requirements as “NEMA premium efficient” and the requirements generally exceed those of the Energy Policy Act of 1992 (EPACT). Motors not specified as “high efficiency or premium efficient” shall comply with EPACT.
- D. Single-phase Motors: Capacitor-start type for hard starting applications. Motors for centrifugal fans and pumps may be split phase or permanent split capacitor (PSC).
- E. Poly-phase Motors: NEMA Design B, Squirrel cage, induction type. Each two-speed motor shall have two separate windings. A time delay (20 seconds minimum) relay shall be provided for switching from high to low speed.
- F. Rating: Rating shall be continuous duty at 100 percent capacity in an ambient temperature of 40° C (104° F); minimum horsepower as shown on drawings; maximum horsepower in normal operation shall not exceed nameplate rating without service factor.
- G. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame shall be measured at the time of final inspection.

2.6 VARIABLE SPEED MOTOR CONTROLLERS

- A. Refer to Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS for specifications.

- B. The combination of controller and motor shall be provided by the respective pump manufacturer, 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 efficient type, “invertor duty”, and be approved by the motor controller manufacturer. The controller-motor combination shall be guaranteed to provide full motor nameplate horsepower in variable frequency operation. Both driving and driven motor/fan sheaves shall be fixed pitch.
- D. Controller shall not add any current or voltage transients to the input AC power distribution system, DDC controls, sensitive medical equipment, etc., nor shall be affected from other devices on the AC power system.

2.7 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 48 mm (3/16-inch) high of brass with black-filled letters, or rigid black plastic with white letters specified in Section 09 91 00, PAINTING shall be permanently fastened to the equipment. Unit components such as water heaters, tanks, coils, filters, fans, etc. shall be identified.
- C. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 48 mm (3/16-inch) high riveted or bolted to the equipment.
- D. Control Items: 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.
- E. 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 13 mm (1/2-inch) high for number designation, and not less than 6.4 mm(1/4-inch) for service designation on 19 gage, 38 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.
 - 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 216 mm (8-1/2 inches) by 280 mm (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.

2.8 FIRE STOPPING

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

2.9 GALVANIZED REPAIR COMPOUND

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

2.10 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), 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 227 kg (500 pounds) shall be submitted for approval of the Resident Engineer 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 102 mm (4 inches) thick when approved by the Resident Engineer for each job condition.
 3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 102 mm (4 inches) thick when approved by the Resident Engineer 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 23 mm (7/8-inch) outside diameter.
- E. Attachment to Metal Pan or Deck: As required for materials specified in Section 05 31 00, STEEL DECKING and Section 05 36 00, COMPOSITE METAL DECKING.

- F. For Attachment to Wood Construction: Wood screws or lag bolts.
- G. Hanger Rods: Hot-rolled steel, ASTM A36 or A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 38 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.
- H. Multiple (Trapeze) Hangers: Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (No. 12 gage), designed to accept special spring held, hardened steel nuts. Trapeze hangers are not permitted for steam supply and condensate piping.
1. Allowable hanger load: Manufacturers rating less 91kg (200 pounds).
 2. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4-inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 13 mm (1/2-inch) galvanized steel bands, or insulated calcium silicate shield for insulated piping at each hanger.
- I. Pipe Hangers and Supports: (MSS SP-58), use hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or 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.

- 4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.
- i. Supports for plastic or glass piping: As recommended by the pipe manufacturer with black rubber tape extending one inch beyond steel support or clamp. Spring Supports (Expansion and contraction of vertical piping):
 - 1) Movement up to 20 mm (3/4-inch): Type 51 or 52 variable spring unit with integral turn buckle and load indicator.
 - 2) Movement more than 20 mm (3/4-inch): Type 54 or 55 constant support unit with integral adjusting nut, turn buckle and travel position indicator.
- j. Spring hangers are required on all plumbing system pumps one horsepower and greater.
2. Plumbing Piping (Other Than General Types):
 - a. Horizontal piping: Type 1, 5, 7, 9, and 10.
 - b. Chrome plated piping: Chrome plated supports.
 - c. Hangers and supports in pipe chase: Prefabricated system ABS self-extinguishing material, not subject to electrolytic action, to hold piping, prevent vibration and compensate for all static and operational conditions.
 - d. Blocking, stays and bracing: Angle iron or preformed metal channel shapes, 1.3 mm (18 gage) minimum.
- J. Pre-insulated Calcium Silicate Shields:
 1. Provide 360 degree water resistant high density 965 kPa (140 psi) compressive strength calcium silicate shields encased in galvanized metal.
 2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
 3. Shield thickness shall match the pipe insulation.
 4. The type of shield is selected by the temperature of the pipe, the load it must carry, and the type of support it will be used with.
 - a. Shields for supporting cold water shall have insulation that extends a minimum of one inch past the sheet metal.
 - b. The insulated calcium silicate shield shall support the maximum allowable water filled span as indicated in MSS-SP 69. To support the load, the shields shall have one or more of the following features: structural inserts 4138 kPa (600 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.
- K. Seismic Restraint of Piping: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

2.11 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 25 mm (1 inch) above finished floor and provide sealant for watertight joint.
 - 2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
 - 3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.
- D. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of Resident Engineer.
- E. Sheet metal, plastic, or moisture resistant fiber sleeves shall be provided for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.
- F. Cast iron or zinc coated pipe sleeves shall be provided for pipe passing through exterior walls below grade. The space between the sleeve and pipe shall be made watertight with a modular or link rubber seal. The link seal shall be applied at both ends of the sleeve.
- G. Galvanized steel or an alternate black iron pipe with asphalt coating sleeves shall be for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. A galvanized steel Sleeve shall be provided for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, sleeves shall be connected with a floor plate.
- H. Brass Pipe Sleeves shall be provided for pipe passing through quarry tile, terrazzo or ceramic tile floors. The sleeve shall be connected with a floor plate.
- I. Sleeve clearance through floors, walls, partitions, and beam flanges shall be 25 mm (1 inch) greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation plus 25 mm (1 inch) in diameter. Interior openings shall be caulked tight with 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 TOOLS AND LUBRICANTS

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

2.13 WALL, FLOOR AND CEILING PLATES

- A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.
- B. Thickness: Not less than 2.4 mm (3/32-inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025-inch) for up to 80 mm (3 inch) pipe, 0.89 mm (0.035-inch) for larger pipe.
- C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Wall plates shall be used where insulation ends on exposed water supply pipe drop from overhead. A watertight joint shall be provided in spaces where brass or steel pipe sleeves are specified.

2.14 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 RE/COTR 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 RE/COTR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to RE/COTR 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 and pneumatic interconnections are not shown but must be provided.
- G. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.
- H. Protection and Cleaning:
1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the Resident Engineer. Damaged or defective items in the opinion of the Resident Engineer, shall be replaced.
 2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. 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 25 MPa (3000 psi) minimum, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE 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. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments and computer workstations. 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 plumbers 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 RE/COTR 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 Resident Engineer.
- B. The use of chain pipe supports, wire or strap hangers; wood for blocking, stays and bracing, or hangers suspended from piping above shall not be permitted. Rusty products shall be replaced.

- C. Hanger rods shall be used that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. A minimum of 15 mm (1/2-inch) clearance between pipe or piping covering and adjacent work shall be provided.
- D. For horizontal and vertical plumbing pipe supports, refer to the International Plumbing Code (IPC), 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 50 mm (2 inch) excess on all edges. Structural drawings shall be reviewed for additional requirements. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top, and shall be suitable for painting.
 - 3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a grout material to permit alignment and realignment.
 - 4. For seismic anchoring, refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

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.
- B. All devices and equipment shall be equipped with required lubrication fittings. A minimum of one liter (one quart) of oil and 0.5 kg (one pound) of grease of manufacturer's recommended grade and type for each different application shall be provided. All materials shall be delivered to RE/COTR in unopened containers that are properly identified as to application.

- C. A separate grease gun with attachments for applicable fittings shall be provided for each type of grease applied.
- D. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.
- E. All lubrication points shall be extended to one side of the equipment.

3.6 PLUMBING SYSTEMS DEMOLITION

- A. Rigging access, other than indicated on the drawings, shall be provided after approval for structural integrity by the RE/COTR. 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 RE or COTR 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 RE/COTR and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these plans and specifications. Such material shall be removed from Government property expeditiously and shall not be allowed to accumulate.

3.7 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 5 mm (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. Vibration within specified tolerance shall be verified prior to extended operation. Temporary use of equipment is specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.

3.10 OPERATING AND PERFORMANCE TESTS

- A. Prior to the final inspection, all required tests shall be performed as specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TESTS and submit the test reports and records to the Resident Engineer.
- B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost to the Government.
- C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then make performance tests 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 RE/COTR 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, speed, horsepower, impeller size, 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. Lubrication instructions, type and quantity of lubricant shall be included.
- F. Schematic diagrams and wiring diagrams of all control systems corrected to include all field modifications shall be included.
- G. Set points of all interlock devices shall be listed.
- H. Trouble-shooting guide for the control system troubleshooting guide shall be inserted into the Operations and Maintenance Manual.
- I. The combustion control system sequence of operation corrected with submittal review comments shall be inserted into the Operations and Maintenance Manual.
- J. Emergency procedures.

3.12 INSTRUCTIONS TO VA PERSONNEL

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

3.13 COMMISSIONING

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

- - - E N D - - -

SECTION 22 05 12
GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION:

This section describes the general motor requirements for plumbing 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.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 SUBMITTALS:

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS
- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Motor nameplate information shall be submitted including electrical ratings, dimensions, mounting details, materials, horsepower, power factor, current as a function of speed, current efficiency, speed as a function of load, RPM, enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.
 - 3. Motor parameters required for the determination of the Reed Critical Frequency of vertical hollow shaft motors shall be submitted.
- C. Manuals:
 - 1. Companion copies of complete maintenance and operating manuals, including technical data sheets and application data shall be submitted simultaneously with the shop drawings.

D. Certification: Two weeks prior to final inspection, unless otherwise noted, four copies of the following certification shall be submitted to the Resident Engineer:

1. Certification shall be submitted stating that the motors have been properly applied, installed, adjusted, lubricated, and tested.

1.5 APPLICABLE PUBLICATIONS:

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

B. National Electrical Manufacturers Association (NEMA):

MG 1-07.....Motors and Generators

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

C. National Fire Protection Association (NFPA):

70-11National Electrical Code (NEC)

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. Voltage ratings shall be as follows:

1. Single phase:

- a. Motors connected to 120-volt systems: 115 volts.
- b. Motors connected to 208-volt systems: 200 volts.
- c. Motors connected to 240 volt or 480 volt systems: 230/460 volts, dual connection.

2. Three phase:

- a. Motors connected to 208-volt systems: 200 volts.
- b. Motors, less than 74.6 kW (100 HP), connected to 240 volt or 480 volt systems: 230/460 volts, dual connection.
- c. Motors, 74.6 kW (100 HP) or larger, connected to 240-volt systems: 230 volts.
- d. Motors, 74.6 kW (100 HP) or larger, connected to 480-volt systems: 460 volts.
- e. Motors connected to high voltage systems: Shall conform to NEMA Standards for connection to the nominal system voltage shown on the drawings.

C. Number of phases shall be as follows:

1. Motors, less than 373 W (1/2 HP): Single phase.
2. Motors, 373 W (1/2 HP) and larger: 3 phase.

3. Exceptions:
 - a. Hermetically sealed motors.
 - b. Motors for equipment assemblies, less than 746 W (1 HP), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.
- D. Horsepower ratings shall be adequate for operating the connected loads continuously in the prevailing ambient temperatures in areas where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation.
- E. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting and running torque.
- F. Motor Enclosures:
 1. Shall be the NEMA types shown on the drawings for the motors.
 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.
 3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.
 4. All motors in hazardous locations shall be approved for the application and meet the Class and Group as required by the area classification.
- G. Electrical Design Requirements
 1. Motors shall be continuous duty.
 2. The insulation system shall be rated minimum of class B, 130° C (266° F).
 3. The maximum temperature rise by resistance at rated power shall not exceed Class B limits, 80° C (176° F).
 4. The speed/torque and speed/current characteristics shall comply with NEMA Design A or B, as specified.
 5. Motors shall be suitable for full voltage starting, unless otherwise noted.
 6. Motors for variable frequency drive applications shall adhere to NEMA standards publication MG 1, Part 30, Application considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable voltage or Adjustable frequency controls, or both, or Part 31, Definite Purpose Inverter Fed Polyphase Motors.

H. Mechanical Design Requirements

1. Bearings shall be rated for a minimum of 26,280 hours L-10 life at full load direct coupled, except vertical high thrust motors.
 2. Vertical motors shall be capable of withstanding a momentary up thrust of at least 30% of normal down thrust.
 3. Grease lubricated bearings shall be designed for electric motor use. Grease shall be capable of the temperatures associated with electric motors and shall be compatible with Polyurea based greases.
 4. Grease fittings, if provided, shall be Alemite type or equivalent.
 5. Oil lubricated bearings, when specified, shall have an externally visible sight glass to view oil level.
 6. Vibration shall not exceed 0.15 inch per second, unfiltered peak.
 7. Noise level shall meet the requirements of the application.
 8. Motors on 180 frames and larger shall have provisions for lifting eyes or lugs capable of a safety factor of 5.
 9. All external fasteners shall be corrosion resistant.
 10. Condensation heaters, when specified, shall keep motor windings at least 5° C (41° F) above ambient temperature.
 11. Winding thermostats, when specified shall be normally closed, connected in series.
 12. Grounding provisions shall be in the main terminal box.
- I. Additional requirements for specific motors, as indicated in other sections, shall also apply.
- J. NEMA Premium Efficiency Electric Motors, Motor Efficiencies: All permanently wired polyphase motors of 746 Watts (1 Horsepower) or more shall meet the minimum full-load efficiencies as indicated in the following table, and as specified in this specification. Motors of 746 Watts (one horsepower) 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.

Minimum Efficiencies Open Drip-Proof				Minimum Efficiencies Totally Enclosed Fan-Cooled			
Rating kW (HP)	1200 RPM	1800 RPM	3600 RPM	Rating kW (HP)	1200 RPM	1800 RPM	3600 RPM
0.746 (1)	82.5%	85.5%	77.0%	0.746 (1)	82.5%	85.5%	77.0%
1.12 (1.5)	86.5%	86.5%	84.0%	1.12 (1.5)	87.5%	86.5%	84.0%
1.49 (2)	87.5%	86.5%	85.5%	1.49 (2)	88.5%	86.5%	85.5%
2.24 (3)	88.5%	89.5%	85.5%	2.24 (3)	89.5%	89.5%	86.5%
3.73 (5)	89.5%	89.5%	86.5%	3.73 (5)	89.5%	89.5%	88.5%
5.60 (7.5)	90.2%	91.0%	88.5%	5.60 (7.5)	91.0%	91.7%	89.5%
7.46 (10)	91.7%	91.7%	89.5%	7.46 (10)	91.0%	91.7%	90.2%
11.2 (15)	91.7%	93.0%	90.2%	11.2 (15)	91.7%	92.4%	91.0%
14.9 (20)	92.4%	93.0%	91.0%	14.9 (20)	91.7%	93.0%	91.0%
18.7 (25)	93.0%	93.6%	91.7%	18.7 (25)	93.0%	93.6%	91.7%
22.4 (30)	93.6%	94.1%	91.7%	22.4 (30)	93.0%	93.6%	91.7%
29.8 (40)	94.1%	94.1%	92.4%	29.8 (40)	94.1%	94.1%	92.4%
37.3 (50)	94.1%	94.5%	93.0%	37.3 (50)	94.1%	94.5%	93.0%
44.8 (60)	94.5%	95.0%	93.6%	44.8 (60)	94.5%	95.0%	93.6%
56.9 (75)	94.5%	95.0%	93.6%	56.9 (75)	94.5%	95.4%	93.6%
74.6 (100)	95.0%	95.4%	93.6%	74.6 (100)	95.0%	95.4%	94.1%
93.3 (125)	95.0%	95.4%	94.1%	93.3 (125)	95.0%	95.4%	95.0%
112 (150)	95.4%	95.8%	94.1%	112 (150)	95.8%	95.8%	95.0%
149.2 (200)	95.4%	95.8%	95.0%	149.2 (200)	95.8%	96.2%	95.4%

K. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at 1200 RPM, 1800 RPM and 3600 RPM. Power factor correction capacitors shall be installed unless the motor is controlled by a variable frequency drive. The power factor correction capacitors shall be able to withstand high voltage transients and power line variations without breakdown.

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

Megger all motors after installation, before start-up. All shall test free from grounds.

3.3 COMMISSIONING

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

--- E N D ---

SECTION 22 05 19
METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

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. Water Meter.
 2. Pressure Gages.
 3. BACnet communication protocol
 4. Product certificates for each type of meter and gauge
- C. Operations and Maintenance manual shall include:
1. System Description
 2. Major assembly block diagrams
 3. Troubleshooting and preventive maintenance guidelines
 4. Spare parts information.
- D. Shop Drawings shall include the following:
1. One line, wiring and terminal diagrams including terminals identified, protocol or communication modules, and Ethernet connections.

1.5 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 Standards Institute (ANSI):
American Society of Mechanical Engineers (ASME): (Copyrighted Society)
B40.1-05Gauges-Pressure Indicating Dial Type-Elastic
- C. American Water Works Association (AWWA):
C700-07 (R 2003)Standard for Cold Water Meters, Displacement Type, Bronze
Main Case
C701-07Cold Water Meters-Turbine Type, for Customer Service
AWWA/ ANSI
C702-01Cold water meters – Compound Type
- D. International Code Council (ICC):
IPC-06.....(2007 Supplement) International Plumbing Code

1.6 AS-BUILT DOCUMENTATION

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

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

PART 2 – PRODUCTS

2.1 DISPLACEMENT WATER METER

- A. For pipe sizes under 50 mm (2 inches), the water meter shall be displacement type, full size nutating disc, magnetic drive, sealed register, and fully conform to AWWA C700. The meter register shall indicate flow in liters (U.S. gallons).
- B. The water meter shall be rated for use at temperatures ranging from -40° C (-40° F) and +70° C (158° F) and operate at a working pressure of 1034 kPa (150-psig).
- C. The meter case, bottom caps, and register box lids shall be constructed from cast bronze.

2.2 TURBINE WATER METER

- A. For pipe sizes 2" and larger the water meter shall be Turbine type, Class II, in-line, horizontal axis, and fully conform to AWWA C701. The meter Register shall indicate flow in liters (U.S. gallons).
- B. The water meter shall be rated for use at temperatures ranging from -40° C (-40° F) and +70° C (158° F) and operate at a working pressure of 1034 kPa (150-psig).
- C. The turbine case shall be constructed of bronze.
- D. The register box rings and lid shall be made of cast copper alloy containing not less than 75% copper. Forged or die cast copper alloy containing not less than 75% copper or a suitable synthetic polymer.
- E. The flow measuring turbine shall be made of vulcanized hard rubber or suitable synthetic polymer with specific gravity approximately equal to that of water. The measuring turbine shall have sufficient dimensional stability to retain operating clearances at the full range of working temperatures.
- F. All external case closures, such as rings, clamps, screws, bolts, cap bolts, nuts and washers shall be designed for easy removal following lengthy service.

- G. The turbine meter shall have flanged ends and supplied with companion flanges, gaskets, and with bolts and nuts. The companion flanges shall be made of cast iron.
- H. The meter shall not register less than 97% and not more than 103% of the water actually passing through it at any rate of flow within the normal test flow limits specified in AWWA 701.
- I. The meter shall not register less than 97% and not more than 103% of the water actually passing through it at any rate of flow within the normal test flow limits specified in AWWA 702 except in the registration of flows within the changeover period from bypass meter to main meter.

2.3 WATER METER STRAINER

- A. All meters sizes 50 mm or DN50 (2 inches) and above, shall be fitted with a bronze inlet strainer with top access. The strainer shall conform to AWWA 702.

2.4 WATER METER PROGRAMMING

- A. All meters 50 mm or DN50 (2 inches) and above shall be programmable with software supplied by the meter manufacturer.
- B. The software shall have a Microsoft based interface and operate on the latest Windows operating system. The software shall allow the user to configure the meter, troubleshoot the meter, query and display meter parameters, and configure data and stored values.
- C. The meter firmware shall be upgradeable through one of the communication ports without removing the unit from service.
- D. the meter shall include output for analog 4-20 milliamp signals and binary output.
- E. The meter shall have two dry contact relays outputs for alarm or control functions.

2.5 WATER METER COMMUNICATION PROTOCOL

- A. The meter shall use a native BACnet Ethernet communication protocol supporting HTTP or Modbus. The communications shall be protected against surges induced on its communications channels.

2.6 PRESSURE GAGES FOR WATER AND SEWAGE USAGE

- A. ANSI B40.1 all metal case 114 mm (4-1/2 inches) diameter, bottom connected throughout, graduated as required for service, and identity labeled. Range shall be 0 to 1375 kPa (0 to 200 psi) gauge.
- B. The pressure element assembly shall be bourdon tube. The mechanical movement shall be lined to pressure element and connected to pointer.
- C. The dial shall be non-reflective aluminum with permanently etched scale markings graduated in kPa and psi.
- D. The pointer shall be dark colored metal.
- E. The window shall be glass.

- F. The ring shall be brass or stainless steel.
- G. The accuracy shall be grade A, plus or minus 1 percent of middle half of scale range.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Direct mounted pressure gages shall be installed in piping tees with pressure gage located on pipe at the most readable position.
- B. Valves and snubbers shall be installed in piping for each pressure gage.
- C. Test plugs shall be installed on the inlet and outlet pipes all heat exchangers or water heaters serving more than one plumbing fixture.
- D. Pressure gages shall be installed where indicated on the drawings and at the following locations:
 - 1. Building water service entrance into building
 - 2. Inlet and outlet of each pressure reducing valve
 - 3. Suction and discharge of each domestic water pump or re-circulating hot water return pump.
- E. Water meter installation shall conform to AWWA C700, AWWA C701, and AWWA C702.
Electrical installations shall conform to IEEE C2, NFPA 70 (National Electric Code), and to the requirements specified herein. New materials shall be provided.
- F. Each water meter shall communicate with the building energy management and control system and report daily water consumption and peak daily flow rate.

3.2 FIELD QUALITY CONTROL

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

3.3 TRAINING

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

3.10 COMMISSIONING

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

---END---

SECTION 22 05 23
GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section describes the requirements for general-duty valves for domestic water and sewer systems.

1.2 RELATED WORK

- A. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

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. Valves.
 - 2. Backflow Preventers.
 - 3. Pressure Reducing Valves.
 - 4. Backwater Valves
 - 5. Chainwheels
 - 6. All items listed in Part 2 - Products.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society for Testing and Materials (ASTM):A536-84(R 2004) Standard Specification for Ductile Iron Castings.

- C. American Society of Sanitary Engineering (ASSE)
 - ASSE 1003-01 (R 2003)Performance Requirements for Water Pressure Reducing Valves
 - ASSE 1012-02Backflow Preventer with Intermediate Atmospheric Vent
 - ASSE 1013-05Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers
- D. International Code Council (ICC)
 - IPC-06 (R 2007).....International Plumbing Code
- E. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):
 - SP-25-98Standard Marking System for Valves, Fittings, Flanges and Unions
 - SP-67-02a (R 2004) Butterfly Valve of the Single flange Type (Lug Wafer)
 - SP-70-06Cast Iron Gate Valves, Flanged and Threaded Ends
 - SP-72-99Ball Valves With Flanged or Butt Welding For General Purpose
 - SP-80-03Bronze Gate, Globe, Angle and Check Valves.
 - SP-110-96Ball Valve Threaded, Socket Welding, Solder Joint, Grooved and Flared Ends

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Valves shall be prepared for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set angle, gate, and globe valves closed to prevent rattling.
 - 4. Set ball and plug valves open to minimize exposure of functional surfaces
 - 5. Set butterfly valves closed or slightly open.
 - 6. Block check valves in either closed or open position.
- B. Valves shall be prepared for storage as follows:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher than ambient dew point temperature.
- C. A sling shall be used for large valves. The sling shall be rigged to avoid damage to exposed parts. Hand wheels or stems shall not be used as lifting or rigging points.

PART 2 - PRODUCTS

2.1 VALVES

- A. Asbestos packing and gaskets are prohibited.
- B. Bronze valves shall be made with dezincification resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc shall not be permitted.

- C. Valves in insulated piping shall have 50 mm or DN50 (2 inch) stem extensions and extended handles of non-thermal conductive material that allows operating the valve without breaking the vapor seal or disturbing the insulation. Memory stops shall be fully adjustable after insulation is applied.
- D. Exposed Valves over 65 mm or DN65 (2-1/2 inches) installed at an elevation over 3.6 meters (12 feet) shall have a chain-wheel attachment to valve hand-wheel, stem, or other actuator.
- E. Ball valves, pressure regulating valves, gate valves, globe valves, and plug valves used to supply potable water shall meet the requirements of NSF 61.
- F. Shut-off:
 - 1. Cold, Hot and Re-circulating Hot Water:
 - a. 50 mm or DN50 (2 inches) and smaller: Ball, MSS SP-72, SP-110, Ball valve shall be full port three piece or two piece with a union design with adjustable stem package. Threaded stem designs are not allowed. The ball valve shall have a SWP rating of 1035 kPa (150 psig) and a CWP rating of 4140 kPa (600 psig). The body material shall be Bronze ASTM B584, Alloy C844.
 - b. Less than 100 mm DN100 (4 inches): Butterfly shall have an iron body with EPDM seal and aluminum bronze disc. The butterfly valve shall meet MSS SP-67, type I standard. The butterfly valve shall have a SWP rating of 1380 kPa (200 psig). The valve design shall be lug type suitable for bidirectional dead-end service at rated pressure. The body material shall meet ASTM A 536, ductile iron.
 - c. 100 mm (DN100) (4 inches) and larger:
 - 1) Class 125, OS&Y, Cast Iron Gate Valve. The gate valve shall meet MSS-SP-70 type I standard. The gate valve shall have a CWP rating of 1380 kPa (200 psig). The valve materials shall meet ASTM A 126, grey iron with bolted bonnet, flanged ends, bronze trim, and solid wedge disc. The gate valve shall be gear operated for sizes under 200 mms or DN200 (8 inches) and crank operated for sizes 200 mms or DN200 (8 inches) and above
 - 2) Single flange, ductile iron butterfly valves: The single flanged butterfly valve shall meet the MSS SP-67 standard. The butterfly valve shall have a CWP rating of 1380 kPa (200 psig). The butterfly valve shall be lug type, suitable for bidirectional dead-end service at rated pressure without use of downstream flange. The body material shall comply with ASTM A536 ductile iron. The seat shall be EPDM with stainless steel disc and stem.

- 3) Grooved end, ductile iron butterfly valves. The grooved butterfly valve shall meet the MSS SP-67 standard. The grooved butterfly valve shall have a CWP rating of 1380 kPa (200 psig). The valve materials shall be polyamide coated ductile iron conforming to ASTM A536 with two piece stainless steel stem, EPDM encapsulated ductile iron disc, and EPDM seal. The butterfly valve shall be gear operated
2. Reagent Grade Water: Valves for reagent grade, reverse osmosis, or deionized water service shall be ball type of same material as used for pipe.

C. Balancing:

1. Hot Water Re-circulating, 80 mm or DN80 (3 inches) and smaller manual balancing valve shall be of bronze body, brass ball construction with glass and carbon filled TFE seat rings and designed for positive shutoff. The manual balancing valve shall have differential pressure read-out ports across the valve seat area. The read out ports shall be fitting with internal EPT inserts and check valves. The valve body shall have 8 mm or DN8 NPT (¼" NPT) tapped drain and purge port. The valves shall have memory stops that allow the valve to close for service and then reopened to set point without disturbing the balance position. All valves shall have calibrated nameplates to assure specific valve settings.
2. Larger than 80 mm or DN80 (3 inches): Manual balancing valves shall be of heavy duty cast iron flanged construction with 862 kPa (125 psi) flange connections. The flanged manual balancing valves shall have either a brass ball with glass and carbon filled TFE seal rings or fitted with a bronze seat, replaceable bronze disc with EPDM seal insert and stainless steel stem. The design pressure shall be 1207 kPa (175) at 121 deg C (250 deg F).

D. Check:

1. Check valves less than 80 mm or DN80 (3 inches) and smaller) shall be class 125, bronze swing check valves with non metallic Buna-N disc. The check valve shall meet MSS SP-80 Type 4 standard. The check valve shall have a CWP rating of 1380 kPa (200 psig). The check valve shall have a Y pattern horizontal body design with bronze body material conforming to ASTM B 62, solder joints, and PTFE or TFE disc.
2. Larger than 100 mm or DN100 (4 inches and larger):
 - a. Check valves shall be class 125, iron swing check valve with lever and weight closure control. The check valve shall meet MSS SP-71 Type I standard. The check valve shall have a CWP rating of 1380 kPa (200 psig). The check valve shall have a clear or full waterway body design with gray iron body material conforming to ASTM A 126, bolted bonnet, flanged ends, bronze trim.

- b. All check valves on the discharge side of submersible sump pumps shall have factory installed exterior level and weight with sufficient weight to prevent the check valve from hammering against the seat when the sump pump stops.
- E. Globe:
 - 1. 80 mm or DN80 (3 inches) or smaller: Class 150, bronze globe valve with non metallic disc. The globe valve shall meet MSS SP-80, Type 2 standard. The globe valve shall have a CWP rating of 2070 kPa (300 psig). The valve material shall be bronze with integral seal and union ring bonnet conforming to ASTM B 62 with solder ends, copper-silicon bronze stem, TPFE or TFE disc, malleable iron hand wheel.
 - 2. Larger than 80 mm or DN80 (3 inches): Similar to above, except with cast iron body and bronze trim, class 125, iron globe valve. The globe valve shall meet MSS SP-85, Type 1 standard. The globe valve shall have a CWP rating of 1380 kPa (200 psig). The valve material shall be gray iron with bolted bonnet conforming to ASTM A 126 with flanged ends, bronze trim, malleable iron handwheel.

2.2 WATER PRESSURE REDUCING VALVE AND CONNECTIONS

- A. 80 mm or DN80 (3 inches) or smaller: The pressure reducing valve shall consist of a bronze body and bell housing, a separate access cover for the plunger, and a bolt to adjust the downstream pressure. The bronze bell housing and access cap shall be threaded to the body and shall not require the use of ferrous screws. The assembly shall be of the balanced piston design and shall reduce pressure in both flow and no flow conditions. The assembly shall be accessible for maintenance without having to remove the body from the line.
- B. 100 mm or DN100 (4 inches) and larger: The pressure reducing valve shall consist of a flanged cast iron body and rated to 1378-kPa (200-psig). The valve shall have a large Hycar diaphragm for sensitive response.
- C. The regulator shall have a tap for pressure gauge.
- D. The regulator shall have a temperature rating of 100° C (210° F) for hot water or hot water return service. Pressure regulators shall have accurate pressure regulation to 6.9-kPa (+/- 1 psig).
- E. Setting: Entering water pressure, discharge pressure, capacity, size, and related measurements shall be as shown on the drawings.
- F. Connections Valves and Strainers: shut off valves shall be installed on each side of reducing valve and a bypass line equal in size to the regulator inlet pipe shall be installed with a normally closed globe valve. A strainer shall be installed on inlet side of, and same size as pressure reducing valve. A pressure gage shall be installed on the low pressure side of the line.

2.3 BACKWATER VALVE

- A. The backwater valve shall have a cast iron body, automatic type ABS valve seat and flapper which are slightly open during periods of non operation. The cleanout shall be extended to the finish floor and fit with a threaded countersunk plug. A clamping device shall be included when the cleanout extends through the waterproofing membrane.
- B. When the backwater valve is installed greater than 600 mm (24 inches) below the finish floor elevation, a pit or manhole large enough for a repair person can enter to service the backwater valve shall be installed.

2.4 BACKFLOW PREVENTERS

- A. A backflow prevention assembly shall be installed at any point in the plumbing system where the potable water supply comes in contact with a potential source of contamination. The backflow prevention assembly shall be ASSE 1013 listed and certified.
- B. Reduced pressure backflow preventers shall be installed in the following applications.
 - 1. Deionizers.
 - 2. Sterilizers.
 - 3. Water make up to heating systems, cooling tower, chilled water system, generators, and similar equipment consuming water.
 - 4. Water service entrance from loop system.
 - 5. Atmospheric Vacuum Breaker: ASSE 1001
 - a. Hose bibs and sinks w/threaded outlets.
 - b. Disposers.
 - c. Showers (hand held type).
 - d. Hydrotherapy units.
 - e. Film processor.
 - f. Detergent system
 - g. Fume hoods
 - h. Glassware washers
- C. The reduced pressure principle backflow prevention assembly shall be ASSE listed 1013 with full port OS&Y gate valves and an integral relief monitor switch. The main body and access cover shall be epoxy coated duct iron conforming to ASTM A536 grade 4. The seat ring and check valve shall be Noryl (NSF listed). The stem shall be stainless steel conforming to ASTM A276. The seat disc elastomer shall be EPDM. The checks and the relief valve shall be accessible for maintenance without removing the device from the line. An epoxy coated wye type strainer with flanged connections shall be installed on the inlet.

- D. The atmospheric vacuum breaker shall be ASSE listed 1001. The main body shall be either cast bronze. All internal polymers shall be NSF listed. The seat disc elastomer shall be silicone. The device shall be accessible for maintenance without removing the device from the service line. The installation shall not be in a concealed or inaccessible location or where the venting of water from the device during normal operation is deemed objectionable.
- E. The double check detector backflow prevention assembly shall be ASSE listed 1048 and supply with full port OS&Y gate valves. The main body and access cover shall be epoxy coated ductile iron conforming to ASTM A536 grade. The seat ring and check valve shall be Noryl (NSF listed). The stem shall be stainless steel conforming to ASTM A 276. The seat disc elastomers shall be EPDM. The first and second check valve shall be accessible for maintenance without removing the device from the line.

2.5 CHAINWHEELS

- A. Valve chain wheel assembly with sprocket rim brackets and chain shall be constructed according to the following:
 - 1. Brackets: type, number, size, and fasteners required to mount actuator on valve.
 - 2. Attachment: For connection to ball or butterfly or valve stem.
 - 3. Sprocket rim with chain guides: ductile or cast iron of type and size required for valve with zinc coating.
 - 4. Chain: hot dipped galvanized steel of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Valve interior shall be examined for cleanliness, freedom from foreign matter, and corrosion. Special packing materials shall be removed, such as blocks, used to prevent disc movement during shipping and handling.
- B. Valves shall be operated in positions from fully open to fully closed. Guides and seats shall be examined and made accessible by such operations.
- C. Threads on valve and mating pipe shall be examined for form and cleanliness.
- D. Mating flange faces shall be examined for conditions that might cause leakage. Bolting shall be checked for proper size, length, and material. Gaskets shall be verified for proper size and that its material composition is suitable for service and free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Valves shall be located for easy access and shall be provide with separate support. Valves shall be accessible with access doors when installed inside partitions or above hard ceilings.
- C. Valves shall be installed in horizontal piping with stem at or above center of pipe
- D. Valves shall be installed in a position to allow full stem movement.
- E. Install chain wheels on operators for ball or butterfly or gate and globe valves NPS 100 mm or DN100 4 inches and larger and more than 12 feet above floor. Chains shall be extended to 1500 mm 3600 mm (60 inches) above finished floor.
- F. Check valves shall be installed for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.

3.3 ADJUSTING

- A. Valve packing shall be adjusted or replaced after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves shall be replaced if persistent leaking occurs.

3.4 COMMISSIONING

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

- - E N D - - -

SECTION 22 07 11
PLUMBING INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Field applied insulation for thermal efficiency and condensation control for
 - 1. Plumbing piping and equipment.
- B. Definitions
 - 1. ASJ: All service jacket, white finish facing or jacket.
 - 2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.
 - 3. Cold: Equipment or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.
 - 4. Concealed: Piping above ceilings and in chases, interstitial space, and pipe spaces.
 - 5. Exposed: Piping and equipment exposed to view in finished areas including mechanical equipment rooms or exposed to outdoor weather. Shafts, chases, interstitial spaces, unfinished attics, crawl spaces and pipe basements are not considered finished areas.
 - 6. FSK: Foil-scrim-kraft facing.
 - 7. Hot: Plumbing equipment or piping handling media above 41 degrees C (105 degrees F).
 - 8. Density: kg/m^3 - kilograms per cubic meter (Pcf - pounds per cubic foot).
 - 9. Thermal conductance: Heat flow rate through materials.
 - a. Flat surface: Watts per square meter (BTU per hour per square foot).
 - b. Pipe or Cylinder: Watts per square meter (BTU per hour per linear foot).
 - 10. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).
 - 11. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.
 - 12. R: Pump recirculation.
 - 13. CW: Cold water.
 - 14. SW: Soft water.
 - 15. HW: Hot water.
 - 16. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Mineral fiber and bond breaker behind sealant.
- B. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: General mechanical requirements and items, which are common to more than one section of Division 22.
- C. Section 22 05 19, METERS AND GAGES FOR PLUMBING PIPING
- D. Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING: Hot and cold water piping.
- E. Section 26 32 13, ENGINE GENERATORS: Exhaust stacks and muffler.
- F. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS. Requirements for commissioning, systems readiness checklists, and training.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

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

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

4.3.3.1.1 Where these products are to be applied with adhesives, they shall be tested with such adhesives applied, or the adhesives used shall have a maximum flame spread index

of 25 and a maximum smoke developed index of 50 when in the final dry state. (*See 4.2.4.2.*)

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

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

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

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

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

1.5 SUBMITTALS

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

- d. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation.
- e. Make reference to applicable specification paragraph numbers for coordination.

C. Samples:

1. Each type of insulation: Minimum size 4 inches square for board/block/ blanket; 6 inches long, full diameter for round types.
2. Each type of facing and jacket: Minimum size 4 inches square.
3. Each accessory material: Minimum 4 ounce liquid container or 4 ounce dry weight for adhesives / cement / mastic.

1.6 STORAGE AND HANDLING OF MATERIAL

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

1.7 APPLICABLE PUBLICATIONS

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

- C449-07Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
- C533-09Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
- C534-08Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
- C547-07Standard Specification for Mineral Fiber pipe Insulation
- C552-07Standard Specification for Cellular Glass Thermal Insulation
- C553-08Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
- C585-09Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System) R (1998)
- C612-10Standard Specification for Mineral Fiber Block and Board Thermal Insulation
- C1126-10Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation
- C1136-10Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
- D1668-97a (2006).....Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing
- E84-10Standard Test Method for Surface Burning Characteristics of Building Materials
- E119-09C.....Standard Test Method for Fire Tests of Building Construction and Materials
- E136-09 b.....Standard Test Methods for Behavior of Materials in a Vertical Tube Furnace at 750 degrees C (1380 F)
- E. National Fire Protection Association (NFPA):
- 101-09Life Safety Code
- 251-06Standard methods of Tests of Fire Endurance of Building Construction Materials
- 255-06Standard Method of tests of Surface Burning Characteristics of Building Materials

F. Underwriters Laboratories, Inc (UL):

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

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

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

PART 2 - PRODUCTS

2.1 MINERAL FIBER OR FIBER GLASS

- A. ASTM C612 (Board, Block), Class 1 or 2, density 48 kg/m^3 (3 pcf), $k = 0.037$ (.26) at 24 degrees C (75 degrees F), external insulation for temperatures up to 204 degrees C (400 degrees F).
- B. ASTM C553 (Blanket, Flexible) Type I, Class B-5, Density 32 kg/m^3 (2 pcf), $k = 0.04$ (0.27) at 24 degrees C (75 degrees F), for use at temperatures up to 204 degrees C (400 degrees F)
- C. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, $k = 0.037$ (0.26) at 24 degrees C (75 degrees F), for use at temperatures up to 230 degrees C (450 degrees F) with an all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.

2.2 MINERAL WOOL OR REFRACTORY FIBER

- A. Comply with Standard ASTM C612, Class 3, 850 degrees F.

2.3 RIGID CELLULAR PHENOLIC FOAM

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

2.4 CELLULAR GLASS CLOSED-CELL

- A. Comply with Standard ASTM C177, C518, density 120 kg/m^3 (7.5 pcf) nominal, $k = 0.033$ (0.29) at 75 degrees F.
- B. Pipe insulation for use at temperatures up to 400 degrees F with all service vapor retarder jacket.

2.5 POLYISOCYANURATE CLOSED-CELL RIGID

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

- B. Equipment and duct insulation, ASTM C 591, type IV, $K=0.027(0.19)$ at 24 degrees C (75 degrees F), for use at temperatures up to 149 degrees C (300 degrees F) with PVDC or all service jacket vapor retarder jacket.

2.6 FLEXIBLE ELASTOMERIC CELLULAR THERMAL

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

2.7 CALCIUM SILICATE

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

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

2.8 INSULATION FACINGS AND JACKETS

- A. Vapor Retarder, higher strength with low water permeance = 0.02 or less perm rating, Beach puncture 50 units for insulation facing on pipe insulation jackets. Facings and jackets shall be all service type (ASJ) or PVDC Vapor Retarder jacketing.

- B. ASJ jacket shall be white kraft bonded to 1 mil thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for painting without sizing. Jackets shall have minimum 1-1/2 inch lap on longitudinal joints and minimum 3 inch butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.
- C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK) or PVDC vapor retarder jacketing type for concealed ductwork and equipment.
- D. Field applied vapor barrier jackets shall be provided, in addition to the specified facings and jackets, on all exterior piping as well as on interior piping exposed to outdoor air (i.e.; in ventilated attics, piping in ventilated (not air conditioned) spaces, etc.) in high humidity areas conveying fluids below ambient temperature. The vapor barrier jacket shall consist of a multi-layer laminated cladding with a maximum water vapor permeance of 0.001 perms. The minimum puncture resistance shall be 30 inch-pounds for interior locations and 80 inch-pounds for exterior or exposed locations or where the insulation is subject to damage.
- E. Glass Cloth Jackets: Presized, minimum 7.8 ounces per square yard, 300 psig bursting strength with integral vapor retarder where required or specified. Weather proof if utilized for outside service.
- F. Factory composite materials may be used provided
- G. Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be polyvinyl chloride (PVC) conforming to Fed Spec L-P-335, composition A, Type II Grade GU, and Type III, minimum thickness 0.03 inches. Provide color matching vapor retarder pressure sensitive tape.
- H. Aluminum Jacket-Piping systems and circular breeching and stacks: ASTM B209, 3003 alloy, H-14 temper, 0.023 inch minimum thickness with locking longitudinal joints. Jackets for elbows, tees and other fittings shall be factory-fabricated to match shape of fitting and of 0.024 inch minimum thickness aluminum. Fittings shall be of same construction as straight run jackets but need not be of the same alloy. Factory-fabricated stainless steel bands shall be installed on all circumferential joints. Bands shall be 0.5 inch wide on 18 inch centers. System shall be weatherproof if utilized for outside service.
- I. Aluminum jacket-Rectangular breeching: ASTM B209, 3003 alloy, H-14 temper, 0.020 inches thick with 1-1/4 inch corrugations or 0.032 inches thick with no corrugations. System shall be weatherproof if used for outside service.

2.9 PIPE COVERING PROTECTION SADDLES

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

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

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

2.10 ADHESIVE, MASTIC, CEMENT

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

2.11 MECHANICAL FASTENERS

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

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

2.12 REINFORCEMENT AND FINISHES

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

2.13 FIRESTOPPING MATERIAL

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

2.14 FLAME AND SMOKE

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

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Required pressure tests of piping joints and connections shall be completed and the work approved by the Resident Engineer for application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.
- B. Except for specific exceptions, insulate all specified equipment, and piping (pipe, fittings, valves, accessories). Insulate each pipe individually. Do not use scrap pieces of insulation where a full length section will fit.

- C. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 60 degrees F and below. Lap and seal vapor barrier over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 6 inches.
- D. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.
- E. Construct insulation on parts of equipment such as cold water pumps and heat exchangers that must be opened periodically for maintenance or repair, so insulation can be removed and replaced without damage. Install insulation with bolted 20 gage galvanized steel or aluminum covers as complete units, or in sections, with all necessary supports, and split to coincide with flange/split of the equipment.
- F. Insulation on hot piping and equipment shall be terminated square at items not to be insulated, access openings and nameplates. Cover all exposed raw insulation with white sealer or jacket material.
- G. Protect all insulations outside of buildings with aluminum jacket using lock joint or other approved system for a continuous weather tight system. Access doors and other items requiring maintenance or access shall be removable and sealable.
- H. Plumbing work not to be insulated:
 - 1. Piping and valves of fire protection system.
 - 2. Chromium plated brass piping.
 - 3. Water piping in contact with earth.
 - 4. Small horizontal cold water branch runs in partitions to individual fixtures may be without insulation for maximum distance of 1 foot.
 - 5. Distilled water piping.
- I. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.
- J. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights.

Use of polyurethane spray-foam to fill a PVC elbow jacket is prohibited on cold applications.

K. Firestop Pipe insulation:

1. Provide firestopping insulation at fire and smoke barriers through penetrations. Fire stopping insulation shall be UL listed as defines in Section 07 84 00, FIRESTOPPING.
2. Pipe penetrations requiring fire stop insulation including, but not limited to the following:
 - a. Pipe risers through floors
 - b. Pipe chase walls and floors
 - c. Smoke partitions
 - d. Fire partitions

L. Freeze protection of above grade outdoor piping (over heat tracing tape): 0.75 thick insulation, for all pipe sizes 3 inches and smaller and 1 inch thick insulation for larger pipes. Provide metal jackets for all pipes. Provide for cold water make-up where indicated on the drawings as described in Section 23 21 13, HYDRONIC PIPING (electrical heat tracing systems).

M. Provide vapor barrier jackets over insulation as follows:

1. All piping exposed to outdoor weather.
2. All interior piping conveying fluids exposed to outdoor air (i.e. in attics, ventilated (not air conditioned) spaces, etc.) below ambient air temperature in high humidity areas.

N. Provide metal jackets over insulation as follows:

1. All plumbing piping exposed to outdoor weather.
2. Piping exposed in building, within 6 feet of the floor, that connects to sterilizers, kitchen and laundry equipment. Jackets may be applied with pop rivets. Provide aluminum angle ring escutcheons at wall, ceiling or floor penetrations.
3. A 2 inch overlap is required at longitudinal and circumferential joints.

3.2 INSULATION INSTALLATION

A. Mineral Fiber Board:

1. Faced board: Apply board on pins spaced not more than 12 inches on center each way, and not less than 3 inches from each edge of board. In addition to pins, apply insulation bonding adhesive to entire underside of horizontal metal surfaces. Butt insulation edges tightly and seal all joints with laps and butt strips. After applying speed clips cut pins off flush and apply vapor seal patches over clips.
2. Plain board:
 - a. Insulation shall be scored, beveled or mitered to provide tight joints and be secured to equipment with bands spaced 9 inches on center for irregular surfaces or with pins and clips on flat surfaces. Use corner beads to protect edges of insulation.

- b. For hot equipment: Stretch 1 inch mesh wire, with edges wire laced together, over insulation and finish with insulating and finishing cement applied in one coat, 1/4 inch thick, trowel led to a smooth finish.
 - c. For cold equipment: Apply meshed glass fabric in a tack coat 60 to 70 square feet per gallon of vapor mastic and finish with mastic at 12 to 15 square feet per gallon over the entire fabric surface.
- 3. Cold equipment: 1-1/2 inch thick insulation faced with ASJ.
 - a. Water filter, chemical feeder pot or tank.
 - b. Pneumatic, cold storage water and surge tanks.
- 4. Hot equipment: 1-1/2 inch thick insulation faced with ASJ.
 - a. Domestic water heaters and hot water storage tanks (not factory insulated).
 - b. Booster water heaters for dietetics dish and pot washers and for washdown grease-extracting hoods.
- B. Molded Mineral Fiber Pipe and Tubing Covering:
 - 1. Fit insulation to pipe, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.
 - 2. Contractor's options for fitting, flange and valve insulation:
 - a. Insulating and finishing cement for sizes less than 4 inches operating at surface temperature of 61 degrees F or more.
 - b. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts. Provide two insert layers for pipe temperatures below 40 degrees F, or above 250 degrees F. Secure first layer of insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.
 - c. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place. For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 16 degrees C (60 degrees F) or less, vapor seal with a layer of glass fitting tape imbedded between two 1/16 inch coats of vapor barrier mastic.
 - d. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 2 inches.

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

C. Rigid Cellular Phenolic Foam:

1. Rigid closed cell phenolic insulation may be provided for piping, ductwork and equipment for temperatures up to 121 degrees C (250 degrees F).
2. Note the NFPA 90A burning characteristics requirements of 25/50 in paragraph 1.3.B
3. Provide secure attachment facilities such as welding pins.
4. Apply insulation with joints tightly drawn together
5. Apply adhesives, coverings, neatly finished at fittings, and valves.
6. Final installation shall be smooth, tight, neatly finished at all edges.
7. Minimum thickness in millimeters (inches) specified in the schedule at the end of this section.
8. Condensation control insulation: Minimum 1.0 inch thick for all pipe sizes.
 - a. Plumbing piping as follows:
 - 1) Body of roof and overflow drains horizontal runs and offsets (including elbows) of interior downspout piping in all areas above pipe basement.
 - 2) Waste piping from electric water coolers and icemakers to drainage system.
 - 3) Waste piping located above basement floor from ice making and film developing equipment and air handling units, from equipment (including trap) to main vertical waste pipe.
 - 4) MRI quench vent piping.
 - 5) Bedpan sanitizer atmospheric vent
 - 6) Reagent grade water piping.
 - 7) Cold water piping.

D. Cellular Glass Insulation:

1. Pipe and tubing, covering nominal thickness in millimeters and inches as specified in the schedule at the end of this section.
2. Underground Piping Other than or in lieu of that Specified in Section 22 11 00, FACILITY WATER DISTRIBUTION, Type II, factory jacketed with a 3 mm laminate jacketing consisting of 10 ft x 10 ft asphalt impregant⁴ed glass fabric, bituminous mastic and outside protective plastic film.
 - a. 3 inches thick for hot water piping.
 - b. As scheduled at the end of this section for chilled water piping.

- c. Underground piping: Apply insulation with joints tightly butted. Seal longitudinal self-sealing lap. Use field fabricated or factory made fittings. Seal butt joints and fitting with jacketing as recommended by the insulation manufacturer. Use 4 inch wide strips to seal butt joints.
 - d. Provide expansion chambers for pipe loops, anchors and wall penetrations as recommended by the insulation manufacturer.
 - e. Underground insulation shall be inspected and approved by the Resident Engineer as follows:
 - 1) Insulation in place before coating.
 - 2) After coating.
 - f. Sand bed and backfill: Minimum 3 inches all around insulated pipe or tank, applied after coating has dried.
3. Cold equipment: 2 inch thick insulation faced with ASJ.
- E. Polyisocyanurate Closed-Cell Rigid Insulation:
- 1. Polyisocyanurate closed-cell rigid insulation (PIR) may be provided for exterior piping and equipment for temperature up to 300 degree F.
 - 2. Install insulation, vapor retarder and jacketing per manufacturer's recommendations. Particular attention should be paid to recommendations for joint staggering, adhesive application, external hanger design, expansion/contraction joint design and spacing and vapor retarder integrity.
 - 3. Install insulation with all joints tightly butted (except expansion) joints in hot applications).
 - 4. If insulation thickness exceeds 2.5 inches, install as a double layer system with longitudinal (lap) and butt joint staggering as recommended by manufacturer.
 - 5. For cold applications, vapor retarder shall be installed in a continuous manner. No staples, rivets, screws or any other attachment device capable of penetrating the vapor retarder shall be used to attach the vapor retarder or jacketing. No wire ties capable of penetrating the vapor retarder shall be used to hold the insulation in place. Banding shall be used to attach PVC or metal jacketing.
 - 6. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. The elbow/ fitting insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/ fitting. Use of polyurethane spray-foam to fill PVC elbow jacket is prohibited on cold applications.
 - 7. For cold applications, the vapor retarder on elbows/fittings shall be either mastic-fabric-mastic or 2 mil thick PVDC vapor retarder adhesive tape.

8. All PVC and metal jacketing shall be installed so as to naturally shed water. Joints shall point down and shall be sealed with either adhesive or caulking (except for periodic slip joints).
9. Note the NFPA 90A burning characteristic requirements of 25/50 in paragraph 1.3B. Refer to paragraph 3.1 for items not to be insulated.
10. Minimum thickness in millimeter (inches) specified in the schedule at the end of this section.

F. Flexible Elastomeric Cellular Thermal Insulation:

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

G. Calcium Silicate:

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

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

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

3.3 COMMISSIONING

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

3.4 PIPE INSULATION SCHEDULE

Provide insulation for piping systems as scheduled below:

Insulation Thickness Millimeters (Inches)					
		Nominal Pipe Size Millimeters (Inches)			
Operating Temperature Range/Service	Insulation Material	Less than 25 (1)	25 – 32 (1 – 1-1/4)	38 – 75 (1-1/2 - 3)	100 (4) and Above
38-60 degrees C (100-140 degrees F) (Domestic Hot Water Supply and Return)	Mineral Fiber (Above ground piping only)	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
38-60 degrees C (100-140 degrees F) (Domestic Hot Water Supply and Return)	Rigid Cellular Phenolic Foam (Above ground piping only)	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
38-60 degrees C (100-140 degrees F) (Domestic Hot Water Supply and Return)	Polyiso-cyanurate Closed-Cell Rigid (Exterior Locations only)	38 (1.5)	38 (1.5)	----	----
38-60 degrees C (100-140 degrees F) (Domestic Hot Water Supply and Return)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	38 (1.5)	38 (1.5)	----	----
4-16 degrees C (40-60 degrees F) (Ice water piping)	Rigid Cellular Phenolic Foam (Above ground piping only)	25 (1.0)	25(1.0)	25 (1.0)	25 (1.0)
4-16 degrees C (40-60 degrees F) (Ice water piping)	Polyiso-cyanurate Closed-Cell Rigid(Exterior Locations only)	25 (1.0)	25(1.0)	25 (1.0)	25 (1.0)
(4-16 degrees C) (40-60 degrees F) (Ice water piping)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	25 (1.0)	25(1.0)	25 (1.0)	25 (1.0)

--- 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 this Division is part of the construction process. Documentation and testing of these systems, as well as training of the VA's Operation and Maintenance personnel, is required in cooperation with the VA and the Commissioning Agent.
- B. The following Plumbing systems will be commissioned:
 - 1. Domestic Hot Water Systems (Domestic water heaters, steam-to-hot water converters, hot water circulating pumps and motors, thermostatic mixing valves, controls).
 - 2. Domestic Water Booster Pumps (Controls, piping, compression tanks, pumps, motors, and Variable Speed Drives).

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. 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 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.
- B. Cost of Retesting: The cost associated with Pre-Functional Checklist corrections and resubmissions shall be solely the responsibility of the contractor. Any required Pre-Functional Checklist correction and resubmission by the contractor shall not be considered a justified reason for a claim of delay or for a time extension by the contractor. Time for the commissioning agent for Pre-Functional Checklist correction verifications or expanded Pre-Functional Checklist sampling verifications will be “back-charged” to the responsible subcontractor at a cost of \$3000 per man-day.

3.2 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. The Commissioning Agent may witness selected Contractor tests. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.3 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 execution. 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.

3.4 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. 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 01 and Division 22 Sections for additional Contractor training requirements.

----- END -----

SECTION 22 11 00
FACILITY WATER DISTRIBUTION

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Penetrations in rated enclosures
- B. Section 09 91 00, PAINTING: Preparation and finish painting and identification of piping systems.
- C. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- D. Section 23 07 11, HVAC INSULATION.
- E. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS: Requirements for commissioning, systems readiness checklist, and training.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

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. All items listed in Part 2 - Products.

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 Standards Institute (ANSI) and American Society of Mechanical Engineers (ASME): (Copyrighted Society)

A13.1-2007.....	Scheme for Identification of Piping Systems
B16.3-2006	Malleable Iron Threaded Fittings Classes 150 and 300
B16.9-2007.....	Gray Iron Threaded Fittings Classes 125 and 250
B16.9-2007	Factory-Made Wrought Butt Welding Fittings ANSI/ASME
B16.11-2009	Forged Fittings, Socket-Welding and Threaded ANSI/ASME
B16.12-2009	Cast Iron Threaded Drainage Fittings ANSI/ASME
B16.15-2006	Cast Bronze Threaded Fittings Classes 125 and 250
	ANSI/ASME
B16.18-01 (R2005)	Cast Copper Alloy Solder-Joint Pressure Fittings ANSI/ASME
B16.22-01 (R2005)	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
	ANSI/ASME Element ANSI/ASME
NSF/ANSI 61	Drinking Water System Components - Health Effects

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

A47/A47M-99(2009)	Ferritic Malleable Iron Castings Revision 1989
A53/A53M-07.....	Pipe, Steel, Black And Hot-Dipped, Zinc-coated Welded and
	Seamless
A183-03(2009).....	Carbon Steel Track Bolts and Nuts
A269-10.....	Standard Specification for Seamless and Welded Austenitic
	Stainless Steel Tubing for General Service
A312/A312M-09.....	Seamless, Welded, and Heavily Cold Worked Austenitic
	Stainless Steel Pipes
A403/A403M-10a.....	Standard Specification for Wrought Austenitic Stainless Steel
	Piping Fittings
A536-84(2009).....	Ductile Iron Castings
A733-03(2009).....	Welded and Seamless Carbon Steel and Austenitic Stainless
	Steel Pipe Nipples
B32-08	Solder Metal
B61-08	Steam or Bronze Castings
B62-09	Composition Bronze or Ounce Metal Castings
B75-02	Seamless Copper Tube
B88-09	Seamless Copper Water Tube
B300-10	AWWA Standard for Hypochlorites

- B301-10AWWA Standard for Liquid Chlorine
- B584-09a.....Copper Alloy Sand Castings for General Applications Revision
A
- B687-99(2005) e1Brass, Copper, and Chromium-Plated Pipe Nipples
- D1785-06Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic
Pipe, Schedules 40, 80, and 120
- D2000-08Rubber Products in Automotive Applications
- D4101-09Propylene Plastic Injection and Extrusion Materials
- D2447-03Polyethylene (PE) Plastic Pipe, Schedule 40 and 80, Based on
Outside Diameter
- D2564-04(2009) e1Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe
and Fittings
- D4101-09Propylene Plastic Injection and Extrusion Materials
- E1120-08.....Standard Specification For Liquid Chlorine
- E1229-08.....Standard Specification For Calcium Hypochlorite
- D. American Water Works Association (AWWA):
- C110-08Ductile Iron and Gray Iron Fittings - 75 mm thru 1200 mm (3
inch thru 48 inches) for Water and other liquids AWWA/ANSI
- C151/A21.51-09Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-
Lined Molds, for Water or Other Liquids AWWA/ ANSI
- C153/A21.53-06AWWA Standard for Ductile-Iron Compact Fittings for Water
Service AWWA/ANSI
- C203-08Coal-Tar Protective Coatings and Linings for Steel Water
Pipelines - Enamel and Tape - Hot Applied AWWA/ANSI
- C213-07Fusion Bonded Epoxy Coating For The Interior & Exterior Of
Steel Water Pipelines
- C651-05Disinfecting Water Mains
- E. American Welding Society (AWS):
- A5.8/A5.8M:2004.....Filler Metals for Brazing
- F. International Plumbing Code
- International Plumbing Code – 2009
- G. American Society of Sanitary Engineers (ASSE):
- ANSI/ASSE (Plumbing)
- 1001-2008Pipe Applied Atmospheric Type Vacuum Breakers

ANSI/ASSE 1010-2004 Water Hammer Arresters

ANSI/ASSE 1018-2001 Performance for trap seal primer valves – potable water supplied.

ANSI/ASSE (Plumbing)

1020-2004 Pressure Vacuum Breaker Assembly

H. Plumbing and Drainage Institute (PDI):

PDI WH-201 2007 Water Hammer Arrestor

1.6 QUALITY ASSURANCE

- A. Submit prior to welding of steel piping a certificate of Welder's certification. The certificate shall be current and more than one year old.
- B. For mechanical pressed sealed fittings, only tools of fitting manufacture shall be used.
- C. Mechanical pressed fittings shall be installed by factory trained workers.
- D. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be by the same manufacturer as the groove components.
- E. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

1.7 SPARE PARTS

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

PART 2 - PRODUCTS

2.1 UNDERGROUND WATER SERVICE CONNECTIONS TO BUILDINGS

- A. From inside face of exterior wall to a distance of approximately 1500 mm (5 feet) outside of building and underground inside building, material selected shall be the same for the size specified.
- B. Seventy five millimeters (3 inch) Diameter and Over: Ductile iron, AWWA C151, 850 kPa (125 psi) water steam pressure (WSP), exterior bituminous coating, and cement lined. Provide flanged and anchored connection to interior piping.
- C. Under 75 mm (3 inch) Diameter: Copper tubing, ASTM B88, Type K, seamless, annealed. Fittings as specified under Article 2.2, INTERIOR DOMESTIC WATER PIPING. Use brazing alloys, AWS A5.8, Classification BCuP.

2.2 ABOVE GROUND (INTERIOR) WATER PIPING

- A. Pipe: Copper tube, ASTM B88, Type K or L, drawn. For pipe 150 mm (6 inches) and larger, stainless, steel ASTM A312, schedule 10 may be used.

B. Fittings for Copper Tube:

1. Wrought copper or bronze castings conforming to ANSI B16.18 and B16.22. Unions shall be bronze, MSS SP72 & SP 110, Solder or braze joints. Use 95/5 tin and antimony for all soldered joints.
2. Grooved fittings, 50 to 150 mm (2 to 6 inch) wrought copper ASTM B75 C12200, 125 to 150 mm (5 to 6 inch) bronze casting ASTM B584, CDA 844. Mechanical grooved couplings, ductile iron, ASTM A536 (Grade 65-45-12), or malleable iron, ASTM A47 (Grade 32510) housing, with EPDM gasket, steel track head bolts, ASTM A183, coated with copper colored alkyd enamel.
3. Mechanical press sealed fittings, 65 mm (2-1/2") in size and smaller. Fittings shall be double pressed type NSF/ANSI 61 approved and utilize EPDM (Ethylene Propylene Diene Monomer) non toxic synthetic rubber sealing elements.
4. Mechanically formed tee connection: Form mechanically extracted collars in a continuous operation by drilling pilot hole and drawing out tube surface to form collar, having a height of not less than three times the thickness of tube wall. Adjustable collaring device shall 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. Braze joints.

C. Fittings for Stainless Steel:

1. Stainless steel butt-welded fittings, Type 316, Schedule 10, conforming to ANSI B16.9.
2. Grooved fittings, stainless steel, Type 316, Schedule 10, conforming to ASTM A403. Segmentally fabricated fittings are not allowed. Mechanical grooved couplings, ductile iron, ASTM A536 (Grade 65-45-12), or Malleable iron, ASTM A47 (Grade 32510) housing, with EPDM gasket, steel track head bolts, ASTM A183, coated with copper colored alkyd enamel.

D. Adapters: Provide adapters for joining screwed pipe to copper tubing.

E. Solder: ASTM B32 Composition Sb5 HA or HB. Provide non-corrosive flux.

F. Brazing alloy: AWS A5.8, Classification BCuP.

G. Reagent Grade Water Piping and Dialysis Water Piping:

1. Polypropylene, ASTM D4101, Schedule 80 pressure pipe with dimensions in conformance with ASTM D2447, but without additions of modifiers, plasticizers, colorants, stabilizers or lubricants. This virgin un-plasticized pipe and fittings shall transport 10 megohm water with no loss of purity. Provide socket fusion joints.

2. Polyethylene, food and medical grade, capable of transporting 10 megohm water with no loss of purity. Processed by continuous compression molding without the addition of fillers, polymer modifiers or processing aids. Uniform color with no cracks, flaws, blisters or other imperfections in appearance. Provide heat fusion butt welded joints. In accordance with manufacturer's recommendations, provide continuous channel support under all horizontal piping.
3. Reverse Osmosis (RO) Water Piping:
 - a. Low Pressure Feed, Reject and Recycle Piping (75 psi and under): ASTM D 1785, Schedule 80 PVC, socket welded and flanged.
 - b. RO Product Tubing From Each Membrane Housing: ASTM D1785, Schedule 80 PVC, socket welded and flanged.
 - c. Low Pressure Control and Pressure Gage Tubing: Polyethylene.
 - d. High Pressure Reject and Recycle Piping (above 75 psi): ASTM A269, Type 304 schedule 10 stainless steel with butt welded joints.
 - e. High Pressure Control and Pressure Gage Tubing: 1000 psi burst nylon.

2.3 EXPOSED WATER PIPING

- A. Finished Room: Use full iron pipe size chrome plated brass piping for exposed water piping connecting fixtures, casework, cabinets, equipment and reagent racks when not concealed by apron including those furnished by the Government or specified in other sections.
 1. Pipe: Fed. Spec. WW-P-351, standard weight.
 2. Fittings: ANSI B16.15 cast bronze threaded fittings with chrome finish, (125 and 250).
 3. Nipples: ASTM B 687, Chromium-plated.
 4. Unions: Mss SP-72, SP-110, Brass or Bronze with chrome finish. Unions 65 mm (2-1/2 inches) and larger shall be flange type with approved gaskets.
- B. Unfinished Rooms, Mechanical Rooms and Kitchens: Chrome-plated brass piping is not required. Paint piping systems as specified in Section 09 91 00, PAINTING.

2.4 ETO (ETHYLENE OXIDE) STERILIZER WATER SUPPLY PIPING

- A. Stainless steel, ASTM A312, Schedule 10 with stainless steel butt welded fittings. Provide on sterilizer water supply.

2.5 TRAP PRIMER WATER PIPING:

- A. Pipe: Copper tube, ASTM B88, type K, hard drawn.
- B. Fittings: Bronze castings conforming to ANSI B16.18 Solder joints.
- C. Solder: ASTM B32 composition Sb5. Provide non-corrosive flux.

2.6 STRAINERS

- A. Provide on high pressure side of pressure reducing valves, on suction side of pumps, on inlet side of indicating and control instruments and equipment subject to sediment damage and where shown on drawings. Strainer element shall be removable without disconnection of piping.
- B. Water: Basket or "Y" type with easily removable cover and brass strainer basket.
- C. Body: Smaller than 80 mm (3 inches), brass or bronze; 80 mm (3 inches) and larger, cast iron or semi-steel with epoxy coating and NSF 61 compliant.

2.7 DIELECTRIC FITTINGS

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

2.8 STERILIZATION CHEMICALS

- A. Hypochlorites ANSI/AWWA B300-10
- B. Liquid Chlorine ANSI/AWWA B301-10

2.9 WATER HAMMER ARRESTER:

- A. Closed copper tube chamber with permanently sealed 410 kPa (60 psig) air charge above a Double O-ring piston. Two high heat Buna-N O-rings pressure packed and lubricated with FDA approved silicone compound. All units shall be designed in accordance with ASSE 1010 for sealed wall installations without an access panel. Size and install in accordance with Plumbing and Drainage Institute requirements (PDI WH 201). Provide water hammer arrestors at:
 - 1. All solenoid valves.
 - 2. All groups of two or more flush valves.
 - 3. All quick opening or closing valves.
 - 4. All medical washing equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Comply with the International Plumbing Code and the following:
 - 1. Install branch piping for water from the piping system and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.
 - 2. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for plastic and glass, shall be reamed to full size after cutting.
 - 3. All pipe runs shall be laid out to avoid interference with other work.
 - 4. Install union and shut-off valve on pressure piping at connections to equipment.
 - 5. Pipe Hangers, Supports and Accessories:
 - a. All piping shall be supported per the International Plumbing Code, Chapter No. 3.

- b. Shop Painting and Plating: Hangers, supports, rods, inserts and accessories used for pipe supports shall be shop coated with red lead or zinc chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.
- c. Floor, Wall and Ceiling Plates, Supports, Hangers:
 - 1) Solid or split unplated cast iron.
 - 2) All plates shall be provided with set screws.
 - 3) Pipe Hangers: Height adjustable clevis type.
 - 4) Adjustable Floor Rests and Base Flanges: Steel.
 - 5) Concrete Inserts: "Universal" or continuous slotted type.
 - 6) Hanger Rods: Mild, low carbon steel, fully threaded or Threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
 - 7) Riser Clamps: Malleable iron or steel.
 - 8) Rollers: Cast iron.
 - 9) Self-drilling type expansion shields shall be "Phillips" type, with case hardened steel expander plugs.
 - 10) Hangers and supports utilized with insulated pipe and tubing shall have 180 degree (min.) metal protection shield Centered on and welded to the hanger and support. The shield shall be 4 inches in length and be 16 gauge steel. The shield shall be sized for the insulation.
 - 11) Miscellaneous Materials: As specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. Provide all necessary auxiliary steel to provide that support.
 - 12) With the installation of each flexible expansion joint, provide piping restraints for the upstream and downstream section of the piping at the flexible expansion joint. Provide calculations supporting the restraint length design and type of selected restraints.
- 6. Install chrome plated cast brass escutcheon with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

7. Penetrations:

- a. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING. Completely fill and seal clearances between raceways and openings with the fire stopping materials.
- b. Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS.

B. Piping shall conform to the following:

1. Domestic Water:

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

3.2 TESTS

- A. General: Test system either in its entirety or in sections.
- B. Potable Water System: Test after installation of piping and domestic water heaters, but before piping is concealed, before covering is applied, and before plumbing fixtures are connected. Fill systems with water and maintain hydrostatic pressure of 690 kPa (100 psi) gage for two hours. No decrease in pressure is allowed. Provide a pressure gage with a shutoff and bleeder valve at the highest point of the piping being tested.
- C. Reagent Grade Water Systems: Fill system with water and maintain hydrostatic pressure of 690 kPa (100 psi) gage during inspection and prove tight.
- D. All Other Piping Tests: Test new installed piping under 1 1/2 times actual operating conditions and prove tight.

3.3 STERILIZATION

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

3.4 COMMISSIONING

- A. Provide commissioning documentation 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 22 13 00
FACILITY SANITARY AND VENT PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

This section pertains to sanitary sewer and vent systems, including piping, equipment and all necessary accessories as designated in this section.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Penetrations in rated enclosures.
- B. Section 09 91 00, PAINTING: Preparation and finish painting and identification of piping systems.
- C. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: Pipe Hangers and Supports, Materials Identification.
- D. Section 23 07 11, HVAC INSULATION: Pipe Insulation.
- E. Section 07 92 00, JOINT SEALANTS: Sealant products.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

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. Piping.
 - 2. Floor Drains.
 - 3. Grease Removal Unit.
 - 4. Cleanouts.
 - 5. All items listed in Part 2 - Products.

- C. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane or the floor drain.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME): (Copyrighted Society)
 - A112.6.3-01 (R 2007).....Standard for Floor and Trench Drains
 - A13.1-07Scheme for Identification of Piping Systems
 - B16.3-06 Malleable Iron Threaded Fittings, Classes 150 and 300.
 - B16.4-06Standard for Grey Iron Threaded Fittings Classes 125 and 250
 - B16.12-98 (R 2006)Cast Iron Threaded Drainage Fittings
 - B16.15-06Cast Bronze Threaded Fittings, Classes 125 and 250
- C. American Society for Testing and Materials (ASTM):
 - A47/A47M-99 (R 2004)Standard Specification for Steel Sheet, Aluminum Coated, by the Hot Dip Process
 - A53/A53M-07.....Standard Specification for Pipe, Steel, Black And Hot-Dipped, Zinc-coated, Welded and Seamless
 - A74-06Standard Specification for Cast Iron Soil Pipe and Fittings
 - A183-03Standard Specification for Carbon Steel Track Bolts and Nuts
 - A536-84(R 2004).....Standard Specification for Ductile Iron Castings
 - B32-08Standard Specification for Solder Metal
 - B75-02Standard Specification for Seamless Copper Tube
 - B306-02Standard Specification for Copper Drainage Tube (DWV)
 - B584-06a.....Standard Specification for Copper Alloy Sand Castings for General Applications
 - C564-03a.....Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
 - D2000-08Standard Classification System for Rubber Products in Automotive Applications
 - D2564-04E1Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
 - D2665-08Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings

D. International Code Council:

IPC-06.....International Plumbing Code

E. Cast Iron Soil Pipe Institute (CISPI):

301-05Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm
Drain, Waste, and Vent Piping Applications

310-04Coupling for Use in Connection with Hubless Cast Iron Soil Pipe
and Fittings for Sanitary and Storm Drain, Waste, and Vent
Piping Applications

F. American Society of Sanitary Engineers (ASSE):

1018-01Trap Seal Primer Valves – Potable, Water Supplied

G. Plumbing and Drainage Institute (PDI):

PDI WH-201Water Hammer Arrestor

PART 2 - PRODUCTS

2.1 SANITARY WASTE, DRAIN, AND VENT PIPING

A. Cast iron waste, drain, and vent pipe and fittings

1. Cast iron waste, drain, and vent pipe and fittings shall be used for the following applications:
 - a. pipe buried in or in contact with earth
 - b. sanitary pipe extensions to a distance of approximately 1500 mm (5 feet) outside of the building.
 - c. interior waste and vent piping above grade.
2. Cast iron Pipe shall be bell and spigot or hubless (plain end or no-hub or hubless).
3. The material for all pipe and fittings shall be cast iron soil pipe and fittings and shall conform to the requirements of CISPI Standard 301, ASTM A-888, or ASTM A-74.
4. Joints for hubless pipe and fittings shall conform to the manufacturer's installation instructions. Couplings for hubless joints shall conform to CISPI 310. Joints for hub and spigot pipe shall be installed with compression gaskets conforming to the requirements of ASTM Standard C-564 or be installed with lead and oakum.

B. Copper Tube, (DWV):

1. Copper DWV tube sanitary waste, drain and vent pipe may be used for piping above ground, except for urinal drains.
2. The copper DWV tube shall be drainage type, drawn temper conforming to ASTM B306.
3. The copper drainage fittings shall be cast copper or wrought copper conforming to ASME B16.23 or ASME 16.29.
4. The joints shall be lead free, using a water flushable flux, and conforming to ASTM B32.

2.2 EXPOSED WASTE PIPING

- A. Full iron pipe size chrome plated brass piping shall be used in finished rooms for exposed waste piping connecting fixtures, casework, cabinets, equipment and reagent racks when not concealed by apron including those furnished by the Government or specified in other sections.
 - 1. The Pipe shall meet Fed. Spec. WW-P-351, standard weight.
 - 2. The Fittings shall conform to ANSI B16.15, cast bronze threaded fittings with chrome finish, (125 and 250).
 - 3. Nipples shall conform to ASTM B 687, Chromium-plated.
 - 4. Unions shall be brass or bronze with chrome finish. Unions 65 mm (2-1/2 inches) and larger shall be flange type with approved gaskets.
- B. In unfinished Rooms such as mechanical Rooms and Kitchens, Chrome-plated brass piping is not required. The pipe materials specified under the paragraph "Sanitary Waste, Drain, and Vent Piping" can be used. The sanitary pipe in unfinished rooms shall be painted as specified in Section 09 91 00, PAINTING.

2.3 SPECIALTY PIPE FITTINGS

- A. Transition pipe couplings shall join piping with small differences in outside diameters or different materials. End connections shall be of the same size and compatible with the pipes being joined. The transition coupling shall be elastomeric, sleeve type reducing or transition pattern and include shear and corrosion resistant metal, tension band and tightening mechanism on each end. The transition coupling sleeve coupling shall be of the following material:
 - 1. For cast iron soil pipes, the sleeve material shall be rubber conforming to ASTM C564.
- B. The dielectric fittings shall conform to ASSE 1079 with a pressure rating of 860 kPa (125 psig) at a minimum temperature of 82°C (180°F). The end connection shall be solder joint copper alloy and threaded ferrous.
- C. Dielectric flange insulating kits shall be of non conducting materials for field assembly of companion flanges with a pressure rating of 1035 kPa (150 psig). The gasket shall be neoprene or phenolic. The bolt sleeves shall be phenolic or polyethylene. The washers shall be phenolic with steel backing washers.
- D. The di-electric nipples shall be electroplated steel nipple complying with ASTM F 1545 with a pressure rating of 2070 kPa (300 psig) at 107°C (225°F). The end connection shall be male threaded. The lining shall be inert and noncorrosive propylene.

2.4 CLEANOUTS

- A. Cleanouts shall be the same size as the pipe, up to 100 mm (4 inches); and not less than 100 mm (4 inches) for larger pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. Minimum clearance of 600 mm (24 inches) shall be provided for clearing a clogged sanitary line.
- B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside calk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 50 mm (2 inches). When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In the carpeted areas, carpet cleanout markers shall be provided. Two way cleanouts shall be provided where indicated on drawings and at every building exit. The loading classification for cleanouts in sidewalk areas or subject to vehicular traffic shall be heavy duty type.
- C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 600 mm (24 inches) above the floor. If there are no fixtures installed on the lowest floor, the cleanout shall be installed at the base of the stack. The cleanouts shall be extended to the wall access cover. Cleanout shall consist of sanitary tees. Nickel-bronze square frame and stainless steel cover with minimum opening of 150 by 150 mm (6 by 6 inches) shall be furnished at each wall cleanout. Where the piping is concealed, a fixture trap or a fixture with integral trap, readily removable without disturbing concealed pipe, shall be accepted as a cleanout equivalent providing the opening to be used as a cleanout opening is the size required.
- D. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/hubless cast iron ferrule. Plain end (hubless) piping in interstitial space or above ceiling may use plain end (hubless) blind plug and clamp.

2.5 FLOOR DRAINS

- A. Floor drains shall comply with ANSI A112.6.3. A caulking flange, inside gasket, or hubless connection shall be provided for connection to cast iron pipe, screwed or no hub outlets for connection to steel pipe. The drain connection shall be bottom outlet. A membrane clamp and extensions shall be provided, if required, where installed in connection with waterproof membrane. Puncturing membrane other than for drain opening will not be permitted. Double drainage pattern floor drains shall have integral seepage pan for embedding into floor construction, and weep holes to provide adequate drainage from pan to drain pipe. For drains not installed in connection with a waterproof membrane, a 2.2 kg (16-ounce) soft copper membrane, 600 mm (24 inches) square or another approved waterproof membrane shall be provided.
- B. Floor drain shall comply with ANSI A112.6.3. The type C floor drain shall have a cast iron body, double drainage pattern, clamping device, light duty square or round nickel bronze adjustable strainer and grate with vandal proof screws. The grate shall be square, 150 mm (6 inches) minimum.
- C. Floor drains shall comply with ANSI A112.6.3. The type D floor drain shall have a Cast iron body with flange, integral reversible clamping device, seepage openings and 185 mm (6 inch) diameter or square satin nickel bronze or satin bronze strainer with 100 mm (4 inch) flange.
- D. Floor drains shall comply with ANSI A112.6.3. The type E floor drain shall have a heavy, cast iron body, double drainage pattern, heavy non-tilting nickel bronze grate not less than 300 mm (12 inches) square, removable sediment bucket. Clearance between body and bucket shall be ample for free flow of waste water. For traffic use, an extra heavy duty load classification ductile iron grate shall be provided.
- E. Floor drain shall comply with ANSI A112.6.3. The type F floor drain shall be have a cast iron body with flange, integral reversible clamping device, seepage openings and a 225 mm (9 inch) two-piece satin nickel-bronze or satin bronze strainer for use with seamless vinyl floors.
- F. Floor drain shall comply with ANSI A112.6.3. The type G floor drain shall have a cast iron body, shallow type with double drainage flange and removable, perforated aluminum sediment bucket. The type G drain shall have all interior and exposed exterior surfaces coated with acid resistant porcelain enamel finish. The floor drain shall have a clamping device. The frame and grate shall be nickel bronze. The grate shall be approximately 200 mm (8 inches) in diameter. The space between body of drain and basket shall be sufficient for free flow of waste water.
- G. Open Sight Drains (OSDs) shall be cast iron, constructed as shown by detail.

2.6 TRAPS

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

2.7 TRAP SEAL PRIMER VALVES AND TRAP SEAL PRIMER SYSTEMS

- A. Trap Primer (TP-1): The trap seal primer system shall be electronic type conforming to ASSE 1044.
1. The controller shall have a 24 hour programmable timer, solid state, 6 outlet zones, minimum adjustable run time of 1 minute for each zone, 12 hour program battery backup, manual switch for 120VAC power, 120VAC to 24VAC internal transformer, fuse protected circuitry, UL listed, 120VAC input-24VAC output, constructed of enameled steel or plastic.
 2. The cabinet shall be recessed mounting with a stainless steel cover.
 3. The solenoid valve shall have a brass body, Buna "N" seats, normally closed, 5.98 kPa (125 psi) rated, 24VAC.
 4. The control wiring shall be copper in accordance with the latest edition of the National Electric Code, Article 725 and not less than 18 gauge. All wiring shall be in conduit and in accordance with Division 26 of the specifications.
 5. The vacuum breaker shall conform to ASSE 1001.
- B. Trap Primer (TP-2): The trap seal primer valve shall be hydraulic, supply type with a pressure rating of 5.98 kPa (125 psig) and conforming to standard ASSE 1018.
1. The inlet and outlet connections shall be 15 mm or DN15 (NPS 1/2 inch)
 2. The trap seal primer valve shall be fully automatic with an all brass or bronze body.
 3. The trap seal primer valve shall be activated by a drop in building water pressure, no adjustment required.
 4. The trap seal primer valve shall include a manifold when serving two, three, or four traps.
 5. The manifold shall be omitted when serving only one trap.

2.8 WATERPROOFING

- A. A sleeve flashing device shall be provided at points where pipes pass through membrane waterproofed floors or walls. The sleeve flashing device shall be manufactured, cast iron fitting with clamping device that forms a sleeve for the pipe floor penetration of the floor membrane. A galvanized steel pipe extension shall be included in the top of the fitting that will extend 50 mm (2 inches) above finished floor and galvanized steel pipe extension in the bottom of the fitting that will extend through the floor slab. A waterproof caulked joint shall be provided at the top hub.
- B. Walls: See detail shown on drawings.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

- A. The pipe installation shall comply with the requirements of the International Plumbing Code (IPC) and these specifications.
- B. Branch piping shall be installed for waste from the respective piping systems and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.
- C. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe shall be reamed to full size after cutting.
- D. All pipe runs shall be laid out to avoid interference with other work.
- E. The piping shall be installed above accessible ceilings where possible.
- F. The piping shall be installed to permit valve servicing or operation.
- G. Unless specifically indicated on the drawings, the minimum slope shall be 2% slope.
- H. The piping shall be installed free of sags and bends.
- I. Seismic restraint shall be installed where required by code.
- J. Changes in direction for soil and waste drainage and vent piping shall be made using appropriate branches, bends and long sweep bends. Sanitary tees and short sweep quarter bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and eighth bend fittings shall be used if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

- K. Buried soil and waste drainage and vent piping shall be laid beginning at the low point of each system. Piping shall be installed true to grades and alignment indicated with unbroken continuity of invert. Hub ends shall be placed upstream. Required gaskets shall be installed according to manufacturer's written instruction for use of lubricants, cements, and other installation requirements.
- L. Cast iron piping shall be installed according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings"
- M. Aboveground copper tubing shall be installed according to CDA's "Copper Tube Handbook".

3.2 JOINT CONSTRUCTION

- A. Hub and spigot, cast iron piping with gasket joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Hub and spigot, cast iron piping with calked joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
- C. Hubless or No-hub, cast iron piping shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless piping coupling joints.
- D. For threaded joints, thread pipe with tapered pipe threads according to ASME B1.20.1. The threads shall be cut full and clean using sharp disc cutters. Threaded pipe ends shall be reamed to remove burrs and restored to full pipe inside diameter. Pipe fittings and valves shall be joined as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service
 - 2. Pipe sections with damaged threads shall be replaced with new sections of pipe.
- E. Copper tube and fittings with soldered joints shall be joined according to ASTM B828. A water flushable, lead free flux conforming to ASTM B813 and a lead free alloy solder conforming to ASTM B32 shall be used.

3.3 SPECIALTY PIPE FITTINGS

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

3.3 PIPE HANGERS, SUPPORTS AND ACCESSORIES:

- A. All piping shall be supported according to the International Plumbing Code (IPC), Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, and these specifications. Where conflicts arise between these the code and Section 22 05 11, the most restrictive or the requirement that specifies supports with highest loading or shortest spacing shall apply.

- B. Hangers, supports, rods, inserts and accessories used for pipe supports shall be shop coated with zinc chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.
- C. Horizontal piping and tubing shall be supported within 300 mm (12 inches) of each fitting or coupling.
- D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:
 - 1. 40 mm or DN40 to 50 mm or DN50 (NPS 1-1/2 inch to NPS 2 inch): 1500 mm (60 inches) with 10 mm (3/8 inch) rod.
 - 2. 80 mm or DN 80 (NPS 3 inch): 1500 mm (60 inches) with 13 mm (1/2 inch) rod.
 - 3. 100 mm or DN100 to 125 mm or DN125 (NPS 4 to NPS 5): 1500 mm (60 inches) with 16 mm (5/8 inch) rod.
 - 4. 150 mm or DN150 to 200 mm or DN200 (NPS 6 inch to NPS 8 inch): 1500 mm (60 inches) with 19 mm (3/4 inch) rod.
 - 5. 250 mm or DN250 to 300 mm or DN 300 (NPS 10 inch to NPS 12 inch): 1500 mm (60 inch) with 22 mm (7/8 inch) rod.
- E. The maximum spacing for plastic pipe shall be 1.22 m (4 feet).
- F. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 4.57 m (15 feet).
- G. In addition to the requirements in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, floor, wall and ceiling plates, supports, and hangers shall have the following characteristics:
 - 1. Solid or split unplated cast iron.
 - 2. All plates shall be provided with set screws.
 - 3. Height adjustable clevis type pipe hangers.
 - 4. Adjustable floor rests and base flanges shall be steel.
 - 5. Hanger rods shall be low carbon steel, fully threaded or threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
 - 6. Riser clamps shall be malleable iron or steel.
 - 7. Rollers shall be cast iron.
 - 8. See Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, for requirements on insulated pipe protective shields at hanger supports.

- H. Miscellaneous materials shall be provided as specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. All necessary auxiliary steel shall be provided to provide that support.
- I. Cast escutcheon with set screw shall be provided at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
- J. Penetrations:
1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, a fire stop shall be installed that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING. Clearances between raceways and openings shall be completely filled and sealed with the fire stopping materials.
 2. Water proofing: At floor penetrations, clearances shall be completely sealed around the pipe and make watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS.
- K. Piping shall conform to the following:
1. Waste and Vent Drain to main stacks:

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

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

3.4 TESTS

- A. Sanitary waste and drain systems shall be tested either in its entirety or in sections.
- B. Waste System tests shall be conducted before trenches are backfilled or fixtures are connected. A water test or air test shall be conducted, as directed.
1. If entire system is tested for a water test, tightly close all openings in pipes except highest opening, and fill system with water to point of overflow. If the waste system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 3 m (10 foot) head of water. In testing successive sections, test at least upper 3 m (10 feet) of next preceding section so that each joint or pipe except upper most 3 m (10 feet) of system has been submitted to a test of at least a 3 m (10 foot) head of water. Water shall be kept in the system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.

2. For an air test, an air pressure of 35 kPa (5 psig) gage shall be maintained for at least 15 minutes without leakage. A force pump and mercury column gage shall be used for the air test.
3. After installing all fixtures and equipment, open water supply so that all p-traps can be observed. For 15 minutes of operation, all p-traps shall be inspected for leaks and any leaks found shall be corrected.
4. Final Tests: Either one of the following tests may be used.
 - a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke under pressure of 1.3 kPa (1 inch of water) with a smoke machine. Chemical smoke is prohibited.
 - b. Peppermint Test: Introduce (2 ounces) of peppermint into each line or stack.

3.5 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of section 22 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 22 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 22 14 00
FACILITY STORM DRAINAGE

PART 1 - GENERAL

1.1 DESCRIPTION

This section describes the requirements for storm drainage systems, including piping and all necessary accessories as designated in this section.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Penetrations in rated enclosures.
- B. Section 09 91 00, PAINTING: Preparation and finish painting and identification of piping systems.
- C. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: Pipe Hangers and Supports, Materials Identification.
- D. Section 23 07 11, HVAC INSULATION: Pipe Insulation.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

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. Piping.
 - 2. Roof Drains.
 - 3. Cleanouts.
 - 4. All items listed in Part 2 - Products.
- C. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane.

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 Standards Institute (ANSI).
- C. American Society of Mechanical Engineers (ASME): (Copyrighted Society)
 - A112.21.2m-83Roof Drains
 - A13.1-07Scheme for Identification of Piping Systems
 - B16.3-06 Malleable Iron Threaded Fittings, Classes 150 and 300.
 - B16.9-07Factory-Made Wrought Steel Butt welding Fittings
 - B16.11-05Forged Steel Fittings, Socket-Welding and Threaded
 - B16.12-98 (R 2006)Cast Iron Threaded Drainage Fittings
 - B16.15-06)Cast Bronze Threaded Fittings, Class 125 and 250
 - B16.18-01 (R 2005)Cast Copper Alloy Solder-Joint Pressure Fittings
 - B16.22-01 (R 2005)Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
- D. American Society for Testing and Materials (ASTM):
 - A47-99 (R 2004)Standard Specification for Steel Sheet, Aluminum Coated, by the
Hot-Dip Process
 - A53-07Standard Specification for Pipe, Steel, Black And Hot-Dipped,
Zinc-coated Welded and Seamless
 - A74-06Standard Specification for Cast Iron Soil Pipe and Fittings
 - A183-03)Standard Specification for Carbon Steel Track Bolts and Nuts
 - A312-03Standard Specification for Seamless and Welded Austenitic
Stainless Steel Pipe
 - A536-84(R 2004)Standard Specification for Ductile Iron Castings
 - A733-03Standard Specification for Welded and Seamless Carbon Steel
and Austenitic Stainless Steel Pipe Nipples
 - B32-04Standard Specification for Solder Metal
 - B61-08Standard Specification for Steam or Bronze Castings
 - B62-02Standard Specification for Composition Bronze or Ounce Metal
Castings
 - B75-02Standard Specification for Seamless Copper Tube
 - B88-03Standard Specification for Seamless Copper Water Tube
 - B306-02Standard Specification for Copper Drainage Tube (DWV)

- B584-08Standard Specification for Copper Alloy Sand Castings for
General Applications
- B687-99Standard Specification for Brass, Copper, and Chromium-Plated
Pipe Nipples
- C564-06a.....Standard Specification for Rubber Gaskets for Cast Iron Soil
Pipe and Fittings
- D2000-08Standard Classification System for Rubber Products in
Automotive Applications
- D4101-07Standard Specification for Propylene Plastic Injection and
Extrusion Materials
- D2447-03Standard Specification for Polyethylene (PE) Plastic Pipe,
Schedule 40 and 80, Based on Outside Diameter
- D2564-04e1Standard Specification for Solvent Cements for Poly (Vinyl
Chloride) (PVC) Plastic Pipe and Fittings
- D2665-07Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic
Drain, Waste, and Vent Pipe and Fittings
- E. American Welding Society (AWS):
- A5.8-04Specification for Filler Metals for Brazing and Braze Welding
- F. International Code Council (ICC):
- IPC-06.....International Plumbing Code
- G. Cast Iron Soil Pipe Institute (CISPI):
- 301-05Hubless Cast Iron Soil and Fittings for Sanitary and Storm
Drain, Waste, and Vent Piping Applications
- 310-04Couplings for Use in Connection with Hubless Cast Iron Soil
and Fittings for Sanitary and Storm Drain, Waste, and Vent
Piping Applications
- H. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):
- SP-72-99Standard for Ball Valves with Flanged or Butt Welding For
General Purpose
- SP-110-96Ball Valve Threaded, Socket Welding, Solder Joint, Grooved
and Flared Ends

PART 2 - PRODUCTS

2.1 STORM WATER DRAIN PIPING

A. Cast Iron Storm Pipe and Fittings:

1. Cast iron storm pipe and fittings shall be used for the following applications:
 - a. Pipe buried in or in contact with earth.
 - b. Extension of pipe to a distance of approximately 1500 mm (5 feet) outside of building walls.
 - c. Interior storm piping above grade.
 - d. All mechanical equipment rooms or other areas containing mechanical air handling equipment.
2. The cast iron storm Pipe shall be bell and spigot, or hubless (plain end or no-hub) as required by selected jointing method.
3. The material for all pipe and fittings shall be cast iron soil pipe and fittings and shall conform to the requirements of CISPI Standard 301, ASTM A-888, or ASTM A-74.
4. Joints for hubless pipe and fittings shall conform to the manufacturer's installation instructions. Couplings for hubless joints shall conform to CISPI 310. Joints for hub and spigot pipe shall be installed with compression gaskets conforming to the requirements of ASTM Standard C-564 or be installed with lead and oakum.

B. Copper Tube, (DWV): May be used for piping above ground.

1. The copper DWV tube shall be drainage type, drawn temper conforming to ASTM B306.
2. The Copper drainage fittings shall be cast copper or wrought copper conforming to ASME B16.23 or ASME 16.29.
3. The joints shall be lead free, using a water flushable flux, and conforming to ASTM B32.

2.2 PUMPED DRAIN PIPING:

- #### **A. Pumped drain piping under 100 mm (4 inches) shall be copper tube conforming to ASTM B88, type K or L. For pumped drain piping 100 mm (4 inches) and above, galvanized steel conforming to A 53, seamless, schedule 40 may be used.**
- #### **B. Pumped drain pipe fittings shall comply with the following:**
1. Wrought copper or bronze castings conforming to ANSI B16.18 and B16.22.
 2. Unions shall be bronze, MSS SP-72, SP-110. Solder or braze joints.

3. Grooved fittings, 65 mm to 100 mm (2-1/2 to 4 inch) wrought copper ASTM A75 C12200, 125 to 150 mm (5 to 6 inch) bronze castings ASTM B584, CDA 844. Mechanical grooved couplings, ductile iron, ASTM A536 (Grade 65-45-12), malleable iron, ASTM A47 (Grade 32510) housing, with EPDM gasket, steel track head bolts, ASTM A183, coated with colored alkyd enamel.
- C. Adapters shall be provided for joining screwed pipe to copper tubing.
- D. The solder shall use a non-corrosive flux conforming to ASTM B32.

2.3 SPECIALTY PIPE FITTINGS

- A. Transition pipe couplings shall join piping with small differences in outside diameters or be of different materials. End connections shall be of the same size and compatible with the pipes being joined. The transition coupling shall be elastomeric, sleeve type reducing or transition pattern and include shear erring and corrosion resistant metal tension band and tightening mechanism on each end. The transition coupling sleeve coupling shall be of the following material:
 1. For cast iron soil pipes, the sleeve material shall be rubber conforming to ASTM C564.
- B. The dielectric fittings shall conform to ASSE 1079 with a pressure rating of 860 kPa (125 psig) at a minimum temperature of 82°C (180°F). The end connection shall be solder joint copper alloy and threaded ferrous.
- C. Dielectric flange insulating kits shall be of non conducting materials for field assembly of companion flanges with a pressure rating of 1035 kPa (150 psig). The gasket shall be neoprene or phenolic. The bolt sleeves shall be phenolic or polyethylene. The washers shall be phenolic with steel backing washers.
- D. The dielectric nipples shall be electroplated steel nipple comply with ASTM F 1545 with a pressure ratings of 2070 kPa (300 psig) at 107°C (225°F). The end connection shall be male threaded. The lining shall be inert and noncorrosive propylene.

2.4 CLEANOUTS

- A. Cleanouts shall be the same size as the pipe, up to 100 mm (4 inches); not less than 100 mm (4 inches) for larger pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. A minimum clearance of 600 mm (24 inches) shall be provided for clearing a clogged storm sewer line.

- B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside calk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 50 mm (2 inches). When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In the carpeted areas, carpet cleanout markers shall be provided. Two way cleanouts where shall be provided where indicated on the drawings and at each building exit. The loading classification for cleanouts in sidewalk areas or subject to vehicular traffic shall be heavy duty.
- C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 600 mm (24 inches) above the floor. The cleanouts shall be extended to the wall access cover. Cleanout shall consist of sanitary tees. Nickel bronze square frame and stainless steel cover with minimum opening of 150 mm by 150 mm (6 inch by 6 inch) shall be provided at each wall cleanout.
- D. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/no hub cast iron ferrule. Plain end (no-hub) piping in interstitial space or above ceiling may use plain end (no-hub) blind plug and clamp.

2.5 ROOF DRAINS AND CONNECTIONS

- A. Roof Drains: Roof Drains (RD) shall be cast iron with clamping device for making watertight connection. Free openings through strainer shall be twice area of drain outlet. For roof drains not installed in connection with a waterproof membrane, a soft copper membrane shall be provided 300 mm (12 inches) in diameter greater than outside diameter of drain collar. An integral gravel stop shall be provided for drains installed on roofs having built up roofing covered with gravel or slag. Integral no-hub, soil pipe gasket or threaded outlet connection shall be provided.
 - 1. Flat Roofs: The roof drain shall have a beehive or dome shaped strainer with integral flange not less than 300 mm (12 inches) in diameter. For an insulated roof, a roof drain with an adjustable drainage collar shall be provided, which can be raised or lowered to meet required insulation heights, sump receiver and deck clamp. The Bottom section shall serve as roof drain during construction before insulation is installed.

2. Canopy Roofs: The roof drain shall have a beehive or dome shaped strainer with the integral flange not larger than 200 mm (8 inches) in diameter. For an insulated roof, the roof drain shall be provided with an adjustable drainage collar, which can be raised or lowered to meet the required insulation heights, sump receiver and deck clamp. Bottom section shall serve as roof drain during construction before insulation is installed.
3. Promenade Decks: the roof drain shall be the same as for canopy roofs, except decks shall have flat, round, loose, non-slip, bronze grate set in square, non-slip, bronze frame.
4. Portico Roofs and Gutters: Roof drains shall be horizontal angle type drain with flat bottom and horizontal outlet at the same elevation as the pipe to which it is connected. Strainer shall be removable angle grate type.
5. Protective Roof Membrane Insulation Assembly: The roof drain shall have a perforated stainless steel extension filter, non puncturing clamp ring, large sump with extra wide roof flange and deck clamp.
 - a. Non pedestrian Roofs: The roof drain shall have large polypropylene or aluminum locking dome.
 - b. Pedestrian Roof: The roof drain shall have a bronze promenade top 350 mm (14 inches) square, set in square secured frame support collar.
6. Roof Drains, Overflow: Roof Drains identified as overflow drains shall have a 50 mm (2 inch) water dam integral to the drain body.
7. Roof drains in areas subject to freezing shall have heat tape and shall be insulated.
- B. Expansion Joints: Expansions joints shall be heavy cast iron with cast brass or copper expansion sleeve having smooth bearing surface working freely against a packing ring held in place and under pressure of a bolted gland ring, forming a water and air tight flexible joint. Asbestos packing is prohibited.
- C. Interior Downspouts: An expansion joint shall be provided, specified above, at top of run on straight, vertical runs of downspout piping 12 m (40 feet) long or more.
- D. Downspout Nozzle: The downspout nozzle fitting shall be of brass, unfinished, with internal pipe thread for connection to downspout.

2.6 WATERPROOFING

- A. A sleeve flashing device shall be provided at points where pipes pass through membrane waterproofed floors or walls. The sleeve flashing device shall be manufactured, cast iron fitting with clamping device that forms a sleeve for the pipe floor penetration of the floor membrane. A galvanized steel pipe extension shall be included in the top of the fitting that will extend 50 mm (2 inches) above finished floor and galvanized steel pipe extension in the bottom of the fitting that will extend through the floor slab. A waterproofed caulked joint shall be provided at the top hub.
- B. Walls: See detail shown on drawings.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

- A. The pipe installation shall comply with the requirements of the International code and these specifications.
- B. Branch piping shall be installed from the piping system and connect to all drains and outlets.
- C. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe shall be reamed to full size after cutting.
- D. All pipe runs shall be laid out to avoid interference with other work.
- E. The piping shall be installed above accessible ceilings to allow for ceiling panel removal.
- F. Unless otherwise stated on the documents, minimum horizontal slope shall be one inch for every 1.22 m (4 feet) of pipe length.
- G. The piping shall be installed free of sags and bends.
- H. Seismic restraint shall be installed where required by code.
- I. Changes in direction for storm drainage piping shall be made using appropriate branches, bends and long sweep bends. Sanitary tees and short sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and 1/8 bend fittings shall be used if two fixtures are installed back to back or side by side with common drain pipe. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- J. Buried storm drainage piping shall be laid beginning at the low point of each system. Piping shall be installed true to grades and alignment indicated with unbroken continuity of invert. Hub ends shall be placed upstream. Required gaskets shall be installed according to manufacturer's written instruction for use of lubricants, cements, and other installation requirements.
- K. Cast iron piping shall be installed according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings"

- L. Aboveground copper tubing shall be installed according to CDA's "Copper Tube Handbook".

3.2 JOINT CONSTRUCTION

- A. Hub and spigot, cast iron piping with gasket joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Hub and spigot, cast iron piping with calked joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
- C. Hubless, cast iron piping shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless piping coupling joints.
- D. For threaded joints, thread pipe with tapered pipe threads according to ASME B1.20.1. The threads shall be cut full and clean using sharp disc cutters. Threaded pipe ends shall be reamed to remove burrs and restored to full pipe inside diameter. Pipe fittings and valves shall be joined as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service
 - 2. Pipe sections with damaged threads shall be replaced with new sections of pipe.
- E. Copper tube and fittings with soldered joints shall be joined according to ASTM B828. A water flushable, lead free flux conforming to ASTM B813 and a lead free alloy solder conforming to ASTM B32 shall be used.

3.3 SPECIALTY PIPE FITTINGS

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

3.4 PIPE HANGERS, SUPPORTS AND ACCESSORIES:

- A. All piping shall be supported according to the International plumbing code, Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, and these specifications.
- B. Hangers, supports, rods, inserts and accessories used for Pipe supports shall be shop coated with zinc Chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.
- C. Horizontal piping and tubing shall be supported within 300 mm (12 inches) of each fitting or coupling.
- D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:
 - 1. NPS 1-1/2 to NPS 2 (DN 40 to DN 50): 1500 mm (60 inches) with 10 mm (3/8 inch) rod.
 - 2. NPS 3 (DN 80): 1500 mm (60 inches) with 13 mm (1/2 inch) rod.

3. NPS 4 to NPS 5 (DN 100 to DN 125): 1500 mm (60 inches) with 16 mm (5/8 inch) rod.
 4. NPS 6 to NPS 8 (DN 150 to DN 200): 1500 mm (60 inches) with 19 mm (3/4 inch) rod.
 5. NPS 10 to NPS 12 (DN 250 to DN 300): 1500 mm (60 inches) with 22 mm (7/8 inch) rod.
- E. The maximum support spacing for horizontal plastic shall be 1.22 m (4 feet).
- F. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 4.57 m (15 feet).
- G. In addition to the requirements in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, floor, Wall and Ceiling Plates shall have the following characteristics:
1. Solid or split unplated cast iron.
 2. All plates shall be provided with set screws.
 3. Height adjustable clevis type pipe hangers.
 4. Adjustable Floor Rests and Base Flanges shall be steel.
 5. Hanger Rods shall be low carbon steel, fully threaded or Threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
 6. Riser Clamps shall be malleable iron or steel.
 7. Roller shall be cast iron.
 8. Hangers and supports utilized with insulated pipe and tubing shall have 180 degree (min.) metal protection shield Centered on and welded to the hanger and support. The shield shall be 4 inches in length and be 16 gage steel. The shield shall be sized for the insulation.
- H. Miscellaneous Materials shall be provided as specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. All necessary auxiliary steel shall be provided to provide that support.
- I. Cast escutcheon with set screw shall be installed at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
- J. Penetrations:
1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, a fire stop shall be installed that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING. Clearances between raceways and openings shall be completely filled and sealed with the fire stopping materials.
 2. Water proofing: At floor penetrations, Clearances around the pipe shall be completely sealed and made watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS.

K. Piping shall conform to the following:

1. Storm Water Drain and Vent Drain to main stacks:

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

3.5 TESTS

- A. Storm sewer system shall be tested either in its entirety or in sections.
- B. Storm Water Drain tests shall be conducted before trenches are backfilled or fixtures are connected. A water test or air test shall be conducted, as directed.
 1. If entire system is tested with water, tightly close all openings in pipes except the highest opening, and fill system with water to point of overflow. If system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 3 m (10 foot) head of water. In testing successive sections, test at least upper 3 m (10 feet) of next preceding section so that each joint or pipe except upper most 3 m (10 feet) of system has been submitted to a test of at least a 3 m (10 foot) head of water. Water shall be kept in the system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
 2. For an air test, an air pressure of 35 kPa (5 psi) gage shall be maintained for at least 15 minutes without leakage. A force pump and mercury column gage shall be used for the test.
 3. Final Tests: Either one of the following tests may be used.
 - a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke under pressure of 1.3 kPa (1 inch of water) with a smoke machine. Chemical smoke is prohibited.
 - b. Peppermint Test: Introduce .06 liters (2 ounces) of peppermint into each line or stack.

3.6 COMMISSIONING

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

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SECTION 22 14 29 SUMP PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Sump pumps. See schedule on Drawings for pump capacity and head.

1.2 RELATED WORK

- A. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- B. Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT.
- C. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS. Requirements for commissioning, systems readiness checklist, and training.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

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. Pump:
 - a. Manufacturer and model.
 - b. Operating speed.
 - c. Capacity.
 - d. Characteristic performance curves.
 - 2. Motor:
 - a. Manufacturer, frame and type.
 - b. Speed.
 - c. Current Characteristics and W (HP).
 - d. Efficiency.

- C. Certified copies of all the factory and construction site test data sheets and reports.
- D. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replaceable parts:
 - 1. Include complete list which indicates all components of the system.
 - 2. Include complete diagrams of the internal wiring for each item of equipment.
 - 3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
- E. Completed System Readiness Checklist 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 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. National Electrical Manufacturers Association (NEMA):
 - ICS6-93 (2006)Industrial Control and Systems Enclosures
 - 250-2008Enclosures for Electrical Equipment (1000 Volts Maximum)
- C. Underwriters' Laboratories, Inc. (UL):
 - 508-99 (R2008).....Standards For Industrial Control Equipment

PART 2 - PRODUCTS

2.1 SUMP PUMP

- A. Centrifugal, vertical, submersible pump and motor, designed for 60 degrees C (140 degrees F) maximum water service. Driver shall be electric motor. Support shall be rigid type. Provide perforated, suction strainer. Systems may include one, two, or more pumps with alternator as required by: Contract Documents Pump shall be capable of continuous duty cycle.
 - 1. Pump housings may be cast iron, bronze, aluminum, plastic or stainless steel. Cast iron and aluminum housings for submersible pumps shall be epoxy coated.
- B. Impeller: Brass, bronze or cast iron.
- C. Shaft: Stainless steel or other approved corrosion-resisting metal.
- D. Bearings: As required to hold shaft alignment, anti-friction type for thrust permanently lubricated.

- E. Motor: Maximum 40 degrees C (104 degrees F) ambient temperature rise above the maximum fluid temperature being pumped, drip-proof completely enclosed, voltage and phase as shown in schedule on Electrical drawings conforming to NEMA 250 Type 6P. Size the motor capacity to operate pump without overloading the motor at any point on the pump curve. Refer to Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT.
- F. Starting Switch: Manually-operated, tumbler type.
- G. Automatic Control and Level Alarm: Furnish a control panel in a Nema 1 enclosure for indoors or in a Nema 4X enclosure for outdoors. The controls shall be suitable for operation with the electrical characteristics listed on the Electrical drawings. The control panel shall have a level control system with switches to start and stop pumps automatically, and to activate a high water alarm. The level control system will include sensors in the sump that detect the level of the liquid. The sensors may be float type switches, ultrasonic level sensors, transducers, or other appropriate equipment. The high water alarm shall have a red beacon light at the control panel and a buzzer, horn, or bell. The alarm shall have a silencing switch. Provide auxiliary contacts for remote alarming to the Energy Control Center and BAC net compatible open-protocol type interface to DDC Controls System.
1. The circuitry of the control panel shall include:
 - a. power switch to turn on/off the automatic control mechanism
 - b. HOA switches to manually override automatic control mechanism
 - c. run lights to indicate when pumps are powered up
 - d. level status lights to indicate when water in sump has reached the predetermined on/off and alarm levels
 - e. magnetic motor contactors
 - f. disconnect/breaker for each pump
 - g. automatic motor overload protection
 2. Sensors that detect the level of water in the sump shall be so arranged as to allow the accumulation of enough volume of liquid below the normal on level that the pump will run for a minimum cycle time as recommended by the pump manufacturer. Sensors shall be located to activate the alarm adequately before the water level rises to the inlet pipe.
 3. Provide two separate power supplies to the control panel, one for the control/alarm circuitry and one for power to the pump motors. Each power supply is to be fed from its own breaker so that if a pump overload trips a breaker, the alarm system will still function. Each power supply is to be wired in its own conduit.

4. Wiring from the sump to the control panel shall have separate conduits for the pump power and for the sensor switches. All conduits are to be sealed at the basin and at the control panel to prevent the intrusion of moisture and of flammable and/or corrosive gases.
- H. Sump: Furnish cast iron or fiberglass basin with gas tight covers. Cover shall have 280 mm by 380 mm (11-inch by 15-inch) manhole with bolted cover, vent connection, openings for pumps and controls. Sump shall be sized to allow an adequate volume of water to accumulate for a minimum one minute cycle of pump operation.
- I. Provide a check and ball valve in the discharge of each pump.
- J. Removal/Disconnect System: In a system utilizing a submersible pump, where sump depth, pump size, or other conditions make removal of the pump unusually difficult or unsafe, a removal/disconnect system shall be provided. The system will consist of a discharge fitting mounted on vertical guide rails attached to the sump. The pump shall be fitted with an adapter fitting that easily connects to/disconnects from the discharge fitting as the pump is raised from or lowered into the sump. The discharge piping will connect to the discharge fitting so that it is not necessary to disconnect any piping in order to remove the pump. Where the sump depth is greater than five feet or other conditions exist to make the removal of the pump difficult or hazardous, the system shall include a rail guided quick disconnect apparatus to allow the pump to be pulled up out of the sump without workers entering the sump and without disconnecting the piping.

PART 3 - EXECUTION

3.1 STARTUP AND TESTING

- A. Make tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- B. The tests shall include system capacity and all control and alarm functions.
- C. When any defects are detected, correct defects and repeat test.
- D. The commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior to notice.

3.2 COMMISSIONING

- A. Provide commissioning documentation 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.

3.3 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 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

--- 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. Flush panel access doors: Section 08 31 13, ACCESS DOORS AND FRAMES.
- C. Through bolts: Section 10 21 13, TOILET COMPARTMENTS.
- D. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- E. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS: Requirements for commissioning, systems readiness checklist, and training.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 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.

1.5 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. Furnish keys for lock shield stops to Resident Engineer.
- C. Supply from stops not integral with faucet shall be chrome plated copper flexible tubing or flexible stainless steel with inner core of non-toxic polymer.
- D. Supply pipe from wall to valve stop shall be rigid threaded IPS copper alloy pipe, i.e. red brass pipe nipple, chrome plated where exposed.
- E. Psychiatric Area: Provide stainless steel drain guard for all lavatories not installed in casework.

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 LAMINAR FLOW CONTROL DEVICE

- A. Smooth, bright stainless steel or satin finish, chrome plated metal laminar flow device shall provide non-aeration, clear, coherent laminar flow that will not splash in basin. Device shall also have a flow control restrictor and have vandal resistant housing.
- B. Flow Control Restrictor:
 1. Capable of restricting flow from 95 ml/s to 110 ml/s (1.5 gpm to 1.7 gpm) for lavatories; 125 ml/s to 140 ml/s (2.0 gpm to 2.2 gpm) for sinks P-505 through P-520, P-524 and P-528; and 170 ml/s to 190 ml/s (2.75 gpm to 3.0 gpm) for dietary food preparation and rinse sinks or as specified.
 2. Compensates for pressure fluctuation maintaining flow rate specified above within 10 percent between 170 kPa and 550 kPa (25 psi and 80 psi).
 3. Operates by expansion and contraction, eliminates mineral/sediment build-up with self-cleaning action, and is capable of easy manual cleaning.

2.5 CARRIERS

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

2.6 WATER CLOSETS

- A. Water Closet (Floor Mounted, ANSI 112.19.2M, Figure 6) - office and industrial, elongated bowl, siphon jet 1.28 gallons per flush, floor outlet. Top of rim shall be 435 mm to 438 mm (17-1/8 inches to 17 -1/4 inches) above finished floor.
1. Seat: Institutional/Industrial, extra heavy duty, chemical resistant, solid plastic, open front less cover for elongated bowls, integrally molded bumpers, concealed check hinge with stainless steel post. Seat shall be posture contoured body design. Color shall be white.
 2. Fittings and Accessories: Floor flange fittings-cast iron; Gasket-wax; bolts with chromium plated cap nuts and washers.
 3. Flush valve: Large chloramines resistant diaphragm, semi-red brass valve body, exposed chrome plated, non-hold-open ADA approved side oscillating handle, water saver design 1.28 gallons per flush with maximum 10 percent variance, top spud connection, adjustable tailpiece, one-inch IPS screwdriver back check angle stop with vandal resistant cap, high back pressure vacuum breaker, and sweat solder adapter with cover tube and cast set screw wall flange. Set centerline of inlet 292 mm (11-1/2 inches) above rim. Seat bumpers shall be integral part of flush valve. Valve body, cover, tailpiece and control stop shall be in conformance with ASTM Alloy classification for semi-red brass.

2.7 URINALS

- A. Urinal (Wall Hung, ANSI A112.19.2M, Figure 30) bowl with integral flush distribution, wall to front of flare 356 mm (14 inches). Wall hung with integral trap, siphon jet flushing action 4 L (1.0 gallons) per flush with 50 mm (2 inches) back outlet and 19 mm (3/4 inch) top inlet spud.
1. Support urinal with chair carrier and install with rim 600 mm (24 inches) above finished floor.
 2. Flushing Device: Large chloramines resistant diaphragm, semi-red brass body, exposed flush valve non-hold-open, water saver design, 19 mm (3/4 inch) capped screwdriver angle stop valve. Set centerline of inlet 292 mm (11-1/2 inches) above urinal. Valve body, cover, tailpiece, and control stop shall be in conformance with ASTM alloy classification for semi-red brass.
- B. Urinal (Wheelchair, Wall Hung, ANSI A112.19.2M, Figure 30) bowl with integral flush distribution, wall to front of flare 356 mm (14 inches). Wall hung with integral trap, siphon jet flushing action 4 L (1.0 gallon per flush) with 51 mm (2 inches) back outlet and 19 mm (3/4 inch) top inlet spud.
1. Support urinal with chair carrier and install with rim 381 mm (15 inches) above finished floor.

2. Flushing Device: Large chloramines resistant diaphragm, semi-red brass body, exposed flush valve, non-hold-open, water saver design, 19 mm (3/4 inch) capped screwdriver angle stop valve. Set centerline of inlet 292 mm (11-1/2 inches) above urinal. Valve body, cover, tailpiece and control stop shall be in conformance with ASTM alloy classification for semi-red brass.

2.8 LAVATORIES

- A. Dimensions for lavatories are specified, Length by width (distance from wall) and depth.
- B. Brass components in contact with water shall contain no more than 3 percent lead content by dry weight.
- C. Lavatory (ASME/ANSI A112.19.2M, Figure 16) straight back, approximately 457 mm by 381 mm (18 inches by 15 inches) and a 102 mm (4 inches) maximum apron, first quality vitreous china. Punching for faucet on 102 mm (4 inches) centers. Support lavatory to wall with steel wall plate. Set with rim 864 mm (34 inches) above finished floor:
 1. Faucet: Solid cast brass construction with washerless ceramic disc mixing cartridge type and centrally exposed rigid gooseneck spout with outlet 127-152 mm (5-6 inches) above rim. Provide laminar flow control device. One hundred two millimeters (4-inch) wrist blade type handles on faucets shall be cast, formed or drop forged copper alloy. Faucet, wall and floor escutcheons shall be either copper alloy or CRS. Exposed metal parts, including exposed part under valve handle when in open position, shall be chrome plated with a smooth bright finish.
 2. Drain: Cast or wrought brass with flat grid strainer and offset tailpiece, chrome plated finish.
 3. Stops: Angle type. See paragraph 2.2. Stops
 4. Trap: Cast copper alloy, 38 mm by 32 mm (1-1/2 inches by 1-1/4 inches) P-trap. Adjustable with connected elbow and 1.4 mm thick (17 gauge) tubing extension to wall. Exposed metal trap surface, and connection hardware shall be chrome plated with a smooth bright finish. Set trap parallel to wall.
 5. Provide cover for drain, stops and trap per A.D.A 4-19.4.
- D. Lavatory (Counter Mounted ASME/ANSI A112.19.2M, Figure 25) vitreous china, self-rimming, approximately 483 mm (19 inches) in diameter with punching for faucet on 203 mm (8 inches) centers. Mount unit in countertop.
 1. Faucet: Solid cast brass construction with washerless ceramic disc mixing cartridge type, rigid gooseneck spout with outlet 102 mm to 127 mm (4 inches to 5 inches) above slab with 102 mm (4 inches) wrist blade handles. Provide laminar flow control device. Faucet, wall and floor escutcheons shall be either copper alloy or CRS. Exposed metal parts shall be chrome plated with a smooth bright finish.

2. Drain: cast or wrought brass with flat grid strainer, offset tailpiece, brass, chrome plated.
 3. Stops: Angle type. See paragraph 2.2. Stops
 4. Trap: Cast copper alloy, 38 mm by 32 mm (1-1/2 inches by 1-1/4 inches) P-trap, adjustable with connected elbow and 1.4mm thick (17 gauge) tubing extension to wall. Exposed metal trap surface and connection hardware shall be chrome plated with a smooth bright finish. Set trap parallel to the wall.
 5. Provide cover for drain, stops and trap per A.D.A 4-19.4.
- E. Lavatory (Wrist Control, ASME/ANSI A112.19.2M, Figure 16) straight back, approximately 508 mm by 457 mm (20 inches by 18 inches) and a 102 mm (4 inches) minimum apron, first quality vitreous china. Punching for faucet shall be on 203 mm (8 inches) centers. Set rim 864 mm (34 inches) above finished floor.
1. Faucet: Solid cast brass construction with washerless ceramic mixing cartridge type and centrally exposed rigid gooseneck spout with outlet 102 mm to 127 mm (4 inches to 5 inches) above rim. Provide laminar flow control device. One hundred two millimeter (4-inch) wrist blade type, handles on faucets shall be cast, formed or drop forged copper alloy. Faucet, wall and floor escutcheons shall be either copper alloy or CRS. Exposed metal parts, including exposed part under valve handle when in open position, shall be chrome plated with a smooth bright finish.
 2. Drain: Cast or wrought brass with flat grid strainer, offset tailpiece, chrome plated.
 3. Stops: Angle type. See paragraph 2.2.Stops
 4. Trap: Cast copper alloy, 38 mm by 32 mm (1-1/2 inches by 1-1/4 inches) P-trap. Adjustable with connected elbow and 1.4 mm thick (17 gauge) tubing extension to wall. Exposed metal trap surface, and connection hardware shall be chrome plated with a smooth bright finish. Set trap parallel to the wall.
 5. Provide cover for drain, stops and trap per A.D.A 4-19.4.

2.9 SINKS

- A. Dimensions for sinks and laundry tubs are specified, length by width (distance from wall) and depth.

- B. Service Sink (Corner, Floor Mounted) stain resistant terrazzo, 711 mm by 711 mm by 305 mm (28 inches by 28 inches by 12 inches) with 152 mm (6 inches) drop front. Terrazzo, composed of marble chips and white Portland cement, shall develop compressive strength of 20684 kPa (3000 psi) seven days after casting. Provide extruded aluminum cap on front side.
1. Faucet: Solid brass construction, combination faucet with replaceable monel seat, removable replacement unit containing all parts subject to wear, integral stops, mounted on wall above sink. Spout shall have a pail hook, 19 mm (3/4 inch) hose coupling threads, vacuum breaker, and top or bottom brace to wall. Four-arm handles on faucets shall be cast, formed, or drop forged copper alloy. Escutcheons shall be either forged copper alloy or CRS. Exposed metal parts, including exposed part under valve handle when in open position, shall have a smooth bright finish. Provide 914 mm (36 inches) hose with wall hook. Centerline of rough in is 1219 mm (48 inches) above finished floor.
 2. Drain: Seventy six millimeter (3 inches) cast brass drain with nickel bronze strainer.
 3. Trap: P-trap, drain through floor.
- C. Clinic Service Sink (Flushing Rim, Wall Hung) approximately 508 mm by 635 mm (20 inches by 25 inches) by 203 mm (8 inches) deep. Support with ASME/ANSI A112. 6.1M chair carrier and secure with 10 mm (3/8 inch) bracket studs and nuts. Set sink with rim 762 mm (30 inches) above finished floor. Provide 762 mm (30 inches) CRS drainboard where required, without corrugations and with heavy duty CRS brackets.
1. Faucet: Elbow control, wall hung, integral stops, single spout with 19 mm (3/4 inch) hose threaded outlet and pail hook, vacuum breaker and brace to wall. Outlet 356 mm to 381 mm (14 inches to 15 inches) from wall. Exposed metal parts shall be chromium plated with a smooth bright finish. Provide laminar flow control device.
 2. Flush valve: Large diaphragm, semi-red brass body, Foot pedal operated, exposed chromium plated flush valve with screwdriver back check straight stop with cap, union outlet, street ells, elevated high pressure vacuum breaker, casing cover, 32 mm (1-1/4 inches) elbow flush connection from finished wall to 38 mm (1-1/2 inches) top spud. Spud coupling, wall and spud flanges.

3. Bed Pan Washer: Mechanical pedal mixing valve, wall hung, with double self-closing pedal valve with loose key stops, renewable seats and supply from valve to nozzle with wall hook hose connection; 1219 mm (48 inches) of heavy duty rubber hose, with extended spray outlet elevated vacuum breaker, indexed lift up pedals having clearance of not more than 13 mm (1/2 inch) above the floor and not less than 356 mm (14 inches) from wall when in operation. Supply pipe from wall to valve stop shall be rigid, threaded, IPS copper alloy pipe. Exposed metal parts shall be chromium plated with a smooth bright finish. Provide valve plate for foot control. Provide inline laminar flow control device.
- D. Sink, (CRS, Double Compartment, Counter Top, ASME/ANSI A112.19.3M, Kitchen Sinks, Figure 6) self rimming, approximately 838 mm by 559 mm (33 inches by 22 inches) with two compartments inside dimensions approximately 343 mm by 406 mm by 191 mm (13-1/2 inches by 16 inches by 7-1/2 inches), minimum 20 gage CRS. Corners and edges shall be well rounded.
 1. Faucet: Kitchen sink, solid brass construction, swing spout, chrome plated copper alloy with spray and hose.
 2. Drain: Drain plug with cup strainer, stainless steel.
 3. Trap: Cast copper alloy, 38 mm (1-1/2 inches) P-trap with cleanout plug, continuous drain with wall connection and escutcheon.
 4. Provide cover for drain, stops and trap per A.D.A 4-19.4.
- E. Sink (CRS, Single Compartment, Counter Top ASME/ANSI A112.19.2M, Figure 5) self rimming, back faucet ledge, approximately 533 mm by 559 mm (21 inches by 22 inches) with single compartment inside dimensions approximately 406 mm by 483 mm by 191 mm (16 inches by 19 inches by 7-1/2 inches) deep. Shall be minimum of 1.3 mm thick (18 gauge) CRS. Corners and edges shall be well rounded:
 1. Faucet: Solid brass construction, deck mounted combination faucet with monel or ceramic seats, removable replacement unit containing all parts subject to wear, swivel gooseneck spout with approximately 203 mm (8 inches) reach with spout outlet 152 mm (6 inches) above deck and 102 mm (4 inches) wrist blades. Faucet shall be polished chrome plated.
 2. Drain: Drain plug with cup strainer, stainless steel.
 3. Trap: Cast copper alloy 38 mm (1-1/2 inches) P-trap with cleanout plug. Provide wall connection and escutcheon.
 4. Provide cover for drain, stops and trap per A.D.A 4-19.4.

2.10 DISPENSER, DRINKING WATER

- A. Standard rating conditions: 10 degrees C (50 degrees F) water with 27 degrees C (80 degrees F) inlet water temperature and 32 degrees C (90 degrees F) ambient air temperature.
- B. Electric Water Cooler (Mechanically Cooled, Wall Hung, Self-contained, Wheelchair) bubbler style, 5 ml/s (5 gph) minimum capacity, lead free. Top shall be CRS anti-splash design. Cabinet, CRS, satin finish, approximately 457 mm by 457 mm by 635 mm (18 inches by 18 inches by 25 inches) high with mounting plate. Set bubbler 914 mm (36 inches) above finished floor. Unit shall be push bar operated with front and side bar and automatic stream regulator. All trim polished chrome plated.

2.11 EMERGENCY FIXTURES

- A. Emergency Shower:
 - 1. Shower Head: Polished chrome plated, 203 mm (8 inches) in diameter.
 - 2. Installation: Head shall be 2134 mm (84 inches) above floor.
 - 3. Valves: Stay-open ball type, chrome plated, operated by a 610 mm (24 inches) stainless steel pull-rod with triangle handle. Pull-down opens valve push-up closes valve.
- B. Emergency Shower and Eye and Face Wash (Free Standing):
 - 1. Shower Head: Polished chrome plated, 203 mm (8 inches) in diameter, install head 2134 mm (84 inches) above floor. Equip with stay-open ball valve, chrome plated. Operate valve with 610 mm (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 13 mm (1/2 inch) stay open ball valve operated by push flag handle. Mount eye and face wash spray heads 1067 mm (42 inches) above finished floor.
 - 3. Shower head and emergency eye and face wash shall be mounted to stanchion with floor flange through floor waste connection and P-trap. Paint stanchion same color as room interior.
- C. Emergency Eye and Face Wash (Wall Mounted): CRS, wall mounted, foot pedal control. Mount eye and face wash spray heads 1067 mm (42 inches) above finished floor. Pedal shall be wall mounted, entirely clear of floor, and be hinged to permit turning up. Receptor shall be complete with drain plug with perforated strainer, P-trap and waste connection to wall with escutcheon.

2.12 HYDRANT, HOSE BIBB AND MISCELLANEOUS DEVICES

- A. Wall Hydrant: Cast bronze non-freeze hydrant with detachable T-handle. Brass operating rod within casing of bronze pipe of sufficient length to extend through wall and place valve inside building. Brass valve with coupling and union elbow having metal-to-metal seat. Valve rod and seat washer removable through face of hydrant; 19 mm (3/4 inch) hose thread on spout; 19 mm (3/4 inch) pipe thread on inlet. Finish may be rough; exposed surfaces shall be chrome plated. Set not less than 457 mm (18 inches) nor more than 914 mm (36 inches) above grade. On porches and platforms, set approximately 762 mm (30 inches) above finished floor. Provide integral vacuum breaker which automatically drains when shut off.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Fixture Setting: Opening between fixture and floor and wall finish shall be sealed as specified under Section 07 92 00, JOINT SEALANTS.
- B. Supports and Fastening: Secure all fixtures, equipment and trimmings to partitions, walls and related finish surfaces. Exposed heads of bolts and nuts in finished rooms shall be hexagonal, polished chrome plated brass with rounded tops.
- C. Through Bolts: For free standing marble and metal stud partitions refer to Section 10 21 13, TOILET COMPARTMENTS.
- D. Toggle Bolts: For hollow masonry units, finished or unfinished.
- E. Expansion Bolts: For brick or concrete or other solid masonry. Shall be 6 mm (1/4 inch) diameter bolts, and to extend at least 76 mm (3 inches) into masonry and be fitted with loose tubing or sleeves extending into masonry. Wood plugs, fiber plugs, lead or other soft metal shields are prohibited.
- F. Power Set Fasteners: May be used for concrete walls, shall be 6 mm (1/4 inch) threaded studs, and shall extend at least 32 mm (1-1/4 inches) into wall.
- G. Tightly cover and protect fixtures and equipment against dirt, water and chemical or mechanical injury.
- H. Where water closet waste pipe has to be offset due to beam interference, provide correct and additional piping necessary to eliminate relocation of water closet.
- I. Do not use aerators on lavatories and sinks.

3.2 CLEANING

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

3.4 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 22 66 00
CHEMICAL-WASTE SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 DESCRIPTION

This section describes the requirements for chemical waste systems, including piping, equipment and all necessary accessories as designated in this section.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Penetrations in rated enclosures:
- B. Section 09 91 00, PAINTING: Preparation and finish painting and identification of piping systems.
- C. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- D. Section 22 07 11, PLUMBING INSULATION: Pipe Insulation.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

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. Piping.
 - 2. Floor Drains.
 - 3. All items listed in Part 2 - Products.
- C. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane or the floor drain.

1.5 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 Standards Institute (ANSI):
American Society of Mechanical Engineers (ASME): (Copyrighted Society)
A13.1-07Scheme for Identification of Piping Systems
B16.11-01Forged Steel Fittings, Socket-Welding and Threaded
B16.12-98 (R 2006)Cast Iron Threaded Drainage Fittings ANSI/ASME
B16.15-06(R 2006)Cast Bronze Threaded Fittings ANSI/ASME
- C. American Society for Testing and Materials (ASTM):
A74-06Standard Specification for Cast Iron Soil Pipe and Fittings
A183-03)Standard Specification for Carbon Steel Track Bolts and Nuts
A312-08Standard Specification for Seamless and Welded Austenitic
Stainless Steel Pipe
A733-03Standard Specification for Welded and Seamless Carbon Steel
and Austenitic Stainless Steel Pipe Nipples
C564-03a.....Standard Specification for Rubber Gaskets for Cast Iron Soil
Pipe and Fittings
D401-07Standard Specification for Propylene Plastic Injection and
Extrusion Materials
D2447-03Standard Specification for Polyethylene (PE) Plastic Pipe,
Schedule 40 and 80, Based on Outside Diameter
D2564-04e1Standard Specification for Solvent Cements for Poly (Vinyl
Chloride) (PVC) Plastic Pipe and Fittings
D2665-07Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic
Drain, Waste, and Vent Pipe and Fittings
D4101-07Standard Specification for Propylene Plastic Injection and
Extrusion Materials
- D. International Code Council:
IPC-06International Plumbing Code
- E. Cast Iron Soil Pipe Institute (CISPI):
301-05Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm
Drain, Waste, and Vent Piping Applications

310-04Coupling for Use in Connection with Hubless Cast Iron Soil Pipe
and Fittings for Sanitary and Storm Drain, Waste, and Vent
Piping Applications

PART 2 - PRODUCTS

2.1 CHEMICAL RESISTANT WASTE AND VENT PIPING

- A. The material shall include connecting fittings in stacks or mains.
- B. The chemical resistant waste and vent piping shall be high silicon iron pipe and drainage pattern fittings conforming to ASTM A861. The cast iron pipe shall be close grained, containing not less than 14.25 percent silicon content.
 - 1. The joints shall be mechanical joint type with stainless steel clamps with TFE inner sleeve and CR outer sleeve.
 - 2. The joints shall be bell and Spigot Joint type joint using acid resistant packing and lead calking materials.
- C. The chemical resistant waste and vent pipe material shall be extruded polypropylene plastic pipe and drainage pattern fittings conforming to ASTM F1412. The polypropylene pipe and fittings shall be schedule 40 and made from a polypropylene resin with a fire retardant additive complying with ASTM D4101 with mechanical joints for sizes under 3 inches (DN 75) and fusion and mechanical joints for sizes 3 inches (DN 75) and over.
- D. The chemical resistant waste and vent pipe material shall be PVDF pipe and drainage pattern fittings conforming to ASTM F1673. The PVDF pipe and fittings shall be schedule with mechanical joints for sizes under 80 mm (3 inches) and fusion and mechanical joints for sizes 80 mm (3 inches and over).
- E. The chemical resistant waste and vent pipe material shall be type 316L stainless steel pipe and drainage pattern fittings conforming to ASME A112.3.1 and ASTM A 666. The stainless steel pipe shall have socket and spigot ends for gasket joints having piping manufacturer's FPM lip-seal rubber gaskets shaped to fit socket groove with plastic backup ring.

2.2 ETO WATER PIPING

- A. ETO water pipe material shall be schedule 10, stainless steel, conforming to ASTM A312 with butt welded joints and fittings.

2.3 PIPING SPECIALTIES

- A. Plastic dilution traps shall be corrosion resistant polypropylene with removable base and mechanical joint connections. The dilution tanks shall have a 3.8 liter (one gallon) capacity with a clear base. The dilution tank shall have two 40 mm or DN40 (NPS 1-1/2) top inlets and one 40 mm or DN40 (NPS 1-1/2) side outlet.

- B. High silicon iron dilution traps shall have 40 mm or DN40 to 50 mm or DN50 (NPS 1-1/2 or NPS 2) as required for fixture and waste with mechanical joints, and conforming to ASTM A861.
- C. Glass drain line interceptor drum traps shall have 40 mm or DN40 to 50 mm or DN50 (NPS 1-1/2 or NPS 2) as required for fixture and waste and conforming to ASTM C 1053.
- D. Corrosion resistant P-trap or drum trap shall have 40 mm or DN40 to 50 mm or DN50 (NPS 1-1/2 or NPS 2) as required for fixture and waste and conform to ASTM A 861 for high silicon iron pipe with hubless joints, ASTM D4101 for polypropylene pipe with mechanical joints, ASTM D 3222 for PVDF pipe with mechanical joints, and ASTM C 1053 for glass pipe with coupling connections.

2.4 NEUTRALIZATION TANKS

- A. Plastic neutralization tanks shall be constructed from corrosion resistant plastic materials with removable, gastight cover. The tank shall be filled with limestone 25 to 75 mm (1 to 3 inch) chips or lumps with a calcium carbonate content exceeding 90 percent.

2.5 CLEANOUTS

- A. Cleanouts shall be the same size as the pipe, up to 100 mm or DN100 (4 inches); not less than 100 mm or DN100 (4 inches) for larger pipe. Cleanouts for chemical waste drain pipe shall be of same material as the pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. A minimum clearance of 600 mm (24 inches) shall be provided for clearing a clogged chemical waste drain.
- B. Floor cleanouts shall have cast iron body and frame with square adjustable scoriated secured nickel bronze top. The cleanout shall be vertically adjustable for a minimum of 50 mm or DN50 (2 inches). When a waterproof membrane is used in the floor system, a clamping collar shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In the carpeted areas, carpet cleanout markers shall be provided. Two way cleanouts shall be provided where indicated on drawings.

- C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 600 mm (24 inches) above the floor. If there are no fixtures installed on the lowest floor, the cleanout shall be installed at the base of the stack. The cleanouts shall be extended to the wall access cover. The vertical cleanout shall consist of sanitary tees. Nickel bronze square frame and stainless steel cover shall be furnished with a minimum opening of 150 by 150 mm (6 by 6 inches) at each wall cleanout. Where the piping is concealed, a fixture trap or a fixture with integral trap, readily removable without disturbing concealed roughing work, shall be accepted as a cleanout equivalent providing the opening to be used as a cleanout opening is the size required.
- D. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/no hub cast iron ferrule. Plain end (no-hub) piping in interstitial space or above ceiling may use plain end (no-hub) blind plug and clamp.

2.6 FLOOR DRAINS

- A. Chemical resistant floor drain and p-trap. Double drainage pattern with integral seepage pan for embedding in floor and weep holes to provide adequate drainage from pan to drain pipe. Floor drain shall be polypropylene, flame retardant, Schedule 40 or 80. Provide outlet of floor drain suitable for properly joining a perforated or slotted floor level grate.

2.7 WATERPROOFING

- A. A sleeve flashing device shall be provide at points where pipes pass through membrane waterproofed floors or walls. The sleeve flashing device shall be manufactured, cast iron fitting with clamping device that forms a sleeve for the pipe floor penetration of the floor membrane. A galvanized steel pipe extension shall be included in the top of the fitting that will extend 50 mm (2 inches) above finished floor and galvanized steel pipe extension in the bottom of the fitting that will extend through the floor slab. A waterproofed caulked joint shall be provided at the top hub.
- B. Walls: See detail shown on drawings.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

- A. The pipe installation shall comply with the requirements of the International plumbing code and these specifications.
- B. Branch piping for chemical waste piping system shall be installed and connected to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.
- C. Piping shall be installed for reagent racks. The piping shall be arranged neatly and located as required by the equipment.

- D. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for plastic and glass, shall be reamed to full size after cutting.
- E. All pipe runs shall be laid out to avoid interference with other work.
- F. The piping shall be installed above accessible ceilings to allow for ceiling panel removal.
- G. The piping shall be installed to permit valve servicing or operation.
- H. The piping shall be installed at the indicated slopes or according to the International plumbing code.
- I. The piping shall be installed free of sags and bends.
- J. Seismic restraint shall be installed where required by code.
- K. Changes in direction for chemical waste drainage and vent piping shall be made using appropriate branches, bends and long sweep bends. Sanitary tees and short sweep quarter bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and eighth bend fittings shall be used if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- L. Buried soil and waste drainage and vent piping shall be laid beginning at the low point of each system. Piping shall be installed true to grades and alignment indicated with unbroken continuity of invert. Hub ends shall be placed upstream. Required gaskets shall be installed according to manufacturer's written instruction for use of lubricants, cements, and other installation requirements.
- M. Cast iron piping shall be installed according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

3.2 JOINT CONSTRUCTION

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

- D. For threaded joints, thread pipe with tapered pipe threads according to ASME B1.20.1. The threads shall be cut full and clean using sharp disc cutters. Threaded pipe ends shall be reamed to remove burrs and restored to full pipe inside diameter. Pipe fittings and valves shall be joined as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service
 2. Pipe sections with damaged threads shall be replaced with new sections of pipe.

3.3 SPECIALTY PIPE FITTINGS

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

3.4 PIPE HANGERS, SUPPORTS, AND ACCESSORIES

- A. All piping shall be supported according to the International plumbing code, Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, and these specifications.
- B. Hangers, supports, rods, inserts and accessories used for Pipe supports shall be shop coated with zinc Chromate primer paint.
- C. Horizontal piping and tubing shall be supported within 300 mm (12 inches) of each fitting or coupling.
- D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:
1. 40 mm or DN40 to 50 mm or DN50 (NPS 1-1/2 to NPS 2): 1500 mm (60 inches) with 10 mm (3/8 inch) rod.
 2. 80 mm or DN 80 (NPS 3): 1500 mm (60 inches) with 13 mm (1/2 inch) rod.
 3. 100 mm or DN 100 to 125 mm or DN125 (NPS 4 to NPS 5): 1500 mm (60 inches) with 16 mm (5/8 inch) rod.
 4. 150 mm or DN150 to 200 mm or DN200 (NPS 6 to NPS 8): 1500 mm (60 inches) with 19 mm (3/4 inch) rod.
 5. 250 mm or DN250 to 300 mm or DN300 (NPS 10 to NPS 12): 1500 mm (60 inches) with 22 mm (7/8 inch) rod.
- E. Vinyl coated hangers shall be installed for glass piping. The maximum horizontal spacing and minimum rod diameters shall be:
1. For 25 mm or DN25 to 32 mm DN32 (NPS 1 and NPS 1-1/4), the maximum spacing shall be 1.22 meters (48 inches) with 10 mm (3/8 inch).

2. For 40 mm or DN40 and 50 mm or DN50 (NPS 1-1/2 and NPS 2), the maximum spacing shall be 1.83 meters (72 inches) with 10 mm (3/8 inch).
 3. For 80 mm or DN80 (NPS 3 inch), the maximum spacing shall be 1.83 meters (72 inches) with 13 mm (1/2 inch).
 4. For 100 mm (DN100) (NPS 4 inch), the maximum spacing shall be 1.83 meters (72 inches) with 16 mm (5/8 inch).
- F. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 4.57 meters (15 feet). In addition to the requirements in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING,
- G. In addition to the requirements in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, floor, Wall and Ceiling Plates, Supports, and Hangers shall have the following characteristics:
1. Solid or split unplated cast iron.
 2. All plates shall be provided with set screws.
 3. Height adjustable clevis type pipe hangers.
 4. Adjustable Floor Rests and Base Flanges shall be steel.
 5. Hanger Rods shall be carbon steel, fully threaded or Threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
 6. Riser Clamps shall be malleable iron or steel.
 7. Rollers shall be Cast iron.
 8. Hangers and supports utilized with insulated pipe and tubing shall have 180 degree (min.) metal protection shield Centered on and welded to the hanger and support. The shield shall be 100 mm (4 inches) in length and be 16 gauge steel. The shield shall be sized for the insulation.
- H. Miscellaneous Materials: As specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. Provide all necessary auxiliary steel to provide that support.
- I. Cast escutcheon with set screw shall be installed at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

J. Penetrations:

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

K. Chemical waste and vent piping shall conform to the following:

1. Where waste lines from fixtures are shown on plans to be chemical resistant, vents from those fixtures shall also be chemical resistant.
2. Mechanically Joined Polypropylene Pipe requires a pre-grooved pipe or cutting of a groove in each pipe section using a rotation cutting tool. Polypropylene chemical resistant pipe pitch shall be 6 mm minimum (1/4 inch per foot) minimum. Mechanically joined pipe shall not be installed below grade.
3. Plastic chemical waste pipe shall not be installed within 23 m (75 feet) of hot water appliances (autoclaves, dishwashers, sterilizers) and similar equipment.
4. High silicon content cast iron pipe with bell and spigot joints and heat fusion plastic pipe may be used below grade under building.
5. Stainless steel, mechanical joints shall not be installed below grade.
6. Stainless Steel Piping system shall be Joined and supported per manufacturer's recommendations.

3.5 TESTS

- A. The chemical resistant pipe system shall be tested either in its entirety or in sections.
- B. Tests for Chemical Resistant Waste, vent, and Silver Recovery Systems shall be conducted before trenches are backfilled or fixtures are connected. A water test or air test shall be conducted as directed.
 1. If entire system is tested using a water test, tightly close all openings in pipes except highest opening, and fill system with water to point of overflow. If system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 3 m (10 foot) head of water. In testing successive sections, test at least upper 3 m (10 feet) of next preceding section so that each joint or pipe except upper most 3 m (10 feet) of system has been submitted to a test of at least a 3 m (10 foot) head of water. Water shall be kept in system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.

2. Air pressure test of 35 kPa (5 psi) gage shall be maintained for at least 15 minutes without leakage. A force pump and mercury column gage shall be used for the test.
3. Final Tests: Either one of the following tests may be used.
 - a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke under pressure of 1.3 kPa (1 inch of water) with a smoke machine. Chemical smoke is prohibited.
 - b. Peppermint Test: Introduce (two ounces) of peppermint into each line or stack.

3.6 COMMISSIONING

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

- - - E N D - - -

SECTION 23 05 11
COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

- A. Section 00 72 00, GENERAL CONDITIONS
- B. Section 01 00 00, GENERAL REQUIREMENTS
- C. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES
- D. Section 02 65 00, UNDERGROUND STORAGE TANK REMOVAL
- E. Section 31 20 00, EARTH MOVING: Excavation and Backfill
- F. Section 03 30 00, CAST-IN-PLACE CONCRETE: Concrete and Grout
- G. Section 05 31 00, STEEL DECKING, and Section 05 36 00, COMPOSITE METAL DECKING:
Building Components for Attachment of Hangers
- H. Section 05 50 00, METAL FABRICATIONS
- I. Section 07 84 00, FIRESTOPPING
- J. Section 07 60 00, FLASHING AND SHEET METAL: Flashing for Wall and Roof Penetrations
- K. Section 07 92 00, JOINT SEALANTS
- L. Section 09 91 00, PAINTING
- M. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM
GENERATION
- N. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND
EQUIPMENT
- O. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC
- P. Section 23 07 11, HVAC INSULATION
- Q. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC
- R. Section 23 10 00, FACILITY FUEL SYSTEMS
- S. Section 23 21 13, HYDRONIC PIPING
- T. Section 23 21 23, HYDRONIC PUMPS

- U. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING
- V. Section 23 22 23, STEAM CONDENSATE PUMPS
- W. Section 23 25 00, HVAC WATER TREATMENT
- X. Section 23 31 00, HVAC DUCTS AND CASINGS
- Y. Section 23 34 00, HVAC FANS
- Z. Section 23 36 00, AIR TERMINAL UNITS
- AA. Section 23 37 00, AIR OUTLETS AND INLETS
- BB. Section 23 40 00, HVAC AIR CLEANING DEVICES
- CC. Section 23 64 00, PACKAGED WATER CHILLERS
- DD. Section 23 65 00, COOLING TOWERS
- EE. Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS
- FF. Section 23 74 13, PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS
- GG. Section 23 82 00, CONVECTION HEATING AND COOLING UNITS
- HH. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for
commissioning, systems readiness checklists, and training
- II. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS
- JJ. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL
COMPONENT: Seismic restraints for piping

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™
CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Mechanical, electrical and associated systems shall be safe, reliable, efficient, durable, easily and safely operable and maintainable, easily and safely accessible, and in compliance with applicable codes as specified. The systems shall be comprised of high quality institutional-class and industrial-class products of manufacturers that are experienced specialists in the required product lines. All construction firms and personnel shall be experienced and qualified specialists in industrial and institutional HVAC.
- B. Flow Rate Tolerance for HVAC Equipment: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- C. Equipment Vibration Tolerance:
 - 1. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT. Equipment shall be factory-balanced to this tolerance and re-balanced on site, as necessary.
 - 2. After HVAC air balance work is completed and permanent drive sheaves are in place, perform field mechanical balancing and adjustments required to meet the specified vibration tolerance.
- D. Products Criteria:
 - 1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years (or longer as specified elsewhere). The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other specification sections for any exceptions and/or additional requirements.
 - 2. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.
 - 3. Conform to codes and standards as required by the specifications. Conform to local codes, if required by local authorities such as the natural gas supplier, if the local codes are more stringent than those specified. Refer any conflicts to the Resident Engineer.
 - 4. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.
 - 5. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.

6. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
 7. Asbestos products or equipment or materials containing asbestos shall not be used.
- E. Equipment Service Organizations:
1. HVAC: Products and systems shall be supported by service organizations that maintain a complete inventory of repair parts and are located within 50 miles to the site.
- F. HVAC Mechanical Systems Welding: Before any welding is performed, contractor shall submit a certificate certifying that welders comply with the following requirements:
1. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualifications".
 2. Comply with provisions of ASME B31 series "Code for Pressure Piping".
 3. Certify that each welder has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.
- G. Execution (Installation, Construction) Quality:
1. Apply and install all items in accordance with manufacturer's written instructions. Refer conflicts between the manufacturer's instructions and the contract drawings and specifications to the Resident Engineer for resolution. Provide written hard copies or computer files of manufacturer's installation instructions to the Resident Engineer at least two weeks prior to commencing installation of any item. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations is a cause for rejection of the material.
 2. Provide complete layout drawings required by Paragraph, SUBMITTALS. Do not commence construction work on any system until the layout drawings have been approved.
- 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.

1.5 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, and with requirements in the individual specification sections.
- B. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements.

- C. If equipment is submitted which differs in arrangement from that shown, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.
- D. Prior to submitting shop drawings for approval, contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.
- E. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient.
- F. Layout Drawings:
 - 1. Submit complete consolidated and coordinated layout drawings for all new systems, and for existing systems that are in the same areas. Refer to Section 00 72 00, GENERAL CONDITIONS, Article, SUBCONTRACTS AND WORK COORDINATION.
 - 2. The drawings shall include plan views, elevations and sections of all systems and shall be on a scale of not less than 1:32 (3/8-inch equal to one foot). Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings shall clearly show locations and adequate clearance for all equipment, piping, valves, control panels and other items. Show the access means for all items requiring access for operations and maintenance. Provide detailed layout drawings of all piping and duct systems.
 - 3. Do not install equipment foundations, equipment or piping until layout drawings have been approved.
 - 4. In addition, for HVAC systems, provide details of the following:
 - a. Mechanical equipment rooms.
 - b. Hangers, inserts, supports, and bracing.
 - c. Pipe sleeves.
 - d. Duct or equipment penetrations of floors, walls, ceilings, or roofs.

- G. Manufacturer's Literature and Data: Submit under the pertinent section rather than under this section.
1. Submit belt drive with the driven equipment. Submit selection data for specific drives when requested by the Resident Engineer.
 2. Submit electric motor data and variable speed drive data with the driven equipment.
 3. Equipment and materials identification.
 4. Fire-stopping materials.
 5. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.
 6. Wall, floor, and ceiling plates.
- H. HVAC Maintenance Data and Operating Instructions:
1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.
 2. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.
- I. Provide copies of approved HVAC equipment submittals to the Testing, Adjusting and Balancing Subcontractor.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning, Heating and Refrigeration Institute (AHRI):
430-2009Central Station Air-Handling Units
- C. American National Standard Institute (ANSI):
B31.1-2007Power Piping
- D. Rubber Manufacturers Association (ANSI/RMA):
IP-20-2007Specifications for Drives Using Classical V-Belts and Sheaves
IP-21-2009Specifications for Drives Using Double-V (Hexagonal) Belts
IP-22-2007Specifications for Drives Using Narrow V-Belts and Sheaves
- E. Air Movement and Control Association (AMCA):
410-96Recommended Safety Practices for Air Moving Devices

- F. American Society of Mechanical Engineers (ASME):
- Boiler and Pressure Vessel Code (BPVC):
- Section IX-2007 Welding and Brazing Qualifications
- Code for Pressure Piping:
- B31.1-2007 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
- 70-11 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

1.7 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

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

B. Cleanliness of Piping and Equipment Systems:

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

1.8 JOB CONDITIONS – WORK IN EXISTING BUILDING

- A. Building Operation: Government employees will be continuously operating and managing all facilities, including temporary facilities, that serve the medical center.
- B. Maintenance of Service: Schedule all work to permit continuous service as required by the medical center.
- C. Steam and Condensate Service Interruptions: Limited steam and condensate service interruptions, as required for interconnections of new and existing systems, will be permitted by the Resident Engineer during periods when the demands are not critical to the operation of the medical center. These non-critical periods are to be determined by Resident Engineer. Provide at least one week advance notice to the Resident Engineer.
- D. Phasing of Work: Comply with all requirements shown on drawings or specified.

- E. Building Working Environment: Maintain the architectural and structural integrity of the building and the working environment at all times. Maintain the interior of building at 18 degrees C (65 degrees F) minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. No storm water or ground water leakage permitted. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA.
- F. Acceptance of Work for Government Operation: As new facilities are made available for operation and these facilities are of beneficial use to the Government, inspections will be made and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After correction of deficiencies as necessary for beneficial use, the Contracting Officer will process necessary acceptance and the equipment will then be under the control and operation of Government personnel.
- G. Temporary Facilities: Refer to Article, TEMPORARY PIPING AND EQUIPMENT in this section

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

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

2.2 COMPATIBILITY OF RELATED EQUIPMENT

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

2.3 BELT DRIVES

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

2.4 DRIVE GUARDS

- A. For machinery and equipment, provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor to prevent damage to equipment and injury to personnel. Drive guards may be excluded where motors and drives are inside factory fabricated air handling unit casings.
- B. Pump shafts and couplings shall be fully guarded by a sheet steel guard, covering coupling and shaft but not bearings. Material shall be minimum 16-gage sheet steel; ends shall be braked and drilled and attached to pump base with minimum of four 6 mm (1/4-inch) bolts. Reinforce guard as necessary to prevent side play forcing guard onto couplings.
- C. V-belt and sheave assemblies shall be totally enclosed, firmly mounted, non-resonant. Guard shall be an assembly of minimum 22-gage sheet steel and expanded or perforated metal to permit observation of belts. 25 mm (one-inch) diameter hole shall be provided at each shaft centerline to permit speed measurement.
- D. Materials: Sheet steel, cast iron, expanded metal or wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.
- E. Access for Speed Measurement: 25 mm (One inch) diameter hole at each shaft center.

2.5 LIFTING ATTACHMENTS

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

2.6 ELECTRIC MOTORS

- A. All material and equipment furnished and installation methods shall conform to the requirements of Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT; Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS; and, Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide special energy efficient premium efficiency type motors as scheduled.

2.7 VARIABLE SPEED MOTOR CONTROLLERS

- A. Refer to Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS for specifications.

- B. The combination of controller and motor shall be provided by the manufacturer of the driven equipment, such as pumps and fans, and shall be rated for 100 percent output performance. Multiple units of the same class of equipment, i.e. air handlers, fans, pumps, shall be product of a single manufacturer.
- C. Motors shall be premium efficiency type and be approved by the motor controller manufacturer. The controller-motor combination shall be guaranteed to provide full motor nameplate horsepower in variable frequency operation. Both driving and driven motor/fan sheaves shall be fixed pitch.
- D. Controller shall not add any current or voltage transients to the input AC power distribution system, DDC controls, sensitive medical equipment, etc., nor shall be affected from other devices on the AC power system.
- E. Controller shall be provided with the following operating features and accessories:
 - 1. Suitable for variable torque load.
 - 2. Provide thermal magnetic circuit breaker or fused switch with external operator and incoming line fuses. Unit shall be rated for minimum 100K AIC. Provide AC input line reactors (5% impedance) on incoming power line. Provide output line reactors on line between drive and motor where the distance between the breaker and motor exceeds 50 feet.

2.8 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Use symbols, nomenclature and equipment numbers specified, shown on the drawings and shown in the maintenance manuals. Identification for piping is specified in Section 09 91 00, PAINTING.
- B. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 48 mm (3/16-inch) high of brass with black-filled letters, or rigid black plastic with white letters specified in Section 09 91 00, PAINTING permanently fastened to the equipment. Identify unit components such as coils, filters, fans, etc.
- C. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 48 mm (3/16-inch) high riveted or bolted to the equipment.
- D. Control Items: Label all temperature and humidity sensors, controllers and control dampers. Identify and label each item as they appear on the control diagrams.
- E. Valve Tags and Lists:
 - 1. HVAC: Provide for all valves other than for equipment in Section 23 82 00, CONVECTION HEATING AND COOLING UNITS.

2. Valve tags: Engraved black filled numbers and letters not less than 13 mm (1/2-inch) high for number designation, and not less than 6.4 mm (1/4-inch) for service designation on 19 gage 38 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.
3. Valve lists: Typed or printed plastic coated card(s), sized 216 mm (8-1/2 inches) by 280 mm (11 inches) showing tag number, valve function and area of control, for each service or system. Punch sheets for a 3-ring notebook.
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.

2.9 FIRESTOPPING

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

2.10 GALVANIZED REPAIR COMPOUND

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

2.11 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. Supports for Roof Mounted Items:
 1. Equipment: Equipment rails shall be galvanized steel, minimum 1.3 mm (18 gauge), with integral baseplate, continuous welded corner seams, factory installed 50 mm by 100 mm (2 by 4) treated wood nailer, 1.3 mm (18 gauge) galvanized steel counter flashing cap with screws, built-in cant strip, (except for gypsum or tectum deck), minimum height 280 mm (11 inches). For surface insulated roof deck, provide raised cant strip to start at the upper surface of the insulation.
 2. Pipe/duct pedestals: Provide a galvanized Unistrut channel welded to U-shaped mounting brackets which are secured to side of rail with galvanized lag bolts.
- C. 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.
- D. Attachment to Concrete Building Construction:
 1. Concrete insert: MSS SP-58, Type 18.

2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 102 mm (four inches) thick when approved by the Resident Engineer for each job condition.
 3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 102 mm (four inches) thick when approved by the Resident Engineer for each job condition.
- E. Attachment to Steel Building Construction:
1. Welded attachment: MSS SP-58, Type 22.
 2. Beam clamps: MSS SP-58, Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 23mm (7/8-inch) outside diameter.
- F. Attachment to Metal Pan or Deck: As required for materials specified in Section 05 31 00, STEEL DECKING. Section 05 36 00, COMPOSITE METAL DECKING.
- G. Attachment to existing structure: Support from existing floor/roof frame.
- H. Attachment to Wood Construction: Wood screws or lag bolts.
- I. Hanger Rods: Hot-rolled steel, ASTM A36 or A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 38 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.
- J. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (No. 12 gage), designed to accept special spring held, hardened steel nuts. Not permitted for steam supply and condensate piping.
1. Allowable hanger load: Manufacturers rating less 91kg (200 pounds).
 2. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4-inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 13mm (1/2-inch) galvanized steel bands, or preinsulated calcium silicate shield for insulated piping at each hanger.
- K. Supports for Piping Systems:
1. Select hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or preinsulated calcium silicate shields. Provide Type 40 insulation shield or preinsulated calcium silicate shield at all other types of supports and hangers including those for preinsulated piping.

2. Piping Systems except High and Medium Pressure Steam (MSS SP-58):
 - a. Standard clevis hanger: Type 1; provide locknut.
 - b. Riser clamps: Type 8.
 - c. Wall brackets: Types 31, 32 or 33.
 - d. Roller supports: Type 41, 43, 44 and 46.
 - e. Saddle support: Type 36, 37 or 38.
 - f. Turnbuckle: Types 13 or 15. Preinsulate.
 - g. U-bolt clamp: Type 24.
 - h. Copper Tube:
 - 1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with non adhesive isolation tape to prevent electrolysis.
 - 2) For vertical runs use epoxy painted or plastic coated riser clamps.
 - 3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.
 - 4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.
 - i. Supports for plastic or glass piping: As recommended by the pipe manufacturer with black rubber tape extending one inch beyond steel support or clamp.
3. High and Medium Pressure Steam (MSS SP-58):
 - a. Provide eye rod or Type 17 eye nut near the upper attachment.
 - b. Piping 50 mm (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 20 mm (3/4-inch): Type 51 or 52 variable spring unit with integral turn buckle and load indicator.
 - 2) Movement more than 20 mm (3/4-inch): Type 54 or 55 constant support unit with integral adjusting nut, turn buckle and travel position indicator.
4. Convertor and Expansion Tank Hangers: May be Type 1 sized for the shell diameter.
Insulation where required will cover the hangers.

L. Pre-insulated Calcium Silicate Shields:

1. Provide 360 degree water resistant high density 965 kPa (140 psi) compressive strength calcium silicate shields encased in galvanized metal.
2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.

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

2.12 PIPE PENETRATIONS

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

- F. Galvanized Steel or an alternate Black Iron Pipe with asphalt coating Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, connect sleeve with floor plate.
- G. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.
- H. Sleeves are not required for wall hydrants for fire department connections or in drywall construction.
- I. Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.
- J. Sealant and Adhesives: Shall be as specified in Section 07 92 00, JOINT SEALANTS.
- K. Seismic Restraint of Piping and Ductwork: Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENT: Comply with MSS SP-127.

2.13 DUCT PENETRATIONS

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

2.14 SPECIAL TOOLS AND LUBRICANTS

- A. Furnish, and turn over to the Resident Engineer, tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.
- 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 Resident Engineer.
- E. Lubricants: A minimum of 0.95 L (one quart) of oil, and 0.45 kg (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.

2.15 WALL, FLOOR AND CEILING PLATES

- A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.
- B. Thickness: Not less than 2.4 mm (3/32-inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025-inch) for up to 80 mm (3-inch pipe), 0.89 mm (0.035-inch) for larger pipe.
- C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

2.16 ASBESTOS

- A. Materials containing asbestos are not permitted.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

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

2. Locate holes to avoid interference with structural members such as beams or grade beams.
Holes shall be laid out in advance and drilling done only after approval by Resident Engineer.
If the Contractor considers it necessary to drill through structural members, this matter shall be referred to Resident Engineer for approval.
 3. Do not penetrate membrane waterproofing.
- F. Interconnection of Instrumentation or Control Devices: Generally, electrical and pneumatic interconnections are not shown but must be provided.
- G. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.
- H. Electrical Interconnection of Controls and Instruments: This generally not shown but must be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments and computer workstations. Comply with NFPA-70.
- I. Protection and Cleaning:
1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the Resident Engineer. Damaged or defective items in the opinion of the Resident Engineer, shall be replaced.
 2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and equipment against dirt, water chemical, or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.
- J. Concrete and Grout: Use concrete and shrink compensating grout 25 MPa (3000 psi) minimum, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.
- K. Install gages, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gages to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.
- L. Install steam piping expansion joints as per manufacturer's recommendations.

M. Work in Existing Building:

1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00 00, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).
2. As specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will least interfere with normal operation of the facility.
3. Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills, will be permitted only with approval of the Resident Engineer. Locate openings that will least effect structural slabs, columns, ribs or beams. Refer to the Resident Engineer for determination of proper design for openings through structural sections and opening layouts approval, prior to cutting or drilling into structure. After Resident Engineer's approval, carefully cut opening through construction no larger than absolutely necessary for the required installation.

N. Switchgear/Electrical Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints. Installation of piping, ductwork, leak protection apparatus or other installations foreign to the electrical installation shall be located in the space equal to the width and depth of the equipment and extending from to a height of 1.8 m (6 ft.) above the equipment of to ceiling structure, whichever is lower (NFPA 70).

O. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost to the Government.
2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

3.2 TEMPORARY PIPING AND EQUIPMENT

A. Continuity of operation of existing facilities will generally require temporary installation or relocation of equipment and piping.

- B. The Contractor shall provide all required facilities in accordance with the requirements of phased construction and maintenance of service. All piping and equipment shall be properly supported, sloped to drain, operate without excessive stress, and shall be insulated where injury can occur to personnel by contact with operating facilities. The requirements of 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 Resident Engineer 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 Resident Engineer.
- B. Use of chain, wire or strap hangers; wood for blocking, stays and bracing; or, hangers suspended from piping above will not be permitted. Replace or thoroughly clean rusty products and paint with zinc primer.

- C. Use hanger rods that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 15 mm (1/2-inch) clearance between pipe or piping covering and adjacent work.
- D. HVAC Horizontal Pipe Support Spacing: Refer to MSS SP-69. Provide additional supports at valves, strainers, in-line pumps and other heavy components. Provide a support within one foot of each elbow.
- E. HVAC Vertical Pipe Supports:
 - 1. Up to 150 mm (6-inch pipe), 9 m (30 feet) long, bolt riser clamps to the pipe below couplings, or welded to the pipe and rests supports securely on the building structure.
 - 2. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.
- F. Overhead Supports:
 - 1. The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.
 - 2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.
 - 3. Tubing and capillary systems shall be supported in channel troughs.
- G. Floor Supports:
 - 1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Anchor and dowel concrete bases and structural systems to resist forces under operating 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 50 mm (2 inch) excess on all edges. Boiler foundations shall have horizontal dimensions that exceed boiler base frame dimensions by at least 150 mm (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 Resident Engineer. Such access shall be provided without additional cost or time to the Government. Where work is in an operating plant, provide approved protection from dust and debris at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.
- B. In an operating facility, maintain the operation, cleanliness and safety. Government personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and plant operation. Confine the work to the immediate area concerned; maintain cleanliness and wet down demolished materials to eliminate dust. Do not permit debris to accumulate in the area to the detriment of plant operation. Perform all flame cutting to maintain the fire safety integrity of this plant. Adequate fire extinguishing facilities shall be available at all times. Perform all work in accordance with recognized fire protection standards. Inspection will be made by personnel of the VA Medical Center, and Contractor shall follow all directives of the RE or COTR with regard to rigging, safety, fire safety, and maintenance of operations.
- C. Completely remove all piping, wiring, conduit, and other devices associated with the equipment not to be re-used in the new work. This includes all pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. Seal all openings, after removal of equipment, pipes, ducts, and other penetrations in roof, walls, floors, in an approved manner and in accordance with plans and specifications where specifically covered. Structural integrity of the building system shall be maintained. Reference shall also be made to the drawings and specifications of the other disciplines in the project for additional facilities to be demolished or handled.
- D. All valves including gate, globe, ball, butterfly and check, all pressure gages and thermometers with wells shall remain Government property and shall be removed and delivered to Resident Engineer and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these plans and specifications. Such material shall be removed from Government property expeditiously and shall not be allowed to accumulate.

3.6 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. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats.
6. Paint shall withstand the following temperatures without peeling or discoloration:
 - a. Condensate and feedwater -- 38 degrees C (100 degrees F) on insulation jacket surface and 120 degrees C (250 degrees F) on metal pipe surface.
 - b. Steam -- 52 degrees C (125 degrees F) on insulation jacket surface and 190 degrees C (375 degrees F) on metal pipe surface.
7. Final result shall be smooth, even-colored, even-textured factory finish on all items.
Completely repaint the entire piece of equipment if necessary to achieve this.

3.7 IDENTIFICATION SIGNS

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

3.8 MOTOR AND DRIVE ALIGNMENT

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

3.9 LUBRICATION

- A. Lubricate all devices requiring lubrication prior to initial operation. Field-check all devices for proper lubrication.
- B. Equip all devices with required lubrication fittings or devices. Provide a minimum of one liter (one quart) of oil and 0.5 kg (one pound) of grease of manufacturer's recommended grade and type for each different application; also provide 12 grease sticks for lubricated plug valves. Deliver all materials to Resident Engineer in unopened containers that are properly identified as to application.
- C. Provide a separate grease gun with attachments for applicable fittings for each type of grease applied.
- D. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.

3.10 COMMISSIONING

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

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

3.11 STARTUP AND TEMPORARY OPERATION

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

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 23 05 11, COMMON WORK RESULTS FOR HVAC.
- C. Section 23 21 23, HYDRONIC PUMPS.
- D. Section 23 22 23, STEAM CONDENSATE PUMPS.
- E. Section 23 34 00, HVAC FANS.
- F. Section 23 36 00, AIR TERMINAL UNITS.
- G. Section 23 64 00, PACKAGED WATER CHILLERS.
- H. Section 23 65 00, COOLING TOWERS.
- I. Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- J. Section 23 74 13, PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS.
- K. Section 23 82 00, CONVECTION HEATING AND COOLING UNITS.
- L. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 SUBMITTALS:

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Provide documentation to demonstrate compliance with drawings and specifications.
 - 2. Include electrical ratings, efficiency, bearing data, power factor, frame size, dimensions, mounting details, materials, horsepower, voltage, phase, speed (RPM), enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.
- C. Manuals:
 - 1. Submit simultaneously with the shop drawings, companion copies of complete installation, maintenance and operating manuals, including technical data sheets and application data.
- D. Certification: Two weeks prior to final inspection, unless otherwise noted, submit four copies of the following certification to the Resident Engineer:
 - 1. Certification that the motors have been applied, installed, adjusted, lubricated, and tested according to manufacturer published recommendations.
- E. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

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. National Electrical Manufacturers Association (NEMA):
 - MG 1-2006 Rev. 1 2009Motors 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):
 - 70-2011National Electrical Code (NEC)
- D. Institute of Electrical and Electronics Engineers (IEEE):
 - 112-04Standard Test Procedure for Polyphase Induction Motors and Generators

- E. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
90.1-2007Energy Standard for Buildings Except Low-Rise Residential
Buildings

PART 2 - PRODUCTS

2.1 MOTORS:

- A. For alternating current, fractional and integral horsepower motors, NEMA Publications MG 1 and MG 2 shall apply.
- B. All material and equipment furnished and installation methods shall conform to the requirements of Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide premium efficiency type motors as scheduled. Unless otherwise specified for a particular application, use electric motors with the following requirements.
- C. Single-phase Motors: Motors for centrifugal fans and pumps may be split phase or permanent split capacitor (PSC) type. Provide capacitor-start type for hard starting applications.
1. Contractor's Option - Electrically Commutated motor (EC Type): Motor shall be brushless DC type specifically designed for applications with heavy duty ball bearings and electronic commutation. The motor shall be speed controllable down to 20% of full speed and 85% efficient at all speeds.
- D. Poly-phase Motors: NEMA Design B, Squirrel cage, induction type.
1. Two Speed Motors: Each two-speed motor shall have two separate windings. Provide a time-delay (20 seconds minimum) relay for switching from high to low speed.
- E. Voltage ratings shall be as follows:
1. Single phase:
 - a. Motors connected to 120-volt systems: 115 volts.
 - b. Motors connected to 240 volt or 480 volt systems: 230/460 volts, dual connection.
 2. Three phase:
 - a. Motors, less than 74.6 kW (100 HP), connected to 240 volt or 480 volt systems: 208-230/460 volts, dual connection.

- F. Number of phases shall be as follows:
1. Motors, less than 373 W (1/2 HP): Single phase.
 2. Motors, 373 W (1/2 HP) and larger: 3 phase.
 3. Exceptions:
 - a. Hermetically sealed motors.
 - b. Motors for equipment assemblies, less than 746 W (one HP), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.
- G. Motors shall be designed for operating the connected loads continuously in a 40°C (104°F) environment, where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation. If the motors exceed 40°C (104°F), the motors shall be rated for the actual ambient temperatures.
- H. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting and running torque.
- I. Motor Enclosures:
1. Shall be the NEMA types as specified and/or shown on the drawings.
 2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types, which are most suitable for the environmental conditions where the motors are being installed. Enclosure requirements for certain conditions are as follows:
 - a. Motors located outdoors, indoors in wet or high humidity locations, or in unfiltered airstreams shall be totally enclosed type.
 - b. Where motors are located in an NEC 511 classified area, provide TEFC explosion proof motor enclosures.
 - c. Where motors are located in a corrosive environment, provide TEFC enclosures with corrosion resistant finish.
 3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.
- J. Special Requirements:
1. Where motor power requirements of equipment furnished deviate from power shown on plans, provide electrical service designed under the requirements of NFPA 70 without additional time or cost to the Government.
 2. Assemblies of motors, starters, controls and interlocks on factory assembled and wired devices shall be in accordance with the requirements of this specification.

3. Wire and cable materials specified in the electrical division of the specifications shall be modified as follows:
 - a. Wiring material located where temperatures can exceed 71 degrees C (160 degrees F) shall be stranded copper with Teflon FEP insulation with jacket.
 - b. Other wiring to control panels shall be NFPA 70 designation THWN.
 - c. Provide shielded conductors or wiring in separate conduits for all instrumentation and control systems where recommended by manufacturer of equipment.
4. Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.
5. Motors utilized with variable frequency drives shall be rated “inverter-duty” per NEMA Standard, MG1, Part 31.4.4.2. Provide motor shaft grounding apparatus that will protect bearings from damage from stray currents.
- K. Additional requirements for specific motors, as indicated in the other sections listed in Article 1.2, shall also apply.
- L. Energy-Efficient Motors (Motor Efficiencies): All permanently wired polyphase motors of 746 Watts (1 HP) or more shall meet the minimum full-load efficiencies as indicated in the following table. Motors of 746 Watts or more with open, drip-proof or totally enclosed fan-cooled enclosures shall be NEMA premium efficiency type, unless otherwise indicated. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section. Motors not specified as “premium efficiency” shall comply with the Energy Policy Act of 2005 (EPACT).

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

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

3.4 COMMISSIONING

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

3.5 DEMONSTRATION AND TRAINING

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

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

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

- A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete inertia bases.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- C. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING: Requirements for flexible pipe connectors to reciprocating and rotating mechanical equipment.
- D. Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS: Requirements for optional Air Handling Unit internal vibration isolation.
- E. Section 23 31 00, HVAC DUCTS AND CASINGS: requirements for flexible duct connectors, sound attenuators and sound absorbing duct lining.
- F. SECTION 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC: requirements for sound and vibration tests.
- G. SECTION 23 37 00, AIR OUTLETS AND INLETS: noise requirements for G-grilles.
- H. SECTION 23 21 23, HYDRONIC PUMPS: vibration isolation requirements for pumps.
- I. SECTION 23 34 00, HVAC FANS: sound and vibration isolation requirements for fans.
- J. SECTION 23 65 00, COOLING TOWERS: requirements for sound and vibration isolation for cooling towers.
- K. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

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

B. Noise Criteria:

1. Noise levels in all 8 octave bands due to equipment and duct systems shall not exceed following NC levels:

TYPE OF ROOM	NC LEVEL
Bathrooms and Toilet Rooms	40
Conference Rooms	35
Corridors	40
Examination Rooms	35
Laboratories (With Fume Hoods)	45 to 55
Lobbies, Waiting Areas	40
Offices, Large Open	40
Offices, Small Private	35
X-Ray and General Work Rooms	40

2. For equipment which has no sound power ratings scheduled on the plans, the contractor shall select equipment such that the fore-going noise criteria, local ordinance noise levels, and OSHA requirements are not exceeded. Selection procedure shall be in accordance with ASHRAE Fundamentals Handbook, Chapter 7, Sound and Vibration.

3. An allowance, not to exceed 5db, may be added to the measured value to compensate for the variation of the room attenuating effect between room test condition prior to occupancy and design condition after occupancy which may include the addition of sound absorbing material, such as, furniture. This allowance may not be taken after occupancy. The room attenuating effect is defined as the difference between sound power level emitted to room and sound pressure level in room.
 4. In absence of specified measurement requirements, measure equipment noise levels three feet from equipment and at an elevation of maximum noise generation.
- C. Seismic Restraint Requirements ($I_p=1.5$):
1. Equipment:
 - a. All mechanical equipment not supported with isolators external to the unit shall be securely anchored to the structure. Such mechanical equipment shall be properly supported to resist a horizontal force of 20 percent of the weight of the equipment furnished.
 - b. All mechanical equipment mounted on vibration isolators shall be provided with seismic restraints capable of resisting a horizontal force of 50 percent of the weight of the equipment furnished.
 2. Piping: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
 3. Ductwork: Refer to Section 23 31 00, HVAC DUCTS AND CASINGS.
- D. Allowable Vibration Tolerances for Rotating, Non-reciprocating Equipment: Not to exceed a self-excited vibration maximum velocity of 5 mm per second (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions or measured at equipment mounting feet if bearings are concealed. Measurements for internally isolated fans and motors may be made at the mounting feet.

1.5 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:
1. Vibration isolators:
 - a. Floor mountings
 - b. Hangers
 - c. Snubbers
 - d. Thrust restraints
 2. Bases.

3. Seismic restraint provisions and bolting.
 4. Acoustical enclosures.
- C. Isolator manufacturer shall furnish with submittal load calculations for selection of isolators, including supplemental bases, based on lowest operating speed of equipment supported.
- D. Seismic Requirements: Submittals are required for all equipment anchors, supports and seismic restraints. Submittals shall include weights, dimensions, standard connections, and manufacturer's certification that all specified equipment will withstand seismic Lateral Force requirements as shown on drawings.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):
2009 Fundamentals Handbook, Chapter 7, Sound and Vibration
- C. American Society for Testing and Materials (ASTM):
A123/A123M-09.....Standard Specification for Zinc (Hot-Dip Galvanized) Coatings
on Iron and Steel Products
A307-07bStandard Specification for Carbon Steel Bolts and Studs, 60,000
PSI Tensile Strength
D2240-05(2010).....Standard Test Method for Rubber Property - Durometer
Hardness
- D. Manufacturers Standardization (MSS):
SP-58-2009Pipe Hangers and Supports-Materials, Design and Manufacture
- E. Occupational Safety and Health Administration (OSHA):
29 CFR 1910.95Occupational Noise Exposure
- F. American Society of Civil Engineers (ASCE):
ASCE 7-10Minimum Design Loads for Buildings and Other Structures.
- G. American National Standards Institute / Sheet Metal and Air Conditioning Contractor's National Association (ANSI/SMACNA):
001-2008Seismic Restraint Manual: Guidelines for Mechanical Systems,
3rd Edition.
- H. International Code Council (ICC):
2009 IBC.....International Building Code.

- I. Department of Veterans Affairs (VA):
H-18-8 2010.....Seismic Design Requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

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

2.2 SEISMIC RESTRAINT REQUIREMENTS FOR EQUIPMENTS

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

2.3 VIBRATION ISOLATORS

- A. Floor Mountings:
 - 1. Double Deflection Neoprene (Type N): Shall include neoprene covered steel support plated (top and bottom), friction pads, and necessary bolt holes.
 - 2. Spring Isolators (Type S): Shall be free-standing, laterally stable and include acoustical friction pads and leveling bolts. Isolators shall have a minimum ratio of spring diameter-to--operating spring height of 1.0 and an additional travel to solid equal to 50 percent of rated deflection.

3. Captive Spring Mount for Seismic Restraint (Type SS):
 - a. Design mounts to resiliently resist seismic forces in all directions. Snubbing shall take place in all modes with adjustment to limit upward, downward, and horizontal travel to a maximum of 6 mm (1/4-inch) before contacting snubbers. Mountings shall have a minimum rating of one G coefficient of gravity as calculated and certified by a registered structural engineer.
 - b. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50 percent of the rated deflection. Mountings shall have ports for spring inspection. Provide an all directional neoprene cushion collar around the equipment bolt.
 4. Spring Isolators with Vertical Limit Stops (Type SP): Similar to spring isolators noted above, except include a vertical limit stop to limit upward travel if weight is removed and also to reduce movement and spring extension due to wind loads. Provide clearance around restraining bolts to prevent mechanical short circuiting. Isolators shall have a minimum seismic rating of one G.
 5. Pads (Type D), Washers (Type W), and Bushings (Type L): Pads shall be natural rubber or neoprene waffle, neoprene and steel waffle, or reinforced duck and neoprene. Washers and bushings shall be reinforced duck and neoprene. Washers and bushings shall be reinforced duck and neoprene. Size pads for a maximum load of 345 kPa (50 pounds per square inch).
 6. Seismic Pad (Type DS): Pads shall be natural rubber / neoprene waffle with steel top plate and drilled for an anchor bolt. Washers and bushings shall be reinforced duck and neoprene. Size pads for a maximum load of 345 kPa (50 pounds per square inch).
- B. Hangers: Shall be combination neoprene and springs unless otherwise noted and shall allow for expansion of pipe.
1. Combination Neoprene and Spring (Type H): Vibration hanger shall contain a spring and double deflection neoprene element in series. Spring shall have a diameter not less than 0.8 of compressed operating spring height. Spring shall have a minimum additional travel of 50 percent between design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.
 2. Spring Position Hanger (Type HP): Similar to combination neoprene and spring hanger except hanger shall hold piping at a fixed elevation during installation and include a secondary adjustment feature to transfer load to spring while maintaining same position.

3. Neoprene (Type HN): Vibration hanger shall contain a double deflection type neoprene isolation element. Hanger rod shall be separated from contact with hanger bracket by a neoprene grommet.
 4. Spring (Type HS): Vibration hanger shall contain a coiled steel spring in series with a neoprene grommet. Spring shall have a diameter not less than 0.8 of compressed operating spring height. Spring shall have a minimum additional travel of 50 percent between design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.
 5. Hanger supports for piping 50 mm (2 inches) and larger shall have a pointer and scale deflection indicator.
 6. Hangers used in seismic applications shall be provided with a neoprene and steel rebound washer installed ¼' clear of bottom of hanger housing in operation to prevent spring from excessive upward travel
- C. Snubbers: Each spring mounted base shall have a minimum of four all-directional or eight two directional (two per side) seismic snubbers that are double acting. Elastomeric materials shall be shock absorbent neoprene bridge quality bearing pads, maximum 60 durometer, replaceable and have a minimum thickness of 6 mm (1/4 inch). Air gap between hard and resilient material shall be not less than 3 mm (1/8 inch) nor more than 6 mm (1/4 inch). Restraints shall be capable of withstanding design load without permanent deformation.
- D. Thrust Restraints (Type THR): Restraints shall provide a spring element contained in a steel frame with neoprene pads at each end attachment. Restraints shall have factory preset thrust and be field adjustable to allow a maximum movement of 6 mm (1/4 inch) when the fan starts and stops. Restraint assemblies shall include rods, angle brackets and other hardware for field installation.

2.4 BASES

- A. Rails (Type R): Design rails with isolator brackets to reduce mounting height of equipment and cradle machines having legs or bases that do not require a complete supplementary base. To assure adequate stiffness, height of members shall be a minimum of 1/12 of longest base dimension but not less than 100 mm (4 inches). Where rails are used with neoprene mounts for small fans or close coupled pumps, extend rails to compensate overhang of housing.
- B. Integral Structural Steel Base (Type B): Design base with isolator brackets to reduce mounting height of equipment which require a complete supplementary rigid base. To assure adequate stiffness, height of members shall be a minimum of 1/12 of longest base dimension, but not less than 100 mm (four inches).

- C. Inertia Base (Type I): Base shall be a reinforced concrete inertia base. Pour concrete into a welded steel channel frame, incorporating prelocated equipment anchor bolts and pipe sleeves. Level the concrete to provide a smooth uniform bearing surface for equipment mounting. Provide grout under uneven supports. Channel depth shall be a minimum of 1/12 of longest dimension of base but not less than 150 mm (six inches). Form shall include 13-mm (1/2-inch) reinforcing bars welded in place on minimum of 203 mm (eight inch) centers running both ways in a layer 40 mm (1-1/2 inches) above bottom. Use height saving brackets in all mounting locations. Weight of inertia base shall be equal to or greater than weight of equipment supported to provide a maximum peak-to-peak displacement of 2 mm (1/16 inch).
- D. Curb Mounted Isolation Base (Type CB): Fabricate from aluminum to fit on top of standard curb with overlap to allow water run-off and have wind and water seals which shall not interfere with spring action. Provide resilient snubbers with 6 mm (1/4 inch) clearance for wind resistance. Top and bottom bearing surfaces shall have sponge type weather seals. Integral spring isolators shall comply with Spring Isolator (Type S) requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

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

- B. Inspection and Adjustments: Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls. Adjust, repair, or replace isolators as required to reduce vibration and noise transmissions to specified levels.

3.2 ADJUSTING

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

3.3 COMMISSIONING

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

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SELECTION GUIDE FOR VIBRATION ISOLATORS

EQUIPMENT	ON GRADE			20FT FLOOR SPAN			30FT FLOOR SPAN			40FT FLOOR SPAN			50FT FLOOR SPAN		
	BASE	ISOL	MIN	BASE	ISOL	MIN	BASE	ISOL	MIN	BASE	ISOL	MIN	BASE	ISOL	MIN
	TYPE	TYPE	DEFL	TYPE	TYPE	DEFL	TYPE	TYPE	DEFL	TYPE	TYPE	DEFL	TYPE	TYPE	DEFL
CHILLERS															
CENTRIFUGAL	B	D	0.3	B	SP	0.8	---	SP	1.5	B	SP	1.5	B	SP	3.5
PUMPS															
CLOSE COUPLED	UP TO 1-1/2 HP	---	---	---	D,L, W	---	---	D,L, W	---	---	D,L, W	---	---	D,L, W	---
	2 HP & OVER	---	---	---	I	S	0.8	I	S	1.5	I	S	1.5	I	S
LARGE INLINE	Up to 25 HP	---	---	---	S	0.75	---	S	1.50	---	S	1.50	---	---	NA
	26 HP THRU 30 HP	---	---	---	S	1.0	---	S	1.50	---	S	2.50	---	---	NA
ROOF FANS															
ABOVE OCCUPIED AREAS:															
5 HP & OVER	---	---	---	CB	S	1.0	CB	S	1.0	CB	S	1.0	CB	S	1.0

CENTRIFUGAL FANS															
UP TO 50 HP:															
UP TO 200 RPM	B	N	0.3	B	S	2.5	B	S	2.5	B	S	3.5	B	S	3.5
201 - 300 RPM	B	N	0.3	B	S	2.0	B	S	2.5	B	S	2.5	B	S	3.5
301 - 500 RPM	B	N	0.3	B	S	2.0	B	S	2.0	B	S	2.5	B	S	3.5
501 RPM & OVER	B	N	0.3	B	S	2.0	B	S	2.0	B	S	2.0	B	S	2.5
COOLING TOWERS															
UP TO 500 RPM	---	---	---	---	SP	2.5	---	SP	2.5	---	SP	2.5	---	SP	3.5
501 RPM & OVER	---	---	---	---	SP	0.75	---	SP	0.75	---	SP	1.5	---	SP	2.5
AIR HANDLING UNIT PACKAGES															
SUSPENDED:															
UP THRU 5 HP	---	---	---	---	H	1.0	---	H	1.0	---	H	1.0	---	H	1.0
FLOOR MOUNTED:															
UP THRU 5 HP	---	D	---	---	S	1.0	---	S	1.0	---	S	1.0	---	S	1.0
7-1/2 HP & OVER:															
UP TO 500 RPM	---	D	---	R	S, THR	1.5	R	S, THR	2.5	R	S, THR	2.5	R	S, THR	2.5

501 RPM & OVER	---	D	---	---	S, THR	0.8	---	S, THR	0.8	R	S, THR	1.5	R	S, THR	2.0
CONDENSING UNITS															
ALL	---	SS	0.25	---	SS	0.75	---	SS	1.5	CB	SS	1.5	---	---	NA
IN-LINE CENTRIFUGAL AND VANE AXIAL FANS, FLOOR MOUNTED: (APR 9)															
UP THRU 50 HP:															
UP TO 300 RPM	---	D	---	R	S	2.5	R	S	2.5	R	S	2.5	R	S	3.5
301 - 500 RPM	---	D	---	R	S	2.0	R	S	2.0	R	S	2.5	R	S	2.5
501 - & OVER	---	D	---	---	S	1.0	---	S	1.0	R	S	2.0	R	S	2.5

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

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General Mechanical Requirements.
- B. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT: Noise and Vibration Requirements.
- C. Section 23 07 11, HVAC INSULATION: Piping and Equipment Insulation.
- D. Section 23 64 00, PACKAGED WATER CHILLERS: Testing Refrigeration Equipment.
- E. Section 23 65 00, COOLING TOWERS: Cooling Tower Performance Testing.

- F. Section 23 36 00, AIR TERMINAL UNITS: Terminal Units Performance.
- G. Section 23 31 00, HVAC DUCTS AND CASINGS: Duct Leakage.
- H. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Controls and Instrumentation Settings.
- I. Section 23 82 00, CONVECTION HEATING AND COOLING UNITS
- J. Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS
- K. Section 23 74 13, PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS
- L. Section 23 34 00, HVAC FANS
- M. Section 23 21 23, HYDRONIC PUMPS
- N. Section 23 22 23, STEAM CONDENSATE PUMPS
- O. Section 23 37 00, AIR OUTLETS AND INLETS
- P. Section 23 21 13, HYDRONIC PIPING
- Q. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS. Requirements for commissioning, systems readiness checklists, and training
- R. Section 23 05 12 GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS FOR GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Refer to Articles, Quality Assurance and Submittals, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- B. Qualifications:
 - 1. TAB Agency: The TAB agency shall be a subcontractor of the General Contractor and shall report to and be paid by the General Contractor.

2. The TAB agency shall be either a certified member of AABC or certified by the NEBB to perform TAB service for HVAC, water balancing and vibrations and sound testing of equipment. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the agency loses subject certification during this period, the General Contractor shall immediately notify the Resident Engineer and submit another TAB firm for approval. Any agency that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any work related to the TAB. All work performed in this Section and in other related Sections by the TAB agency shall be considered invalid if the TAB agency loses its certification prior to Contract completion, and the successor agency's review shows unsatisfactory work performed by the predecessor agency.
3. TAB Specialist: The TAB specialist shall be either a member of AABC or an experienced technician of the Agency certified by NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the General Contractor shall immediately notify the Resident Engineer and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB specialist shall be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by an approved successor.
4. TAB Specialist shall be identified by the General Contractor within 60 days after the notice to proceed. The TAB specialist will be coordinating, scheduling and reporting all TAB work and related activities and will provide necessary information as required by the Resident Engineer. The responsibilities would specifically include:
 - a. Shall directly supervise all TAB work.
 - b. Shall sign the TAB reports that bear the seal of the TAB standard. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC or NEBB.
 - c. Would follow all TAB work through its satisfactory completion.
 - d. Shall provide final markings of settings of all HVAC adjustment devices.
 - e. Permanently mark location of duct test ports.

5. All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of 3 projects comparable in size and complexity to this project. Qualifications must be certified by the TAB agency in writing. The lead technician shall be certified by AABC or NEBB
- C. Test Equipment Criteria: The instrumentation shall meet the accuracy/calibration requirements established by AABC National Standards or by NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems and instrument manufacturer. Provide calibration history of the instruments to be used for test and balance purpose.
- D. Tab Criteria:
1. One or more of the applicable AABC, NEBB or SMACNA publications, supplemented by ASHRAE Handbook "HVAC Applications" Chapter 36, and requirements stated herein shall be the basis for planning, procedures, and reports.
 2. Flow rate tolerance: Following tolerances are allowed. For tolerances not mentioned herein follow ASHRAE Handbook "HVAC Applications", Chapter 36, as a guideline. Air Filter resistance during tests, artificially imposed if necessary, shall be at least 100 percent of manufacturer recommended change over pressure drop values for pre-filters and after-filters.
 - a. Air handling unit and all other fans, cubic meters/min (cubic feet per minute): Minus 0 percent to plus 10 percent.
 - b. Air terminal units (maximum values): Minus 2 percent to plus 10 percent.
 - c. Exhaust hoods/cabinets: 0 percent to plus 10 percent.
 - d. Minimum outside air: 0 percent to plus 10 percent.
 - e. Individual room air outlets and inlets, and air flow rates not mentioned above: Minus 5 percent to plus 10 percent except if the air to a space is 100 CFM or less the tolerance would be minus 5 to plus 5 percent.
 - f. Heating hot water pumps and hot water coils: Minus 5 percent to plus 5 percent.
 - g. Chilled water and condenser water pumps: Minus 0 percent to plus 5 percent.
 - h. Chilled water coils: Minus 0 percent to plus 5 percent.
 3. Systems shall be adjusted for energy efficient operation as described in PART 3.
 4. Typical TAB procedures and results shall be demonstrated to the Resident Engineer for one air distribution system (including all fans, three terminal units, three rooms randomly selected by the Resident Engineer) and one hydronic system (pumps and three coils) as follows:
 - a. When field TAB work begins.
 - b. During each partial final inspection and the final inspection for the project if requested by VA.

1.5 SUBMITTALS

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

1.6 APPLICABLE PUBLICATIONS

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

3rd Edition 2009Procedural Standards for Whole Building Systems

Commissioning of New Construction

E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

3rd Edition 2002.....HVAC SYSTEMS Testing, Adjusting and Balancing

PART 2 - PRODUCTS

2.1 PLUGS

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

2.2 INSULATION REPAIR MATERIAL

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

PART 3 - EXECUTION

3.1 GENERAL

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

3.2 DESIGN REVIEW REPORT

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

3.3 SYSTEMS INSPECTION REPORT

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

3.4 DUCT AIR LEAKAGE TEST REPORT

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

3.5 SYSTEM READINESS REPORT

- A. The TAB Contractor shall measure existing air and water flow rates associated with existing systems utilized to serve renovated areas as indicated on drawings. Submit report of findings to Resident Engineer.
- B. Inspect each System to ensure that it is complete including installation and operation of controls. Submit report to RE in standard format and forms prepared and or approved by the Commissioning Agent.
- C. Verify that all items such as ductwork piping, ports, terminals, connectors, etc., that is required for TAB are installed. Provide a report to the Resident Engineer.

3.6 TAB REPORTS

- A. Submit an intermediate report for 25 percent of systems and equipment tested and balanced to establish satisfactory test results.
- B. The TAB contractor shall provide raw data immediately in writing to the Resident Engineer if there is a problem in achieving intended results before submitting a formal report.
- C. If over 20 percent of readings in the intermediate report fall outside the acceptable range, the TAB report shall be considered invalid and all contract TAB work shall be repeated and re-submitted for approval at no additional cost to the owner.
- D. Do not proceed with the remaining systems until intermediate report is approved by the Resident Engineer.

3.7 TAB PROCEDURES

- A. Tab shall be performed in accordance with the requirement of the Standard under which TAB agency is certified by either AABC or NEBB.
- B. General: During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.
- C. Coordinate TAB procedures with existing systems and any phased construction completion requirements for the project. Provide TAB reports for each phase of the project prior partial final inspections of each phase of the project.

- D. Allow sufficient time in construction schedule for TAB and submission of all reports for an organized and timely correction of deficiencies.
- E. Air Balance and Equipment Test: Include air handling units, fans, terminal units, fan coil units, room diffusers/outlets/inlets, and laboratory fume hoods.
 - 1. Artificially load air filters by partial blanking to produce air pressure drop of manufacturer's recommended pressure drop.
 - 2. Adjust fan speeds to provide design air flow. V-belt drives, including fixed pitch pulley requirements, are specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
 - 3. Test and balance systems in all specified modes of operation, including variable volume and fire emergency modes. Verify that dampers and other controls function properly.
 - 4. Variable air volume (VAV) systems:
 - a. Coordinate TAB, including system volumetric controls, with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
 - b. Section 23 36 00, AIR TERMINAL UNITS, specifies that maximum and minimum flow rates for air terminal units (ATU) be factory set. Check and readjust ATU flow rates if necessary. Balance air distribution from ATU on full cooling maximum scheduled cubic meters per minute (cubic feet per minute). Reset room thermostats and check ATU operation from maximum to minimum cooling, to the heating mode, and back to cooling. Record and report the heating coil leaving air temperature when the ATU is in the maximum heating mode. Record and report outdoor air flow rates under all operating conditions (The test shall demonstrate that the minimum outdoor air ventilation rate shall remain constant under all operating conditions).
 - c. Adjust operating pressure control setpoint to maintain the design flow to each space with the lowest setpoint.
 - 5. Record final measurements for air handling equipment performance data sheets.
- F. Water Balance and Equipment Test: Include circulating pumps, convertors, coils, coolers and condensers:
 - 1. Coordinate water chiller flow balancing with Section 23 64 00, PACKAGED WATER CHILLERS.
 - 2. Adjust flow rates for equipment. Set coils and evaporator to values on equipment submittals, if different from values on contract drawings.
 - 3. Primary-secondary (variable volume) systems: Coordinate TAB with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. Balance systems at design water flow and then verify that variable flow controls function as designed.

4. Record final measurements for hydronic equipment on performance data sheets. Include entering and leaving water temperatures for heating and cooling coils, and for convertors. Include entering and leaving air temperatures (DB/WB for cooling coils) for air handling units and reheat coils. Make air and water temperature measurements at the same time.

3.8 VIBRATION TESTING

- A. Furnish instruments and perform vibration measurements as specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT. Field vibration balancing is specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Provide measurements for all rotating HVAC equipment of 373 watts (1/2 horsepower) and larger, including centrifugal/screw compressors, cooling towers, pumps, fans and motors.
- B. Record initial measurements for each unit of equipment on test forms and submit a report to the Resident Engineer. Where vibration readings exceed the allowable tolerance Contractor shall be directed to correct the problem. The TAB agency shall verify that the corrections are done and submit a final report to the Resident Engineer.

3.9 SOUND TESTING

- A. Perform and record required sound measurements in accordance with Paragraph, QUALITY ASSURANCE in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
 1. Take readings in rooms, approximately ten percent of all rooms. The Resident Engineer may designate the specific rooms to be tested.
 2. Provide cooling tower sound measurements. Refer to Section 23 65 00, COOLING TOWERS.
- B. Take measurements with a calibrated sound level meter and octave band analyzer of the accuracy required by AABC or NEBB.
- C. Sound reference levels, formulas and coefficients shall be according to ASHRAE Handbook, "HVAC Applications", Chapter 46, SOUND AND VIBRATION CONTROL.
- D. Determine compliance with specifications as follows:
 1. When sound pressure levels are specified, including the NC Criteria in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT:
 - a. Reduce the background noise as much as possible by shutting off unrelated audible equipment.
 - b. Measure octave band sound pressure levels with specified equipment "off."
 - c. Measure octave band sound pressure levels with specified equipment "on."

- d. Use the DIFFERENCE in corresponding readings to determine the sound pressure due to equipment.

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

Sound pressure level due to equipment equals sound pressure level with equipment "on" minus FACTOR.

- e. Plot octave bands of sound pressure level due to equipment for typical rooms on a graph which also shows noise criteria (NC) curves.
2. When sound power levels are specified:
 - a. Perform steps 1.a. thru 1.d., as above.
 - b. For indoor equipment: Determine room attenuating effect, i.e., difference between sound power level and sound pressure level. Determined sound power level will be the sum of sound pressure level due to equipment plus the room attenuating effect.
 - c. For outdoor equipment: Use directivity factor and distance from noise source to determine distance factor, i.e., difference between sound power level and sound pressure level. Measured sound power level will be the sum of sound pressure level due to equipment plus the distance factor. Use 10 meters (30 feet) for sound level location.
 3. Where sound pressure levels are specified in terms of dB(A), as in Section 23 65 00, COOLING TOWERS, measure sound levels using the "A" scale of meter. Single value readings will be used instead of octave band analysis.
 - E. Where measured sound levels exceed specified level, the installing contractor or equipment manufacturer shall take remedial action approved by the Resident Engineer and the necessary sound tests shall be repeated.
 - F. Test readings for sound testing could go higher than 15 percent if determination is made by the Resident Engineer based on the recorded sound data.

3.10 MARKING OF SETTINGS

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

3.11 IDENTIFICATION OF TEST PORTS

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

3.12 PHASING

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

3.13 COMMISSIONING

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

- - E N D - - -

SECTION 23 07 11
HVAC INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Field applied insulation for thermal efficiency and condensation control for
 - 1. HVAC piping, ductwork and equipment.
- B. Definitions
 - 1. ASJ: All service jacket, white finish facing or jacket.
 - 2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.
 - 3. Cold: Equipment, ductwork or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.
 - 4. Concealed: Ductwork and piping above ceilings and in chases and pipe spaces.
 - 5. Exposed: Piping, ductwork, and equipment exposed to view in finished areas including mechanical and electrical equipment rooms or exposed to outdoor weather. Attics and crawl spaces where air handling units are located are considered to be mechanical rooms. Shafts, chases, crawl spaces and pipe basements are not considered finished areas.
 - 6. FSK: Foil-scrim-kraft facing.
 - 7. Hot: HVAC Ductwork handling air at design temperature above 16 degrees C (60 degrees F); HVAC equipment or piping handling media above 41 degrees C (105 degrees F).
 - 8. Density: kg/m^3 - kilograms per cubic meter (Pcf - pounds per cubic foot).
 - 9. Runouts: Branch pipe connections up to 25-mm (one-inch) nominal size to fan coil units or reheat coils for terminal units.
 - 10. Thermal conductance: Heat flow rate through materials.
 - a. Flat surface: Watt per square meter (BTU per hour per square foot).
 - b. Pipe or Cylinder: Watt per square meter (BTU per hour per linear foot).
 - 11. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).
 - 12. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.
 - 13. HPS: High pressure steam (415 kPa [60 psig] and above).
 - 14. HPR: High pressure steam condensate return.

- 15. MPS: Medium pressure steam (110 kPa [16 psig] thru 414 kPa [59 psig].
- 16. MPR: Medium pressure steam condensate return.
- 17. LPS: Low pressure steam (103 kPa [15 psig] and below).
- 18. LPR: Low pressure steam condensate gravity return.
- 19. PC: Pumped condensate.
- 20. HWH: Hot water heating supply.
- 21. HWHR: Hot water heating return.
- 22. CPD: Condensate pump discharge.
- 23. R: Pump recirculation.
- 24. CW: Cold water.
- 25. HW: Hot water.
- 26. CH: Chilled water supply.
- 27. CHR: Chilled water return.
- 28. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Mineral fiber and bond breaker behind sealant.
- B. Section 11 41 21, WALK-IN COOLERS AND FREEZERS: Insulation used in refrigerators and freezers.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- D. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT
- E. Section 23 21 23, HYDRONIC PUMPS
- F. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING
- G. Section 23 22 23, STEAM CONDENSATE PUMPS
- H. Section 23 64 00, PACKAGED WATER CHILLERS: Compressor, evaporator and piping.
- I. Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING: Piping and equipment.
- J. Section 23 21 13, HYDRONIC PIPING: Hot water, chilled water, and glycol piping.
- K. Section 23 31 00, HVAC DUCTS AND CASINGS: Ductwork, plenum and fittings.
- L. Section 26 32 13, ENGINE GENERATORS: Exhaust stacks and muffler.
- M. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS. Requirements for commissioning, systems readiness checklists, and training.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

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

B. Criteria:

1. Comply with NFPA 90A, particularly paragraphs 4.3.3.1 through 4.3.3.6, 4.3.10.2.6, and 5.4.6.4, parts of which are quoted as follows:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

- (1) Not exceeding a 25.4 mm (1 in.) average clearance on all sides
- (2) Filled solid with an approved material capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste when subjected to the time-temperature fire conditions required for fire barrier penetration as specified in NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*

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

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

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

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

1.5 SUBMITTALS

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

B. Shop Drawings:

1. All information, clearly presented, shall be included to determine compliance with drawings and specifications and ASTM, federal and military specifications.

a. Insulation materials: Specify each type used and state surface burning characteristics.

b. Insulation facings and jackets: Each type used. Make it clear that white finish will be furnished for exposed ductwork, casings and equipment.

c. Insulation accessory materials: Each type used.

d. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation.

- e. Make reference to applicable specification paragraph numbers for coordination.
- C. Samples:
1. Each type of insulation: Minimum size 100 mm (4 inches) square for board/block/ blanket; 150 mm (6 inches) long, full diameter for round types.
 2. Each type of facing and jacket: Minimum size 100 mm (4 inches square).
 3. Each accessory material: Minimum 120 ML (4 ounce) liquid container or 120 gram (4 ounce) dry weight for adhesives / cement / mastic.

1.6 STORAGE AND HANDLING OF MATERIAL

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

1.7 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. Federal Specifications (Fed. Spec.):
- L-P-535E (2)- 99.....Plastic Sheet (Sheeting): Plastic Strip; Poly (Vinyl Chloride) and Poly (Vinyl Chloride - Vinyl Acetate), Rigid.
- C. Military Specifications (Mil. Spec.):
- MIL-A-3316C (2)-90Adhesives, Fire-Resistant, Thermal Insulation
- MIL-A-24179A (1)-87Adhesive, Flexible Unicellular-Plastic Thermal Insulation
- MIL-C-19565C (1)-88Coating Compounds, Thermal Insulation, Fire-and Water-Resistant, Vapor-Barrier
- MIL-C-20079H-87.....Cloth, Glass; Tape, Textile Glass; and Thread, Glass and Wire-Reinforced Glass
- D. American Society for Testing and Materials (ASTM):
- A167-99(2004).....Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
- B209-07Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
- C411-05Standard test method for Hot-Surface Performance of High-Temperature Thermal Insulation
- C449-07Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement

- C533-09Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
- C534-08Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
- C547-07Standard Specification for Mineral Fiber pipe Insulation
- C552-07Standard Specification for Cellular Glass Thermal Insulation
- C553-08Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
- C585-09Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System) R (1998)
- C612-10Standard Specification for Mineral Fiber Block and Board Thermal Insulation
- C1126-04Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation
- C1136-10Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
- D1668-97a (2006).....Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing
- E84-10.....Standard Test Method for Surface Burning Characteristics of Building Materials
- E119-09c.....Standard Test Method for Fire Tests of Building Construction and Materials
- E136-09b.....Standard Test Methods for Behavior of Materials in a Vertical Tube Furnace at 750 degrees C (1380 F)
- E. National Fire Protection Association (NFPA):
- 90A-09Standard for the Installation of Air Conditioning and Ventilating Systems
- 101-09Life Safety Code
- 251-06Standard methods of Tests of Fire Endurance of Building Construction Materials
- 255-06Standard Method of tests of Surface Burning Characteristics of Building Materials

F. Underwriters Laboratories, Inc (UL):

723UL Standard for Safety Test for Surface Burning Characteristics
of Building Materials with Revision of 09/08

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

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

PART 2 - PRODUCTS

2.1 MINERAL FIBER OR FIBER GLASS

- A. ASTM C612 (Board, Block), Class 1 or 2, density 48 kg/m^3 (3 pcf), $k = 0.037$ (0.26) at 24 degrees C (75 degrees F), external insulation for temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.
- B. ASTM C553 (Blanket, Flexible) Type I, Class B-3, Density 16 kg/m^3 (1 pcf), $k = 0.045$ (0.31) at 24 degrees C (75 degrees F), for use at temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.
- C. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, $k = 0.037$ (0.26) at 24 degrees C (75 degrees F), for use at temperatures up to 230 degrees C (450 degrees F) with an all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.

2.2 MINERAL WOOL OR REFRACTORY FIBER

- A. Comply with Standard ASTM C612, Class 3, 450 degrees C (850 degrees F).

2.3 RIGID CELLULAR PHENOLIC FOAM

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

2.4 CELLULAR GLASS CLOSED-CELL

- A. Comply with Standard ASTM C177, C518, density 120 kg/m^3 (7.5 pcf) nominal, $k = 0.033$ (0.29) at 24 degrees C (75 degrees F).
- B. Pipe insulation for use at temperatures up to 200 degrees C (400 degrees F) with all service vapor retarder jacket.

2.5 POLYISOCYANURATE CLOSED-CELL RIGID

- A. Preformed (fabricated) pipe insulation, ASTM C591, type IV, $K=0.027(0.19)$ at 24 degrees C (75 degrees F), flame spread not over 25, smoke developed not over 50, for use at temperatures up to 149 degree C (300 degree F) with factory applied PVDC or all service vapor retarder jacket with polyvinyl chloride premolded fitting covers.
- B. Equipment and duct insulation, ASTM C 591, type IV, $K=0.027(0.19)$ at 24 degrees C (75 degrees F), for use at temperatures up to 149 degrees C (300 degrees F) with PVDC or all service jacket vapor retarder jacket.

2.6 FLEXIBLE ELASTOMERIC CELLULAR THERMAL

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

2.7 CALCIUM SILICATE

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

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

2.8 INSULATION FACINGS AND JACKETS

- A. Vapor Retarder, higher strength with low water permeance = 0.02 or less perm rating, Beach puncture 50 units for insulation facing on exposed ductwork, casings and equipment, and for pipe insulation jackets. Facings and jackets shall be all service type (ASJ) or PVDC Vapor Retarder jacketing.
- B. ASJ jacket shall be white kraft bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 75 mm (3 inch) butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.
- C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK) or PVDC vapor retarder jacketing type for concealed ductwork and equipment.
- D. Glass Cloth Jackets: Presized, minimum 0.18 kg per square meter (7.8 ounces per square yard), 2000 kPa (300 psig) bursting strength with integral vapor retarder where required or specified. Weather proof if utilized for outside service.
- E. Factory composite materials may be used provided that they have been tested and certified by the manufacturer.
- F. Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be polyvinyl chloride (PVC) conforming to Fed Spec L-P-335, composition A, Type II Grade GU, and Type III, minimum thickness 0.7 mm (0.03 inches). Provide color matching vapor retarder pressure sensitive tape.
- G. Aluminum Jacket-Piping systems: ASTM B209, 3003 alloy, H-14 temper, 0.6 mm (0.023 inch) minimum thickness with locking longitudinal joints. Jackets for elbows, tees and other fittings shall be factory-fabricated to match shape of fitting and of 0.6 mm (0.024) inch minimum thickness aluminum. Fittings shall be of same construction as straight run jackets but need not be of the same alloy. Factory-fabricated stainless steel bands shall be installed on all circumferential joints. Bands shall be 13 mm (0.5 inch) wide on 450 mm (18 inch) centers. System shall be weatherproof if utilized for outside service.

2.9 REMOVABLE INSULATION JACKETS

A. Insulation and Jacket:

1. Non-Asbestos Glass mat, type E needled fiber.
2. Temperature maximum of 450°F, Maximum water vapor transmission of 0.00 perm, and maximum moisture absorption of 0.2 percent by volume.
3. Jacket Material: Silicon/fiberglass and LFP 2109 pure PTFE.
4. Construction: One piece jacket body with three-ply braided pure Teflon or Kevlar thread and insulation sewn as part of jacket. Belt fastened.

2.10 PIPE COVERING PROTECTION SADDLES

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

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

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

2.11 ADHESIVE, MASTIC, CEMENT

- A. Mil. Spec. MIL-A-3316, Class 1: Jacket and lap adhesive and protective finish coating for insulation.
- B. Mil. Spec. MIL-A-3316, Class 2: Adhesive for laps and for adhering insulation to metal surfaces.
- C. Mil. Spec. MIL-A-24179, Type II Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.
- D. Mil. Spec. MIL-C-19565, Type I: Protective finish for outdoor use.

- E. Mil. Spec. MIL-C-19565, Type I or Type II: Vapor barrier compound for indoor use.
- F. ASTM C449: Mineral fiber hydraulic-setting thermal insulating and finishing cement.
- G. Other: Insulation manufacturers' published recommendations.

2.12 MECHANICAL FASTENERS

- A. Pins, anchors: Welded pins, or metal or nylon anchors with galvanized steel-coated or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.
- B. Staples: Outward clinching monel or galvanized steel.
- C. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy.
- D. Bands: 13 mm (0.5 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

2.13 REINFORCEMENT AND FINISHES

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

2.14 FIRESTOPPING MATERIAL

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

2.15 FLAME AND SMOKE

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

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Required pressure tests of duct and piping joints and connections shall be completed and the work approved by the Resident Engineer for application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.

- B. Except for specific exceptions, insulate entire specified equipment, piping (pipe, fittings, valves, accessories), and duct systems. Insulate each pipe and duct individually. Do not use scrap pieces of insulation where a full length section will fit.
- C. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 16 degrees C (60 degrees F) and below. Lap and seal vapor retarder over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 150 mm (6 inches).
- D. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.
- E. Construct insulation on parts of equipment such as chilled water pumps and heads of chillers, convertors and heat exchangers that must be opened periodically for maintenance or repair, so insulation can be removed and replaced without damage. Install insulation with bolted 1 mm thick (20 gage) galvanized steel or aluminum covers as complete units, or in sections, with all necessary supports, and split to coincide with flange/split of the equipment.
- F. Insulation on hot piping and equipment shall be terminated square at items not to be insulated, access openings and nameplates. Cover all exposed raw insulation with white sealer or jacket material.
- G. Protect all insulations outside of buildings with aluminum jacket using lock joint or other approved system for a continuous weather tight system. Access doors and other items requiring maintenance or access shall be removable and sealable.
- H. Insulate PRVs, flow meters, and steam traps.
- I. HVAC work not to be insulated:
 - 1. Internally insulated ductwork and air handling units.
 - 2. Exhaust air ducts and plenums, and ventilation exhaust air shafts.
 - 3. Equipment: Expansion tanks, flash tanks, hot water pumps, steam condensate pumps.
 - 4. In hot piping: Unions, flexible connectors, control valves, safety valves and discharge vent piping, vacuum breakers, thermostatic vent valves, steam traps 20 mm (3/4 inch) and smaller, exposed piping through floor for convectors and radiators. Insulate piping to within approximately 75 mm (3 inches) of uninsulated items.
- J. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.

- K. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. The elbow/ fitting insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/ fitting. Use of polyurethane spray-foam to fill a PVC elbow jacket is prohibited on cold applications.
- L. Firestop Pipe and Duct insulation:
1. Provide firestopping insulation at fire and smoke barriers through penetrations. Fire stopping insulation shall be UL listed as defines in Section 07 84 00, FIRESTOPPING.
 2. Pipe and duct penetrations requiring fire stop insulation including, but not limited to the following:
 - a. Pipe risers through floors
 - b. Pipe or duct chase walls and floors
 - c. Smoke partitions
 - d. Fire partitions
- M. Freeze protection of above grade outdoor piping (over heat tracing tape): 26 mm (10 inch) thick insulation, for all pipe sizes 75 mm(3 inches) and smaller and 25 mm(1inch) thick insulation for larger pipes. Provide metal jackets for all pipes. Provide for cold water make-up to cooling towers and condenser water piping and chilled water piping as described in Section 23 21 13, HYDRONIC PIPING (electrical heat tracing systems).
- N. Provide vapor barrier jackets over insulation as follows:
1. All piping and ductwork exposed to outdoor weather.
- O. Provide metal jackets over insulation as follows:
1. All piping and ducts exposed to outdoor weather.
 2. A 50 mm (2 inch) overlap is required at longitudinal and circumferential joints.

3.2 INSULATION INSTALLATION

- A. Mineral Fiber Board:
1. Faced board: Apply board on pins spaced not more than 300 mm (12 inches) on center each way, and not less than 75 mm (3 inches) from each edge of board. In addition to pins, apply insulation bonding adhesive to entire underside of horizontal metal surfaces. Butt insulation edges tightly and seal all joints with laps and butt strips. After applying speed clips cut pins off flush and apply vapor seal patches over clips.

2. Plain board:
 - a. Insulation shall be scored, beveled or mitered to provide tight joints and be secured to equipment with bands spaced 225 mm (9 inches) on center for irregular surfaces or with pins and clips on flat surfaces. Use corner beads to protect edges of insulation.
 - b. For hot equipment: Stretch 25 mm (1 inch) mesh wire, with edges wire laced together, over insulation and finish with insulating and finishing cement applied in one coat, 6 mm (1/4 inch) thick, trowel led to a smooth finish.
 - c. For cold equipment: Apply meshed glass fabric in a tack coat 1.5 to 1.7 square meter per liter (60 to 70 square feet per gallon) of vapor mastic and finish with mastic at 0.3 to 0.4 square meter per liter (12 to 15 square feet per gallon) over the entire fabric surface.
 - d. Chilled water pumps: Insulate with removable and replaceable 1 mm thick (20 gage) aluminum or galvanized steel covers lined with insulation. Seal closure joints/flanges of covers with gasket material. Fill void space in enclosure with flexible mineral fiber insulation.
3. Exposed, unlined ductwork and equipment in unfinished areas, mechanical and electrical equipment rooms and duct work exposed to outdoor weather:
 - a. 50 mm (2 inch) thick insulation faced with ASJ (white all service jacket): Supply air duct.
 - b. 50 mm (2 inch) thick insulation faced with ASJ: Return air duct.
 - c. Outside air intake ducts: 25 mm (one inch) thick insulation faced with ASJ.
 - d. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a reinforcing membrane and two coats of vapor barrier mastic or multi-layer vapor barrier with a maximum water vapor permeability of 0.001 perms.
4. Cold equipment: 40 mm (1-1/2 inch) thick insulation faced with ASJ.
 - a. Chilled water pumps, chemical feeder pot or tank.
5. Hot equipment: 40 mm (1-1/2 inch) thick insulation faced with ASJ.
 - a. Convertors, air separators, steam condensate pump receivers.
 - b. Reheat coil casing.
 - c. Domestic water heaters and hot water storage tanks (not factory insulated).

B. Flexible Mineral Fiber Blanket:

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

C. Molded Mineral Fiber Pipe and Tubing Covering:

1. Fit insulation to pipe or duct, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.
2. Contractor's options for fitting, flange and valve insulation:
 - a. Insulating and finishing cement for sizes less than 100 mm (4 inches) operating at surface temperature of 16 degrees C (61 degrees F) or more.
 - b. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts. Provide two insert layers for pipe temperatures below 4 degrees C (40 degrees F), or above 121 degrees C (250 degrees F). Secure first layer of insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.

- c. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place. For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 16 degrees C (60 degrees F) or less, vapor seal with a layer of glass fitting tape imbedded between two 2 mm (1/16 inch) coats of vapor barrier mastic.
 - d. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 50 mm (2 inches).
 - 3. Nominal thickness in millimeters and inches specified in the schedule at the end of this section.
- D. Rigid Cellular Phenolic Foam:
- 1. Rigid closed cell phenolic insulation may be provided for piping, ductwork and equipment for temperatures up to 121 degrees C (250 degrees F).
 - 2. Note the NFPA 90A burning characteristics requirements of 25/50 in paragraph 1.3.B
 - 3. Provide secure attachment facilities such as welding pins.
 - 4. Apply insulation with joints tightly drawn together
 - 5. Apply adhesives, coverings, neatly finished at fittings, and valves.
 - 6. Final installation shall be smooth, tight, neatly finished at all edges.
 - 7. Minimum thickness in millimeters (inches) specified in the schedule at the end of this section.
 - 8. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a maximum water vapor permeance of 0.00 perms.
 - 9. Condensation control insulation: Minimum 25 mm (1.0 inch) thick for all pipe sizes.
 - a. HVAC: Cooling coil condensation piping to waste piping fixture or drain inlet. Omit insulation on plastic piping in mechanical rooms.
- E. Cellular Glass Insulation:
- 1. Pipe and tubing, covering nominal thickness in millimeters and inches as specified in the schedule at the end of this section.
 - 2. Underground Piping Other than or in lieu of that Specified in Section 23 21 13, HYDRONIC PIPING: Type II, factory jacketed with a 3 mm laminate jacketing consisting of 3000 mm x 3000 mm (10 ft x 10 ft) asphalt impregnated glass fabric, bituminous mastic and outside protective plastic film.
 - a. 75 mm (3 inches) thick for hot water piping.
 - b. As scheduled at the end of this section for chilled water piping.

- c. Underground piping: Apply insulation with joints tightly butted. Seal longitudinal self-sealing lap. Use field fabricated or factory made fittings. Seal butt joints and fitting with jacketing as recommended by the insulation manufacturer. Use 100 mm (4 inch) wide strips to seal butt joints.
 - d. Provide expansion chambers for pipe loops, anchors and wall penetrations as recommended by the insulation manufacturer.
 - e. Underground insulation shall be inspected and approved by the Resident Engineer as follows:
 - 1) Insulation in place before coating.
 - 2) After coating.
 - f. Sand bed and backfill: Minimum 75 mm (3 inches) all around insulated pipe or tank, applied after coating has dried.
 - 3. Cold equipment: 50 mm (2 inch) thick insulation faced with ASJ for chilled water pumps, water filters, chemical feeder pots or tanks, expansion tanks, air separators and air purgers.
 - 4. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a reinforcing membrane and two coats of vapor barrier mastic or multi-layer vapor barrier with a water vapor permeability of 0.00 perms.
- F. Polyisocyanurate Closed-Cell Rigid Insulation:
- 1. Polyisocyanurate closed-cell rigid insulation (PIR) may be provided for exterior piping, equipment and ductwork for temperature up to 149 degree C (300 degree F).
 - 2. Install insulation, vapor barrier and jacketing per manufacturer's recommendations. Particular attention should be paid to recommendations for joint staggering, adhesive application, external hanger design, expansion/contraction joint design and spacing and vapor barrier integrity.
 - 3. Install insulation with all joints tightly butted (except expansion) joints in hot applications).
 - 4. If insulation thickness exceeds 63 mm (2.5 inches), install as a double layer system with longitudinal (lap) and butt joint staggering as recommended by manufacturer.
 - 5. For cold applications, vapor barrier shall be installed in a continuous manner. No staples, rivets, screws or any other attachment device capable of penetrating the vapor barrier shall be used to attach the vapor barrier or jacketing. No wire ties capable of penetrating the vapor barrier shall be used to hold the insulation in place. Banding shall be used to attach PVC or metal jacketing.

6. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. The elbow/ fitting insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/ fitting. Use of polyurethane spray-foam to fill PVC elbow jacket is prohibited on cold applications.
 7. For cold applications, the vapor barrier on elbows/fittings shall be either mastic-fabric-mastic or 2 mil thick PVDC vapor barrier adhesive tape.
 8. All PVC and metal jacketing shall be installed so as to naturally shed water. Joints shall point down and shall be sealed with either adhesive or caulking (except for periodic slip joints).
 9. Underground piping: Follow instructions for above ground piping but the vapor retarder jacketing shall be 6 mil thick PVDC or minimum 30 mil thick rubberized bituminous membrane. Sand bed and backfill shall be a minimum of 150 mm (6 inches) all around insulated pipe.
 10. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a water vapor permeance of 0.00 perms.
 11. Note the NFPA 90A burning characteristic requirements of 25/50 in paragraph 1.3B. Refer to paragraph 3.1 for items not to be insulated.
 12. Minimum thickness in millimeter (inches) specified in the schedule at the end of this section.
- G. Flexible Elastomeric Cellular Thermal Insulation:
1. Apply insulation and fabricate fittings in accordance with the manufacturer's installation instructions and finish with two coats of weather resistant finish as recommended by the insulation manufacturer.
 2. Pipe and tubing insulation:
 - a. Use proper size material. Do not stretch or strain insulation.
 - b. To avoid undue compression of insulation, provide cork stoppers or wood inserts at supports as recommended by the insulation manufacturer. Insulation shields are specified under Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
 - c. Where possible, slip insulation over the pipe or tubing prior to connection, and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed. Make changes from mineral fiber insulation in a straight run of pipe, not at a fitting. Seal joint with tape.
 3. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.

4. Pipe insulation: nominal thickness in millimeters (inches as specified in the schedule at the end of this section.
5. Minimum 20 mm (0.75 inch) thick insulation for pneumatic control lines for a minimum distance of 6 m (20 feet) from discharge side of the refrigerated dryer.
6. Use Class S (Sheet), 20 mm (3/4 inch) thick for the following:
 - a. Chilled water pumps
 - b. Bottom and sides of metal basins for winterized cooling towers (where basin water is heated).
 - c. Chillers, insulate any cold chiller surfaces subject to condensation which has not been factory insulated.
 - d. Piping inside refrigerators and freezers: Provide heat tape under insulation.
7. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a water vapor permeance of 0.00 perms.

H. Calcium Silicate:

1. Minimum thickness in millimeter (inches) specified in the schedule at the end of this section for piping .
2. Engine Exhaust Insulation for Emergency Generator and Diesel Driven Fire Pump: Type II, Class D, 65 mm (2 1/2 inch) nominal thickness. Cover exhaust completely from engine through roof or wall construction, including muffler. Secure with 16 AWG galvanized annealed wire or 0.38 x 12 mm 0.015 x 1/2 IN wide galvanized bands on 300 mm 12 IN maximum centers. Anchor wire and bands to welded pins, clips or angles. Apply 25 mm 1 IN hex galvanized wire over insulation. Fill voids with 6 mm 1/4 IN insulating cement.

3.3 COMMISSIONING

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

3.4 PIPE INSULATION SCHEDULE

Provide insulation for piping systems as scheduled below:

Insulation Thickness (Inches)					
		Nominal Pipe Size (Inches)			
Operating Temperature Range/Service	Insulation Material	Less than (1)	(1 – 1-1/4)	(1-1/2 - 3)	(4) and Above
(251-350 degrees F) (HPS, MPS)	Mineral Fiber (Above ground piping only)	(2-1/2)	(2-1/2)	(3)	(3-1/2)
(200-500 degrees F) (HPS, HPR)	Calcium Silicate	(2)	(2)	(2)	(2)
(212-250 degrees F) (HPR, MPR, LPS, vent piping from PRV Safety Valves, Condensate receivers and flash tanks)	Mineral Fiber (Above ground piping only)	(2-1/2)	(2-1/2)	(3)	(3)
(212-250 degrees F) (HPR, MPR, LPS, vent piping from PRV Safety Valves, Condensate receivers and flash tanks)	Rigid Cellular Phenolic Foam	(2)	(2)	(3)	(3)
(100-200 degrees F) (LPR, PC, HWH, HWHR)	Mineral Fiber (Above ground piping only)	(1)	(1)	(1-1/2)	(1-1/2)
(100-211 degrees F) (LPR, PC, HWH, HWHR)	Rigid Cellular Phenolic Foam	(1-1/2)	(1-1/2)	(2)	(2)
(100-200 degrees F) (LPR, PC, HWH, HWHR)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	(1-1/2)	(1-1/2)	----	----

Insulation Thickness (Inches)					
		Nominal Pipe Size (Inches)			
(40-60 degrees F) (CH, CHR, and RS for DX refrigeration)	Rigid Cellular Phenolic Foam	(1-1/2)	(1-1/2)	(1-1/2)	(1-1/2)
(40-60 degrees F) (CH and CHR within chiller room and pipe chase and underground)	Cellular Glass Closed-Cell	(1-1/2)	(1-1/2)	(2)	(2)
(40-60 degrees F) (CH, CHR, and RS for DX refrigeration)	Cellular Glass Closed-Cell	(1)	(1)	(1-1/2)	(1-1/2)
(40-60 degrees F) (CH, CHR, where underground)	Polyiso- cyanurate Closed-Cell Rigid	(1-1/2)	(1-1/2)	(2)	(2)
(40-60 degrees F) (CH, CHR, and RS for DX refrigeration)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	(1-1/2)	(1-1/2)	-----	-----

--- E N D ---

SECTION 23 08 00
COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section apply to all sections of Division 23.
- B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned 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 the HVAC 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 this Division is part of the construction process. Documentation and testing of these systems, as well as training of the VA's Operation and Maintenance personnel, is required in cooperation with the VA and the Commissioning Agent.
- B. The following HVAC systems will be commissioned:
 - 1. Air Handling Systems (Fans, motors, Variable Speed Drives, cooling coils and control valves, heating coils and control valves, filters, dampers, safeties such as smoke detectors or freezestats and damper end switches, controls, gages, and vibration isolation).
 - 2. Fan Coil Units and Air Terminal Units.

3. Heating Hot Water Systems (Steam Convertors, controls, instrumentation and gages, heating water pumps and motors, Variable Speed Drives, expansion tanks).
4. Condensate Return Systems (Condensate receivers and transfer pumps, motors, controls, pump alternator, alarms and instrumentation, safeties).
5. Chilled Water Systems (Water Chillers, Free Cooling Plate Frame Heat Exchanger, chilled water pumps and motors, Variable Speed Drives, chiller motor/compressor, controls, instrumentation and safeties, isolation valves, blending valves, side stream water cleaners/scrubbers/filters, expansion tanks).
6. Condenser Water Systems for Chillers (Cooling Towers, condenser water pumps and motors, Variable Speed Drives, cooling tower fans, cooling tower sump level controls, open-circuit water treatment system, water treatment injection pumps and motors, water treatment controls, cooling tower basin heaters and controls, side stream water cleaners/scrubbers/filters, tower bypass valves).
7. Exhaust Fans (Fan, motor, Variable Speed Drives, controls and safeties).
8. Direct Digital Control System (BACnet or similar Local Area Network (LAN), Operator Work Station hardware and software, building controller hardware and software, terminal unit controller hardware and software, all sequences of operation, system accuracy and response time).
9. HVAC Water Treatment Systems (Closed circuits – including shot feeders and final water analysis, open circuits – including water analysis, chemical/biocide tanks, injection piping, chemical/biocide pumps and motors, controls, water meter, and automatic blowdown).

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. 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 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.

- B. Cost of Retesting: The cost associated with Pre-Functional Checklist corrections and resubmissions shall be solely the responsibility of the contractor. Any required Pre-Functional Checklist correction and resubmission by the contractor shall not be considered a justified reason for a claim of delay or for a time extension by the contractor. Time for the commissioning agent for Pre-Functional Checklist correction verifications or expanded Pre-Functional Checklist sampling verifications will be “back-charged” to the responsible subcontractor at a cost of \$3000 per man-day.

3.2 CONTRACTORS TESTS

- A. Contractor tests as required by other sections of Division 23 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. The Commissioning Agent may witness selected Contractor tests. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.3 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 execution. 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.

3.4 TRAINING OF VA PERSONNEL

- A. Training of the VA's 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. 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 01 and Division 23 Sections for additional Contractor training requirements.

----- END -----

SECTION 230923
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SCOPE: Contractor shall furnish and install a complete automatic temperature control system including all control wiring, conduit, field equipment, DDC panels, variable frequency drives, air terminal controllers, fan coil unit controllers, and central equipment. System shall provide for the automatic control and monitoring of the following systems and equipment: air handling units, hood exhaust fans, chilled water system, heating water system, steam system, fan coil units, supply air terminals, miscellaneous alarms, and other equipment as indicated on the Drawings. All equipment and software shall be the most recent technology released by the manufacturer.

1.2 EXISTING EQUIPMENT: Existing equipment may be reused provided its reuse does not detract from its ability to perform its presently assigned tasks. If the manufacturer's existing system does not meet the above Specification, it shall be replaced or upgraded.

1.3 COORDINATION

A. Air Handling Units

1. Air handling units shall be furnished with mixing boxes including airflow measuring stations and return air dampers. Actuators for return air dampers are specified in this Section. Refer to drawings for quantities, sizes, and locations of control dampers.
2. Filters shall be furnished with magnehelic air gauges.

B. Air Terminals

1. Supply Air Terminals
 - a. Supply air terminals are specified in Section 23 36 00 AIR TERMINAL UNITS. Supply air terminals shall be furnished with dampers and averaging velocity pressure sensors. Actuators for terminal dampers are specified in this Section.
 - b. Power wiring (120V) for supply air terminals is specified in the Electrical Specifications. Control transformers, enclosures, and 24 VAC power wiring to controllers are specified in this Section.

C. Chilled Water System

1. Flow meter is specified in this Section. Furnish the flow meter to the Mechanical Contractor for installation.
2. Sensors and brass wells for temperature sensors are specified in this Section. Furnish the wells to the Mechanical Contractor for installation.

D. Chillers

1. Water chillers shall be furnished with chilled water and condenser water flow switches.
2. Water chillers will be furnished with unit mounted variable frequency drives and control panels. Control panels include an EMS interface.
3. Control and interlock wiring for new chillers is specified in this Section.

E. Commissioning: A competent control technician shall assist in the testing, adjusting, and balancing process.

F. Communications Cabling

1. Communications Cabling: Cabling for EMS trunk and EMS LAN shall be installed in EMT conduit. Cable sizes, quantities, and types shall be suitable for the application. Cabling shall be fully tested after installation for integrity, accurate data transfer, and interference.

G. Control Dampers and Actuators

1. Air handling unit control air dampers are furnished with the air handling units. Control air damper actuators are specified in this Section.
2. Duct / louver control air dampers and actuators are specified in this Section. Refer to drawings for quantities, sizes, and locations of control dampers.
3. Damper end switches are specified in this Section.

H. Control Valves

1. Control valves and actuators for chilled water, steam convertors, humidifiers, tower water bypass, free cooling changeover, tower water head pressure control, and heating water are specified in this Section.

I. Control Wiring

1. Control wiring shall be numbered at all terminations in accordance with the submitted diagrams. Control wiring in mechanical rooms and where exposed shall be installed in EMT conduit.
2. Control wiring above ceilings shall be installed in an organized manner using bridle rings or hooks for cable management. Cable management supports shall be installed at 5 feet centers. Control wiring shall be installed in accordance with the National Electric Code.
3. Conduit below grade shall be Schedule 40 PVC.

J. Cooling Towers

1. Cooling towers shall be furnished with vibration cutoff switch and basin heat control panels. Panels shall be shipped loose for field installation. Installation of panels is specified in the Electrical Specifications. Basin heat control panels shall include low water cut-off and thermostat.
2. Control and interlock wiring for cooling towers is specified in this Section.
3. Water level sensors for cooling tower basins are specified in this Section.

K. Direct Digital Control Panels, Field Equipment Panels, and Operator's Terminal

1. Power (120V) for DDC Panels and Field Equipment Panels is specified in the Electrical Specifications. Control transformers for 24 VAC power are specified in this Section.
2. Telephone outlets for DDC panels are specified in the Electrical Specifications.

L. Electrical Switchboard

1. Main electrical switchboard shall be equipped with a power monitoring system. Power monitoring system shall have an EMS interface. Wiring from power monitoring system to EMS is specified in this Section.

M. Emergency Generators

1. Emergency generators shall be furnished with vented day tanks. Tanks shall include float switches.
2. Solenoid valves for generator day tanks are specified in this Section.

N. Fans

1. Exhaust fans shall be furnished with motorized dampers and electric actuators. Wiring to dampers is specified in this Section.

O. Fan Coil Units

1. Power wiring (120V) for fan coil unit controllers is specified in the Electrical Specifications. Control transformers, enclosures, and 24 VAC power wiring to controllers are specified in this Section.
2. Chilled water and heating water control valves for fan coil units are specified in this Section. Furnish control valves to the Mechanical Contractor for installation.
3. Fan coil unit fan speed contactors are specified in this Section.

P. Flow Measuring Devices

1. Water flow meters are specified in this Section.
2. Sensors and brass wells for temperature sensors are specified in this Section.

Q. Fume Hood Controllers

1. Fume hood controllers, including operator displays and keyboards are specified in this Section.

R. Heating Water System

1. Flow meters are specified in this Section. Furnish the flow meters to the Mechanical Contractor for installation.
2. Sensors and brass wells for temperature sensors are specified in this Section. Furnish the wells to the Mechanical Contractor for installation.
3. Steam control valves for the heating water converters are specified in this Section. Furnish the steam control valves to the Mechanical Contractor for installation.
4. Differential pressure transmitters are specified in this Section.
5. Variable frequency drives for the heating water pumps are specified in this Section. Control and interlock wiring for heating water pump drives is specified in this Section.
6. Power wiring for heating water pump variable frequency drives is specified in the Electrical Specifications.

S. Humidifiers - Electric

1. Power for the control panel and the humidifier is specified in the Electrical Specifications.
2. Airflow switch is specified in this Section.
3. High limit duct humidity switch is specified in this Section.

T. Motor Starters

1. Motor starters are specified in the Electrical Specifications. Starters shall be furnished with control transformers, HOA switches, and auxiliary contacts.

U. Refrigerant Alarms, Monitor and Sensors

1. Refrigerant monitors and sensors are specified in this Section. Power (120V) for refrigerant monitor is specified in the Electrical Specifications.
2. Audible refrigerant alarms are specified in this Section.

V. Smoke Dampers

1. Smoke dampers and actuators are specified in Section 23 31 00 HVAC DUCTS AND CASINGS. Remote smoke dampers shall be furnished with pneumatic actuators. Pneumatic tubing for smoke dampers is specified in this Section.

W. Smoke Detectors, Duct Mounted

1. Duct mounted smoke detectors are specified in the Fire Detection and Alarm Specifications. Wiring from smoke detectors to fire alarm panel. Fire alarm panel is specified in the Fire Detection and Alarm Specifications.
2. Panel shall be furnished with programmable relays for air handling unit safety shutdown purposes. Control wiring from fire alarm panel relays to air handling unit field equipment panels is specified in this Section.

X. Steam System

1. Flow meter is specified in this Section. Furnish the flow meter to the Mechanical Contractor for installation.
2. Steam pressure transmitters are specified in this Section.

Y. Switchgear Interface: Main electrical distribution panel shall be equipped with a power monitoring system. Power monitoring system shall have an EMS interface. Wiring from power monitoring system interface to DDC Panel is specified in this Section.

Z. Testing, Adjusting, and Balancing: A competent control technician shall assist in the testing, adjusting, and balancing process.

AA. Variable Frequency Drives

1. Variable frequency drives are specified in this Section. Drives shall be furnished with control transformers, HOA switches, speed potentiometer, manual start/stop controls, remote start/stop terminals, safety interlock terminals, status terminals, EMS interface, and 4-20 mA input for remote speed control. Control and interlock wiring for variable frequency drives is specified in this Section.

BB. Variable Speed Pumping System

1. Variable frequency drives are specified in this Section. Variable speed pumping system for chilled water flow shall be furnished with variable frequency drives, control panel, chilled water flow meter, and differential pressure transmitters.
2. Other chilled water flow meters (to be located at each water chiller) are specified in this Section.
3. Control panel shall include dry contact outputs for pump status and system alarm status. Panel shall also include a 4-20 mA output for secondary chilled water flow (repeat of flow meter signal).
4. Control wiring for differential pressure transmitters is specified in this Section. Cables for chilled water flow meter shall be furnished with the flow meter. Installation of cables is specified in this Section.

1.4 QUALITY ASSURANCE

- A. Materials and equipment shall be the products of manufacturers regularly engaged in the production and installation of temperature control systems. Materials and equipment shall be the manufacturer's latest standard design that complies with the specifications.
- B. Control system shall be installed using competent workmen who are fully trained in the installation of temperature control equipment.
- C. All electronic equipment shall conform to the requirements of FCC Regulations, Part 15, Section 15, governing radio frequency and electromagnetic interference and shall be so labeled.
- D. All system components shall be designed to be fault tolerant. Components shall operate in a satisfactory manner and without damage at plus 10% to minus 15% rated voltage and plus 3% to minus 3% line frequency. All inputs and outputs shall be equipped with static, transient, and short-circuit protection.
- E. All air handling unit penetrations required for control equipment and conduit shall be sealed in a manner that will allow the air handling unit leakage rate to meet the specified limit.

1.5 SUBMITTALS

- A. General: Submittal documents shall include as a minimum the following information: catalog data sheets, written sequences of operation, valve schedules, damper schedules, system flow diagrams, wiring diagrams, bill of materials, program flow charts, point lists, and raceway riser diagrams. All information pertaining to a specific item of equipment or system shall be located on a single drawing to the extent practical.
- B. Catalog Data Sheets: Data sheets shall be clearly marked so as to indicate the specific characteristics of the equipment and devices to be furnished. Data sheets shall be marked with the appropriate equipment designations consistent with the diagrams and bill of materials.
- C. Diagrams: All air lines and wiring shall be numbered. Diagrams shall include the relevant sections of all packaged equipment control panels such that the exact nature of the interface between the panels and the temperature control system is indicated. Each device shall have a unique designation. Raceway riser diagrams shall indicate the routing and contents of all conduits and raceways installed under this project. The source (panel number and circuit number) of all power connections to the temperature control system shall be indicated.

- D. Sequences of Operation: Sequences of operation shall include references to the specific devices involved in the execution of the sequence including panel inputs and outputs, transducers, relays, valves, dampers, etc.

1.6 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS FOR GREEN GLOBES™ CERTIFICATION.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Siemens (Powers of Arkansas)

2.2 COMMUNICATIONS NETWORK

- A. The design of the EMS communications network shall consist of a high performance peer-to-peer system (EMS Trunk), air terminal controller, laboratory controller, fan coil unit controller, and variable frequency drive local area network (EMS LAN), switchgear interface cabling (EMS Switchgear), and fume hood controller interface cabling (EMS Fume Hood).
- B. Operator's Terminal, Operator Workstation (existing), and DDC panels shall reside directly on the EMS trunk such that communications may be executed directly between devices.
- C. Network shall provide high-speed data transfer rates for alarm reporting, report generation, and the upload/download activities. Data transfer rates shall be sufficient such that an alarm occurring at any DDC Panel, Laboratory Controller, Air Terminal Controller, or Fan Coil Unit Controller is displayed at the operator's terminal and the operator workstation within 5 seconds.
- D. Network shall provide for the automatic synchronization of real-time clocks, message and alarm buffering, and error detection.
- E. The EMS LAN shall communicate bi-directionally with the EMS trunk through the DDC panels for the transmission of global data.

- F. Communication speed at the EMS trunk level shall be a minimum of 115k baud.
Communication speed at the EMS LAN level shall be a minimum of 4,800 baud.
- G. Isolation shall be provided at all EMS trunk and EMS LAN terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

2.3 FIELD EQUIPMENT

- A. Alarms: Audible alarm shall be equipped with a silence pushbutton. Alarms shall be suitable for the mechanical room environment (noise, heat, moisture, dust, etc.).
- B. Communications Cabling
 - 1. Communications cabling (EMS trunk, EMS LAN, fume hood LAN and switchgear LAN) shall be installed in EMT conduit. Cable sizes, quantities, and types shall be suitable for the application. Cabling shall be fully tested after installation for integrity, accurate data transfer, and interference.
- C. Control Wiring
 - 1. Control wiring shall be numbered at all terminations in accordance with the submitted diagrams. Control wiring in mechanical rooms and where exposed shall be installed in EMT conduit.
 - 2. Control wiring above ceilings shall be installed in an organized manner using bridge rings or hooks for cable management. Cable management supports shall be installed at 5 feet centers. Control wiring shall be installed in accordance with the National Electric Code.
 - 3. Conduit below grade shall be Schedule 40 PVC.
- D. Dampers
 - 1. Control Dampers: Control dampers shall be ultra-low leakage type with blade and edge seals. Damper frames and blades shall be either galvanized steel or aluminum. Maximum damper blade length shall be 48 inches. All blades shall be provided with bearings and must be interconnected for smooth and uniform operation. Dampers utilized in mixing applications shall be parallel blade type. Dampers shall be rated for a maximum leakage rate in the fully closed position of 6 CFM per square foot at 4 inches w.c..
- E. Damper Actuators
 - 1. Air Terminal Damper Actuators: Actuators shall be of the 24 VAC spring return or incremental type with a minimum torque of 35 lb-in. Actuators shall maintain last position on a power failure.

2. Electric Damper Actuators: Actuators for return air dampers shall be of the two-position electric type. Dampers shall be normally open.
3. Electronic Damper Actuators: Actuators shall be of the 24 VAC spring return or incremental type with a minimum torque of 35 lb-in. Actuators shall maintain last position on a power failure.
4. Control Damper Actuators: Actuators shall be of the pneumatic spring return type with replaceable diaphragm, metal housing, and 4 inch stroke. Each damper actuator shall be equipped with factory mounted pilot positioning relay to provide full main air for repositioning and adjustable start and range adjustments.

F. Damper End Switches

1. End switches for damper position verification shall be installed on all smoke dampers.

G. Field Equipment Panels: All control components not required by function to be remotely located such as sensing devices and valves shall be installed in metal enclosures. Enclosures shall be lockable with a hinged front door. All wiring terminations shall be made at numbered terminal blocks. Air gauges shall be installed at the input and output of all pneumatic devices. Nameplates shall be installed at all devices.

H. Gauges

1. Magnehelic Gauges: Magnehelic gauges for static pressure indication shall be installed at field equipment panels. Gauges for supply air static pressure indicated shall have a range of 0" to 5" w.c.. Gauges for exhaust air static pressure indication shall have a range of 0" to 3" w.c.. Gauges for laboratory pressure indication shall have a range of -0.25" to +0.25" w.c.. Gauge for building pressure indication shall have a range of -0.5" to +0.5" w.c..

I. Measuring Stations

1. Water Flow Measuring Stations
 - a. Furnish and install vortex shedding flow meters equal to Fluidyne's Hydro-Flow Model 3100. The flow meter shall be a retractable insertion, vortex shedding type, using a piezo-resistive sensor to detect vortex signals. The flow meter's wetted measuring element shall have no moving parts. The flow meter shall be capable of being installed or removed under full flow conditions. The flow meter shall be installed with 2" NPT threadolet. The flow meter's retractor shall be constructed of aluminum, and the ball valve constructed of bronze. The ball valve shall have 2" NPTF connections. The shedder bar shall be constructed of 316 stainless steel.

- b. Each flow meter shall be individually factory wet flow calibrated. Combined linearity and repeatability shall be $\pm 1.0\%$ of full scale. Metering range shall be from 0.3 to 15 ft/sec. The operating temperature range shall be from 32 degrees to 250 degrees. The flow meter shall operate under a maximum process pressure of 150 psi.
- c. The electronic components shall be hermetically sealed. The flow meter shall have a 4-20 mA current output. The flow meter shall have a LCD display that alternately shows 4-digit flow rate and 8-digit totalized flow. The flow meter shall have a 2 year warranty.

J. Meters

- 1. Chilled Water Flow Meter: Chilled water flow meter shall be Rosemount Model 8705 flow tubes with Rosemount Model 8732C transmitter.
- 2. Steam Flow Meter: Steam flow meter shall be Hersey Ramapo Mark V with Model 1050 strain gage transmitter and integral pressure sensor.

K. Motor Contactors

- 1. Contactors for fan coil units shall have the proper coil voltage and contact rating for the application.

L. Refrigerant Monitor and Sensors

- 1. Refrigerant sensors shall be interference free compound specific type capable of detecting concentrations as low as 1 ppm. Monitors shall be multiple channel type with digital display, alarm relay output, monitor failure output and automatic zero feature. Sensors and monitors shall be suitable for the mechanical room environment (heat, dust, moisture, etc.). Monitor alarm limit shall be adjustable.

2. Refrigerant Monitor: Refrigerant monitor shall be Yokagawa HGM300 or approved equal. Monitor shall detectors, display, outputs, water trap, and purge filter. Detectors shall be of the infrared non-dispersive type. Detectors shall be compatible with refrigerant HFC-134a. Sensitivity shall be 1 PPM. The measuring range shall be 4 to 1000 PPM. The display shall include 3 indicator lights (“on”, “alarm”, and “fault”). The monitor shall be suitable for installation in a mechanical room environment (32 to 122 deg. F non-condensing). The Monitor shall be equipped with 4 SPDT alarm contacts including 3 alarm levels and 1 system fault. Contacts shall be rated for 120V/5 amperes. The refrigerant sensing lines shall be 1/4” OD plastic tubing in 1/2” EMT. Sensing lines shall be Yokagawa M1100AA or equal. Line end filters shall be Yokagawa M1104KH or equal. The exhaust purge line shall be 3/8” OD plastic tubing in 1/2” EMT. Monitor shall comply with the requirements ASHRAE Standard 15.
3. Audible Alarm: Audible refrigerant alarm shall be installed where noted on the drawings. Alarms shall be equipped with a silence feature. Alarms shall be suitable for the mechanical room environment (noise, heat, moisture, dust, etc.).

M. Relays

1. Control Relays: Relays shall be Square D or approved equal with coil voltages, contact arrangements, and contact ratings suitable for the application.
2. Current Relays: Current relays for motor status indication shall be of the self-powered solid-state type with adjustable setpoint and range suitable for the application.
3. Electro-Pneumatic Relays: Relays shall be of the electric to pressure type with a two-position air valve. Air valve shall be equipped with normally open, normally closed, and common connections. Coil voltages shall be as required for the application. Relays shall be rated for 30 psig maximum pressure and 600 SCIM air flow at a differential pressure of 1 psig at an inlet pressure of 20 psig.

N. Sensors

1. Current Sensors: Current sensors for motor status indication shall be of the microprocessor based type. Sensors shall output a 4-20 mA signal that is proportional to motor current.
2. Space Temperature Sensors: Sensors shall be installed in a durable plastic case with metal base plate and ventilation openings. Sensor shall be thermistor type. Sensor range shall be 20/120 deg. F. Sensor accuracy shall be plus or minus 1.0 deg. F.

3. Duct Mounted Temperature Sensors: Duct temperature sensors shall be furnished with averaging elements where indicated. Averaging elements shall be of sufficient length to sufficiently cover the duct cross-sectional area. Sensors shall be thermistor or platinum RTD type. Sensor range shall be as required for the application. Sensor accuracy shall be plus or minus 0.5 deg. F.
 4. Pipe Mounted Temperature Sensors: Sensors shall be installed in brass temperature wells. Sensors shall be thermistor or platinum RTD type. Sensor range shall be as required for the application. Sensor accuracy shall be plus or minus 0.5 deg. F.
 5. Strap-On Temperature Sensors: Strap-on temperature sensors shall be used for domestic hot water return temperature sensing applications only. Sensor accuracy shall be plus or minus 0.5 deg
 6. Water Level Sensors: Cooling tower basin water level sensors shall be of the conductivity type with adjustable settings for low water alarm, open fill valve, close fill valve, and high water alarm.
- O. Static Pressure Sensing Lines: Static pressure sensing lines shall be 3/8 inch plastic tubing installed in 1/2" minimum EMT conduit.
- P. Switches
1. Airflow Switches: Airflow switches shall be installed where indicated to detect airflow or absence of airflow in ducts. Switch shall be single pole double throw activated by stainless steel paddle. For ducts less than 50 square inches, switch shall close on a minimum velocity of 100 fpm horizontal air flow and 350 fpm vertical. For ducts greater than 50 square inches, switch shall close on a minimum velocity of 250 fpm horizontal air flow and 650 fpm vertical.
 2. Current Switches: Current switches for motor status indication shall be of the microprocessor based type. Switches shall be capable of detecting between normal and abnormal loads (self-calibrating). Current switches shall be Hawkeye H934 or approved equal.
 3. Differential Pressure Switches: Differential pressure switches shall be used to provide dirty filter alarm indication. Setpoints shall be adjustable.
 4. Electric Pressure Switches: Electric pressure switches shall be of the electric to pressure type with a two-position air valve. Air valve shall be equipped with normally open, normally closed, and common connections. Coil voltages shall be as required for the application. Relays shall be rated for 30 psig maximum pressure and 600 SCIM air flow at a differential pressure of 1 psig at an inlet pressure of 20 psig.

5. High Static Pressure Switches: A high static pressure switch with adjustable setpoint shall be installed in the discharge ductwork of each air handling unit. Switches shall have normally closed dry contact outputs (fan safety and digital input) with a manual pushbutton reset.
6. High Temperature Cutout Switches: High limit switch shall be installed in downstream of the fan section of each air handling unit. Unit shall have air coil sensing element, and single throw, double throw snap action switch. Temperature setpoint adjustment shall be from 60 to 130 F with a 2 degree increment.
7. Low Limit Temperature Switches: Low limit switch shall be installed in the mixed air sections of each air handling unit. Sensing elements shall be of appropriate length to sufficiently cover the duct cross-sectional area. Sensing elements shall respond to the lowest temperature sensed by any one foot section. Switches shall have normally closed dry contact outputs (fan safety and digital input) with a manual pushbutton reset.
8. Humidity High Limit Switches: Humidity high limits shall be pneumatic type. High limits shall be set at 90% RH.
9. Water Flow Switches: Chilled water flow switches shall be as manufactured by McDonnell Miller or approved equal. Flow switches shall be equipped with 2 sets of contacts.
10. Suction Pressure Switch: Switch shall be single pole, single throw equal to Penn-Basso P-70AB-C. Switch shall have an adjustable range of 20" vacuum to 100 psig with an adjustable differential of 6 to 50 psi. Switch shall have 1/4" male flare connection.

Q. Thermostats

1. Room thermostats shall be installed in a durable plastic case with base plate and ventilation openings. Thermostats shall be complete with thermistor type sensor, manual override button, digital temperature indication, setpoint slide adjustment, and terminal jack for connection to portable operator's terminal. Sensor range shall be 55/95 deg. F. Sensor accuracy shall be plus or minus 0.5 deg. F. Setpoint accuracy shall be plus or minus 1.0 deg. F.

R. Transducers

1. Pressure Transducers: Transducers shall convert an electronic signal into a linear pneumatic signal. Transducers shall have a factory installed output air gauge. Transducers shall be rated for a maximum pressure of 30 psig. Transducers shall be equipped with an HOA switch and a gradual pressure switch. When the HOA switch is in the "Hand" position the output pressure signal shall be controllable using the gradual pressure switch.

S. Transformers

1. Control transformers shall be suitable for the application. Fuses shall be installed in the primary and secondary wiring. Fuses shall be selected in accordance with the transformer rating.
2. Control Transformers: Control transformers shall be provided for each air terminal and fan coil unit controller. Fuses shall be installed in the primary and secondary circuits as indicated on the Drawings.

T. Transmitters

1. Space Humidity Transmitters: Transmitters shall be installed in a durable plastic case with metal base plate and ventilation openings. Transmitter accuracy shall be plus or minus 5% RH with a range of 20/95% RH. Transmitter element shall be bulk polymer type. Transmitters shall be installed in a durable plastic case with metal base plate and ventilation openings. Transmitter accuracy shall be plus or minus 5% RH with a range of 20/95% RH.
2. Duct Mounted Humidity Transmitters: Transmitter accuracy shall be plus or minus 5% RH with a range of 20/95% RH. Transmitter element shall be bulk polymer type.
3. Building Pressure Transmitter: Building pressure transmitters shall have a range of 0 to 0.10 inches w.g. Transmitter locations shall be where indicated on the Drawings. Transmitter accuracy shall be plus or minus 0.01 inches w.g.
4. Differential Pressure Transmitters: Differential pressure transmitters shall have a range of 0.1 inches w.g. to 1.0 inches w.g. Transmitter accuracy shall be 1% FSO. Output signal shall be 4 - 20 mA. Transmitter shall be temperature compensated with auto zero function.

5. Differential Pressure Transmitters: Differential pressure transmitters shall be as manufactured by Rosemont, Yokagawa, or Foxboro. Transmitter output shall be a 4-20 mA current signal that is directly proportional to the measured differential pressure. Transmitter accuracy shall be $\pm 0.25\%$ of the calibrated span. Transmitter span and zero shall be externally adjustable. Electronics housing shall be low copper aluminum (NEMA 4X). Differential pressure transmitter shall be designed to accommodate pressures up to 2000 psig on either side without damage to the transmitter.
6. Static Pressure Transmitters: Static pressure transmitters shall have a range suitable for the application. Transmitter accuracy shall be plus or minus 0.1 inches w.c.. Sensor locations shall be as directed by the Engineer.
7. Steam Pressure Transmitter: Transmitter shall be connected to the steam piping using manual isolation valve such that the transmitter can be replaced without shutting off steam flow and pressure. Pressure transmitter shall have a pressure range and pressure rating suitable for the application. Transmitter accuracy shall be plus or minus 1.0 psig.
8. Temperature Transmitter: Transmitter shall output a pneumatic signal that is directly proportional to the measure temperature.

U. Valves

1. Chilled Water Control Valves: Control valves shall be modulating two-way type with a minimum shutoff rating of 25 psig. Valves shall be sized for a maximum water pressure drop of 3 psig. Valve types, body material, and pressure rating shall be suitable for the application. Valve connections shall match the material of the connecting piping. Valve stems shall be polished stainless steel. Valve trim shall be polished stainless steel or brass. Valve packing shall be spring-loaded and self-adjusting teflon. Large valve actuators shall be pneumatic spring return type with replaceable diaphragm and metal housing. Smaller valves shall be equipped with actuators shall be 24 VAC spring return or incremental type with a minimum torque of 35 lb-in.

2. Chilled Water, Heating Water, and Tower Water Control Valves: Control valves shall be modulating two-way type with a minimum shutoff rating of 50 psig. Valves shall be of the equal percentage type. Valves shall be sized for a maximum water pressure drop of 3 psig. Valve types, body material, and pressure rating shall be suitable for the application. Valve connections shall match the material of the connecting piping. Valve stems shall be polished stainless steel. Valve trim shall be polished stainless steel or brass. Valve packing shall be spring-loaded and self-adjusting teflon. Valve actuators shall be pneumatic or electronic as indicated on the Drawings. Pneumatic valve actuators shall be equipped with a replaceable diaphragm.
3. Heating Water Control Valves: Control valves shall be modulating two-way or three-way blending type with equal percentage characteristic as indicated on the Drawings. Control valves of the two-way type shall have a minimum shutoff rating of 25 psig. Valves shall be sized for a maximum water pressure drop of 3 psig. Valve types, body material, and pressure rating shall be suitable for the application. Valve connections shall match the material of the connecting piping. Valve trim shall be polished stainless steel. Valve trim shall be polished stainless steel or brass. Valve packing shall be spring-loaded and self-adjusting teflon. Valve actuators shall be 24 VAC spring return or incremental type with a minimum torque of 35 lb-in.
4. Convertor Steam Control Valves: Control valves shall be modulating two-way type. Valves shall be sized for a maximum pressure drop suitable for the application. Valve types, body material, and pressure rating shall be suitable for the application. Valve connections shall match the material of the connecting piping. Valve stems shall be polished stainless steel. Valve trim shall be polished stainless steel or brass. Valve packing shall be spring-loaded and self-adjusting teflon. Valve actuators shall be pneumatic spring return type with replaceable diaphragm and metal housing.
5. Tower Bypass Valves: Valves shall be modulating butterfly type with a pneumatic actuator. Valve body shall be lug-wafer style with an extended neck allowing sufficient clearance for flanges and insulation. Disk shall have 360 degree concentric seating with torque plugs for positive leak-proof connections to the shaft. Seat shall be rated for positive flow shut-off. Valve actuators shall be pneumatic spring return type with replaceable diaphragm and metal housing. Actuator shall provide sufficient torque for proper shut-off. Actuator shall be equipped with a visual valve position indicator. Valves shall be the same size as the adjacent piping.

6. Free Cooling Valve: Control valve shall be of the two-position type with a minimum shutoff rating of 50 psig. Valve size shall be equal to the size of the adjacent piping. Valve type, body material, and pressure rating shall be suitable for the application. Valve connections shall match the material of the connecting piping. Valve stems shall be polished stainless steel. Valve trim shall be polished stainless steel or brass. Valve packing shall be spring-loaded and self-adjusting teflon. Valve actuators shall be pneumatic. Actuator shall be equipped with a replaceable diaphragm.
7. Solenoid Air Valve: A solenoid air valve shall be provided to position the free cooling valve.
8. Tower Water Head Pressure Control Valves: Valves shall be modulating butterfly type with a pneumatic actuator. Valve body shall be lug-wafer style with an extended neck allowing sufficient clearance for flanges and insulation. Disk shall have 360 degree concentric seating with torque plugs for positive leak-proof connections to the shaft. Seat shall be rated for positive flow shut-off. Valve actuators shall be pneumatic spring return type with replaceable diaphragm and metal housing. Actuator shall provide sufficient torque for proper shut-off. Actuator shall be equipped with a visual valve position indicator. Valves shall be sized for a maximum water pressure drop of 3 psig.
9. Tower Fill Valves: Control valves shall be two-position, two-way type. Valve types, body material, and pressure rating shall be suitable for the application. Valve connections shall match the material of the connecting piping. Valve trim and stems shall be polished stainless steel. Valve packing shall be spring-loaded and self-adjusting teflon. Valve actuators shall be of the electric spring return type with metal housing.
10. Liquid Solenoid Valves: Liquid solenoid valves shall be suitable for the application. Coordinate size, capacity, and connection with condensing unit manufacturer.

2.4 DDC PANELS (HARDWARE)

- A. General: DDC panels shall be installed where indicated on the Drawings. Panels shall be rated for a mechanical room environment (32 to 122 F). Panels shall have sufficient input/output point capacity to accommodate the indicated sequences of operation. Panels shall have a minimum spare point capacity of 2 analog outputs, 4 analog inputs, 2 digital outputs, and 2 digital inputs. Panels shall be furnished with processors, memory, power supplies, etc. such that the installation of a future point requires only the installation of the appropriate point module.

- B. Enclosure: Enclosure shall be NEMA 1 type with lockable cover and transparent viewing panels. Enclosure assembly shall include a duplex receptacle and step-down isolation transformer with primary and secondary fuses.
- C. Controller Module: Controllers shall be microprocessor-based with a minimum word size of 16 bits. Controllers shall have sufficient memory (minimum of 1 megabyte) to support its own operating system and the specified sequence of operation and control functions. Controller shall provide a minimum of two RS-232C serial data communication ports for the connection of operator I/O devices such as printers, modems, and operator terminals. Controller shall continuously perform self-diagnostics for its communication system and components. Controller shall provide local and remote annunciation of any detected failures. In the event of a loss of power, the Controller shall provide for an orderly shutdown to prevent the loss of database and operating system software. A battery back-up shall be provided to support the volatile memory and real time clock for a minimum of 72 hours. Upon restoration of power the Controller shall automatically resume full operation without manual intervention. Should the Controller memory be lost for any reason, the user shall have the capability of reloading the Controller via the RS-232C port or the operator workstation.
- D. Point Modules: Point modules shall be modular universal type supporting any combination of analog inputs, analog outputs, digital inputs, and digital outputs. Isolation shall be provided at all point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980. Each digital and analog output shall be equipped with an individual HOA override switch. Gradual switches shall be provided for all analog outputs. Override switches shall be monitored by the Controller such that the operator is informed in the event that automatic control has been disabled. Status indication shall be provided for each digital output and analog output. Status indication for digital outputs shall be accomplished using an LED display. Status indication for analog outputs shall be accomplished using graduated intensity LED's or an analog indication of value.

2.5 DDC PANELS (SOFTWARE)

- A. General: All necessary software to form a complete operating system shall be provided. The software programs specified in this section shall be resident in the DDC panel and shall not be dependent upon the workstation or any other device for execution. Upon restoration of normal power the Controller shall evaluate the status of all equipment and controlled devices and execute changes as necessary to resume normal operations. Control programs shall be capable of incorporating data from any and all other DDC panels and air terminal controllers on the network (global points). Control programs shall also be capable of issuing commands to any device connected to any DDC panel or controller on the network.
- B. Control Programs: Control programs shall be provided for two-position operation, proportional control (P), proportional-integral control (PI), and proportional-integral-derivative control (PID). Proportional gain and integral settings shall be adjustable. Programs shall provide protection against excessive demands during start-up periods by automatically introducing time delays between successive start commands.
- C. Energy Management Programs: Energy management programs shall be provided for scheduling, night setback, demand limiting, heating water reset, tower water reset, and chiller sequencing. Scheduling program shall provide for the optimal starting and stopping of equipment based upon time-of-day and weekly schedules with provisions for holidays and special events.
- D. Custom Programs: Controllers shall provide the capability to implement custom programs for equipment specific processes. Custom programs shall be capable of accommodating complex algorithms based upon information obtained from scheduling, time delays, measured variables, calculated variables, other processes, user-defined constants, alarm events, and arithmetic functions.
- E. Alarm Management: Controllers shall provide the capability to generate and manage alarms based upon analog limits, equipment status, or a combination of analog limits and equipment status. Alarm reports shall as a minimum include the point's English language descriptor and the time and date of occurrence. The user shall also be able to define a more detailed alarm message (up to 200 characters). The user shall be capable of segregating alarm reports between I/O devices (workstation, modem, etc.).

- F. Historical Data Storage and Management: Controllers shall provide the capability to automatically sample, store, and display data for user-selected points. Any physical or calculated point may be designated for trending. Sampling intervals may be based upon pre-defined time increments or a change in value. Each DDC panel shall be capable of storing up to a minimum of 10,000 data samples. Trend data shall be transferred to the workstation by either operator command or whenever the trend storage locations are full. Trend data shall be stored in a format that is compatible with other database and word processing software.
- G. Data Totalization: Controllers shall provide the capability to sample, calculate, and store consumption or production totals on a daily, weekly, or monthly basis for user-selected points. Totalization shall provide for the calculation and storage of accumulations of 99,999.9 units (KWH, gallons, tons, etc.). The totalization routine.

2.6 AIR TERMINAL CONTROLLERS

- A. General: Air terminal controllers shall be provided for each air terminal indicated on the Drawings. Air terminal controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 24 VAC. Air terminal controllers shall be rated for a mechanical room environment (32 to 122 F and 0 to 95% RH non-condensing). Air terminal controllers shall be protected from damage by a durable plastic cover or enclosure. Each controller shall support as a minimum the following types of air terminal operation: VAV cooling only, VAV with hot water reheat, VAV with electric reheat, fan-powered VAV, fan-powered VAV with hot water reheat, and fan-powered VAV with electric reheat. Control application shall be field-selectable. Controller shall be mounted on the air terminal in such a fashion that it is readily accessible to maintenance personnel.
- B. Controller: Controller shall be microprocessor based type with sufficient inputs and outputs to accomplish the indicated sequences of operation. Controller shall perform its primary control functions independently of the DDC panels and EMS LAN communication system. Controller shall receive its real-time clock from the DDC panel. Each controller shall be provided with sufficient memory to accommodate its operating programs, alarm management, and historical data management. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM memory or a minimum battery back-up of 72 hours shall be provided.

- C. Differential Pressure Transducer: Controller shall include a differential pressure transducer for the conversion of differential pressure to air flow. Differential pressure transducer shall be connected to the terminal velocity sensor using pneumatic tubing. Tees and caps shall be provided in this tubing for the connection of field gauges. The transducer shall be capable of measuring air velocities from 0 to 4000 fpm with an accuracy of plus or minus 5%. The transducer shall be automatically calibrated by the controller on a regular basis. "Autozero" modules shall be provided for applications requiring continuous operation at occupied air flow.
- D. Software: Each controller shall have resident programs for the control of air flow and space temperature. Space temperature control shall be accomplished using the PI or PID method such that a maximum tolerance of plus or minus 1 deg. F from setpoint is achieved.

2.7 FAN COIL UNIT CONTROLLERS

- A. General: Fan coil unit controllers shall be provided for each fan coil unit indicated on the Drawings. Fan coil unit controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 24 VAC. Fan coil unit controllers shall be rated for a mechanical room environment (32 to 122 F and 0 to 95% RH non-condensing). Fan coil unit controllers shall be protected from damage by a durable plastic cover or enclosure. Controller shall be mounted on the fan coil unit in a metal enclosure in such a fashion that it is readily accessible to maintenance personnel.
- B. Controller: Controller shall be microprocessor based type with sufficient inputs and outputs to accomplish the indicated sequences of operation. Controller shall perform its primary control functions independently of the DDC panels and EMS LAN communication system. Controller shall receive its real-time clock from the DDC panel. Each controller shall be provided with sufficient memory to accommodate its operating programs, alarm management, and historical data management. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM memory or a minimum battery back-up of 72 hours shall be provided.
- C. Software: Space temperature control shall be accomplished using the PI or PID method such that a maximum tolerance of plus or minus 1 deg. F from setpoint is achieved.

2.8 FUME HOOD CONTROLLERS

- A. General: A fume hood control system including controller, velocity sensor, and operator display with keyboard shall be installed at each fume hood.
- B. Coordination: Installation of fume hood control panels shall be coordinated with the fume hood manufacturer.

- C. Communications: Fume hood controllers shall be connected to a dedicated fume hood LAN.

2.9 VARIABLE FREQUENCY DRIVES

- A. Acceptable Manufacturers: Drives shall be as manufactured by ABB.
- B. Locations: Variable frequency drives shall be provided for the equipment indicated on the Drawings.
- C. Type: Drives shall be variable torque PWM type.
- D. Submittals: Include front and side views of enclosures with overall dimensions, weights, conduit entrance locations, and nameplate legends. Provide catalog sheets indicating voltage, controller size, and ratings. Include complete wiring diagrams.
- E. Enclosure: Drive enclosures shall be NEMA 1 with a hinged lockable door. Provide integral fused disconnect switch or circuit breaker on the line side.
- F. Extra Materials: Provide 2 of each air filter required. Provide 3 of each fuse size and type.
- G. Mechanical Room Environment: Drives shall be suitable for installation in a mechanical room environment (0 - 104 F and 0 - 90% RH non-condensing).
- H. Operator Keypad and Display: Each drive shall be furnished with a keypad and display. Keypad must be removable. Keypad must utilize a minimum of 12 membrane keys with tactile feel. Display to be a minimum of 16 characters per line by 2 lines. Display shall be back lit with adjustable contrast. Keypad shall allow the drive to be manually started and stopped. Keypad shall allow the adjustment of all setpoints and parameters. Keypad shall allow the output frequency to be manually controlled. Keypad and display shall allow the indication of output frequency, diagnostic messages, output voltage, output current, motor data, setpoints, and control parameters.
- I. Diagnostics: Each drive shall be equipped for self-diagnostic operation including reference speed command, heat sink temperature, bus voltage, bus current, PWM frequency, I/O command status, software version, and control settings.
- J. EMS Interface: Each drive shall be equipped with an interface card for direct connection to the DDC panel. Interface shall allow direct communication between the drive and the EMS. Interface shall as a minimum provide the following functions: start/stop, status, and alarm status.
- K. Speed Control: The output frequency of each drive shall be controlled by a 4-20 mA current signal or 0-10 VDC voltage signal from the DDC panel.

L. Ratings

1. Rated Input Voltage: 480 volts, three phase, 60 Hertz
2. Motor Nameplate Voltage: 460 volts, three phase, 60 Hertz
3. Displacement Power Factor: Between 1.0 and 0.95, lagging, over entire range of operating speed and load.
4. Minimum Efficiency at Full Load: 96%

M. Control Wiring: Each drive shall be equipped with a 115 VAC control transformer with fuses. Drive shall be configured and equipped for an automatic restart after a power failure. Each drive shall be equipped with safety interlock and status contacts. Safety interlock terminals shall allow starting under both the automatic and manual modes of operation.

N. Input Line Reactance: Each drive shall be equipped with input and output line reactance. Power line noise shall be limited to a voltage distortion factor and line notch depth as defined in IEEE Standard 519-1981, Guide for Harmonic Control and Reactive Compensation of Static Power Converters. Drives shall not emit either conducted or radiated RFI in excess of the limitations set forth in the FCC Rules and Regulations, Part 15, Subpart J.

2.10 OPERATOR WORKSTATIONS (SOFTWARE)

- A. General: Workstation software shall be user-friendly with English language prompting, English language point descriptions, and mouse/menu driven operations. The software shall provide the following functions: graphical control and display, scheduling of system and equipment operations, collection and analysis of historical data, and the generation or editing of the system database. Software shall provide a multi-tasking environment that allows the user to run several applications and programs simultaneously.
- B. Password Access: A minimum of five levels of password access shall be provided ranging from viewing only to all privileges. System shall support up to 50 unique passwords. System shall automatically generate a log-on/log-off time and activity report for each user. System shall provide an automatic log-off for each user after an adjustable time delay.

- C. System Definition and Configuration: The editing or generation of the system database shall not interfere with normal control operations. Database generation software shall be menu-driven with fill-in-the-blank type forms for the definition of all parameters. Software shall have the capability to add, delete, or modify DDC panels, air terminal controllers, operator workstations, points, custom programs, dial-up telecommunications equipment, passwords, and alarm messages. Changes shall be automatically downloaded to the appropriate DDC panel.
- D. Scheduling: Scheduling of equipment and systems shall be accomplished using a graphical spreadsheet format. Scheduling shall be accomplished by inserting occupancy and vacancy times into the appropriate blocks for each day of the week, holidays, and special days. Temporary overrides shall also be accommodated. Groups of equipment may be scheduled using zone schedules.
- E. Historical Data Storage and Management: Trend data collected from the DDC panels and air terminal controllers shall be stored in a spreadsheet format. Trend data may be displayed in either charts or graphical formats. Trend data shall be automatically stored on the hard drive for future retrieval and use.
- F. Color Graphic Displays: Software shall provide for the development of dynamic color graphic displays for systems and equipment. Software shall include a library of equipment symbols and templates of system configurations.
- G. Alarm Management: Workstation shall provide the capability to generate and manage alarms based upon analog limits, equipment status, or a combination of analog limits and equipment status. Alarm reports shall as a minimum include the point's English language descriptor and the time and date of the occurrence. The user shall also be able to define a more detailed alarm message (up to 200 characters). The user shall be capable of segregating alarm reports between I/O devices.

PART 3 - EXECUTION

3.1 SEQUENCES OF OPERATION: Sequences of operation for each item of equipment and system are indicated on the Drawings.

3.2 PROGRAMMING

- A. General: DDC panels and controllers shall be programmed to provide the indicated sequences of operation. Selection of control mode (P, PI, or PID) shall be based upon the specific devices involved such that the process variables are restored and maintained at the desired level without offset in a responsive and stable manner. Programs shall be written in such a manner that all systems and equipment will default to a safe operation or position in the event of a hardware, communication, or software failure.
- B. Energy Management Programs: Energy management programs shall be implemented where indicated in the sequences of operation.
- C. Custom Programs: Custom programs for equipment specific processes shall be implemented where indicated in the sequences of operation.
- D. Central Equipment Programming: Central equipment programming shall include data base generation, system initialization, weekly schedules, analog limits, change-of-state messages, point groups, color graphic displays, and alarm messages. Color graphic displays shall be generated for the entire network, central steam system, central chilled water system, domestic water heating system, heating water systems, ventilation systems, air handling units, floor plans, air terminals, unit heaters, and fan coil units.
- E. Program Documentation: Documentation in the form of a flow chart and a detailed program listing with English language descriptors shall be provided for each process. The program documents shall be placed in binders located at each DDC panel and at the operator workstation. Program information shall be protected from the environment by plastic laminate or sleeves.

3.3 TESTING, ADJUSTING, AND BALANCING ASSISTANCE: Contractor shall provide assistance to the Testing, Adjusting, and Balancing (TAB) Contractor. A technician employed by the Contractor shall accompany the TAB Contractor throughout the testing, adjusting, and balancing process.

3.4 COMMISSIONING ASSISTANCE: The Contractor shall provide assistance to the Commissioning Agent. A technician employed by the Contractor shall accompany the Commissioning Agent throughout the commissioning process.

- 3.5 TESTING:** When the installation of the system is complete, the Contractor shall execute the following field tests: verify transmission media operation, calibrate all temperature sensors, verify local control and stand-alone operation, and verify proper operation of each control point. The Contractor shall also provide to the Engineer for review and approval trend data each 30 minutes for a 72 hour period for all points served by the automatic temperature control system installed under this Contract. Data shall be provided in Microsoft Excel and PDF format on CD-Rom. Contractor shall also provide the telephone modem number, terminal software, and system password access to the Architect and Owner as required to allow independent verification of system performance.
- 3.6 GUARANTEE:** Contractor shall provide all services, materials, and equipment necessary for the successful operation of the control system for a period of 1 year after substantial completion. Work shall include all scheduled maintenance requirements including adjustments, diagnostics, software updates, and calibration. Scheduled maintenance shall be performed during a minimum of 4 quarterly visits. Response time to the site for unscheduled maintenance shall be not more than 24 hours. Contractor shall furnish and install all software updates released within the warranty period.
- 3.7 RECORD DRAWINGS:** Contractor shall maintain accurate record drawings of the work. A copy of the record drawings (control diagrams and sequences of operation) shall be laminated and mounted at each DDC Panel.
- 3.8 TRAINING:** Contractor shall fully instruct the Owner's maintenance personnel in the proper operation and maintenance of the installed equipment and systems. Training shall address as a minimum the following topics: control diagrams, catalog data, and maintenance manuals, walk-through of project to inspect control components, thorough review of operator workstation, DDC panel and controller functions, color graphic displays, and explanation of scheduled maintenance requirements including adjustment, calibration, and replacement procedure.
- 3.9 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.

3.10 SYSTEM TRENDING & COMMISSIONING

- A. Trending is a method of testing as a standalone method or to augment manual testing. The Contractor shall trend any and all points of the system or systems at intervals specified below.
- B. Alarms are a means to notify the system operator that abnormal conditions are present in the system. Alarms shall be structured into three tiers – Critical, Priority, and Maintenance.
 - 1. Critical alarms are intended to be alarms that require the immediate attention of and action by the Operator. These alarms shall be displayed on the Operator Workstation in a popup style window that is graphically linked to the associated unit's graphical display. The popup style window shall be displayed on top of any active window within the screen, including non DDC system software.
 - 2. Priority level alarms are to be printed to a printer which is connected to the Operator's Work Station located within the engineer's office. Additionally Priority level alarms shall be able to be monitored and viewed through an active alarm application. Priority level alarms are alarms which shall require reaction from the operator or maintenance personnel within a normal work shift, and not immediate action.
 - 3. Maintenance alarms are intended to be minor issues which would require examination by maintenance personnel within the following shift. These alarms shall be generated in a scheduled report automatically by the DDC system at the start of each shift. The generated maintenance report will be printed to a printer located within the engineer's office.
- C. The Contractor shall provide graphical trending through the DDC control system of systems being commissioned. Trending requirements are indicated below and included with the Systems Functional Performance Test Procedures. Trending shall occur before, during and after Systems Functional Performance Testing. The Contractor shall be responsible for producing graphical representations of the trended DDC points that show each system operating properly during steady state conditions as well as during the System Functional Testing. These graphical reports shall be submitted to the Resident Engineer and Commissioning Agent for review and analysis before, during dynamic operation, and after Systems Functional Performance Testing. The Contractor shall provide, but not limited to, the following trend requirements and trend submissions:

1. Pre-testing, Testing, and Post-testing – Trend reports of trend logs and graphical trend plots are required as defined by the Commissioning Agent. The trend log points, sampling rate, graphical plot configuration, and duration will be dictated by the Commissioning Agent. At any time during the Commissioning Process the Commissioning Agent may recommend changes to aspects of trending as deemed necessary for proper system analysis. The Contractor shall implement any changes as directed by the Resident Engineer. Any pre-test trend analysis comments generated by the Commissioning Team should be addressed and resolved by the Contractor, as directed by the Resident Engineer, prior to the execution of Systems Functional Performance Testing.
2. Dynamic plotting – The Contractor shall also provide dynamic plotting during Systems Functional Performance testing at frequent intervals for points determined by the Systems Functional Performance Test Procedure. The graphical plots will be formatted and plotted at durations listed in the Systems Functional Performance Test Procedure.
3. Graphical plotting - The graphical plots shall be provided with a dual y-axis allowing 15 or more trend points (series) plotted simultaneously on the graph with each series in distinct color. The plots will further require title, axis naming, legend etc. all described by the Systems Functional Performance Test Procedure. If this cannot be sufficiently accomplished directly in the Direct Digital Control System then it is the responsibility of the Contractor to plot these trend logs in Microsoft Excel.
4. The following tables indicate the points to be trended and alarmed by system. The Operational Trend Duration column indicates the trend duration for normal operations. The Testing Trend Duration column indicates the trend duration prior to Systems Functional Performance Testing and again after Systems Functional Performance Testing. The Type column indicates point type: AI = Analog Input, AO = Analog Output, DI = Digital Input, DO = Digital Output, Calc = Calculated Point. In the Trend Interval Column, COV = Change of Value. The Alarm Type indicates the alarm priority; C = Critical, P = Priority, and M = Maintenance. The Alarm Range column indicates when the point is considered in the alarm state. The Alarm Delay column indicates the length of time the point must remain in an alarm state before the alarm is recorded in the DDC. The intent is to allow minor, short-duration events to be corrected by the DDC system prior to recording an alarm.

Terminal Unit (VAV) Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Space Temperature	AI	15 Min	12 hours	3 days	P	±5°F from SP	10 min
Air Flow	AI	15 Min	12 hours	3 days	P	±5°F from SP	10 min
SA Temperature	AI	15 Min	12 hours	3 days	P	±5°F from SP	10 min
Local Setpoint	AI	15 Min	12 hours	3 days	M	±10°F from SP	60 min
Unoccupied Override	DI	COV	12 hours	3 days	M	N/A	12 Hours
Damper Position	AO	15 Minutes	12 hours	3 days	N/A		
Heating coil Valve Position	AO	15 Minutes	12 hours	3 days	N/A		

4-Pipe Fan Coil Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Space Temperature	AI	15 Minutes	12 hours	3 days	P	$\pm 5^{\circ}\text{F}$ from SP	10 min
SA Temperature	AI	15 Minutes	12 hours	3 days	P	$\pm 5^{\circ}\text{F}$ from SP	10 min
Pre-Filter Status	AI	None	None	None	M	> SP	1 hour
Water Sensor	DI	COV	12 hours	3 days	M	N/A	30 Min
Cooling Coil Valve Position	AO	15 Minutes	12 hours	3 days	N/A		
Heating coil Valve Position	AO	15 Minutes	12 hours	3 days	N/A		
Fan Coil ON/OFF	DO	COV	12 hours	3 days	M	Status \diamond Command	30 min

Steam and Condensate Pumps Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Steam Flow (LB/HR)	AI	15 Minutes	12 hours	3 days	N/A		
Condensate Pump Run Hours	AI	15 Minutes	12 hours	3 days	N/A		
Water Meter (GPM)	AI	15 Minutes	12 hours	3 days	N/A		
Electric Meter (KW/H)	AI	15 Minutes	12 hours	3 days	N/A		
Chilled Water Flow (TONS)	AI	15 Minutes	12 hours	3 days	N/A		
Condensate Flow (GPM)	AI	15 Minutes	12 hours	3 days	N/A		
High Water Level Alarm	DI	COV	12 hours	3 days	C	True	5 Min
Condensate Pump Start/Stop	DO	COV	12 hours	3 days	P	Status <> Command	10 min

Domestic Hot Water Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Domestic HW Temperature	AI	15 Minute	12 Hours	3 days	C	> 135 °F	10 Min
Domestic HW Temperature	AI	15 Minute	12 Hours	3 days	P	±5°F from SP	10 Min
Dom. Circ. Pump Status	DI	COV	12 Hours	3 days	M	Status \diamond Command	30 min

Hydronic Hot Water Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
System HWS Temperature	AI	15 min	12 hours	3 days	C	±5°F from SP	10 Min
System HWR Temperature	AI	15 min	12 hours	3 days	M	±15°F from SP	300 Min
SWHX-1 Entering Temperature	AI	15 min	12 hours	3 days	P	±5°F from SP	10 Min
SWHX-2 Entering Temperature	AI	15 min	12 hours	3 days	P	±5°F from SP	10 Min
SWHX-1 Leaving Temperature	AI	15 min	12 hours	3 days	P	±5°F from SP	10 Min
SWHX-2 Leaving Temperature	AI	15 min	12 hours	3 days	P	±5°F from SP	10 Min
System Flow (GPM)	AI	15 min	12 hours	3 days	N/A		
System Flow - North Bldg.(GPM)	AI	15 min	12 hours	3 days	N/A		
System Differential Pressure	AI	15 min	12 hours	3 days	P	±10% from SP	8 Min
HW Pump 1 Status	DI	COV	12 Hours	3 days	C	Status <> Command	30 min
HW Pump 2 Status	DI	COV	12 Hours	3 days	C	Status <> Command	30 min

Hydronic Hot Water Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
HW Pump 1 VFD Speed	AO	15 Min	12 Hours	3 days	N/A		
HW Pump 2 VFD Speed	AO	15 Min	12 Hours	3 days	N/A		
Steam Station Control Valve Position	AO	15 Min	12 Hours	3 days	N/A		
Steam Station Bypass Valve Position	AO	15 Min	12 Hours	3 days	N/A		
HW Pump 1 Start/Stop	DO	COV	12 Hours	3 days	N/A		
HW Pump 2 Start/Stop	DO	COV	12 Hours	3 days	N/A		
HWR #1 Valve	DO	COV	12 Hours	3 days	N/A		
HWR #2 Valve	DO	COV	12 Hours	3 days	N/A		

Chilled Water System Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Chiller 1 Entering Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 1 Leaving Temperature	AI	15 Minutes	12 Hours	3 days	P	±5°F from SP	10 Min
Chiller 1 Flow	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 1 Percent Load	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 1 KW Consumption	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 1 Tonnage	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Entering Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Leaving Temperature	AI	15 Minutes	12 Hours	3 days	P	±5°F from SP	10 Min
Chiller 2 Flow	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Percent Load	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 KW Consumption	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Tonnage	AI	15 Minutes	12 Hours	3 days	N/A		
Primary Loop Flow	AI	15 Minutes	12 Hours	3 days	N/A		
Loop Flow - North Bldg.	AI	15 Minutes	12 Hours	3 days	N/A		

Chilled Water System Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Primary Loop Supply Temperature	AI	15 Minutes	12 Hours	3 days	N/A		
Loop Differential Pressure - North Bldg.	AI	15 Minutes	12 Hours	3 days	P	±5% from SP	10 Min
Loop Supply Temp.-North Bldg.	AI	15 Minutes	12 Hours	3 days	N/A		
Loop Return Temp.-North Bldg.	AI	15 Minutes	12 Hours	3 days	N/A		
Loop Tonnage - North Bldg.	AI	15 Minutes	12 Hours	3 days	N/A		
Pump 1 Status	DI	COV	12 Hours	3 days	C	Status \diamond Command	30 min
Pump 2 Status	DI	COV	12 Hours	3 days	C	Status \diamond Command	30 min
Chiller 1 Status	DI	COV	12 Hours	3 days	C	Status \diamond Command	30 min
Chiller 1 Evaporator Iso-Valve	DI	COV	12 Hours	3 days	N/A		
Chiller 1 Evaporator Flow Switch	DI	COV	12 Hours	3 days	N/A		
Chiller 1 Unit Alarm	DI	COV	12 Hours	3 days	C	True	10 Min

Chilled Water System Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Chiller 2 Status	DI	COV	12 Hours	3 days	C	Status \diamond Command	30 min
Chiller 2 Evaporator Iso-Valve	DI	COV	12 Hours	3 days	N/A		
Chiller 2 Evaporator Flow Switch	DI	COV	12 Hours	3 days	N/A		
Chiller 2 Unit Alarm	DI	COV	12 Hours	3 days	C	True	10 Min
Refrigerant Detector	DI	COV	12 Hours	3 days	C	True	10 Min
Refrigerant Exhaust Fan Status	DI	COV	12 Hours	3 days	M	Status \diamond Command	30 min
Emergency Shutdown	DI	COV	12 Hours	3 days	P	True	1 Min
Pump 1 VFD Speed	AO	15 Minutes	12 Hours	3 days	N/A		
Pump 2 VFD Speed	AO	15 Minutes	12 Hours	3 days	N/A		
Pump 1 Start / Stop	DO	COV	12 Hours	3 days	N/A		
Pump 2 Start / Stop	DO	COV	12 Hours	3 days	N/A		
Chiller 1 Enable	DO	COV	12 Hours	3 days	N/A		
Chiller 1 Iso-Valve Command	DO	COV	12 Hours	3 days	N/A		

Chilled Water System Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Chiller 2 Enable	DO	COV	12 Hours	3 days	N/A		
Chiller 2 Iso-Valve Command	DO	COV	12 Hours	3 days	N/A		
Refrigerant Exhaust Fan Start / Stop	DO	COV	12 Hours	3 days	N/A		

Condenser Water System Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Chiller 1 Condenser Entering Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 1 Condenser Leaving Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Condenser Entering Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Condenser Leaving Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 1 Supply Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 1 Return Temp	AI	15 Minutes	12 Hours	3 days	N/A		

Condenser Water System Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Cooling Tower 1 Basin Temp	AI	15 Minutes	12 Hours	3 days	P	< 45 °F	10 Min
Cooling Tower 2 Supply Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 2 Return Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 2 Basin Temp	AI	15 Minutes	12 Hours	3 days	P	< 45 °F	10 Min
Condenser Water Supply Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Condenser Water Return Temp	AI	15 Minutes	12 Hours	3 days	N/A		
Outdoor Air Wet Bulb	AI	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 1 Fan Status	DI	COV	12 Hours	3 days	P	Status <> Command	1 min
Cooling Tower 1 Basin Heat	DI	COV	12 Hours	3 days	N/A		
Cooling Tower 1 Heat Trace	DI	COV	12 Hours	3 days	N/A		
Cooling Tower 2 Fan Status	DI	COV	12 Hours	3 days	P	Status <> Command	1 min
Cooling Tower 2 Basin Heat	DI	COV	12 Hours	3 days	N/A		
Cooling Tower 2 Heat Trace	DI	COV	12 Hours	3 days	N/A		
Chiller 1 Isolation Valve	DI	COV	12 Hours	3 days	P	Status <> Command	1 min

Condenser Water System Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Chiller 2 Isolation Valve	DI	COV	12 Hours	3 days	P	Status \diamond Command	1 min
Condenser Water Pump 1 Status	DI	COV	12 Hours	3 days	P	Status \diamond Command	1 min
Condenser Water Pump 2 Status	DI	COV	12 Hours	3 days	P	Status \diamond Command	1 min
Chiller 1 Condenser Bypass Valve	AO	15 Minutes	12 Hours	3 days	N/A		
Chiller 2 Condenser By-Pass Valve	AO	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 1 Bypass Valve	AO	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 1 Fan Speed	AO	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 2 Bypass Valve	AO	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 2 Fan Speed	AO	15 Minutes	12 Hours	3 days	N/A		
Cooling Tower 1 Fan Start / Stop	DO	COV	12 Hours	3 days	N/A		
Cooling Tower 2 Fan Start / Stop	DO	COV	12 Hours	3 days	N/A		
Condenser Water Pump 1 Start / Stop	DO	COV	12 Hours	3 days	N/A		

Condenser Water System Trending and Alarms							
Point	Type	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Condenser Water Pump 2 Start / Stop	DO	COV	12 Hours	3 days	N/A		

D. The Contractor shall provide the following information prior to Systems Functional Performance Testing. Any documentation that is modified after submission shall be recorded and resubmitted to the Resident Engineer and Commissioning Agent.

1. Point-to-Point checkout documentation;
2. Sensor field calibration documentation including system name, sensor/point name, measured value, DDC value, and Correction Factor.
3. A sensor calibration table listing the referencing the location of procedures to following in the O&M manuals, and the frequency at which calibration should be performed for all sensors, separated by system, subsystem, and type. The calibration requirements shall be submitted both in the O&M manuals and separately in a standalone document containing all sensors for inclusion in the commissioning documentation. The following table is a sample that can be used as a template for submission.

SYSTEM		
Sensor	Calibration Frequency	O&M Calibration Procedure Reference
Discharge air temperature	Once a year	Volume I Section D.3.aa

----- END -----

SECTION 23 10 00
FACILITY FUEL SYSTEMS

PART 1 – GENERAL

1.1 DESCRIPTION

- A. Diesel fuel oil tanks, piping, and accessories located outside, underground as shown on contract drawings. Refer to contract drawings for type of fuel and for tank capacities.

1.2 RELATED WORK

- A. Excavation and backfill for underground tanks and piping: Section 31 20 00, EARTH MOVING and Section 31 20 11, EARTH MOVING (SHORT FORM)
- B. Sealing of pipe penetrations: Section 07 92 00, JOINT SEALANTS.
- C. Primer and finish painting: Section 09 91 00, PAINTING.
- D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- E. Underground conduit systems for tank fluid level monitors and tank and piping leak detectors: Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Approval by Contracting Officer is required of products or services of proposed manufacturers, suppliers and installers, and will be based on Contractor's certification that:
 - 1. Manufacturers regularly and currently manufacture tanks, tank and piping accessories, tank fluid level monitoring.
 - 2. Manufacturers of steel tanks participate in the Quality Assurance Program of the Steel Tank Institute (STI).

3. The design and size of each item of equipment provided for this project is of current production and has been in satisfactory operation on at least three installations for approximately three years. Current models of fluid level with less than three years service experience are acceptable if similar previous models from the same manufacturer have at least three years service experience.
- B. Apply and install materials, equipment and specialties in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract drawings and specifications shall be referred to the Resident Engineer (RE)/Contracting Officers Technical Representative (COTR) for resolution. Provide copies of installation instructions to the RE/COTR two weeks prior to commencing installation of any item.
- C. All equipment shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components or overall assembly.
- D. Tanks, Secondary Containment Systems for Piping, Plastic Piping and Containment Systems, Tank Level Monitoring Systems: Authorized manufacturers representatives shall provide on-site training of installers and supervision of the installation and testing of the equipment and systems to assure conformance to written instructions of manufacturers.
- E. Tank and piping installation contractor shall be certified as acceptable by local and state pollution control authorities.
- F. Entire installation shall conform to requirements of local and state pollution control authorities.
- G. Pipe Welding: Conform to requirements of ASME B31.1. Welders shall show evidence of qualification. Welders shall utilize a stamp to identify their work. Unqualified personnel will be rejected.
- H. Assembly of Glass Fiber Reinforced Plastic Piping: Installation personnel shall have been trained, tested and certified under a procedure approved by the manufacturer of the piping. Proof of certification, in writing, shall be provided to the RE/COTR.
- I. Where specified codes or standards conflict, consult the RE/COTR.
- J. Label of Conformance (definition): Labels of accredited testing laboratories showing conformance to the standards specified.
- K. 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 safe, complete and fully operational system which conforms to contract requirements and in which no item is subject to conditions beyond its design capabilities.

1.5 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Underground Tanks:
 - 1. Drawings of tanks, anchoring devices, heating coils (if required), tank manholes, tank manhole enclosures, access doors for the tank manhole enclosures and all accessories. Include overall dimensions and dimensional locations and sizes of all anchoring devices, pipe connections, access openings.
 - 2. Manufacturer's installation instructions describing recommended foundation, bedding and backfill material, support and anchoring devices, and method of installation.
 - 3. Weight of entire tank assemblies, empty and flooded.
 - 4. Certification of compliance with specified standards.
 - 5. Certification that steel tank manufacturer participates in the Steel Tank Institute (STI) Quality Assurance Program.
 - 6. Data certifying that tanks are designed for surcharge loads of backfill, traffic and other construction.
 - 7. Design and construction of tanks, secondary containment, pipe connections, manholes, anchoring devices, access doors for tank manhole enclosures.
 - 8. Application and performance data on tank coating (steel tanks) from manufacturer of coating.
 - 9. Design of cathodic protection system (when specified) for steel tanks.
- C. Fuel Piping:
 - 1. ASTM and UL compliance.
 - 2. Grade, class or type, schedule number.
 - 3. Manufacturer.
- D. Pipe Fittings, Unions, Flanges:
 - 1. ASTM and UL compliance.
 - 2. ASTM standards number.
 - 3. Catalog cuts.
 - 4. Pressure and temperature rating.
- E. Foot Valves, Check Valves, Overfill Prevention Valves:
 - 1. Catalog cuts showing design and construction.
 - 2. Pressure and temperature ratings.
 - 3. Pressure loss and flow rate data.
 - 4. Materials of construction.

5. Accessories.
- F. Secondary Containment System for Fuel Piping:
 1. Sizes, materials, construction of containment system including end seals, sumps, coatings and pipe supports.
 2. Layout of system.
 3. Installation instructions.
 4. Design of cathodic protection system (steel casing).
- G. Tank Fluid Level Monitoring Instrumentation System:
 1. Drawings showing instruments and in-tank sensing units, with dimensions.
 2. Design and construction of all elements of system.
 3. Installation instructions.
- H. Tank and Piping Accessories: Design, construction, and dimensions of vent caps, fill boxes, fill caps, spill containers and other accessories.

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 RE/COTR. Such repair or replacement shall be at no additional cost to the Government.
 3. Protect new equipment and piping systems against entry of foreign matter on the inside. 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.
 5. Protect plastic piping and tanks from ultraviolet light (sunlight).
- B. Cleanliness of Equipment and Piping:
 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 provide clean systems.
 3. Clean interior of all tanks prior to delivery for beneficial use by the Government.
 4. Contractor shall be fully responsible for all costs, damages and delay arising from failure to provide clean systems and equipment.

1.7 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. Federal Specifications (Fed. Spec.):
- A-A-60005Frames, Covers, Grating, Steps, Sump and Catch Basin,
Manhole
- C. ASTM International (ASTM):
- A36/A36M-08.....Carbon Structural Steel
- A53/A53M-10.....Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and
Seamless
- A106/A106M-10.....Seamless Carbon Steel Pipe for High Temperature Service
- A126-04(R2009).....Gray Iron Castings for Valves, Flanges and Pipe Fittings
- A234/A234M-10.....Piping Fittings of Wrought Carbon Steel and Alloy Steel for
Moderate and High Temperature Service
- B62-09Composition Bronze or Ounce Metal Castings
- D2996-01(2007).....Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced-
Thermosetting-Resin) Pipe
- D. American Society of Mechanical Engineers (ASME):
- B16.5-09Pipe Flanges and Flanged Fittings (NPS ½-24).
- B16.11-09Forged Fittings, Socket-Welding and Threaded
- B31.1-10Code for Pressure Piping, Power Piping with Current
Amendments
- E. National Electrical Manufacturers Association (NEMA):
- 250-08Enclosures for Electrical Equipment (1000 Volts Maximum)
- F. National Fire Protection Association (NFPA):
- 30Flammable and Combustible Liquids Code
- 31Installation of Oil Burning Equipment
- 70-11National Electrical Code
- G. Underwriters Laboratories Inc. (UL):
- 58-98Steel Underground Tanks for Flammable and Combustible
Liquids
- 142-10Steel Aboveground Tanks for Flammable and Combustible
Liquids
- 971-06Non-Metallic Underground Piping for Flammable Liquids

- 1316-06Glass-Fiber-Reinforced Plastic Underground Storage Tanks for
Petroleum Products
- 1746-07External Corrosion Protection System for Steel Underground
Storage Tanks
- 2085-10Protected Above-ground Tanks for Flammable and Combustible
Liquids

H. Steel Tank Institute (STI):

- F001Standard for Fire Resistant Tanks
- F841Dual Wall Underground Steel Storage Tanks
- F894ACT-100 Specification for External Corrosion Protection of FRP
Composite Steel Underground Storage Tanks
- F961ACT-100-U Specification for External Corrosion Protection of
Composite Steel Underground Storage Tanks
- P3STI-P3 Specification and Manual for External Corrosion
Protection of Underground Steel Storage Tanks
- R891Recommended Practice for Hold Down Strap Isolation

I. NACE International (Corrosion Engineers) (NACE):

- SP0169-07Control of External Corrosion on Underground or Submerged
Metallic Piping Systems
- NACE 3/SSPC-SP6-07Commercial Blast Cleaning
- NACE 4/SSPC-SP7-07Brush-off Blast Cleaning

J. American Petroleum Institute (API):

- 1631-01Interior Lining and Periodic Inspection of Underground Storage
Tanks

1.8 PERMITS

Contractor shall obtain and complete all tank permit and registration forms required by governmental authorities.

PART - 2 PRODUCTS

2.1 UNDERGROUND STEEL TANKS

- A. Factory fabricated all welded double-wall steel, horizontal cylindrical configuration, atmospheric pressure, internal and external corrosion protection as specified. Tanks shall be fabricated in accordance with Steel Tank Institute (STI) design standards by manufacturer that participates in STI Quality Assurance Program.

B. Construction:

1. ASTM A36 steel, UL 58 double-wall, 360-degree secondary containment.
2. Conform to NFPA 30 or 31 as applicable.
3. The bottom 60 degrees of all lap or offset circumferential interior seams shall be seal welded 30 degrees each way from bottom centerline to retard corrosion.
4. Design for surcharge loads such as backfill and paving as shown. In addition, in paved areas, design for H-20 (14,500 kg) (32,000 pound) axle loading.
5. Leaks and abrasions are not permitted. Maximum out-of-roundness is one percent of the diameter.
6. Outer wall shall provide leak tight secondary containment that covers 100 percent of tank volume and shall permit migration of any inner tank leakage to the lowest part of the tank where leak detectors are located. Make provisions for leak detectors to be furnished at lowest part of interstitial space between tank walls.

C. Factory Cleaning: Clean interior and exterior. Remove all mill scale, dirt, rust, oil, welding debris, loose coatings and coatings and material incompatible with fuel stored or protective coating to be furnished. Sandblast exterior in accordance with NACE 3 and STI corrosion protection system requirements.

D. Factory Applied Exterior Corrosion Protection System: Steel Tank Institute (STI) //ACT-100 steel/FRP composite (STI F894)//ACT-100-U urethane coating (STI F961)//STI-P3 coating/cathodic protection (STI F841, P3)//technology. Tank shall be labeled to indicate compliance. Provide signed holiday test results. Provide STI standard limited 30 year warranty against internal and external corrosion penetrating the tank.

E. Factory Applied Interior Coating: API 1631 coating from bottom of tank to 1 m (3 feet) from bottom.

F. Tank Manhole Enclosures:

1. Cylindrical enclosures, sized as shown, designed to contain fuel spills from leaking piping. Locate all tank manholes and tank piping connections within the enclosure. Watertight pipe penetrations.
2. Steel, fiberglass or polyethylene. Reinforce to prevent deflection. Leak-tight attachment to tank. Clean and coat interior and exterior of steel enclosure as specified for exterior of tank.
3. In traffic areas, enclosure must be designed to withstand traffic loads (H-20 wheel loading, 14 500 kg, (32,000 lb)) and must have flexible isolation system to prevent wheel loads being transmitted to tank.

4. For steel enclosures, provide cathodic protection system and test station as specified for the tanks.
 5. Access to Manhole Enclosure: Cast iron manhole frames and covers, rated for traffic, minimum opening as shown. Comply with Fed. Spec. A-A-60005.
- G. Pipe Connections to Tanks:
1. Conform to UL 58.
 2. Pipe sizes 100 mm (4 inches) and smaller, threaded. Pipe sizes 150 mm (6 inches) and larger, raised faced slip-on flanges, 1025 kPa (150 pound) ASME rating.
 3. Welded joints required on steel piping located inside tanks.
 4. Provide and coordinate tank connection quantities, sizes and types with requirements of fluid level gage unit; sounding rod; vent, fill, supply and return pipes; and other pipes as shown.
 5. Dielectric insulation on all connections to steel piping.
 6. All tank piping connections, except vent, shall be within the tank manhole enclosures.
- H. Tank Manholes: Provide quantity shown. Bolted cover type, gasketed. Zinc plated bolts, nuts, washers.
- I. Wear (Striker) Plates: Provide 300 mm (12 inch) square, 6 mm (0.25 inch) thick steel plates rolled and seal-welded to bottom of tank directly under all openings.
- J. Lifting Lugs: Provide for rigging tanks.
- K. Hold Down Straps: Provide quantity and design of EPDM-type rubber encased steel straps as recommended by tank manufacturer to anchor tank to concrete ballast slab. Hold down strap electrical isolation shall conform to STI R891. Straps shall have tension load capability equal to hold-down capability of ballast slab, with a minimum safety factor of two. Provide complete anchorage devices, including turnbuckles, for adjusting tension.

2.2 SOIL SEPARATOR MAT

- A. Material: Porous, non-woven polypropylene geotextile, Weight: 135 g per sq. meter (4 ounces per square yard), resistant to all alkalies and weak acids.

2.3 TANK AND PIPING ACCESSORIES

- A. Vent Caps: Galvanized cast iron or cast aluminum with brass or bronze screens, arranged to permit full venting and to prevent entry of foreign material into the vent line. Same pipe size as vent pipe.

2.4 PIPING, VALVES, FITTINGS

- A. Fuel supply and return, tank fill, vents, sounding, pump out, steam and condensate.

B. Steel Pipe and Fittings:

1. Piping: Steel, seamless or electric resistance welded (ERW), ASTM A53 Grade B or ASTM A106 Grade B, Schedule 40. Aboveground piping shall be painted. Refer to Section 09 91 00, PAINTING.
2. Joints: Socket or butt-welded. Threaded joints not permitted except at valves, unions and tank connections.
3. Fittings:
 - a. Butt-welded joints: Steel, ASTM A234, Grade B, ASME B16.9, same schedule as adjoining pipe.
 - b. Socket-welded joints: Forged steel, ASME B16.11, 13 700 kPa (2000 psi) class.
4. Unions: Malleable iron, 2050 kPa (300 psi) class.
5. Companion flanges: Flanges and bolting, ASME B16.5.
6. Welding flanges: Weld neck, ASME B16.5, forged steel ASTM A105, 1025 kPa (150 psi).

C. Glass Fiber Reinforced Plastic (FRP) Pipe and Fittings:

1. Conform to UL 971 and ASTM D2996 using a filament-winding process and epoxy or vinyl ester resins.
2. Design pipe, fittings and joining system for required fuel service, 66 °C (150 °F), 1030 kPa (150 psi) pressure, 68 kPa (20 inches HG) vacuum.
3. Provide an integral resin-rich liner, 0.5 mm (0.020 inches) minimum thickness to enhance the corrosion resistance. Outer layer shall include ultra-violet inhibitors. Joining adhesive shall be designed for the pipe furnished and shall be supplied by the pipe manufacturer.
4. Plastic pipe and fittings are not permitted on steam or condensate service. Plastic piping allowed in underground use only.

D. Foot Valves - Fuel Pump Suction: Double poppet, lapped-in metal-to-metal seats, double-guided stems, 20 mesh inlet screen, same size as fuel suction piping. Foot valve shall be removable to above grade through the tank manhole enclosure or through extractor fitting.

E. Extractor Fittings: Arranged to permit removal of foot valves, overfill prevention valves, and other devices that are located below grade. Access point shall be through a cast iron fill box-type manhole located at grade. Provide extractor wrench.

2.5 SECONDARY CONTAINMENT FOR UNDERGROUND FUEL PIPING SYSTEMS

A. Enclose the fuel supply, return and fill pipes in factory-engineered and fabricated secondary containment conduit systems. The systems shall be complete with end seals, with 25 mm (1.0 inches) minimum continuous annular space, 37 mm (1.5 inches) between carrier pipes, which shall contain all leakage.

B. Steel Conduit with Fusion-Bonded Epoxy Coating and Cathodic Protection:

1. Galvanized carbon steel pipe, ASTM A53, Grade B, Schedule 40 for diameters through 125 mm (5 inches), 3.4 mm (0.134 inch) thick for diameters greater than 125 mm (5 inches) up through 650 mm (26 inches). All welded construction.
2. Sand blast exterior per NACE 3.
3. Coat exterior with 0.5 mm (20 mils) thick fusion-bonded epoxy.
4. Provide cathodic protection designed by corrosion specialist and consisting of galvanic anodes, test stations, interconnecting wiring in conformance with UL 1746 and NACE RP-0169. Electrical isolation required between all connecting systems in manholes and buildings.

C. Steel Conduit with Fiberglass Reinforced Plastic (FRP) Coating:

1. Carbon steel pipe, ASTM A53, Grade B, Schedule 40 for diameters through 125 mm (5 inches), 3.4 mm (0.134 inch) thick for diameters greater than 125 mm (5 inches) up thru 650 mm (26 inches). All welded construction.
2. Blast clean exterior per NACE 4.
3. Apply fiberglass reinforced polyester (FRP) external cladding at least 2.5 mm (0.10 inches) thick with ultra-violet inhibitor. Cladding on field joints shall be equivalent to factory-applied cladding applied on remainder of system.
4. Test entire system for holidays using a 35,000 volt holiday detector.
5. This system not permitted when carrier pipe or tracing system contains steam or condensate.

D. Glass Fiber Reinforced Plastic (FRP) Conduit:

1. Conform to UL 971 and ASTM D2996 using a filament-winding process and epoxy or vinyl ester resins.
2. Design pipe, fittings and joining system for carrier pipe fuel service, 66 °C (150 °F), 1030 kPa (150 psi) pressure, 68 kPa (20 inches Hg) vacuum.
3. Provide an integral resin-rich liner, minimum thickness 0.25 mm (0.010 inch). Outer layer shall include ultra-violet inhibitors.
4. Minimum total wall thickness 1.8 mm (0.07 inch) for diameters below 200 mm (8 inches), 2.8 mm (0.11 inch) for diameters 200 mm (8 inches) and 250 mm (10 inches), 5 mm (0.20 inch) for diameters 250 mm (10 inches) through 500 mm (20 inches), and 6 mm (0.25 inch) for diameters above 500 mm (20 inches).
5. This conduit system is not permitted when carrier pipe or tracing system contains steam or condensate.

- E. Pipe Supports: Provide supports within conduit for fuel carrier pipes spaced 2100 mm (7 feet) apart except 3000 mm (10 feet) apart for carrier pipe size 50 mm (2 inches) through 100 mm (4 inches). Support design shall permit differential movement of pipes, allow drainage of leakage to sumps, and maintain alignment of carrier pipes.
- F. Conduit End Seals: Same material and coating as conduit; leak tight.

2.6 TANK FLUID LEVEL MONITOR AND ALARM SYSTEMS

- A. Existing wireless fuel inventory probe/sensors will be reused within new tank.

2.7 CONCRETE FOUNDATIONS

Concrete ballast foundations for underground tanks and concrete pads for aboveground tanks are specified under Section 03 30 00, CAST-IN-PLACE CONCRETE. Ballast foundations shall be sized for buoyancy of entire tank when empty. Credit for overburden is allowed.

2.8 BURIED UTILITY WARNING TAPE

Tape shall be 0.1 mm (0.004 inch) thick, 150 mm (6 inches) wide, yellow polyethylene with a ferrous metallic core, acid and alkali-resistant and shall have a minimum strength of 12,000 kPa (1750 psi) lengthwise and 10 300 kPa (1500 psi) crosswise with an elongation factor of 350 percent. Provide bold black letters on the tape identifying the type of system. Tape color and lettering shall be unaffected by moisture and other substances contained in the backfill material.

PART 3 - EXECUTION

3.1 INSTALLATION AND TESTING, UNDERGROUND STEEL TANKS

- A. Conform to NFPA 30 or 31 as applicable.
- B. Install tanks on 150 mm (6 inch) thick beds of clean, washed, inert sand that is placed on concrete foundation. Secure tank to concrete ballast foundation with specified straps. Slope tank.
Completed tank installation shall successfully resist buoyant forces of flooding to top of tank when tank is empty.
- C. After tanks are set in place, prior to backfilling, test tanks by applying internal air pressure of 35 kPa to 48 kPa (5 - 7 psi). Also test air space between tank walls at pressure recommended by tank manufacturer. Repair leaks in steel tanks by chipping to bare metal and rewelding. Repair leaks in plastic tank jackets (if furnished) as recommended by tank manufacturer. Retest tanks until all leaks are repaired. Test manhole enclosures by filling with water and proving no leakage for 24 hours. Tests shall be witnessed by Resident Engineer (RE)/Contracting Officers Technical Representative (COTR).

- D. Prior to backfilling, repair all damage to tank coating with the same coating material. Coat all metal parts that will be below grade, including tie-down fittings and straps, bolts, rings, pipes, with the tank coating material. Perform 10,000 volt holiday test on all areas of coating which have been repaired.
- E. Excavation, trenching and backfilling around the tanks is specified under Section 31 20 00, EARTH MOVING. Backfill material shall be same as bedding material and shall conform to printed instructions of tank manufacturer. In addition, there shall be no stones, ashes, or corrosive materials in contact with the tanks. Unstable and unsuitable soil shall be removed and replaced with suitable material. Provide a soil separation mat to keep soil separate from sand and pea gravel. Minimum depth of cover shall conform to NFPA 30 or 31 as applicable. After completion of backfilling, measure tanks internally for out-of-roundness (deflection).
- F. Do not place fluid in the tank until the backfilling and the piping connections to the tanks are complete, and the tanks have been inspected internally by the RE/COTR. Keep the tank excavation dewatered.

3.2 INSTALLATION AND TESTING, UNDERGROUND PIPING SYSTEMS

- A. Arrange fuel and tracing media (if required for heated oil) carrier piping, enclosed in secondary containment piping. Slope piping down toward tanks and leak detectors at 25 mm in 10 m (1 inch in 40 feet).
- B. Steel Fuel and Tracing Media Carrier Piping: All joints butt or socket welding. Threaded piping is not permitted. Piping ends shall be accurately cut, true, and beveled for welding.
- C. Glass Fiber Reinforced Plastic (FRP) Fuel Carrier Piping and Secondary Containment Piping: Install in accordance with printed instructions of pipe manufacturer. Installation personnel trained in accordance with Article, QUALITY ASSURANCE. Plastic piping not permitted in same secondary containment system with steam or condensate piping.
- D. Secondary Containment Piping:
 - 1. Provide sand bedding and backfill material for steel piping and pea gravel for FRP piping.
 - 2. Top of system 450 mm (18 inches) minimum below grade.
 - 3. Design and locate leak detector sumps to intercept all potential leakage. Maximum spacing along each system, 3000 mm (100 feet).
 - 4. Seal all building and manhole wall penetrations with a modular, watertight flexible penetration seal system. The modular penetration seal shall have a nitrile rubber seal, or if a fire separation is required, a high temperature silicone fire seal

5. After placing system, prior to backfill, repair all damage, including coatings, as recommended in printed instructions of system manufacturer. Perform 10,000 volt holiday test on coated steel systems.
6. On steel systems that do not have FRP cladding, install cathodic protection system.
- E. Anchorage of System: When heated oil system is provided, anchor systems and provide expansion loops and bends as shown and as recommended by manufacturer of system. Pipe stress due to thermal expansion shall not exceed the limits in ASME B31.1.
- F. Leak Test: Test carrier pipes with air pressure at 690 kPa (100 psi), and test the containment piping with air pressure at 55 kPa (8 psi). Systems shall hold the pressure for 30 minutes. Repair all leaks and retest.
- G. Coatings for Steel Piping not in Secondary Containment System: Provide urethane coating and cathodic protection.
- H. Buried Utility Warning Tape: Install tape 300 mm (12 inches) below grade above the piping system.

3.3 INSTALLATION, FILL BOXES AND ACCESS MANHOLES AT GRADE

Provide for tank fill, tank sounding, leak detector sensors, and extractor fittings. Set at grade in concrete pads. Refer to detail. Provide identification plate set into the concrete pad that identifies the purpose of the device and type of fuel in the tank.

3.4 INSTALLATION, TANK FLUID LEVEL INDICATOR AND ALARM SYSTEM

- A. Wiring shall conform to NFPA 70.
- B. Locate remote high level alarm on exterior wall or pole in view of tank fill point, 2400 mm (8 feet) above grade.

3.5 TANK MANHOLE ENCLOSURES

All pipe penetrations shall be leak tight permitting no groundwater into enclosure.

3.6 COMMISSIONING

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

--- E N D ---

SECTION 23 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.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 31 20 00, EARTH MOVING: Excavation and backfill.
- D. Section 03 30 00, CAST-IN-PLACE CONCRETE.
- E. Section 07 13 52, MODIFIED BITUMINOUS SHEET WATERPROOFING.
- F. Section 33 10 00, WATER UTILITIES: Underground piping.
- G. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- H. Section 23 21 23, HYDRONIC PUMPS: Pumps.
- I. Section 23 07 11, HVAC INSULATION: Piping insulation.
- J. Section 23 25 00, HVAC WATER TREATMENT: Water treatment for open and closed systems.
- K. Section 23 82 00, CONVECTION HEATING AND COOLING UNITS: VAV and CV units, fan coil units, and radiant ceiling panels.
- L. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Temperature and pressure sensors and valve operators.
- M. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENT: Seismic restraints for piping.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC, 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. For mechanical pressed sealed fittings, only tools of fitting manufacturer shall be used.
- D. Mechanical pressed fittings shall be installed by factory trained workers.
- E. 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
 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. Coordination Drawings: Refer to Article, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- F. As-Built Piping Diagrams: Provide drawing as follows for chilled water, condenser water, and heating hot water system and other piping systems and equipment.
1. One wall-mounted stick file with complete set of prints. Mount stick file in the chiller plant or control room along with control diagram stick file.
 2. One complete set of reproducible drawings.
 3. 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)
- B16.4-06Gray Iron Threaded FittingsB16.18-01 Cast Copper Alloy
Solder joint Pressure fittings
- B16.23-02Cast Copper Alloy Solder joint Drainage fittings
- B40.100-05Pressure Gauges and Gauge Attachments

- C. American National Standards Institute, Inc./Fluid Controls Institute (ANSI/FCI):
70-2-2006.....Control Valve Seat Leakage
- D. American Society of Mechanical Engineers (ASME):
B16.1-98Cast Iron Pipe Flanges and Flanged Fittings
B16.3-2006Malleable Iron Threaded Fittings: Class 150 and 300
B16.4-2006Gray Iron Threaded Fittings: (Class 125 and 250)
B16.5-2003Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24
Metric/Inch Standard
B16.9-07Factory Made Wrought Butt Welding Fittings
B16.11-05Forged Fittings, Socket Welding and Threaded
B16.18-01Cast Copper Alloy Solder Joint Pressure Fittings
B16.22-01Wrought Copper and Bronze Solder Joint Pressure Fittings.
B16.24-06Cast Copper Alloy Pipe Flanges and Flanged Fittings
B16.39-06Malleable Iron Threaded Pipe Unions
B16.42-06Ductile Iron Pipe Flanges and Flanged Fittings
B31.1-08Power Piping
- E. American Society for Testing and Materials (ASTM):
A47/A47M-99 (2004)Ferritic Malleable Iron Castings
A53/A53M-07.....Standard Specification for Pipe, Steel, Black and Hot-Dipped,
Zinc-Coated, Welded and Seamless
A106/A106M-08.....Standard Specification for Seamless Carbon Steel Pipe for
High-Temperature Service
A126-04Standard Specification for Gray Iron Castings for Valves,
Flanges, and Pipe Fittings
A183-03Standard Specification for Carbon Steel Track Bolts and Nuts
A216/A216M-08Standard Specification for Steel Castings, Carbon, Suitable for
Fusion Welding, for High Temperature Service
A234/A234M-07Piping Fittings of Wrought Carbon Steel and Alloy Steel for
Moderate and High Temperature Service
A307-07Standard Specification for Carbon Steel Bolts and Studs, 60,000
PSI Tensile Strength
A536-84 (2004)Standard Specification for Ductile Iron Castings
A615/A615M-08Deformed and Plain Carbon Steel Bars for Concrete
Reinforcement

- A653/A 653M-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
- C177-04 Standard Test Method for Steady State Heat Flux Measurements
and Thermal Transmission Properties by Means of the Guarded
Hot Plate Apparatus
- C478-09 Precast Reinforced Concrete Manhole Sections
- C533-07 Calcium Silicate Block and Pipe Thermal Insulation
- C552-07 Cellular Glass Thermal Insulation
- 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
- 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-70-06Gray Iron Gate Valves, Flanged and Threaded Ends
 SP-71-05Gray Iron Swing Check Valves, Flanged and Threaded Ends
 SP-80-08Bronze Gate, Globe, Angle and Check Valves
 SP-85-02Cast Iron Globe and Angle Valves, Flanged and Threaded Ends
 SP-110-96Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
 SP-125-00Gray Iron and Ductile Iron In-line, Spring Loaded, Center-Guided Check Valves
- K. National Sanitation Foundation/American National Standards Institute, Inc. (NSF/ANSI):
 14-06Plastic Piping System Components and Related Materials
 50-2009aEquipment 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
 61-2008Drinking Water System Components – Health Effects
- L. Tubular Exchanger Manufacturers Association: TEMA 9th Edition, 2007

1.6 SPARE PARTS

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

PART 2 - PRODUCTS

2.1 PIPE AND EQUIPMENT SUPPORTS, PIPE SLEEVES, AND WALL AND CEILING PLATES

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

2.2 PIPE AND TUBING

- A. Chilled Water, Condenser Water, Heating Hot Water, and Vent Piping:
 - 1. Steel: ASTM A53 Grade B, seamless or ERW, Schedule 40.
 - 2. Copper water tube option: ASTM B88, Type K or L, hard drawn.
- B. Extension of Domestic Water Make-up Piping: ASTM B88, Type K or L, hard drawn copper tubing.

C. Cooling Coil Condensate Drain Piping:

1. From air handling units: Copper water tube, ASTM B88, Type M, or schedule 40 PVC plastic piping.
2. From fan coil or other terminal units: Copper water tube, ASTM B88, Type L for runouts and Type M for mains.

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

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

2.3 FITTINGS FOR STEEL PIPE

A. 50 mm (2 inches) and Smaller: Screwed or welded joints.

1. Butt welding: ASME B16.9 with same wall thickness as connecting piping.
2. Forged steel, socket welding or threaded: ASME B16.11.
3. Screwed: 150 pound malleable iron, ASME B16.3. 125 pound cast iron, ASME B16.4, may be used in lieu of malleable iron. Bushing reduction of a single pipe size, or use of close nipples, is not acceptable.
4. Unions: ASME B16.39.
5. Water hose connection adapter: Brass, pipe thread to 20 mm (3/4 inch) garden hose thread, with hose cap nut.

B. 65 mm (2-1/2 inches) and Larger: Welded or flanged joints. Contractor's option: Grooved mechanical couplings and fittings are optional.

1. Butt welding fittings: ASME B16.9 with same wall thickness as connecting piping. Elbows shall be long radius type, unless otherwise noted.
2. Welding flanges and bolting: ASME B16.5:
 - a. Water service: Weld neck or slip-on, plain face, with 6 mm (1/8 inch) thick full face neoprene gasket suitable for 104 degrees C (220 degrees F).
 - 1) Contractor's option: Convolute, cold formed 150 pound steel flanges, with teflon gaskets, may be used for water service.
 - b. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A307, Grade B.

C. Welded Branch and Tap Connections: Forged steel weldolets, or branchlets and threadolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 may be used for drain, vent and gage connections.

D. Grooved Mechanical Pipe Couplings and Fittings (Contractor's Option): Grooved Mechanical Pipe Couplings and Fittings may be used, with cut or roll grooved pipe, in water service up to 110 degrees C (230 degrees F) in lieu of welded, screwed or flanged connections. 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. Contractor's Option: Mechanical press sealed fittings, double pressed type, NSF 50/61 approved, with EPDM (ethylene propylene diene monomer) non-toxic synthetic rubber sealing elements for up to 65 mm (2-1/2 inch) and below are optional for above ground water piping only.
3. Mechanically formed tee connection in water and drain piping: Form mechanically extracted collars in a continuous operation by drilling pilot hole and drawing out tube surface to form collar, having a height of not less than three times the thickness of tube wall. Adjustable collaring device shall insure proper tolerance and complete uniformity of the joint. Notch and dimple joining branch tube in a single process to provide free flow where the branch tube penetrates the fitting.

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

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, 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.

2.6 DIELECTRIC FITTINGS

- A. Provide where copper tubing and ferrous metal pipe are joined.
- B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.
- C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.
- D. Temperature Rating, 99 degrees C (210 degrees F).
- 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 150 mm (6 inches) and larger when the centerline is located 2400 mm (8 feet) or more above the floor or operating platform.
- D. Shut-Off Valves
 - 1. Ball Valves (Pipe sizes 2" and smaller): MSS-SP 110, screwed or solder connections, brass or bronze body with chrome-plated ball with full port and Teflon seat at 4140 kPa (600 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 50 mm (2 inches) of pipe insulation without interfering with valve operation. MSS-SP 67, flange lug type or grooved end rated 1205 kPa (175 psig) working pressure at 93 degrees C (200 degrees F). Valves shall be ANSI Leakage Class VI and rated for bubble tight shut-off to full valve pressure rating. Valve shall be rated for dead end service and bi-directional flow capability to full rated pressure. Not permitted for direct buried pipe applications.
 - a. Body: Cast iron, ASTM A126, Class B. Malleable iron, ASTM A47 electro-plated, or ductile iron, ASTM A536, Grade 65-45-12 electro-plated.
 - b. Trim: Bronze, aluminum bronze, or 300 series stainless steel disc, bronze bearings, 316 stainless steel shaft and manufacturer's recommended resilient seat. Resilient seat shall be field replaceable, and fully line the body to completely isolate the body from the product. A phosphate coated steel shaft or stem is acceptable, if the stem is completely isolated from the product.

- c. Actuators: Field interchangeable. Valves for balancing service shall have adjustable memory stop to limit open position.
 - 1) Valves 150 mm (6 inches) and smaller: Lever actuator with minimum of seven locking positions, except where chain wheel is required.
 - 2) Valves 200 mm (8 inches) and larger: Enclosed worm gear with handwheel, and where required, chain-wheel operator.
 - 3) Gate Valves (Contractor's Option in lieu of Ball or Butterfly Valves):
 - a) 50 mm (2 inches) and smaller: MSS-SP 80, Bronze, 1034 kPa (150 psig), wedge disc, rising stem, union bonnet.
 - b) 65 mm (2 1/2 inches) and larger: Flanged, outside screw and yoke. MSS-SP 70, iron body, bronze mounted, 861 kPa (125 psig) wedge disc.

E. Globe and Angle Valves

1. Globe Valves

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

2. Angle Valves:

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

F. Check Valves

1. Swing Check Valves:

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

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

- a. Body: MSS-SP 125 cast iron, ASTM A126, Class B, or steel, ASTM A216, Class WCB, or ductile iron, ASTM 536, flanged, grooved, or wafer type.

- b. Seat, disc and spring: 18-8 stainless steel, or bronze, ASTM B62. Seats may be elastomer material.
- G. Water Flow Balancing Valves: For flow regulation and shut-off. Valves shall be line size rather than reduced to control valve size.
 - 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 1205 kPa (175 psig) at 93 degrees C (200 degrees F), with stainless steel piston and spring.
 - 2. Brass or ferrous body designed for 2067 kPa (300 psig) service at 121 degrees C (250 degrees F), with corrosion resistant, tamper proof, self-cleaning piston/spring assembly that is easily removable for inspection or replacement.
 - 3. Combination assemblies containing ball type shut-off valves, unions, flow regulators, strainers with blowdown valves and pressure temperature ports shall be acceptable.

2.9 WATER FLOW MEASURING DEVICES

- A. Minimum overall accuracy plus or minus three percent over a range of 70 to 110 percent of design flow. Select devices for not less than 110 percent of design flow rate.
- B. Venturi Type: Bronze, steel, or cast iron with bronze throat, with valved pressure sensing taps upstream and at the throat.
- C. Wafer Type Circuit Sensor: Cast iron wafer-type flow meter equipped with readout valves to facilitate the connecting of a differential pressure meter. Each readout valve shall be fitted with an integral check valve designed to minimize system fluid loss during the monitoring process.
- D. Self-Averaging Annular Sensor Type: Brass or stainless steel metering tube, shutoff valves and quick-coupling pressure connections. Metering tube shall be rotatable so all sensing ports may be pointed down-stream when unit is not in use.
- E. Insertion Turbine Type Sensor: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

F. Flow Measuring Device Identification:

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

G. Portable Water Flow Indicating Meters:

1. Minimum 150 mm (6 inch) diameter dial, forged brass body, beryllium-copper bellows, designed for 1205 kPa (175 psig) working pressure at 121 degrees C (250 degrees F).
2. Bleed and equalizing valves.
3. Vent and drain hose and two 3000 mm (10 feet) lengths of hose with quick disconnect connections.
4. Factory fabricated carrying case with hose compartment and a bound set of capacity curves showing flow rate versus pressure differential.
5. Provide one portable meter for each range of differential pressure required for the installed flow devices.

H. Permanently Mounted Water Flow Indicating Meters: Minimum 150 mm (6 inch) diameter, or 450 mm (18 inch) long scale, for 120 percent of design flow rate, direct reading in lps (gpm), with three valve manifold and two shut-off valves.

2.10 STRAINERS

A. Basket or Y Type.

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

B. Suction Diffusers: Specified in Section 23 21 23, HYDRONIC PUMPS.

2.11 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 50 mm to 100 mm (2 inches to 4 inches), 1137 kPa (165psig) at 121 degrees C (250 degrees F).

- b. Connector sizes 125 mm to 300 mm (5 inches to 12 inches), 965 kPa (140 psig) at 121 degrees C (250 degrees F).
- 3. Provide ductile iron retaining rings and control units.
- B. Mechanical Pipe Couplings:
See other fittings specified under Part 2, PRODUCTS.

2.12 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 - Internally Pressurized Type:
 - 1. Multiple corrugations of Type 304 or Type A240-321 stainless steel.
 - 2. Internal stainless steel sleeve entire length of bellows.
 - 3. External cast iron equalizing rings for services exceeding 340 kPa (50 psig).
 - 4. Welded ends.
 - 5. Design shall conform to standards of EJMA and ASME B31.1.
 - 6. External tie rods designed to withstand pressure thrust force upon anchor failure if one or both anchors for the joint are at change in direction of pipeline.
 - 7. Integral external cover.
- D. 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. Welded ends.
 - 5. Conform to the standards of EJMA and ASME B31.1.
 - 6. Threaded connection at bottom, 25 mm (one inch) minimum, for drain or drip point.
 - 7. Integral external cover and internal sleeve.
- 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. Conform to standards of EJMA.
- F. Expansion Joint (Contractor's Option): 2415 kPa (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 75 mm (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.

2.13 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 NBR.
 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" and smaller to be carbon steel NPT tapings. Piping connections 4" and larger to be studded 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. Combination Air/Dirt Separator: ASME Pressure Vessel Code construction for 150 psig working pressure, flanged inlet and outlet connections, and integral copper bundle of spiral wound tubes. Units shall remove free and entrained air during system start up and continue to eliminate dissolved air through continual circulation and the coalescing action of the spiral wound tubes. Each fitting shall have a separate air and venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral float actuated brass air vent. There shall be no restriction in the connection from the venting chamber to the vent. The fittings shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Unit shall provide air elimination efficiency of 100% free air, 100% entrained air, and 99.6% dissolved air at the installed location. Dirt separation efficiency shall be a minimum of 80% of all particles 30 micron and larger within 100 passes.
- C. Bladder Type Pre-Pressurized Expansion Tank: ASME Pressure Vessel Code construction for 861 kPa (125 psig) working pressure, welded steel shell, rust-proof coated, with a heavy duty butyl replaceable bladder suitable for a maximum operating temperature of 116 degrees C (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.
- D. Pressure Reducing Valve (Water): Diaphragm or bellows operated, spring loaded type, with minimum adjustable range of 28 kPa (4 psig) above and below set point. Bronze, brass or iron body and bronze, brass or stainless steel trim, rated 861 kPa (125 psig) working pressure at 107 degrees C (225 degrees F).
- E. 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.
- F. Automatic Air Vent Valves (where shown): Cast iron or semi-steel body, 1034 kPa (150 psig) working pressure, stainless steel float, valve, valve seat and mechanism, minimum 15 mm (1/2 inch) water connection and 6 mm (1/4 inch) air outlet. Air outlet shall be piped to the nearest floor drain.
- G. Manual Vent Valves: Provide manual vent valves, where indicated or required at the high points of all water systems. Valves shall be 1/4" ball valves equal to Nibco T-560-BR-Y-66 with lever handles.

2.14 WATER FILTERS AND POT CHEMICAL FEEDERS

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

2.15 GAGES, PRESSURE AND COMPOUND

- A. ASME B40.100, Accuracy Grade 1A, (pressure, vacuum, or compound for air, oil or water), initial mid-scale accuracy 1 percent of scale (Qualify grade), metal or phenolic case, 115 mm (4-1/2 inches) in diameter, 6 mm (1/4 inch) NPT bottom connection, white dial with black graduations and pointer, clear glass or acrylic plastic window, suitable for board mounting. Provide red "set hand" to indicate normal working pressure.
- B. Provide brass lever handle union cock. Provide brass/bronze pressure snubber for gages in water service.
- C. Range of Gages: Provide range equal to at least 130 percent of normal operating range.
 - 1. For condenser water suction (compound): Minus 100 kPa (30 inches Hg) to plus 700 kPa (100 psig).

2.16 PRESSURE/TEMPERATURE TEST PROVISIONS

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

2.17 THERMOMETERS

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

2.18 FIRESTOPPING MATERIAL

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

2.19 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
- C. Heat tracing shall be provided to the extent shown on the drawings (Floor plans and Elevations). Heat tracing shall extend below grade to below the defined frost line.
- D. Heating Cable: Flexible, parallel circuit construction consisting of a continuous self-limiting resistance, conductive inner core material between two parallel copper bus wires, designed for cut-to-length at the job site and for wrapping around valves and complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself.
 - 1. Provide end seals at ends of circuits. Wire at the ends of the circuits is not to be tied together.
 - 2. Provide sufficient cable, as recommended by the manufacturer, to keep the pipe surface at 2.2 degrees C (36 degrees F) minimum during winter outdoor design temperature, but not less than the following:
 - a. 75 mm (3 inch) pipe and smaller with 25 mm (1 inch) thick insulation: 4 watts per foot of pipe.
 - b. 100 mm (4 inch) pipe and larger 38 mm (1-1/2 inch) thick insulation: 8 watts per foot of pipe.
- E. 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. 13 mm (1/2 inch) wide fiberglass reinforced pressure sensitive cloth tape to fasten cable to pipe at 300 mm (12 inch) intervals.
 - 3. Pipe surface temperature control thermostat: Cast aluminum, NEMA 4 (watertight) enclosure, 13 mm (1/2 inch) NPT conduit hub, SPST switch rated 20 amps at 208 volts AC, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature at not less than 1.1 degrees C (34 degrees F).
 - 4. Signs: Manufacturer's standard (NEC Code), stamped "ELECTRIC TRACED" located on the insulation jacket at 3000 mm (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. Install heat exchangers at height sufficient to provide gravity flow of condensate to the flash tank and condensate pump.
- D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (one inch) minimum clearance between adjacent piping or other surface. Unless shown otherwise, slope drain piping down in the direction of flow not less than 25 mm (one inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.
- E. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.
- F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted on the drawings.
- G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.
- H. Provide manual or automatic air vent at all piping system high points and drain valves at all low points. Install piping to floor drains from all automatic air vents.
- I. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:
 - 1. Water treatment pot feeders and condenser water treatment systems.

- 2. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.
- J. Thermometer Wells: In pipes 65 mm (2-1/2 inches) and smaller increase the pipe size to provide free area equal to the upstream pipe area.
- K. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC 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.
- 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 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 must 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 LEAK TESTING ABOVEGROUND PIPING

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

3.5 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Water Piping: Clean systems as recommended by the suppliers of chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.
 - 1. Initial flushing: Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system component. Provide temporary piping or hose to bypass coils, control valves, exchangers and other factory cleaned equipment unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place. Isolate or protect clean system components, including pumps and pressure vessels, and remove any component which may be damaged. Open all valves, drains, vents and strainers at all system levels. Remove plugs, caps, spool pieces, and components to facilitate early debris discharge from system. Sectionalize system to obtain debris carrying velocity of 1.8 m/S (6 feet per second), if possible. Connect dead-end supply and return headers as necessary. Flush bottoms of risers. Install temporary strainers where necessary to protect down-stream equipment. Supply and remove flushing water and drainage by various type hose, temporary and permanent piping and Contractor's booster pumps. Flush until clean as approved by the Resident Engineer.
 - 2. Cleaning: Using products supplied in Section 23 25 00, HVAC WATER TREATMENT, circulate systems at normal temperature to remove adherent organic soil, hydrocarbons, flux, pipe mill varnish, pipe joint compounds, iron oxide, and like deleterious substances not removed by flushing, without chemical or mechanical damage to any system component. Removal of tightly adherent mill scale is not required. Keep isolated equipment which is "clean" and where dead-end debris accumulation cannot occur. Sectionalize system if possible, to circulate at velocities not less than 1.8 m/S (6 feet per second). Circulate each section for not less than four hours. Blow-down all strainers, or remove and clean as frequently as necessary. Drain and prepare for final flushing.

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

3.6 WATER TREATMENT

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

3.7 ELECTRIC HEAT TRACING

- A. Install tracing as recommended by the manufacturer.
- B. Coordinate electrical connections.

3.8 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

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

3.9 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.

3.10 SEISMIC BRACING FOR ABOVEGROUND PIPING

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

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SECTION 23 21 23 HYDRONIC PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- E. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING ANDEQUIPMENT.
- F. Section 23 21 13, HYDRONIC PIPING.
- G. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.
- H. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENT: Seismic restraints for piping.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

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

1.5 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.

- 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.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only:
- B. American 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 B16.1-05Cast 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
B62-2009Standard Specification for Composition Bronze or Ounce Metal
Castings
- E. Maintenance and Operating Manuals in accordance with Section 01 00 00, General Requirements.

1.7 DEFINITIONS

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

1.8 SPARE MATERIALS

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

PART 2 - PRODUCTS

2.1 CENTRIFUGAL PUMPS, BRONZE FITTED

A. General:

1. Provide pumps that will operate continuously without overheating bearings or motors at every condition of operation on the pump curve, or produce noise audible outside the room or space in which installed.
2. Provide pumps of size, type and capacity as indicated, complete with electric motor and drive assembly, unless otherwise indicated. Design pump casings for the indicated working pressure and factory test at 1½ times the designed pressure.
3. Provide pumps of the same type, the product of a single manufacturer, with pump parts of the same size and type interchangeable.
4. General Construction Requirements
 - a. Balance: Rotating parts, statically and dynamically.
 - b. Construction: To permit servicing without breaking piping or motor connections.
 - c. Pump Motors: Provide high efficiency motors, inverter duty for variable speed service. Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC 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 23 05 11, COMMON WORK RESULTS FOR HVAC 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. Vertical In-Line Type, Single Suction:

1. Refer to pump schedule for pump flows, heads, motor speed, enclosure, efficiency and power requirements.

2. Pump Casing: Cast Iron for working pressure below 175 psig at 150 F (125 psig ANSI flange rating) and Ductile Iron for working pressures to 375 psig at 150 F (250 psig ANSI flange rating) Suction and discharge connections shall be flanged and the same size and shall be drilled and tapped for seal flush and gauge connections.
3. Impeller: Bronze, fully enclosed type. Dynamically balanced.
4. Shaft: Provide Stainless Steel pump shaft.
5. Coupling: Rigid spacer type of high tensile aluminum alloy couplings shall be split to allow removal from pump and motor shafts, leaving space between the shafts sufficient to replace all mechanical seal components without disturbing the pump or motor.
6. Mechanical Seals: Shall be Stainless Steel outside multi-spring balanced type with Viton secondary seal. Provide bronze gland plate with Stainless Steel hardware. Provide factory installed flush line with manual vent.
7. All split coupled pumps shall be provided with a lower seal chamber throttle bushing.
8. Motor Horsepower: Shown on the schedule are minimum and have been sized for continuous operation without exceeding full load nameplate rating over the entire pump curve, exclusive of service factor.
9. Seal slush line fittings:
 - a. Supply in the flush line to the mechanical seal a 50 micron cartridge filter and sight flow indicator, to suit the working pressure encountered.
 - b. Filters shall be changed, by the installing contractor, after system is flushed and on a regular basis until turned over to the owner.
 - c. Alternately, for pumps with differential pressures exceeding 30 psig.
 - d. Supply in the flush line to the mechanical seal a cyclone type separator, with sight flow indicator.

C. In-Line Circulators:

1. Pump construction shall be cast iron body suitable for 175 psi working pressure. The shaft shall have an integral thrust collar and shall be supported by two oil-lubricated bronze sleeve bearings.

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.

3.3 COMMISSIONING

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

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SECTION 23 22 13
STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Steam, condensate and vent piping inside buildings.

1.2 RELATED WORK

- A. Excavation and backfill: Section 31 20 00, EARTH MOVING.
- 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. Pumps: Section 23 22 23, STEAM CONDENSATE PUMPS.
- D. Piping insulation: Section 23 07 11, HVAC INSULATION.
- E. Water treatment for open and closed systems: Section 23 25 00, HVAC WATER TREATMENT.
- F. Heating Coils and Humidifiers: Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS and SECTION 23 31 00, HVAC DUCTS AND CASING.
- G. Heating and cooling radiant panels: Section 23 82 00, CONVECTION HEATING AND COOLING UNITS.
- H. Temperature and pressure sensors and valve operators: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC, which includes welding qualifications.

1.5 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. Valves of all types.
 - 6. Strainers.
 - 7. Pipe alignment guides.
 - 8. Expansion joints.
 - 9. Expansion compensators.
 - 10. Flexible ball joints: Catalog sheets, performance charts, schematic drawings, specifications and installation instructions.
 - 11. All specified steam system components.
 - 12. Gages.
 - 13. Thermometers and test wells.
 - 14. Electric heat tracing systems.
 - 15. Seismic bracing details for piping.
- C. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:
 - 1. Heat Exchangers (Steam-to-Hot Water).
 - 2. Flash tanks.
- D. Coordination Drawings: Refer to Article, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- E. As-Built Piping Diagrams: Provide drawing as follows for steam and steam condensate piping and other central plant equipment.
 - 1. One wall-mounted stick file for prints. Mount stick file in the chiller plant or adjacent control room along with control diagram stick file.
 - 2. One set of reproducible drawings.

1.6 APPLICABLE PUBLICATIONS

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

- B. American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI):
- B1.20.1-83(R2006) Pipe Threads, General Purpose (Inch)
- B16.4-2006 Gray Iron Threaded Fittings
- C. American Society of Mechanical Engineers (ASME):
- B16.1-2005 Gray Iron Pipe Flanges and Flanged Fittings
- B16.3-2006 Malleable Iron Threaded Fittings
- B16.9-2007 Factory-Made Wrought Buttwelding Fittings
- B16.11-2005 Forged Fittings, Socket-Welding and Threaded
- B16.14-91 Ferrous Pipe Plugs, Bushings, and Locknuts with Pipe Threads
- B16.22-2001 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
- B16.23-2002 Cast Copper Alloy Solder Joint Drainage Fittings
- B16.24-2006 Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150, 300, 400, 600, 900, 1500 and 2500
- B16.39-98 Malleable Iron Threaded Pipe Unions, Classes 150, 250, and 300
- B31.1-2007 Power Piping
- B31.9-2008 Building Services Piping
- B40.100-2005 Pressure Gauges and Gauge Attachments
- Boiler and Pressure Vessel Code: SEC VIII D1-2001, Pressure Vessels, Division 1
- D. American Society for Testing and Materials (ASTM):
- A47-99 Ferritic Malleable Iron Castings
- A53-2007 Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
- A106-2008 Seamless Carbon Steel Pipe for High-Temperature Service
- A126-2004 Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
- A181-2006 Carbon Steel Forgings, for General-Purpose Piping
- A183-2003 Carbon Steel Track Bolts and Nuts
- A216-2008 Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
- A285-01 Pressure Vessel Plates, Carbon Steel, Low-and-Intermediate-Tensile Strength
- A307-2007 Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength

- A516-2006 Pressure Vessel Plates, Carbon Steel, for Moderate-and- Lower
Temperature Service
- A536-84(2004)e1 Standard Specification for Ductile Iron Castings
- B32-2008 Solder Metal
- B61-2008 Steam or Valve Bronze Castings
- B62-2009 Composition Bronze or Ounce Metal Castings
- B88-2003 Seamless Copper Water Tube
- F439-06..... Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic
Pipe Fittings, Schedule 80
- F441-02(2008) Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules
40 and 80
- E. American Welding Society (AWS):
 - A5.8-2004 Filler Metals for Brazing and Braze Welding
 - B2.1-00 Welding Procedure and Performance Qualifications
- F. Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry, Inc.:
 - SP-67-95 Butterfly Valves
 - SP-70-98 Cast Iron Gate Valves, Flanged and Threaded Ends
 - SP-71-97 Gray Iron Swing Check Valves, Flanged and Threaded Ends
 - SP-72-99 Ball Valves with Flanged or Butt-Welding Ends for General
Service
 - SP-78-98 Cast Iron Plug Valves, Flanged and Threaded Ends
 - SP-80-97 Bronze Gate, Globe, Angle and Check Valves
 - SP-85-94 Cast Iron Globe and Angle Valves, Flanged and Threaded Ends
- G. Military Specifications (Mil. Spec.):
 - MIL-S-901D-1989 Shock Tests, H.I. (High Impact) Shipboard Machinery,
Equipment, and Systems
- H. National Board of Boiler and Pressure Vessel Inspectors (NB): Relieving Capacities of Safety
Valves and Relief Valves
- I. Tubular Exchanger Manufacturers Association: TEMA 18th Edition, 2000

PART 2 - PRODUCTS

2.1 PIPE AND EQUIPMENT SUPPORTS, PIPE SLEEVES, AND WALL AND CEILING PLATES

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

2.2 PIPE AND TUBING

- A. Steam Piping: Steel, ASTM A53, Grade B, seamless or ERW; A106 Grade B, Seamless; Schedule 40.
- B. Steam Condensate and Pumped Condensate Piping:
 - 1. Concealed above ceiling, in wall or chase: Copper water tube ASTM B88, Type K, hard drawn.
 - 2. All other locations: Copper water tube ASTM B88, Type K, hard drawn; or steel, ASTM A53, Grade B, Seamless or ERW, or A106 Grade B Seamless, Schedule 80.
- C. Vent Piping: Steel, ASTM A53, Grade B, seamless or ERW; A106 Grade B, Seamless; Schedule 40, galvanized.

2.3 FITTINGS FOR STEEL PIPE

- A. 50 mm (2 inches) and Smaller: Screwed or welded.
 - 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, except for steam and steam condensate piping. Provide 300 pound malleable iron, ASME B16.3 for steam and steam condensate piping. Cast iron fittings or piping is not acceptable for steam and steam condensate piping. Bushing reduction of a single pipe size, or use of close nipples, is not acceptable.
 - 4. Unions: ASME B16.39.
 - 5. Steam line drip station and strainer quick-couple blowdown hose connection: Straight through, plug and socket, screw or cam locking type for 15 mm (1/2 inch) ID hose. No integral shut-off is required.
- B. 65 mm (2-1/2 inches) and Larger: Welded or flanged joints.
 - 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. Steam service: Weld neck or slip-on, raised face, with non-asbestos gasket. Non-asbestos gasket shall either be stainless steel spiral wound strip with flexible graphite filler or compressed inorganic fiber with nitrile binder rated for saturated and superheated steam service 750 degrees F and 1500 psi.
 - 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.

2.4 FITTINGS FOR COPPER TUBING

- A. Solder Joint:
 - 1. Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.
- B. Bronze Flanges and Flanged Fittings: ASME B16.24.
- C. Fittings: ANSI/ASME B16.18 cast copper or ANSI/ASME B16.22 solder wrought copper.

2.5 DIELECTRIC FITTINGS

- A. Provide where copper tubing and ferrous metal pipe are joined.
- B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.
- C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.
- D. Temperature Rating, 121 degrees C (250 degrees F) for steam condensate and as required for steam service.
- E. Contractor's option: On pipe sizes 2" and smaller, screwed end brass gate valves or dielectric nipples may be used in lieu of dielectric unions.

2.6 SCREWED JOINTS

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

2.7 VALVES

- A. Asbestos packing is not acceptable.
- B. All valves of the same type shall be products of a single manufacturer.
- C. Provide chain operators for valves 150 mm (6 inches) and larger when the centerline is located 2100 mm (7 feet) or more above the floor or operating platform.
- D. Shut-Off Valves
 - 1. Gate Valves:
 - a. 50 mm (2 inches) and smaller: MSS-SP80, Bronze, 1034 kPa (150 lb.), wedge disc, rising stem, union bonnet.

- b. 65 mm (2 1/2 inches) and larger: Flanged, outside screw and yoke.
 - 1) High pressure steam 413 kPa (60 psig) and above nominal MPS system): Cast steel body, ASTM A216 grade WCB, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel solid disc and seats. Provide 25 mm (1 inch) factory installed bypass with globe valve on valves 100 mm (4 inches) and larger.
 - 2) All other services: MSS-SP 70, iron body, bronze mounted, 861 kPa (125 psig) wedge disc.
- E. Globe and Angle Valves:
 - 1. Globe Valves:
 - a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Globe valves shall be union bonnet with metal plug type disc.
 - b. 65 mm (2 1/2 inches) and larger:
 - 1) Globe valves for high pressure steam 413 kPa (60 psig) and above nominal MPS system): Cast steel body, ASTM A216 grade WCB, flanged, OS&Y, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.
 - 2) All other services: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for globe valves.
 - 2. Angle Valves
 - a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Angle valves shall be union bonnet with metal plug type disc.
 - b. 65 mm (2 1/2 inches) and larger:
 - 1) Angle valves for high pressure steam 413 kPa (60 psig) and above nominal MPS system): Cast steel body, ASTM A216 grade WCB, flanged, OS&Y, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.
 - 2) All other services: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for angle valves.
- F. Swing Check Valves
 - 1. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 psig), 45 degree swing disc.

2. 65 mm (2-1/2 inches) and Larger:
 - a. Check valves for high pressure steam 413 kPa (60 psig) and above nominal MPS system: Cast steel body, ASTM A216 grade WCB, flanged, OS&Y, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.
 - b. All other services: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-71 for check valves.

2.8 STRAINERS

- A. Basket or Y Type. Tee type is acceptable for gravity flow and pumped steam condensate service.
- B. High Pressure Steam: Rated 1034 kPa (150 psig) saturated steam.
 1. 50 mm (2 inches) and smaller: Iron, ASTM A116 Grade B, or bronze, ASTM B-62 body with screwed connections (250 psig).
 2. 65 mm (2-1/2 inches) and larger: Flanged cast steel or 1723 kPa (250 psig) cast iron.
- C. All Other Services: Rated 861 kPa (125 psig) saturated steam.
 1. 50 mm (2 inches) and smaller: Cast iron or bronze.
 2. 65 mm (2-1/2 inches) and larger: Flanged, iron body.
- D. Screens: Bronze, monel metal or 18-8 stainless steel, free area not less than 2-1/2 times pipe area, with perforations as follows:
 1. 75 mm (3 inches) and smaller: 20 mesh for steam and 1.1 mm (0.045 inch) diameter perforations for liquids.
 2. 100 mm (4 inches) and larger: 1.1 mm (0.045) inch diameter perforations for steam and 3.2 mm (0.125 inch) diameter perforations for liquids.

2.9 PIPE ALIGNMENT

- A. 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.

2.10 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. Minimum Service Requirements:

1. Pressure Containment:

- a. Steam Service 35-200 kPa (5-30 psig): Rated 345 kPa (50 psig) at 148 degrees C (298 degrees F).
- b. Steam Service 214-850 kPa (31-125 psig): Rated 1025 kPa (150 psig) at 186 degrees C (366 degrees F).
- c. Condensate Service: Rated 690 kPa (100 psig) at 154 degrees C (310 degrees F).

2. Number of Full Reverse Cycles without failure: Minimum 1000.

3. Movement: As shown on drawings plus recommended safety factor of manufacturer.

C. Manufacturing Quality Assurance: Conform to Expansion Joints Manufacturers Association Standards.

D. Bellows - Internally Pressurized Type:

1. Multiple corrugations of Type 304 or Type A240-321 stainless steel.
2. Internal stainless steel sleeve entire length of bellows.
3. External cast iron equalizing rings for services exceeding 340 kPa (50 psig).
4. Welded ends.
5. Design shall conform to standards of EJMA and ASME B31.1.
6. External tie rods designed to withstand pressure thrust force upon anchor failure if one or both anchors for the joint are at change in direction of pipeline.
7. Integral external cover.

E. 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. Welded ends.
5. Conform to the standards of EJMA and ASME B31.1.
6. Threaded connection at bottom, 25 mm (one inch) minimum, for drain or drip point.
7. Integral external cover and internal sleeve.

F. 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.

2.11 FLEXIBLE BALL JOINTS

- A. Design and Fabrication: One piece component construction, fabricated from steel with welded ends, designed for a working steam pressure of 1720 kPa (250 psig) and a temperature of 232 degrees C (450 degrees F). Each joint shall provide for 360 degrees rotation in addition to a minimum angular flexible movement of 30 degrees for sizes 6 mm (1/4 inch) to 150 mm (6 inch) inclusive, and 15 degrees for sizes 65 mm (2-1/2 inches) to 750 mm (30 inches). Joints through 350 mm (14 inches) shall have forged pressure retaining members; while size 400 mm (16 inches) through 760 mm (30 inches) shall be of one piece construction.
- B. Material:
 - 1. Cast or forged steel pressure containing parts and bolting in accordance with Section II of the ASME Boiler Code or ASME B31.1. Retainer may be ductile iron ASTM A536, Grade 65-45-12, or ASME Section II SA 515, Grade 70.
 - 2. Gaskets: Steam pressure molded composition design for a temperature range of from minus 10 degrees C (50 degrees F) to plus 274 degrees C (525 degrees F).
- C. Certificates: Submit qualifications of ball joints in accordance with the following test data:
 - 1. Low pressure leakage test: 41 kPa (6psig) saturated steam for 60 days.
 - 2. Flex cycling: 800 Flex cycles at 3445 kPa (500 psig) saturated steam.
 - 3. Thermal cycling: 100 saturated steam pressure cycles from atmospheric pressure to operating pressure and back to atmospheric pressure.
 - 4. Environmental shock tests: Forward certificate from a recognized test laboratory, that ball joints of the type submitted has passed shock testing in accordance with Mil. Spec MIL-S-901.
 - 5. Vibration: 170 hours on each of three mutually perpendicular axis at 25 to 125 Hz; 1.3 mm to 2.5 mm (0.05 inch to 0.1 inch) double amplitude on a single ball joint and 3 ball joint off set.

2.12 STEAM SYSTEM COMPONENTS

- A. Heat Exchanger (Steam to Hot Water): Shell and tube type, U-bend removable tube bundle, steam in shell, water in tubes, equipped with support cradles.
 - 1. Maximum tube velocity: 2.3 m/s (7.5 feet per second).
 - 2. Tube fouling factor: TEMA Standards, but not less than 0.00018 m²K/W (0.001 ft²hrF/Btu).
 - 3. Materials:
 - a. Shell: Steel.
 - b. Tube sheet and tube supports: Steel or brass.
 - c. Tubes: 20 mm (3/4 inch) OD copper.
 - d. Head or bonnet: Cast iron or steel.

4. Construction: In accordance with ASME Pressure Vessel Code for 861 kPa (125 psig) working pressure for shell and tubes. Provide manufacturer's certified data report, Form No. U-1.
- B. Optional Heat Transfer Package: In lieu of field erected individual components, the Contractor may provide a factory or shop assembled package of heat exchangers and other components supported on a welded steel frame.
- C. Steam Pressure Reducing Valves in PRV Stations:
1. Type: Single-seated, diaphragm operated, spring-loaded, external or internal steam pilot-controlled, normally closed, adjustable set pressure. Pilot shall sense controlled pressure downstream of main valve.
 2. Service: Provide controlled reduced pressure to steam piping systems.
 3. Pressure control shall be smooth and continuous with maximum drop of 10 percent. Maximum flow capability of each valve shall not exceed capacity of downstream safety valve(s).
 4. Main valve and pilot valve shall have replaceable valve plug and seat of stainless steel, monel, or similar durable material.
 - a. Pressure rating for high pressure steam: Not less than 1034 kPa (150 psig) saturated steam.
 - b. Connections: Flanged for valves 65 mm (2-1/2 inches) and larger; flanged or threaded ends for smaller valves.
- D. Safety Valves and Accessories: Comply with ASME Boiler and Pressure Vessel Code, Section VIII. Capacities shall be certified by National Board of Boiler and Pressure Vessel Inspectors, maximum accumulation 10 percent. Provide lifting lever. Provide drip pan elbow where shown.
- E. Steam PRV for Individual Equipment: Cast iron or bronze body, screwed or flanged ends, rated 861 kPa (125 psig) working pressure. Single-seated, diaphragm operated, spring loaded, adjustable range, all parts renewable.
- F. Flash Tanks: Horizontal or vertical vortex type, constructed of copper bearing steel, ASTM A516 or ASTM A285, for a steam working pressure of 861 kPa (125 psig) to comply with ASME Code for Unfired Pressure Vessels and stamped with "U" symbol. Perforated pipe inside tank shall be ASTM A53 Grade B, Seamless or ERW, or A106 Grade B Seamless, Schedule 80. Corrosion allowance of 1.6 mm (1/16 inch) may be provided in lieu of the copper bearing requirement. Provide data Form No. U-1.

G. Steam Trap: Each type of trap shall be the product of a single manufacturer. Provide trap sets at all low points and at 61 m (200 feet) intervals on the horizontal main lines.

1. Floats and linkages shall provide sufficient force to open trap valve over full operating pressure range available to the system. Unless otherwise indicated on the drawings, traps shall be sized for capacities indicated at minimum pressure drop as follows:
 - a. For equipment with modulating control valve: 1.7 kPa (1/4 psig), based on a condensate leg of 300 mm (12 inches) at the trap inlet and gravity flow to the receiver.
 - b. For main line drip trap sets and other trap sets at steam pressure: Up to 70 percent of design differential pressure. Condensate may be lifted to the return line.
2. Trap bodies: Bronze, cast iron, or semi-steel, constructed to permit ease of removal and servicing working parts without disturbing connecting piping. For systems without relief valve traps shall be 5. Mechanism: Brass, stainless steel or corrosion resistant alloy. Rated for the pressure upstream of the PRV supplying the system.
3. Balanced pressure thermostatic elements: Phosphor bronze, stainless steel or monel metal.
4. Valves and seats: Suitable hardened corrosion resistant alloy.
5. Floats: Stainless steel.
6. Inverted bucket traps: Provide bi-metallic thermostatic element for rapid release of non-condensables.

H. Thermostatic Air Vent (Steam): Brass or iron body, balanced pressure bellows, stainless steel (renewable) valve and seat, rated 861 kPa (125 psig) working pressure, 20 mm (3/4 inch) screwed connections. Air vents shall be balanced pressure type that responds to steam pressure-temperature curve and vents air at any pressure.

2.13 GAGES, PRESSURE AND COMPOUND

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

- C. Range of Gages: For services not listed provide range equal to at least 130 percent of normal operating range:

Low pressure steam and steam condensate to 103 kPa(15 psig)	0 to 207 kPa (30 psig).
Medium pressure steam and steam condensate nominal 413 kPa (60 psig)	0 to 689 kPa (100 psig).
High pressure steam and steam condensate nominal 620 kPa to 861 kPa (90 to 125 psig)	0 to 1378 kPa (200 psig).
Pumped condensate, steam condensate, gravity or vacuum (30" HG to 30 psig)	0 to 415 kPa (60 psig)

2.14 PRESSURE/TEMPERATURE TEST PROVISIONS

- A. Provide one each of the following test items to the Resident Engineer:
1. 6 mm (1/4 inch) FPT by 3 mm (1/8 inch) diameter stainless steel pressure gage adapter probe for extra long test plug. PETE'S 500 XL is an example.
 2. 90 mm (3-1/2 inch) diameter, one percent accuracy, compound gage, 762 mm (30 inches) Hg to 689 kPa (100 psig) range.
 3. 0 - 104 degrees C (32-220 degrees F) pocket thermometer one-half degree accuracy, 25 mm (one inch) dial, 125 mm (5 inch) long stainless steel stem, plastic case.

2.15 FIRESTOPPING MATERIAL

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

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. Install convertors and other heat exchangers at height sufficient to provide gravity flow of condensate to the flash tank and condensate pump.
- D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (one inch) minimum clearance between adjacent piping or other surface. Unless shown otherwise, slope steam, condensate and drain piping down in the direction of flow not less than 25 mm (one inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.
- E. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.
- F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted on the drawings.
- G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.
- H. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:
 - 1. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.
- I. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11 INSULATION.
- J. Where copper piping is connected to steel piping, provide dielectric connections.
- K. Pipe vents to the exterior. Where a combined vent is provided, the cross sectional area of the combined vent shall be equal to sum of individual vent areas. Slope vent piping one inch in 40 feet (0.25 percent) in direction of flow. Provide a drip trap elbow on relief valve outlets if the vent rises to prevent backpressure. Terminate vent minimum 0.3 M (12 inches) above the roof or through the wall minimum 2.5 M (8 feet) above grade with down turned elbow.

3.2 PIPE JOINTS

- A. Welded: Beveling, spacing and other details shall conform to ASME B31.1 and AWS B2.1. See Welder's qualification requirements under "Quality Assurance" in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

- B. Screwed: Threads shall conform to ASME B1.20; joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.
- C. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.

3.3 EXPANSION JOINTS (BELLOWS AND SLIP TYPE)

- A. Anchors and Guides: 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 must 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 packing.

3.4 STEAM TRAP PIPING

- A. Install to permit gravity flow to the trap. Provide gravity flow (avoid lifting condensate) from the trap where modulating control valves are used. Support traps weighing over 11 kg (25 pounds) independently of connecting piping.

3.5 LEAK TESTING

- A. Inspect all joints and connections for leaks and workmanship and make corrections as necessary, to the satisfaction of the Resident Engineer in accordance with the specified requirements. Testing shall be performed in accordance with the specification requirements.
- B. An operating test at design pressure, and for hot systems, design maximum temperature.
- C. A hydrostatic test at 1.5 times design pressure. For water systems the design maximum pressure would usually be the static head, or expansion tank maximum pressure, plus pump head. Factory tested equipment (convertors, exchangers, coils, etc.) need not be field tested. Avoid excessive pressure on mechanical seals and safety devices.

3.6 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Steam, Condensate and Vent Piping: No flushing or chemical cleaning required. Accomplish cleaning by pulling all strainer screens and cleaning all scale/dirt legs during start-up operation.

3.7 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

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

3.9 COMMISSIONING

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

--- E N D ---

SECTION 23 22 23
STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Steam condensate pumps for Heating, Ventilating and Air Conditioning.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING ANDEQUIPMENT.
- E. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.
- F. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- 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. Select pumps so that required net positive suction head (NPSHR) does not exceed the net positive head available (NPSHA).

4. Pump Driver: Furnish with pump. Size shall be non-overloading at any point on the head-capacity curve including one pump operation in a parallel or series pumping installation.
 5. Provide all pumps with motors, impellers, drive assemblies, bearings, coupling guard and other accessories specified. Statically and dynamically balance all rotating parts.
 6. Furnish each pump and motor with a nameplate giving the manufacturers name, serial number of pump, capacity in GPM and head in feet at design condition, horsepower, voltage, frequency, speed and full load current and motor efficiency.
 7. Test all pumps before shipment. The manufacturer shall certify all pump ratings.
 8. After completion of balancing, provide replacement of impellers or trim impellers to provide specified flow at actual pumping head, as installed.
 9. Furnish one spare seal and casing gasket for each pump to the Resident Engineer.
- C. Allowable Vibration Tolerance for Pump Units: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

1.5 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.
- C. Manufacturer's installation, maintenance and operating instructions, in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Characteristic Curves: Head-capacity, efficiency-capacity, brake horsepower-capacity, and NPSHR-capacity for each pump.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only:
- B. American Iron and Steel Institute (AISI):

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

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

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

ANSI B16.1-05Cast 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
 - B62-09Standard Specification for Composition Bronze or Ounce Metal Castings
- E. Maintenance and Operating Manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

1.6 DEFINITIONS

- A. Capacity: Liters per second (L/s) (Gallons per minute (GPM)) of the fluid pumped.
- B. Head: Total dynamic head in kPa (feet) of the fluid pumped.

PART 2 - PRODUCTS

2.1 CONDENSATE PUMP, PAD-MOUNTED

- A. General: Factory assembled unit consisting of vented receiver tank, motor-driven pumps, interconnecting piping and wiring, motor controls (including starters, if necessary) and accessories, designed to receive, store, and pump steam condensate.
- B. Receiver Tank: Cast iron with threaded openings for connection of piping and accessories and facilities for mounting float switches. Receivers for simplex pumps shall include all facilities for future mounting of additional pump and controls.
- C. Furnish seals for condensate pump with a minimum temperature rating of 121 degrees C (250 degrees F).
- D. Centrifugal Pumps: Bronze fitted with mechanical shaft seals.
 - 1. Designed to allow removal of rotating elements without disturbing connecting piping or pump casing mounting.
 - 2. Shafts: Stainless steel, AISI Type 416 or alloy steel with bronze shaft sleeves.
 - 3. Bearings: Regreaseable ball or roller type.
 - 4. Casing wearing rings: Bronze.
- E. Motors: Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.
- F. Pump Operation:
 - 1. Float Switches: NEMA 1, mounted on receiver tank, to start and stop pumps in response to changes in the water level in the receiver and adjustable to permit the controlled water levels to be changed. Floats and connecting rods shall be copper, bronze or stainless steel.

2. Alternator: Provide for duplex units to automatically start the second pump when the first pump fails in keeping the receiver water level from rising and to alternate the order of starting the pumps. For units 0.25 kW (1/3 horsepower) and smaller, the alternator may be the mechanical type for use in lieu of float switches.
- G. Control Cabinet for 3 Phase (0.37 kW (1/2 hp) and larger) Units: NEMA 1, UL approved, factory wired, enclosing all controls, with indicating lights, manual switches and resets mounted on the outside of the panel. Attach cabinet to the pump set with rigid steel framework, unless remote mounting is noted on the pump schedule.
1. Motor starters: Magnetic contact types with circuit breakers or combination fusible disconnect switches. Provide low voltage control circuits (120 volt maximum) and "hand-off-automatic" (H-O-A) switches for each pump.
 2. Indicating lights for each pump: Green to show that power is on, red to show that the pump is running.
- H. Electric Wiring: Suitable for 93 degrees C (200 degrees F) service; enclosed in liquid-tight flexible metal conduit where located outside of control cabinet.
- I. Receiver Accessories:
1. Thermometer: 34-216 degrees C (100 - 420 degrees F), mounted below minimum water level.
 2. Water level gage glass: Brass with gage cocks which automatically stop the flow of water when the glass is broken. Provide drain on the lower gage cock and protection rods for the glass.

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. Permanently support in-line pumps by the connecting piping only, not from the casing or the motor eye bolt.
- C. Sequence of installation for base-mounted pumps:
1. Level and shim the unit base and grout to the concrete pad.
 2. Shim the driver and realign the pump and driver. Correct axial, angular or parallel misalignment of the shafts.
 3. Connect properly aligned and independently supported piping.
 4. Recheck alignment.
- D. Pad-mounted Condensate Pump: Level, shim, bolt, and grout the unit base onto the concrete pad.

- E. Sump Type Condensate Pump: Apply two coats of asphalt or bituminous compound on the exterior of the receiver tank, and mount level and flush in the floor with waterproofing gaskets and grouting to prevent ground water from entering the building from around the receiver.
- F. Coordinate location of thermometer and pressure gauges as per Section 23 22 13, STEAM AND CONDENSATE HEATING 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.

3.3 COMMISSIONING

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

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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.

1.2 RELATED WORK

- A. Test requirements and instructions on use of equipment/system: Section 01 00 00, GENERAL REQUIREMENTS.
- B. General mechanical requirements and items, which are common to more than one section of Division 23: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- C. Piping and valves: Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.
- D. Cooling Towers: Section 23 65 00, COOLING TOWERS.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

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

- B. Technical Services: Provide the services of an experienced water treatment chemical engineer or technical representative to direct flushing, cleaning, pre-treatment, training, debugging, and acceptance testing operations; direct and perform chemical limit control during construction period and monitor systems for a period of 12 months after acceptance, including not less than 6 service calls and written status reports. Emergency calls are not included. Minimum service during construction/start-up shall be 6 hours.
Chemical Treatment Service shall be provided by ChemTreat.
- C. Field Quality Control and Certified Laboratory Reports: During the one year guarantee period, the water treatment laboratory shall provide not less than 12 reports based on on-site periodic visits, as stated in paragraph 1.3.B, sample taking and testing, and review with VA personnel, of water treatment control for the previous period. In addition to field tests, the water treatment laboratory shall provide certified laboratory test reports. These monitoring reports shall assess chemical treatment accuracy, scale formation, fouling and corrosion control, and shall contain instructions for the correction of any out-of-control condition.
- D. 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.

1.5 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.
- 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.

1.6 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):
70-11National 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 121 degrees C (250 degrees F) and 52 degrees C (125 degrees Fahrenheit) respectively. Heat exchanger fouling and capacity reduction shall not exceed that allowed by fouling factor 0.0005.
- D. Pot Feeder: By-pass type, complete with necessary shut off valves, drain and air release valves, and system connections, for introducing chemicals into system, cast iron or steel tank with funnel or large opening on top for easy chemical addition. Feeders shall be 18.9 L (five gallon) minimum capacity at 860 kPa (125 psig) minimum working pressure.

2.3 CHEMICAL TREATMENT FOR OPEN LOOP SYSTEM(S)

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 IN 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: 0-100 degC (32-212 degF) 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.

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 line.
 - b. Cooling tower bleed off line.
- E. Provide CPVC injection nozzles, ASTM F441 with corporation stop to inject chemical into main circulating water line.
 1. Pressure rating: 700kPa (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 PH 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 spill pallets for chemical drums:
 - 1. Material: Polyethylene.
 - 2. Capacity: 250 L (66 GAL) each.
 - 3. Dimensions each: DN135 (53 IN) length x DN74 (29 IN) wide X DN43 (17 IN) high.
 - 4. Provide each pallet with grating and drain plug.
 - 5. Provide one portable loading ramp.
 - 6. Quantity: Two (2).
- I. Provide liquid level switch assemblies with a CPVC bung hole adapter, ASTM F441, to mount directly into 200 L (55 GAL) chemical drum bung hole.
 - 1. Interface with main control panel.
 - 2. Quantity: Three (3).
- J. Corrosion monitor rack:
 - 1. Materials: Corrosion resistant.
 - 2. Construction: ASME specifications.
 - 3. Number of coupons: four (4).
 - 4. Coupon holders: quick disconnect type.
- K. Provide test kits for monitoring inhibitor levels, total dissolved solids, chlorides, alkalinity and closed system inhibitors.
- L. 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.
 7. Where analysis justifies addition of pH control, provide alteration of chemical formulation.
- M. 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 47 L (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.
- N. Water Analysis: Confirm raw water analysis or provide analysis if none is furnished:
- O. 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 or 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

P. Centrifugal Solid Separator:

1. Material: The separator shall be fabricated of carbon steel with shell material and head material of 0.135 inch wall or heavier. Maximum operating pressure shall be 10.3 bar (150 psi), unless specified otherwise.
2. Finish: Paint coating shall be acrylic urethane, spray-on, and royal blue.
3. Performance: The removal of solids from a pumped/pressurized liquid system shall be accomplished with a centrifugal-action vortex separator. Solids removal efficiency is principally predicated on the difference in specific gravity between the solids and the liquid. Single pass test performance shall be less than 95% removal of solids 74 microns and larger. Pressure loss shall be between 0.3 - 0.8 Bar (5-12 psi).
4. Purging: Evacuation of separated solids shall be accomplished automatically, employing a timer-activated motorized ball valve. Straight-through valve design, with bronze valve body and stainless steel ball in a Teflon seat. NEMA 4 housing for indoor and outdoor installation. Valve size: 50 mm (2").

Q. 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.

2.5 EQUIPMENT AND MATERIALS IDENTIFICATION

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

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Delivery and Storage: Deliver all chemicals in manufacturer's sealed shipping containers. Store in designated space and protect from deleterious exposure and hazardous spills.
- B. Install equipment furnished by the chemical treatment supplier and charge systems according to the manufacturer's instructions and as directed by the Technical Representative.
- C. Refer to Section 23 21 13 HYDRONIC PIPING for chemical treatment piping, installed as follows:
 1. Provide a by-pass line around water meters and bleed off piping assembly. Provide ball valves to allow for bypassing, isolation, and servicing of components.
 2. 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 piping for corrosion monitor rack per manufacturer's installation instructions. Provide ball valves to isolate and service rack.
6. Provide installation supervision, start-up and operating instruction by manufacturer's technical representative.
- D. Before adding cleaning chemical to the closed system, all air handling coils and fan coil units should be isolated by closing the inlet and outlet valves and opening the bypass valves. This is done to prevent dirt and solids from lodging the coils.
- E. Do not valve in or operate system pumps until after system has been cleaned.
- F. After chemical cleaning is satisfactorily completed, open the inlet and outlet valves to each coil and close the by-pass valves. Also, clean all strainers.
- G. 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.

3.2 COMMISSIONING

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

--- E N D ---

SECTION 23 31 00
HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

- A. Fire Stopping Material: Section 07 84 00, FIRESTOPPING.
- B. Outdoor and Exhaust Louvers: Section 08 90 00, LOUVERS AND VENTS.
- C. General Mechanical Requirements: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Noise Level Requirements: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- E. Duct Insulation: Section 23 07 11, HVAC INSULATION.
- F. Plumbing Connections: Section 22 11 00, FACILITY WATER DISTRIBUTION
- G. Air Flow Control Valves and Terminal Units: Section 23 36 00, AIR TERMINAL UNITS.
- H. Supply Air Fans: Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- I. Return Air and Exhaust Air Fans: Section 23 34 00, HVAC FANS.
- J. Air Filters and Filters' Efficiencies: Section 23 40 00, HVAC AIR CLEANING DEVICES.
- K. Duct Mounted Instrumentation: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- L. Testing and Balancing of Air Flows: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

M. Smoke Detectors: Section 28 31 00, FIRE DETECTION AND ALARM.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

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

1.5 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Rectangular ducts:
 - a. Schedules of duct systems, materials and selected SMACNA construction alternatives for joints, sealing, gage and reinforcement.
 - b. Sealants and gaskets.
 - c. Access doors.

2. Round and flat oval duct construction details:
 - a. Manufacturer's details for duct fittings.
 - b. Duct liner.
 - c. Sealants and gaskets.
 - d. Access sections.
 - e. Installation instructions.
 3. Volume dampers, back draft dampers, and remote dampers.
 4. Upper hanger attachments.
 5. Fire dampers, fire doors, and smoke dampers with installation instructions.
 6. Flexible ducts and clamps, with manufacturer's installation instructions.
 7. Flexible connections.
 8. Instrument test fittings.
 9. Details and design analysis of alternate or optional duct systems.
- C. Coordination Drawings: Refer to article, SUBMITTALS, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Civil Engineers (ASCE):

ASCE7-05Minimum Design Loads for Buildings and Other Structures
- C. American Society for Testing and Materials (ASTM):

A167-99(2009).....Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

A653-09Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy coated (Galvannealed) by the Hot-Dip process

A1011-09aStandard Specification for Steel, Sheet and Strip, Hot rolled, Carbon, structural, High-Strength Low-Alloy, High Strength Low-Alloy with Improved Formability, and Ultra-High Strength

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

C1071-05e1Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

- E84-09a.....Standard Test Method for Surface Burning Characteristics of Building Materials
- D. National Fire Protection Association (NFPA):
 - 90A-09Standard for the Installation of Air Conditioning and Ventilating Systems
 - 96-08Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
- E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
 - 2nd Edition – 2005.....HVAC Duct Construction Standards, Metal and Flexible
 - 1st Edition - 1985.....HVAC Air Duct Leakage Test Manual
 - 6th Edition – 2003Fibrous Glass Duct Construction Standards
- F. Underwriters Laboratories, Inc. (UL):
 - 181-08Factory-Made Air Ducts and Air Connectors
 - 555-06Standard for Fire Dampers
 - 555S-06Standard for Smoke Dampers

PART 2 - PRODUCTS

2.1 DUCT MATERIALS AND SEALANTS

- A. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A653, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003 or 5052.
- B. Specified Corrosion Resistant Systems: Stainless steel sheet, ASTM A167, Class 302 or 304, Condition A (annealed) Finish No. 4 for exposed ducts and Finish No. 2B for concealed duct or ducts located in mechanical rooms.
- C. Joint Sealing: Refer to SMACNA HVAC Duct Construction Standards, paragraph S1.9.
 - 1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer. Generally provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable because they do not retain elasticity and bond.
 - 2. Tape: Use only tape specifically designated by the sealant manufacturer and apply only over wet sealant. Pressure sensitive tape shall not be used on bare metal or on dry sealant.
 - 3. Gaskets in Flanged Joints: Soft neoprene.

D. Approved factory made joints may be used.

2.2 DUCT CONSTRUCTION AND INSTALLATION

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

B. Duct Pressure Classification:

0 to 50 mm (2 inch)

> 50 mm to 75 mm (2 inch to 3 inch)

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

Refer to pressure classifications on the floor plans.

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

D. Laboratory Hood, Exhaust and Associated Ductwork: 1.3 mm (18 gage) all welded Stainless steel.

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

1. Elbows: Diameters 80 through 200 mm (3 through 8 inches) shall be two sections die stamped, all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.

2. Provide bell mouth, conical tees or taps, laterals, reducers, and other low loss fittings as shown in SMACNA HVAC Duct Construction Standards.

3. Provide flat side reinforcement of oval ducts as recommended by the manufacturer and SMACNA HVAC Duct Construction Standard S3.13. Because of high pressure loss, do not use internal tie-rod reinforcement unless approved by the Resident Engineer.

F. Casings and Plenums: Construct in accordance with SMACNA HVAC Duct Construction Standards Section 6, including curbs, access doors, pipe penetrations, eliminators and drain pans. Access doors shall be hollow metal, insulated, with latches and door pulls, 500 mm (20 inches) wide by 1200 - 1350 mm (48 - 54 inches) high. Provide view port in the doors where shown. Provide drain for outside air louver plenum. Outside air plenum shall have exterior insulation. Drain piping shall be routed to the nearest floor drain.

- G. Volume Dampers: Single blade or opposed blade, multi-louver type as detailed in SMACNA Standards. Refer to SMACNA Detail Figure 2-12 for Single Blade and Figure 2.13 for Multi-blade Volume Dampers.
- H. Remote Balancing Dampers: Provide remote balancing dampers where dampers are located over inaccessible ceiling or where noted on plans. Dampers shall be powered type or cable type system. Powered type shall be equal to Greenheck EZ Balance system. Cable type shall be equal to Young Regulator cable system. Provide wall and ceiling plates for operation (type and location to be determined by architect).
- I. Duct Hangers and Supports: Refer to SMACNA Standards Section IV. Avoid use of trapeze hangers for round duct.

2.3 DUCT ACCESS DOORS, PANELS AND SECTIONS

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

2.4 FIRE DAMPERS

- A. Galvanized steel, interlocking blade type, UL listing and label, 1-1/2 hour rating, 70 degrees C (160 degrees F) fusible line, 100 percent free opening with no part of the blade stack or damper frame in the air stream.
- B. Minimum requirements for fire dampers:
 - 1. The damper frame may be of design and length as to function as the mounting sleeve, thus eliminating the need for a separate sleeve, as allowed by UL 555. Otherwise provide sleeves and mounting angles, minimum 1.9 mm (14 gage), required to provide installation equivalent to the damper manufacturer's UL test installation.
 - 2. Submit manufacturer's installation instructions conforming to UL rating test.

2.5 SMOKE DAMPERS

- A. Maximum air velocity, through free area of open damper, and pressure loss: Low pressure and medium pressure duct (supply, return, exhaust, outside air): 450 m/min (1500 fpm). Maximum static pressure loss: 32 Pa (0.13 inch W.G.).
- B. Maximum air leakage, closed damper: 0.32 cubic meters /min/square meter (4.0 CFM per square foot) at 750 Pa (3 inch W.G.) differential pressure.
- C. Minimum requirements for dampers:
 - 1. Shall comply with requirements of Table 6-1 of UL 555S, except for the Fire Endurance and Hose Stream Test.
 - 2. Frame: Galvanized steel channel with side, top and bottom stops or seals.
 - 3. Blades: Galvanized steel, parallel type preferably, 300 mm (12 inch) maximum width, edges sealed with neoprene, rubber or felt, if required to meet minimum leakage. Airfoil (streamlined) type for minimum noise generation and pressure drop are preferred for duct mounted dampers.
 - 4. Shafts: Galvanized steel.
 - 5. Bearings: Nylon, bronze sleeve or ball type.
 - 6. Hardware: Zinc plated.
 - 7. Operation: Automatic open/close. No smoke damper that requires manual reset or link replacement after actuation is acceptable. See drawings for required control operation.
- D. Motor operator (actuator): Provide pneumatic or electric as required by the automatic control system, externally mounted on stand-offs to allow complete insulation coverage.

2.6 COMBINATION FIRE AND SMOKE DAMPERS

Combination fire and smoke dampers: Multi-blade type units meeting all requirements of both fire dampers and smoke dampers shall be used where shown and may be used at the Contractor's option where applicable.

2.7 FIRE DOORS

Galvanized steel, interlocking blade type, UL listing and label, 71 degrees C (160 degrees F) fusible link, 3 hour rating and approved for openings in Class A fire walls with rating up to 4 hours, 100 percent free opening with no part of the blade stack or damper frame in the air stream.

2.8 FLEXIBLE AIR DUCT

- A. General: Factory fabricated, complying with NFPA 90A for connectors not passing through floors of buildings. Flexible ducts shall not penetrate any fire or smoke barrier which is required to have a fire resistance rating of one hour or more. Flexible duct length shall not exceed 1.5 m

(5 feet). Provide insulated acoustical air duct connectors in supply air duct systems and elsewhere as shown.

- B. Flexible ducts shall be listed by Underwriters Laboratories, Inc., complying with UL 181. Ducts larger than 200 mm (8 inches) in diameter shall be Class 1. Ducts 200 mm (8 inches) in diameter and smaller may be Class 1 or Class 2.

- C. Insulated Flexible Air Duct: Factory made including mineral fiber insulation with maximum C factor of 0.25 at 24 degrees C (75 degrees F) mean temperature, encased with a low permeability moisture barrier outer jacket, having a puncture resistance of not less than 50 Beach Units. Acoustic insertion loss shall not be less than 3 dB per 300 mm (foot) of straight duct, at 500 Hz, based on 150 mm (6 inch) duct, of 750 m/min (2500 fpm).
- D. Application Criteria:
 - 1. Temperature range: -18 to 93 degrees C (0 to 200 degrees F) internal.
 - 2. Maximum working velocity: 1200 m/min (4000 feet per minute).
 - 3. Minimum working pressure, inches of water gage: 2500 Pa (10 inches) positive, 500 Pa (2 inches) negative.
- E. Duct Clamps: 100 percent nylon strap, 80 kg (175 pounds) minimum loop tensile strength manufactured for this purpose or stainless steel strap with cadmium plated worm gear tightening device. Apply clamps with sealant and as approved for UL 181, Class 1 installation.

2.9 FLEXIBLE DUCT CONNECTIONS

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

2.10 FIRESTOPPING MATERIAL

Refer to Section 07 84 00, FIRESTOPPING.

2.11 DUCT MOUNTED THERMOMETER (AIR)

- A. Stem Type Thermometers: ASTM E1, 7 inch scale, red appearing mercury, lens front tube, cast aluminum case with enamel finish and clear glass or polycarbonate window, brass stem, 2 percent of scale accuracy to ASTM E77 scale calibrated in degrees Fahrenheit.
- B. Thermometer Supports:
 - 1. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.

2. Flange: 3 inch outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.12 DUCT MOUNTED TEMPERATURE SENSOR (AIR)

Refer to Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

2.13 INSTRUMENT TEST FITTINGS

- A. Manufactured type with a minimum 50 mm (two inch) length for insulated duct, and a minimum 25 mm (one inch) length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.
- B. Provide instrument test holes at each duct or casing mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil, cooling coil, and heat recovery unit.

2.14 ELECTROSTATIC SHIELDING

- A. At the point of penetration of shielded rooms ducts shall be made electrically discontinuous by means of a flexible, nonconductive connection outside shielded room.
- B. Metallic duct portion inside shielded room shall be electrically bonded to shielding.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, particularly regarding coordination with other trades and work in existing buildings.
- B. Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards:
 1. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.
 2. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards, Section II. Provide streamliner, when an obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.

3. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA Standards.
 4. Construct casings, eliminators, and pipe penetrations in accordance with SMACNA Standards, Chapter 6. Design casing access doors to swing against air pressure so that pressure helps to maintain a tight seal.
- C. Install duct hangers and supports in accordance with SMACNA Standards, Chapter 4.
- D. Install fire dampers, smoke dampers and combination fire/smoke dampers in accordance with the manufacturer's instructions to conform to the installation used for the rating test. Install fire dampers, smoke dampers and combination fire/smoke dampers at locations indicated and where ducts penetrate fire rated and/or smoke rated walls, shafts and where required by the Resident Engineer. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges per UL and NFPA. Demonstrate re-setting of fire dampers and operation of smoke dampers to the Resident Engineer.
- E. Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.
- F. Flexible duct installation: Refer to SMACNA Standards, Chapter 3. Ducts shall be continuous, single pieces not over 1.5 m (5 feet) long (NFPA 90A), as straight and short as feasible, adequately supported. Centerline radius of bends shall be not less than two duct diameters. Make connections with clamps as recommended by SMACNA. Clamp per SMACNA with one clamp on the core duct and one on the insulation jacket. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including corridor partitions fire rated one hour or two hour. Support ducts SMACNA Standards.
- G. Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.
- H. Control Damper Installation:
1. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.
 2. Assemble multiple sections dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.
 3. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.

4. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.
- I. Air Flow Measuring Devices (AFMD): Install units with minimum straight run distances, upstream and downstream as recommended by the manufacturer.
- J. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement, as determined by Resident Engineer. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to existing ductwork, clean both new and existing ductwork by mopping and vacuum cleaning inside and outside before operation.

3.2 DUCT LEAKAGE TESTS AND REPAIR

- A. Ductwork leakage testing shall be performed by the Testing and Balancing Contractor directly contracted by the General Contractor and independent of the Sheet Metal Contractor.
- B. Ductwork leakage testing shall be performed for the entire air distribution system (including all supply, return, exhaust and relief ductwork), section by section, including fans, coils and filter sections. Based upon satisfactory initial duct leakage test results, the scope of the testing may be reduced by the Resident Engineer on ductwork constructed to the 500 Pa (2" WG) duct pressure classification. In no case shall the leakage testing of ductwork constructed above the 500 Pa (2" WG) duct pressure classification or ductwork located in shafts or other inaccessible areas be eliminated..
- C. Test procedure, apparatus and report shall conform to SMACNA Leakage Test manual. The maximum leakage rate allowed is 4 percent of the design air flow rate.
- D. All ductwork shall be leak tested first before enclosed in a shaft or covered in other inaccessible areas.
- E. All tests shall be performed in the presence of the Resident Engineer and the Test and Balance agency. The Test and Balance agency shall measure and record duct leakage and report to the Resident Engineer and identify leakage source with excessive leakage.
- F. If any portion of the duct system tested fails to meet the permissible leakage level, the Contractor shall rectify sealing of ductwork to bring it into compliance and shall retest it until acceptable leakage is demonstrated to the Resident Engineer.
- G. All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.
- H. Make sure all openings used for testing flow and temperatures by TAB Contractor are sealed properly.

3.3 TESTING, ADJUSTING AND BALANCING (TAB)

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

3.4 OPERATING AND PERFORMANCE TESTS

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

3.5 COMMISSIONING

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

--- E N D ---

SECTION 23 34 00 HVAC FANS

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.
- E. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- F. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- G. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Fans and power ventilators shall be listed in the current edition of AMCA 261, and shall bear the AMCA performance seal.
- C. Operating Limits for Centrifugal Fans: AMCA 99 (Class I, II, and III).

- D. Fans and power ventilators shall comply with the following standards:
 - 1. Testing and Rating: AMCA 210.
 - 2. Sound Rating: AMCA 300.
- E. Vibration Tolerance for Fans and Power Ventilators: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- F. Performance Criteria:
 - 1. The fan schedule shall show the design air volume and static pressure. Select the fan motor HP by increasing the fan BHP by 10 percent to account for the drive losses and field conditions.
 - 2. Select the fan operating point as follows:
 - a. Forward Curve and Axial Flow Fans: Right hand side of peak pressure point
 - b. Air Foil, Backward Inclined, or Tubular: At or near the peak static efficiency
- G. Safety Criteria: Provide manufacturer's standard screen on fan inlet and discharge where exposed to operating and maintenance personnel.
- H. Corrosion Protection:
 - 1. Except for fans in fume hood exhaust service, all steel shall be mill-galvanized, or phosphatized and coated with minimum two coats, corrosion resistant enamel paint. Manufacturers paint and paint system shall meet the minimum specifications of: ASTM D1735 water fog; ASTM B117 salt spray; ASTM D3359 adhesion; and ASTM G152 and G153 for carbon arc light apparatus for exposure of non-metallic material.
 - 2. Fans for general purpose fume hoods, or chemical hoods, and radioisotope hoods shall be constructed of materials compatible with the chemicals being transported in the air through the fan.
- I. Spark resistant construction: If flammable gas, vapor or combustible dust is present in concentrations above 20% of the Lower Explosive Limit (LEL), the fan construction shall be as recommended by AMCA's Classification for Spark Resistant Construction. Drive set shall be comprised of non-static belts for use in an explosive.

1.5 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturers Literature and Data:
 - 1. Fan sections, motors and drives.

2. Centrifugal fans, motors, drives, accessories and coatings.
 3. Prefabricated roof curbs.
 4. Power roof ventilators.
- C. Certified Sound power levels for each fan.
 - D. Motor ratings types, electrical characteristics and accessories.
 - E. Roof curbs.
 - F. Belt guards.
 - G. Maintenance and Operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
 - H. Certified fan performance curves for each fan showing cubic feet per minute (CFM) versus static pressure, efficiency, and horsepower for design point of operation.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Movement and Control Association International, Inc. (AMCA):

99-86	Standards Handbook
210-06	Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
261-09	Directory of Products Licensed to bear the AMCA Certified Ratings Seal - Published Annually
300-08	Reverberant Room Method for Sound Testing of Fans
- C. American Society for Testing and Materials (ASTM):

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

D. National Fire Protection Association (NFPA):

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

E. National Sanitation Foundation (NSF):

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

F. Underwriters Laboratories, Inc. (UL):

181-2005Factory Made Air Ducts and Air Connectors

1.7 EXTRA MATERIALS

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

PART 2 - PRODUCTS

2.1 CENTRIFUGAL FANS

- A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE. Record factory vibration test results on the fan or furnish to the Contractor.
- B. Construction: Wheel diameters and outlet areas shall be in accordance with AMCA standards.
1. Housing: Low carbon steel, arc welded throughout, braced and supported by structural channel or angle iron to prevent vibration or pulsation, flanged outlet, inlet fully streamlined. Provide lifting clips, and casing drain. Provide manufacturer's standard access door. Provide 12.5 mm (1/2 inches) wire mesh screens for fan inlets without duct connections.
 2. Wheel: Steel plate with die formed blades welded or riveted in place, factory balanced statically and dynamically.
 3. Shaft: Designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fans class.
 4. Bearings: Heavy duty ball or roller type sized to produce a B10 life of not less than 50,000 hours, and an average fatigue life of 200,000 hours. Extend filled lubrication tubes for interior bearings or ducted units to outside of housing.
 5. Belts: Oil resistant, non-sparking and non-static.
 6. Belt Drives: Factory installed with final alignment belt adjustment made after installation.
 7. Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15HP, fixed pitch for use with motors larger than 15HP. Select pulleys so that pitch adjustment is at the middle of the adjustment range at fan design conditions.
 8. Motor, adjustable motor base, drive and guard: Furnish from factory with fan. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC for specifications. Provide protective sheet metal enclosure for fans located outdoors.

9. Furnish variable speed fan motor controllers where shown on the drawings. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC for controller/motor combination requirements.

2.2 POWER ROOF VENTILATOR

- A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE.
- B. Type: Centrifugal fan, backward inclined blades. Provide down-blast or up-blast type as indicated.
- C. Construction: Steel or aluminum, completely weatherproof, for curb mounting, exhaust cowl or entire drive assembly readily removable for servicing, aluminum bird screen on discharge, UL approved safety disconnect switch, conduit for wiring, vibration isolators for wheel, motor and drive assembly. Provide electric motor operated damper where indicated.
- D. Motor and Drive: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
Bearings shall be pillow block ball type with a minimum L-50 life of 200,000 hours. Motor shall be located out of air stream.
- E. Prefabricated Roof Curb: As specified in paragraph 2.3 of this section.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install fan, motor and drive in accordance with manufacturer's instructions.
- B. Align fan and motor sheaves to allow belts to run true and straight.
- C. Bolt equipment to curbs with galvanized lag bolts.
- D. Install vibration control devices as shown on drawings and specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

3.2 PRE-OPERATION MAINTENANCE

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

3.3 START-UP AND INSTRUCTIONS

- A. Verify operation of motor, drive system and fan wheel according to the drawings and specifications.
- B. Check vibration and correct as necessary for air balance work.

- C. After air balancing is complete and permanent sheaves are in place perform necessary field mechanical balancing to meet vibration tolerance in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

3.4 COMMISSIONING

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

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SECTION 23 36 00
AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

Air terminal units.

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- B. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT: Noise requirements.
- C. Section 23 31 00, HVAC DUCTS AND CASINGS: Ducts and flexible connectors.
- D. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Valve operators.
- E. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC: Flow rates adjusting and balancing.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

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

1.5 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Air Terminal Units: Submit test data.

- C. Certificates:
 - 1. Compliance with paragraph, QUALITY ASSURANCE.
 - 2. Compliance with specified standards.
- D. Operation and Maintenance Manuals: Submit in accordance with paragraph, INSTRUCTIONS, in Section 01 00 00, GENERAL REQUIREMENTS.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning and Refrigeration Institute (AHRI)/(ARI):
 - 880-08Air Terminals Addendum to ARI 888-98 incorporated into standard posted 15th December 2002
- C. National Fire Protection Association (NFPA):
 - 90A-09Standard for the Installation of Air Conditioning and Ventilating Systems
- D. Underwriters Laboratories, Inc. (UL):
 - 181-08Standard for Factory-Made Air Ducts and Air Connectors
- E. American Society for Testing and Materials (ASTM):
 - C 665-06Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing

1.7 GUARANTY

- A. In accordance with the GENERAL CONDITIONS.

PART 2 - PRODUCTS

2.1 GENERAL

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

- B. Labeling: Control box shall be clearly marked with an identification label that lists such information as nominal CFM, maximum and minimum factory-set airflow limits, coil type and coil connection orientation, where applicable.
- C. Factory calibrate air terminal units to air flow rate indicated. All settings including maximum and minimum air flow shall be field adjustable.
- D. Dampers with internal air volume control: See section 23 31 00, HVAC DUCTS AND CASINGS.
- E. Terminal Sound Attenuators: See Section 23 31 00, HVAC DUCTS AND CASINGS.

2.2 AIR TERMINAL UNITS (BOXES)

- A. General: Factory built, pressure independent units, factory set-field adjustable air flow rate, suitable for single duct applications. Use of dual-duct air terminal units is not permitted. Clearly show on each unit the unit number and factory set air volumes corresponding to the contract drawings. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC work assumes factory set air volumes. Coordinate flow controller sequence and damper operation details with the drawings and Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. All air terminal units shall be brand new products of the same manufacturer.
- B. Capacity and Performance: The Maximum Capacity of a single terminal unit shall not exceed 566 Liters/second (1,200 CFM).
- C. Sound Power Levels: Acoustic performance of the air terminal units shall be based on the design noise levels for the spaces stipulated in Section 23 05 41 (Noise and Vibration Control for HVAC Piping and Equipment). Terminal sound attenuators shall be provided, as required, to meet the intent of the design.
- D. Casing: Unit casing shall be constructed of galvanized steel no lighter than 0.85 mm (22 Gauge). Provide hanger brackets for attachment of supports.
 - 1. Lining material: Suitable to provide required acoustic performance, thermal insulation and prevent sweating. Meet the requirements of NFPA 90A and comply with UL 181 for erosion as well as ASTM C 665 antimicrobial requirements. Insulation shall consist of 13 mm (1/2 IN) thick non-porous foil faced rigid fiberglass insulation of 4-lb/cu.ft, secured by full length galvanized steel z-strips which enclose and seal all edges. Tape and adhesives shall not be used. Materials shall be non-friable and with surfaces, including all edges, fully encapsulated and faced with perforated metal or coated so that the air stream will not detach material.

2. Access panels (or doors): Provide panels large enough for inspection, adjustment and maintenance without disconnecting ducts, and for cleaning heating coils attached to unit, even if there are no moving parts. Panels shall be insulated to same standards as the rest of the casing and shall be secured and gasketed airtight. It shall require no tool other than a screwdriver to remove.
 3. Total leakage from casing: Not to exceed 2 percent of the nominal capacity of the unit when subjected to a static pressure of 750 Pa (3 inch WG), with all outlets sealed shut and inlets fully open.
- E. Construct dampers and other internal devices of corrosion resisting materials which do not require lubrication or other periodic maintenance.
1. Damper Leakage: Not greater than 2 percent of maximum rated capacity, when closed against inlet static pressure of 1 kPa (4 inch WG).
- F. Provide multi-point velocity pressure sensors with external pressure taps.
1. Provide direct reading air flow rate table pasted to box.
- G. Provide static pressure tubes.
- H. Externally powered DDC variable air volume controller and damper actuator to be furnished under Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC for factory mounting on air terminal units. The DDC controller shall be electrically actuated.

PART 3 - EXECUTION

3.1 INSTALLATION

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

3.2 OPERATIONAL TEST

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

3.3 COMMISSIONING

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

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SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

- A. Outdoor and Exhaust Louvers: Section 08 90 00, LOUVERS AND VENTS.
- B. General Mechanical Requirements: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- C. Noise Level Requirements: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- D. Testing and Balancing of Air Flows: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

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

1.5 SUBMITTALS

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

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Diffusion Council Test Code:
 - 1062 GRD-84.....Certification, Rating, and Test Manual 4th Edition
- C. American Society of Civil Engineers (ASCE):
 - ASCE7-05Minimum Design Loads for Buildings and Other Structures
- D. American Society for Testing and Materials (ASTM):
 - A167-99 (2004).....Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip
 - B209-07Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
- E. National Fire Protection Association (NFPA):
 - 90A-09Standard for the Installation of Air Conditioning and Ventilating Systems
- F. Underwriters Laboratories, Inc. (UL):
 - 181-08UL Standard for Safety Factory-Made Air Ducts and Connectors

PART 2 - PRODUCTS

2.1 EQUIPMENT SUPPORTS

Refer to Section 21 05 11, COMMON WORK RESULTS FOR FIRE SUPPRESSION, Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, and Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.2 AIR OUTLETS AND INLETS

- A. Materials:
 - 1. Steel or aluminum. Provide manufacturer's standard gasket.
 - 2. Exposed Fastenings: The same material as the respective inlet or outlet. Fasteners for aluminum may be stainless steel.
 - 3. Contractor shall review all ceiling drawings and details and provide all ceiling mounted devices with appropriate dimensions and trim for the specific locations.
- B. Performance Test Data: In accordance with Air Diffusion Council Code 1062GRD. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT for NC criteria.

C. Air Supply Outlets:

1. Ceiling Diffusers: Suitable for surface mounting, exposed T-bar or special tile ceilings, off-white finish, square or round neck connection as shown on the drawings. Provide plaster frame for units in plaster ceilings.
 - a. Square, louver, fully adjustable pattern: Round neck, surface mounting unless shown otherwise on the drawings. Provide equalizing or control grid.
 - b. Louver face type: Square or rectangular, removable core for 1, 2, 3, or 4 way directional pattern. Provide equalizing or control grid.
 - c. Slot diffuser/plenum:
 - 1) Diffuser: Frame and support bars shall be constructed of heavy gauge extruded aluminum. Form slots or use adjustable pattern controllers, to provide stable, horizontal air flow pattern over a wide range of operating conditions.
 - 2) Galvanized steel boot.
 - 3) Provide inlet connection diameter equal to duct diameter shown on drawings or provide transition coupling if necessary. Inlet duct and plenum size shall be as recommended by the manufacturer.
2. Supply Registers and Grilles: Double deflection type.
 - a. Margin: Flat, 30 mm (1-1/4 inches) wide.
 - b. Bar spacing: 20 mm (3/4 inch) maximum.
 - c. Finish: Off white baked enamel for ceiling mounted units. Wall units shall have a prime coat for field painting, or shall be extruded with manufacturer's standard finish.

D. Return and Exhaust Registers and Grilles:

1. Finish: Off-white baked enamel for ceiling mounted units. Wall units shall have a prime coat for field painting, or shall be extruded aluminum with manufacturer's standard aluminum finish.
2. Standard Type: Fixed horizontal face bars set at 30 to 45 degrees, approximately 30 mm (1-1/4 inch) margin.
3. Egg Crate Grilles: Aluminum or Painted Steel 1/2 by 1/2 by 1/2 inch grid providing 90% free area.
 - a. Heavy extruded aluminum frame shall have countersunk screw mounting. Unless otherwise indicated, register blades and frame shall have factory applied white finish.
 - b. Grille shall be suitable for duct or surface mounting as indicated on drawings. All necessary appurtenances shall be provided to allow for mounting.

PART 3 - EXECUTION

3.1 INSTALLATION

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

3.2 TESTING, ADJUSTING AND BALANCING (TAB)

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

3.3 OPERATING AND PERFORMANCE TESTS

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

3.4 COMMISSIONING

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

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SECTION 23 40 00
HVAC AIR CLEANING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Air filters for heating, ventilating and air conditioning.
- B. Definitions: Refer to ASHRAE Standard 52.2 for definitions of face velocity, net effective filtering area, media velocity, initial resistance (pressure drop), MERV (Minimum Efficiency Reporting Value), PSE (Particle Size Efficiency), particle size ranges for each MERV number, dust holding capacity and explanation of electrostatic media based filtration products versus mechanical filtration products. Refer to ASHRAE Standard 52.2 Appendix J for definition of MERV-A.

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- B. Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS: Filter housing and racks.
- C. Section 23 74 13, PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS: Filter housing and racks.
- D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Air Filter Performance Report for Extended Surface Filters:
 - 1. Submit a test report for each Grade of filter being offered. The report shall not be more than three (3) years old and prepared by using test equipment, method and duct section as specified by ASHRAE Standard 52.2 for type filter under test and acceptable to Resident Engineer, indicating that filters comply with the requirements of this specification. Filters utilizing partial or complete synthetic media will be tested in compliance with pre-conditioning steps as stated in Appendix J. All testing is to be conducted on filters with a nominal 24 inch by 24 inch face dimension. Test for 150 m/min (500 fpm) will be accepted for lower velocity rated filters provided the test report of an independent testing laboratory complies with all the requirements of this specification.
- B. Filter Warranty for Extended Surface Filters: Guarantee the filters against leakage, blow-outs, and other deficiencies during their normal useful life, up to the time that the filter reaches the final pressure drop. Defective filters shall be replaced at no cost to the Government.
- C. Comply with UL Standard 900 for flame test.
- D. Nameplates: Each filter shall bear a label or name plate indicating manufacturer's name, filter size, rated efficiency, and UL classification.

1.5 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data.
- C. Air Filter performance reports.
- D. Suppliers warranty.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc. (ASHRAE):
52.2-2007.....Method of Testing General Ventilation Air-Cleaning Devices for Removal
Efficiency by Particle Size, including Appendix J
- C. American Society of Mechanical Engineers (ASME):
NQA-1-2008Quality Assurance Requirements for Nuclear Facilities
Applications

D. Underwriters Laboratories, Inc. (UL):

900; Revision 15 July 2009 Test Performance of Air Filter Units

PART 2 - PRODUCTS

2.1 REPLACEMENT FILTER ELEMENTS TO BE FURNISHED

- A. To allow temporary use of HVAC systems for testing and in accordance with Paragraph, TEMPORARY USE OF MECHANICAL AND ELECTRICAL SYSTEMS in Section 01 00 00, GENERAL REQUIREMENTS, provide one complete set of spare filters to the Resident Engineer.
- B. The Resident Engineer will direct whether these additional filters will either be installed as replacements for dirty units or turned over to VA for future use as replacements.

2.2 AIR FILTERS

- A. Use factory assembled air filters with supported or non-supported cartridges for removal of particulate matter in air conditioning, heating and ventilating systems. Filter units shall be of the extended surface type fabricated for disposal when the contaminant load limit is reached as indicated by maximum (final) pressure drop.
- B. HVAC Filter Types

HVAC Filter Types				
MERV Value ASHRAE 52.2	MERV-A Value ASHRAE 62.2 Appendix J	Application	Basis Of Design	Thickness /Type
8	8-A	Pre-Filter	Camfil Farr 30/30	50 mm (2-inch) Pleated
11	11-A	Mid-Filter	Camfil Farr Opti-Pac	150 mm (4-inch) Mini-Pleated
14	14-A	After-Filter	Camfil Farr Durafil ES	300 mm (12-inch) Mini-Pleated V-Bank

- C. The filters shall be approved and listed by Underwriters' Laboratories, Inc. as Class 2 when tested according to U. L. Standard 900 and CAN 4-5111.
- D. Filter pressure drops shall be as scheduled in the air handling unit equipment schedules.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Install supports, filters and gages in accordance with manufacturer's instructions.

3.2 START-UP AND TEMPORARY USE

- A. Clean and vacuum air handling units and plenums prior to starting air handling systems.

- B. Install or deliver replacement filter units as directed by the Resident Engineer.

3.3 COMMISSIONING

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

- - E N D - - -

SECTION 23 64 00
PACKAGED WATER CHILLERS

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

- A. Section 00 72 00, GENERAL CONDITIONS.
- B. Section 01 00 00, GENERAL REQUIREMENTS.
- C. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- E. Section 23 21 23, HYDRONIC PUMPS.
- F. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- G. Section 23 21 13, HYDRONIC PIPING.
- H. Section 23 31 00, HVAC DUCTS AND CASINGS
- I. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.
- J. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS
- K. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 DEFINITION

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

1.5 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC, and comply with the following.
- B. Refer to PART 3 herein after and Section 01 00 00, GENERAL REQUIREMENTS for test performance.
- C. Comply with AHRI requirements for testing and certification of the chillers.
- D. Refer to paragraph, WARRANTY, Section 00 72 00, GENERAL CONDITIONS, except as noted below:
 - 1. Provide a 5-year motor and compressor warranty to include materials, parts and labor.
- E. Refer to OSHA 29 CFR 1910.95(a) and (b) for Occupational Noise Exposure Standard
- F. Refer to ASHRAE Standard 15, Safety Standard for Refrigeration System, for refrigerant vapor detectors and monitor.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning, Heating and Refrigeration Institute (AHRI):
 - 370-01Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
 - 495-1999 (R2002).....Refrigerant Liquid Receivers
 - 550/590-03.....Standard for Water Chilling Packages Using the Vapor Compression Cycle
 - 575-94.....Methods for Measuring Machinery Sound within Equipment Space

- j. Refrigerant vapor detectors and monitors.
- C. Maintenance and operating manuals for each piece of equipment in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
- D. Run test report for all chillers.
- E. Product Certificate: Signed by chiller manufacturer certifying that chillers furnished comply with AHRI requirements. The test report shall include calibrated curves, calibration records, and data sheets for the instrumentation used in factory tests.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL WATER-COOLED WATER CHILLERS

- A. General: Chiller shall be factory-assembled and-tested, complete with evaporator, condenser, marine water boxes for condenser and evaporator, compressor, motor, starter, oil heater and cooler, economizer or intercooler, purge system (if required), instrumentation and control piping, operating and safety controls mounted on the chiller, and other auxiliaries necessary for safe and proper operation of the unit. Chiller operation shall be fully automatic. Make provision for space and design piping layout to suit the marine water boxes.
- B. Performance: Provide the capacity as shown on the drawings. Part load and full load efficiency ratings of the chiller shall not exceed those shown on the drawings.
- C. Capacity of a single water-cooled chiller shall not exceed 1,250 Tons (Standard AHRI Conditions).
- D. Applicable Standard: Chillers shall be rated and certified in accordance with AHRI Standard 550/590. Chillers shall be AHRI stamped. Chiller efficiency shall comply with FEMP (Federal Energy Management Progress) requirements.
- E. Hermetic or open: Chillers shall be open or hermetically sealed, using one of the following refrigerants: HCFC-123, HFC-134a or HCFC-410A.

- F. Compressor (Centrifugal Type): Single or multistage, having statically and dynamically balanced impeller, either direct or gear driven. Impeller shaft shall be heat-treated carbon steel of sufficient rigidity to prevent whip or vibration at operating speed. Shaft main bearings shall be of journal type with bronze or babbitt line steel cartridge, aluminum alloy one-piece insert type, or rolling element type. Casing shall be cast iron or steel plate with split sections gasketed and bolted together. Lubrication System shall be forced-feed type and shall provide oil at proper temperature to all parts requiring lubrication. Make provisions to insure lubrication of bearings prior to starting and of shaft seal both on stopping and starting, or bearings and shaft seal shall be submerged in oil. On units providing for forced-feed lubrication prior to starting, a differential oil pressure cutout interlocked with compressor starting equipment shall allow compressor to operate only when required oil pressure is provided to bearings. Capacity control shall be by means of variable inlet guide vanes in the compressor suction to modulate the chiller capacity from 100 to 10 percent of full unit rated capacity without unstable compressor operation. The inlet guide vanes shall be electrically operated upon the actuation of temperature or pressure sensor.
- G. Evaporator: Shell-and-tube type, constructed and tested and stamped in accordance with Section VIII D1 of ASME Boiler and Pressure Vessel Code where applicable for working pressure produced by refrigerant used and water system installed, but not less than 1035 kPa (150 psig) waterside working pressure. Shell shall be fabricated of carbon steel and shall have carbon steel tube sheets; drilled and reamed to accommodate the tubes. Tubes shall be externally and internally enhanced individually replaceable and shall be expanded full diameter into tube sheets, providing a leak proof seal. Intermediate tube supports shall be provided as recommended by the manufacturer to minimize tube vibration, stress, and wear. Performance shall be based on a water velocity not less than 1 m/s (3 fps) nor more than 4 m/s (12 fps), and fouling factor of $0.0000176 \text{ m}^2 \text{ degrees C}$ ($0.0001 \text{ hr. sq. ft. degrees F/Btu}$). Removable marine water box shall be constructed of steel. Design working pressure shall be 1035 kPa (150 psig) pressure tested at 130 percent of working pressure. Water nozzle connections shall be flanged.

- H. Condenser: Shell-and-tube type, constructed, tested, and stamped in accordance with applicable portions of Section VIII D1 of the ASME Boiler and Pressure Vessel Code, where applicable for working pressure produced by the refrigerant used and water system installed, but not less than 1035 kPa (150 psig). Shell shall be fabricated of carbon steel and shall have carbon steel tube sheets; drilled and reamed to accommodate the tubes. Tubes shall be nonferrous metal, externally enhanced, and internally enhanced, individually replaceable, and shall be expanded full diameter into tube sheets, providing a leak proof seal. Intermediate tube support sheets shall be provided as recommended by the manufacturer to minimize tube vibration, stress and wear. Tubes shall fit tightly in the supports to prevent chafing due to vibration or pulsation. Performance of condenser shall be based on a water velocity not less than 1 m/s (3 fps) nor more than 4 m/s (12 fps), and a fouling factor of 0.000044 m² degrees C (0.00025 hr. sq. ft.) degrees F/Btu. Removable marine water box shall be constructed of steel. Design working pressure shall be 1035 kPa (150 psig) pressure tested at 130 percent of working pressure. Water nozzle connections shall be flanged.
- I. Insulation: Evaporator, suction piping, compressor, and all other parts subject to condensation shall be insulated.
- J. Economizer: Provide if required by manufacturer. Flash gas shall be piped from economizer to inlet of intermediate stage impeller wheel. In case of rotary compressor flash gas shall be piped from economizer to the intermediate compressor point. Provide a refrigerant flow control system (float valve or variable/multiple orifice system) to automatically regulate flow of liquid refrigerant through economizer. If external-type economizer is used, such economizer shall be constructed and tested in accordance with Section 8 of ASME Boiler and Pressure Vessel Code for working pressures produced by refrigerant used, unless exempt by Section U-1 of the code.
- K. Motor Load Limiter: Provide a sensing and control system, which will limit maximum load current of compressor motor to a manually selectable percentage of 40 percent to 100 percent of full load current. System shall sense compressor motor current and limit it by modulating inlet guide vanes at the compressor, overriding other controls in their ability to increase loading, but not overriding their ability to reduce loading.

- L. Purge System: Chillers utilizing HCFC-123 and chillers using refrigerants with vapor pressure less than 100 kPa (14.7 psig) shall be supplied with Purge System. Purge unit shall be factory-mounted, complete with necessary, piping, operating and safety controls and refrigerant service valves to isolate the unit from the chilling unit. Purge unit shall be air, water, or refrigerant cooled. When in operation, purge system shall function automatically to remove, water vapor, and condensable gases from refrigeration system and to condense, separate, and return to system any refrigerant present therein. Purge system shall be manually or automatically started and stopped, and shall be assembled as a compact unit. As an option, a fully automatic purge system that operates continuously while main unit is operating may be furnished. Such purge system shall provide a means to signal operator of occurrence of excessive purging indicating abnormal air leakage into unit. The purge system shall be of high efficiency in recapturing the refrigerant at all load and head conditions and with capability to operate when the chiller is off. The purge unit shall be UL listed.
- M. Isolation: Per Specification Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT. Coordinate with seismic requirements.
- N. Refrigerant and Oil:
1. Provide sufficient volume of dehydrated refrigerant and lubricating oil to permit maximum unit capacity operation before and during tests. Refrigerant charge lost during the warranty period due to equipment failure shall be replaced without cost to the Government.
 2. The manufacturer shall certify that chiller components, such as seals, o-ring, motor windings, etc, are fully compatible with the specified refrigerants.
- O. Chillers shall be furnished with chilled water and condenser water flow switches.
- P. Chillers utilizing HCFC-123 shall be supplied with all metal, non-fragmented with reverse buckling design rupture disc and a safety relief valve downstream of the rupture disc.
- Q. Service valves shall be provided to facilitate refrigerant reclaim/removal required during maintenance.
- R. Controls: Chiller shall be furnished with unit mounted, stand-alone, microprocessor-based controls in NEMA 1 enclosure, hinged and lockable, factory wired with a single point power connection and separate control circuit. The control panel provide chiller operation, including monitoring of sensors and actuators, and shall be furnished with light emitting diodes or liquid-crystal display keypad.
1. Following functions shall display as a minimum:
 - a. Date and Time.
 - b. Outdoor air temperature.

- c. Operating set point temperature and pressure.
 - d. Operating hours.
 - e. Operating or alarm status.
 - f. Chilled water temperature-entering and leaving.
 - g. Condenser water temperature-entering and leaving.
 - h. Refrigerant pressure-condenser and evaporator.
 - i. Low oil pump pressure.
 - j. High oil supply pressure.
 - k. Chiller diagnostic codes.
 - l. Current limit set point.
 - m. Number of compressor starts.
 - n. Purge suction temperature, if refrigerant HCFC-123 is used.
 - o. Purge elapsed time, if refrigerant HCFC-123 is used.
2. Control Functions:
- a. Manual or automatic startup and shutdown time schedule.
 - b. Control set points for entering and leaving chilled temperatures.
 - c. Condenser water temperature.
 - d. Current/demand limit.
 - e. Motor load limit.
3. Safety Controls: Following conditions shall shut down the chiller and require manual reset to start:
- a. High condenser pressure.
 - b. High oil temperature.
 - c. High or low oil pressure.
 - d. Loss of flow-condenser or chilled water.
 - e. Low chilled water temperature.
 - f. Low evaporator refrigerant temperature.
 - g. Sensor malfunctions.
 - h. Power fault.
 - i. Extended compressor surge.
 - j. Communication loss between the chiller and its control panel. A signal must be transmitted to Energy Control Center, if provided, for this communication loss and for any abnormal.
4. Chillers shall be pre-wired to terminal strips for interlocked to other equipment.

5. Chiller control panel shall reside on the Siemens campus network, and provide data using open protocol network variable types and configuration properties, BACnet interworking using MS/TP physical data link layer protocol for communication with building automation control system .
6. Auxiliary hydronic system and the chiller(s) shall be electronically interlocked to provide time delay and starting sequence as indicated on control drawings.
7. The chiller control panel shall utilize the following components to automatically take action to prevent unit shutdown due to abnormal operating conditions which will perform as follows.
 - a. High pressure switch that is set to 20 psig (adjustable setting) lower than factory pressure switch that will automatically unload the compressor to help prevent a high pressure condenser control trip. One switch is required for each compressor and indicating light shall also be provided.
 - b. Motor surge pressure that is set at 95% of compressor RLA that will automatically unload the compressor to prevent an over current trip. One protector is required for each compressor and indicating light shall also be provided.
 - c. Low pressure switch that is set at 5 PSIG above the factory low pressure switch that will automatically unload the compressor to help prevent a low evaporator temperature trip. One switch is required for each compressor and indicating light shall also be provided.
 - d. In all the above cases, the chiller will continue to run, in an unloaded state and will continue to produce some chilled water in an attempt to meet the cooling load. However, if the chiller reaches the trip-out limits, the chiller controls will take the chiller off line for protection, and a manual reset is required. Once the "near trip" condition is corrected, the chiller will return to normal operation and can then produce full load cooling.
8. With variation of +/-10% of design flow per minute, chiller shall be able to maintain +/-0.5 degrees F leaving water temperature control. The chiller must be able to withstand a +/- 30% change in flow rate per minute without unit trip. Variations in the primary flow allow for optimal system efficiency, but the chiller must be able to maintain temperature control to help ensure occupant comfort.
9. The chiller control panel shall provide +/-0.5 degrees F leaving water temperature control during normal operation. The chiller shall provide multiple steps leaving chilled water temperature controller to minimize part load energy use and optimize leaving chilled water temperature control. If manufacturer is unable to provide at least several steps of unloading, hot gas bypass shall be required to minimize loss of leaving water temperature control.

10. The chiller control panel shall provide a 2-minute stop-to-start and 5 minute start-to-start solid state timer. If the anti-recycle timers are longer than 5 minutes, then hot-gas bypass shall be provided to limit loss of leaving chilled water temperature control in low-load conditions.
- S. Motor: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Compressor motor furnished with the chiller shall be in accordance with the chiller manufacturer and the electrical specification Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT. Starting torque of the motor shall be suitable for the driven chiller machine.
- T. Variable Speed Drive: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
 1. The centrifugal water chiller shall be furnished with a refrigerant-cooled variable speed drive (VSD). The VSD shall be factory mounted on the chiller and shipped completely factory assembled, wired and tested.
 2. The VSD will be specifically designed to interface with the centrifugal water chiller controls and allow for the operating ranges and specific characteristics of the chiller. The VSD control logic shall optimize chiller efficiency by coordinating compressor motor speed and compressor inlet guide vane position to maintain the chilled water setpoint while avoiding surge. If a surge is detected, VSD surge avoidance logic will make adjustments to move away from and avoid surge at similar conditions in the future.
 3. The VSD efficiency shall be 97% or better at full speed and full load. Fundamental displacement power factor shall be a minimum of 0.96.
 4. The VSD shall be solid state, microprocessor based pulse-width modulated (PWM) design. The VSD shall be voltage and current regulated. Output power devices shall be IGBT transistors.

5. The VSDs shall each be furnished in a NEMA 1 metal enclosure having as minimum a short circuit withstand rating of 65,000 amps per UL 508. It will include three phase input lugs plus a grounding lug for electrical connections, output motor connection via factory installed bus bars and all components properly segregated and completely enclosed in a single metal enclosure.
 - a. Enclosure shall include a padlockable, door-mounted circuit breaker with shunt trip and AIC rating of 65,000 amps.
 - b. The entire chiller package shall be UL/CUL listed.
6. The VSD shall be tested to ANSI/UL Standard 508 and shall be listed by a Nationally Recognized Testing Laboratory (NRTL) as designated by OSHA.
7. Compliance to recommendations stated in IEEE 519-1992.
 - a. The VSD design shall include as standard integrated active rectification control system to limit total demand distortion (TDD) in current at the VSD to less than or equal to 5-percent as measured at the VSD input. If optional active filters are used to meet the less than or equal to 5% TDD, then the losses associated with the filter shall be included in the chiller performance on the selection.
8. The VSD shall include the following features:
 - a. All control circuit voltages are physically and electrically isolated from power circuit voltage.
 - b. 150% instantaneous torque available for improved surge control.
 - c. Soft start, adjustable linear acceleration, coast-to-stop.
 - d. Adjustable current limiting and UL approved electronic motor overload protection.
 - e. Insensitivity to incoming power phase sequence.
 - f. VSD and motor protection from the following faults: - Output line-to-line short circuit protection - Line-to-ground short circuit protection - Phase loss at AFD input - Phase reversal / Imbalance - Over-voltage - Under-voltage - Over temperature
9. The following VSD status indicators shall be available to facilitate startup and maintenance: - Output speed in hertz and rpm - Input line voltage - Input line kW - Output/load amps - Average current in percent RLA - Load power factor - Fault - VSD transistor temperature
10. Service Conditions - at full output power. No external venting or heat exchangers shall be required.
 - a. Operating ambient temperature 32°F-104°F (0°C-40°C).
 - b. Room ambient up to 95% relative humidity.

- c. Elevation to 3300 feet (1000 meters). For every 300 feet above 3300 feet, the rated output current shall be decreased by one percent.
11. A permanent nameplate shall be provided and mounted on the VSD panel. It shall identify the manufacturer, serial or model number identifying the date of manufacturing and component replacement parts, and all current and voltage rating, and as built wiring schematic showing all items provided.

2.6 REFRIGERANT MONITORING AND SAFETY EQUIPMENT

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

PART 3 – EXECUTION

3.1 EXAMINATION

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

3.2 EQUIPMENT INSTALLATION

- A. Install chiller on concrete base with isolation pads.
 - 1. Concrete base is specified in Section 03 30 00, CAST-IN-PLACE CONCRETE
 - 2. Vibration isolator types and installation requirements are specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT
 - 3. Anchor chiller to concrete base according to manufacturer's written instructions and for seismic restraint on vibration isolators.
 - 4. Charge the chiller with refrigerant.
 - 5. Install accessories and any other equipment furnished loose by the manufacturer, including remote flow switches, according to the manufacturer written instructions and electrical requirements.
 - 6. Chillers shall be installed in a manner as to provide easy access for tube pull and removal of compressor and motors etc.
- B. Install refrigerant monitoring and safety equipment in accordance with ASHRAE Standard 15.
- C. Install thermometers and gages as recommended by the manufacturer and/or as shown on drawings.
- D. Piping Connections:
 - 1. Make piping connections to the chiller for chilled water, condenser water, and other connections as necessary for proper operation and maintenance of the equipment.
 - 2. Make equipment connections with flanges and couplings for easy removal and replacement of equipment from the equipment room.
 - 3. Extend vent piping from the relief valve and purge system to the outside.

3.3 STARTUP AND TESTING

- A. Engage manufacturer's factory-trained representative to perform startup and testing service.
- B. Inspect, equipment installation, including field-assembled components, and piping and electrical connections.
- C. After complete installation startup checks, according to the manufacturers written instructions, do the following to demonstrate to the VA that the equipment operate and perform as intended.
 - 1. Check refrigerant charge is sufficient and chiller has been tested for refrigerant leak.
 - 2. Check bearing lubrication and oil levels.
 - 3. Verify proper motor rotation.
 - 4. Verify pumps associated with chillers are installed and operational.
 - 5. Verify thermometers and gages are installed.
 - 6. Verify purge system, if installed, is functional and relief piping is routed outdoor.

7. Operate chiller for run-in-period in accordance with the manufacturer's instruction and observe its performance.
 8. Check and record refrigerant pressure, water flow, water temperature, and power consumption of the chiller.
 9. Test and adjust all controls and safeties. Replace or correct all malfunctioning controls, safeties and equipment as soon as possible to avoid any delay in the use of the equipment.
 10. Prepare a written report outlining the results of tests and inspections, and submit it to the VA.
- D. Engage manufacturer's certified factory trained representative to provide training for 8 hours for the VA maintenance and operational personnel to adjust, operate and maintain equipment, including self-contained breathing apparatus.

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.

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SECTION 23 65 00 COOLING TOWERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Packaged, 2-cell induced draft cross-flow cooling tower complete with fill, fan, inlet louvers and associated accessories and equipment.

1.2 RELATED WORK

- A. Section 03 30 00, CAST IN PLACE CONCRETE: Requirements for concrete inertia bases.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: 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 25 00, HVAC WATER TREATMENT: Requirements for condenser water treatment.
- G. Section 23 31 00, HVAC DUCTS AND CASINGS: Requirements for sheet metal ductwork.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Refer to Article, QUALITY ASSURANCE, in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Design Criteria:
 - 1. Refer to structural drawings for design 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 25 feet in any direction from the tower shall not exceed 73 dB (A). Select “low Noise” model cooling towers, where available. Provide sound attenuators if necessary to meet the noise criteria.

C. Performance Criteria:

1. Manufacturer shall certify that performance of cooling towers will meet contract requirements, stating entering air wet bulb temperature, entering and leaving condenser water temperatures, water flow rates, fan kW (horsepower). Certification shall be made at the time of submittal.
2. Cooling Technology Institute (CTI) Certified Towers: These towers shall have been tested, rated, and certified in accordance with Cooling Technology Institute (CTI) Standard 201, and shall bear the CTI certification label, and shall be listed in the CTI directory of certified cooling towers.
3. The alignment and balancing of the fans, motors and drive shaft as installed shall operate within the vibration tolerance specified in specification Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

1.5 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.

C. Certification:

1. Submit four copies of performance curves, for CTI certified cooling towers, showing compliance with actual conditions specified, to the Resident Engineer two weeks prior to delivery of the equipment.
2. Two weeks prior to final inspection, submit four copies of the following to the Resident Engineer:
 - a. Certification from the manufacturer that the cooling tower(s), accessories, and components are suitable for seismic design category C installations.
 - 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.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American National Standard Institute (ANSI/ASSE)
 - A10.18-2007Safety 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 23-03Performance Test Codes on Atmospheric Water Cooling Equipment
- D. American Society for Testing Materials (ASTM):
 - A385-08Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
 - B117-07aStandard Practice for Operating Salt Spray (Fog) Apparatus
 - B209-07Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
 - E84-08aStandard Test Method for Surface Burning Characteristics of Building Materials
- E. Cooling Technology Institute (CTI):
 - ATC-105-00Acceptance Test Code for Water-Cooling Towers (CTI Code Tower Standard Specifications)
 - ATC-105S-Rev. July 2004Acceptance 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 IncludesMotors and Generators (ANSI)
 - 250-03Enclosures for Electrical Equipment (1000 Volts Maximum)
- G. National Fire Protection Association (NFPA):
 - 70-11National Electrical Code

PART 2 - PRODUCTS

2.1 INDUCED DRAFT OPEN CIRCUIT COOLING TOWER:

- A. Provide an induced draft, factory packaged crossflow cooling tower as scheduled on drawings. Basic construction shall be G-235 galvanized steel. Open gravity type hot water distribution basins and upper interior wetted structure shall stainless steel. Basins shall be fitted with non-clog plastic target nozzle type metering orifices. Single bottom inlet connection shall be provided in floor of each tower cell with internal PVC riser piping with flow balancing manifold headers. Distribution system shall be furnished to allow reduced 50% flow through tower during free cooling operation.
- B. Each fan shall have cast aluminum airfoil blades with anti-recirculation hub assembly. Each blade shall be of the adjustable pitch design with raised pitching boss and shall be factory preset to design conditions. A complete mechanical equipment support shall be provided on which shall be rigidly mounted a right angle helical gear reduction unit and drive motor. Geared reducer shall be of the latest five year maintenance free type, charged with synthetic lubricant at factory and designed for 0-100% speed range. Motors shall be 20 HP, 460 volts, 3 phase, 60 cycle, 1800 RPM, TEFC, Premium Efficiency, Inverter Duty, variable torque, 1.15 service factor and suitable for cooling tower duty. Motor shall be as scheduled and shall not exceed nameplate amperage rating at design loads.
- C. For each tower cell the cold water basin shall be self-cleaning with depressed center section. Cold water collection basin to be of welded seam stainless steel construction. All components in cold water basin, as well as lower wetted tower interior structure shall be of 300L low carbon stainless steel materials. Basins shall be complete with clean out, overflow standpipe, drain and stainless steel right angle sump outlet with 6" diameter Class 125 ANSI B16.1 connections and gaskets, stainless steel anti-vortex plate assemblies and debris screens. Provide factory float-operated, mechanical make-up valve in each fan cell. Provide minimum 8" diameter hole and bolt circle in each basin floor for field piping of equalizer line and isolation valve furnished by Contractor.
- D. Fill shall be PVC film type high performance suitable for operating under winter icing conditions. Air inlet louvers and drift eliminators shall be integral with PVC fill sheets. Three pass drift eliminator shall be rated for drift loss not to exceed 0.005% of design flow rate. Hinged access doors shall be provided in the outer end walls for service access into eliminator and plenum area. Visual inspection of mechanical equipment, cold water basins and adjustment of make-up valve shall be capable from access door without shutdown of tower or recirculating water. Provide heavy gauge welded galvanized steel mesh guard over each fan.

- E. Options and trim required for this installation are to include not less than: Metrix SPDT safety vibration switch in NEMA 4 enclosure with reset plunger for each motor circuit; extended oil line outside fan cylinder to level dipstick for external verification of lubricant level; factory installed and removable covers over hot water distribution basins; OSHA handrail system with access ladder, ladder extension to grade, and safety cage if top of tower is 20' above grade per OSHA regulations; an access platform assembly with handrail for installation at base of tower to allow egress into tower interior and factory installed stainless interior plenum access walkway extending between the access doorways positioned above maximum water operating level. An electric basin heat component system for each cell including weatherproof control panel, solid state controller with thermostat and B/W safety level switch provided. Basin heat shall be sized to maintain 40 degF cold water basin temperature at 0 degF ambient. Basin heat element and probe assembly shall be furnished for field mounting and wiring. All basin heat components submerged in cooling tower water shall be of stainless steel materials.
- F. Special cooling tower material warranty requirement: All rotating parts and components of the air movement system, excluding the drive motor, shall be warranted by the cooling tower manufacturer for a period of five (5) years from date of shipment when maintained in accordance with instructions provided in owner's manuals. All non-rotating parts shall be similarly warranted for a period of 18 months from date of shipment or 12 months from date of start-up, whichever occurs first. Warranty on drive motor shall be that of the motor manufacturer. Cooling tower submittal shall contain a factory certificate of rotating equipment and thermal performance warranties for Owner's Protection to be acceptable under this specification. Mechanical equipment shall be designed for five (5) year maintenance intervals.
- G. The cooling tower manufacturer shall certify that their proposed tower meets the performance standards set forth in CTI Standard STD-201. Performance certifications notwithstanding, the Owner shall have the right to conduct a CTI or ASME on-site performance test during the first year of operation in the presence of CTI or ASME observers as well as the manufacturer's representatives. In the event that the tower fails to perform within the limits of the test tolerance, the cooling tower manufacturer will pay for the cost of the test and will make such corrections as are appropriate and agreeable to the Owner to compensate for the performance deficiency.
- H. Electric Heat Tracing: Provide in specification Section 23 21 13, HYDRONIC PIPING.

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

3.2 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.
- 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 Resident Engineer.
- 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 Resident Engineer. Coordinate this training with that of the chiller, if furnished together.

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.

--- E N D ---

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

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

- A. General mechanical requirements and items, which are common to more than one section of Division 23: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Sound and vibration requirements: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- C. Piping and duct insulation: Section 23 07 11, HVAC INSULATION.
- D. Piping and valves: Section 23 21 13 / 23 22 13, HYDRONIC PIPING / STEAM AND CONDENSATE HEATING PIPING.
- E. Requirements for flexible duct connectors and air leakage: Section 23 31 00, HVAC DUCTS AND CASINGS.
- F. Air filters and filters' efficiency: Section 23 40 00, HVAC AIR CLEANING DEVICES.
- G. HVAC controls: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- H. Testing, adjusting and balancing of air and water flows: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- I. Types of motors: Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.
- J. General Commissioning: Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS
- K. HVAC Commissioning: Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Refer to Article, Quality Assurance, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Air Handling Units Certification
 - 1. Air Handling Units with Plenum Fans:
 - a. Air handling Units with Multiple Fans in an Array shall be tested and rated in accordance with AHRI 430 and AHRI 260.
- C. Heating, Cooling, and Air Handling Capacity and Performance Standards: AHRI 430, AHRI 410, ASHRAE 51, and AMCA 210.
- D. Performance Criteria:
 - 1. The fan motor shall be selected within the rated nameplate capacity, without relying upon NEMA Standard Service Factor.
 - 2. Select the fan operating point as follows:
 - a. Air Foil, Backward Inclined, or Plenum Fans: At or near the peak static efficiency but at an appropriate distance from the stall line.
 - 3. Operating Limits: AMCA 99 and Manufacturer's Recommendations.
- E. Units shall be factory-fabricated, assembled, and tested by a manufacturer, in business of manufacturing similar air-handling units for at least five (5) years.

1.5 SUBMITTALS:

- A. The contractor shall, in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish a complete submission for all air handling units covered in the project. The submission shall include all information listed below. Partial and incomplete submissions shall be rejected without reviews.

B. Manufacturer's Literature and Data:

1. Submittals for AHUs shall include fans, drives, motors, coils, humidifiers, and mixing box with outside/return air dampers, filter housings, and all other related accessories. The contractor shall provide custom drawings showing total air handling unit assembly including dimensions, operating weight, access sections, flexible connections, door swings, controls penetrations, electrical disconnect, lights, duplex receptacles, switches, wiring, utility connection points, unit support system, vibration isolators, drain pan, pressure drops through each component (filter, coil etc).
2. Submittal drawings of section or component only will not be acceptable. Contractor shall also submit performance data including performance test results, charts, curves or certified computer selection data; data sheets; fabrication and insulation details. If the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements. This data shall be submitted in hard copies and in electronic version compatible to AutoCAD version used by the VA at the time of submission.
3. Submit sound power levels in each octave band for the inlet and discharge of the fan and at entrance and discharge of AHUs at scheduled conditions. In absence of sound power ratings refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
4. Provide fan curves showing Liters/Second (cubic feet per minute), static pressure, efficiency, and horsepower for design point of operation and at maximum design Liters/Second (cubic feet per minute).
5. Submit total fan static pressure, external static pressure, for AHU including total, inlet and discharge pressures, and itemized specified internal losses and unspecified internal losses. Refer to air handling unit schedule on drawings.

C. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS. Include instructions for lubrication, filter replacement, motor and drive replacement, spare part lists, and wiring diagrams.

D. Submit written test procedures two weeks prior to factory testing. Submit written results of factory tests for approval prior to shipping.

- E. Submit shipping information that clearly indicates how the units will be shipped in compliance with the descriptions below.
 1. Units shall be shipped in one (1) piece where possible and in shrink wrapping to protect the unit from dirt, moisture and/or road salt.
 2. If not shipped in one (1) piece, provide manufacturer approved shipping splits where required for installation or to meet shipping and/or job site rigging requirements in modular sections. Indicate clearly that the shipping splits shown in the submittals have been verified to accommodate the construction constraints for rigging as required to complete installation and removal of any section for replacement through available access without adversely affecting other sections.
 3. If shipping splits are provided, each component shall be individually shrink wrapped to protect the unit and all necessary hardware (e.g. bolts, gaskets etc.) will be included to assemble unit on site (see section 2.1.A4).
 4. Lifting lugs will be provided to facilitate rigging on shipping splits and joining of segments. If the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI)/(ARI):

410-01	Standard for Forced-Circulation Air-Heating and Air-Cooling Coils
430-09	Central Station Air Handling Units
- C. Air Movement and Control Association International, Inc. (AMCA):

210-07	Laboratory Methods of Testing Fans for Rating
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- D. American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc. (ASHRAE):

170-2008	Ventilation of Health Care Facilities
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- E. American Society for Testing and Materials (ASTM):

ASTM B117-07a.....	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D1654-08	Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D1735-08	Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus

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

F. Military Specifications (Mil. Spec.):

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

G. National Fire Protection Association (NFPA):

NFPA 90AStandard for Installation of Air Conditioning and Ventilating
Systems, 2009

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

PART 2 - PRODUCTS

2.1 AIR HANDLING UNITS

A. General:

1. AHUs shall be fabricated from insulated, solid double-wall galvanized steel without any perforations in draw-through configuration. Casing shall be fabricated as specified in section 2.1.C.2. Galvanizing shall be hot dipped conforming to ASTM A525 and shall provide a minimum of 0.275 kg of zinc per square meter (0.90 oz. of zinc per square foot) (G90). Aluminum constructed units, subject to VA approval, may be used in place of galvanized steel. The unit manufacturer shall provide published documentation confirming that the structural rigidity of aluminum air-handling units is equal or greater than the specified galvanized steel.
2. The contractor and the AHU manufacturer shall be responsible for ensuring that the unit will not exceed the allocated space shown on the drawings, including required clearances for service and future overhaul or removal of unit components. All structural, piping, wiring, and ductwork alterations of units, which are dimensionally different than those specified, shall be the responsibility of the contractor at no additional cost to the government.
3. AHUs shall be fully assembled by the manufacturer in the factory in accordance with the arrangement shown on the drawings. The unit shall be assembled into the largest sections possible subject to shipping and rigging restrictions. The correct fit of all components and casing sections shall be verified in the factory for all units prior to shipment. All units shall be fully assembled, tested, and then split to accommodate shipment and job site rigging. On units not shipped fully assembled, the manufacturer shall tag each section and include air flow direction to facilitate assembly at the job site. Lifting lugs or shipping skids shall be provided for each section to allow for field rigging and final placement of unit.

4. The AHU manufacturer shall provide the necessary gasketing, caulking, and all screws, nuts, and bolts required for assembly. The manufacturer shall provide a factory-trained and qualified local representative at the job site to supervise the assembly and to assure that the units are assembled to meet manufacturer's recommendations and requirements noted on the drawings. Provide documentation to the Contracting Officer that the local representative has provided services of similar magnitude and complexity on jobs of comparable size. If a local representative cannot be provided, the manufacturer shall provide a factory representative.
5. Gaskets: All door and casing and panel gaskets and gaskets between air handling unit components, if joined in the field, shall be high quality which seal air tight and retain their structural integrity and sealing capability after repeated assembly and disassembly of bolted panels and opening and closing of hinged components. Bolted sections may use a more permanent gasketing method provided they are not disassembled.
6. Structural Rigidity: Provide structural reinforcement when required by span or loading so that the deflection of the assembled structure shall not exceed $L/240$ of the span based on a differential static pressure of 1991 PA (8 inch WG) or higher.

B. Base:

1. Provide a heavy duty steel base for supporting all major AHU components. Bases shall be constructed of structural steel C channels minimum 6 inch high. Welded or bolted cross members shall be provided as required for lateral stability.
2. AHUs shall be completely self supporting for installation on concrete housekeeping pad, steel support pedestals, or suspended as shown on drawings.
3. The AHU bases not constructed of galvanized steel shall be cleaned, primed with a rust inhibiting primer, and finished with rust inhibiting exterior enamel.

C. Casing (including wall, floor and roof):

1. General: AHU casing shall be constructed as solid double wall, galvanized steel insulated panels without any perforations, integral of or attached to a structural frame. The thickness of insulation, mode of application and thermal breaks shall be such that there is no visible condensation on the exterior panels of the AHU located in the non-conditioned spaces.

2. Double wall galvanized steel panels, minimum 51 mm (2 inches) thick, constructed of minimum 1.3 mm (18 gauge) outer skin and 1.0 mm (20 gauge) solid inner skin to limit wall, roof and floor deflection to not exceed an L/240 ratio when the unit casing is pressurized to ± 8 in. w.g.. Deflection shall be measured at the midpoint of the panel height. Total housing leakage shall not exceed 1% of rated cfm when the unit casing is pressurized to ± 8 in. w.g. The outer (skin) and inner panels shall be solid.
3. Blank-Off: Provide blank-offs as required to prevent air bypass between the AHU sections, around coils, and filters.
4. Casing Construction:

Table 2.1.C.2

Outer Panel	0.8 mm (22 Gage) Minimum
Inner Panel	0.8 mm (22 Gage) Minimum
Insulation	Foam
Thickness	50 mm (2 inch) Minimum
Density	48 kg/m ³ (3.0 lb/ft ³) Minimum
Total R Value	2.3 m ² .K/W (13.0 ft ² .°F.hr/Btu) Minimum

5. Casing panels shall be secured to the support structure with stainless steel or zinc-chromate plated screws and gaskets installed around the panel perimeter. Panels shall be completely removable to allow removal of fan, coils, and other internal components for future maintenance, repair, or modifications. Welded exterior panels are not acceptable.

6. Access Doors: Provide in each access section and where shown on drawings. Show single-sided and double-sided access doors with door swings on the floor plans. Doors shall be a minimum of 50 mm (2 inch) thick with same double wall construction as the unit casing. Doors shall be a minimum of 600 mm (24 inches) wide, unless shown of different size on drawings, and shall be the full casing height up to a maximum of 1850 mm (6 feet). Doors shall be gasketed, hinged, and latched to provide an airtight seal. The access doors for fan section, mixing box, humidifier, coil section shall include a minimum 150 mm x 150 mm (6 inch x 6 inch) double thickness, with air space between the glass panes tightly sealed, reinforced glass or Plexiglas window in a gasketed frame.
 - a. Hinges: Manufacturers standard, designed for door size, weight and pressure classifications. Hinges shall hold door completely rigid with minimum 45 kg (100 lb) weight hung on latch side of door.
 - b. Latches: Non-corrosive alloy construction, with operating levers for positive cam action, operable from either inside or outside. Doors that do not open against unit operating pressure shall allow the door to ajar and then require approximately 0.785 radian (45 degrees) further movement of the handle for complete opening. Latch shall be capable of restraining explosive opening of door with a force not less than 1991 Pa (8 inch WG).
 - c. Gaskets: Neoprene, continuous around door, positioned for direct compression with no sliding action between the door and gasket. Secure with high quality mastic to eliminate possibility of gasket slipping or coming loose.
7. Provide sealed sleeves, metal or plastic escutcheons or grommets for penetrations through casing for power and temperature control wiring and pneumatic tubing. Coordinate with electrical and temperature control subcontractors for number and location of penetrations. Coordinate lights, switches, and duplex receptacles and disconnect switch location and mounting. All penetrations and equipment mounting may be provided in the factory or in the field. All field penetrations shall be performed neatly by drilling or saw cutting. No cutting by torches will be allowed. Neatly seal all openings airtight.

D. Floor:

1. Unit floor shall be level without offset space or gap and designed to support a minimum of 488 kg/square meter (100 lbs per square foot) distributed load without permanent deformation or crushing of internal insulation. Provide adequate structural base members beneath floor in service access sections to support typical service foot traffic and to prevent damage to unit floor or internal insulation.

2. Where indicated, furnish and install floor drains, flush with the floor, with nonferrous grate cover and stub through floor for external connection.
- E. Condensate Drain Pan: Drain pan shall be designed to extend entire length of cooling coils including headers and return bends. Depth of drain pan shall be at least 43 mm (1.7 inches) and shall handle all condensate without overflowing. Drain pan shall be double-wall, double sloping type, and fabricated from stainless (304) with at least 50 mm (2 inch) thick insulation sandwiched between the inner and outer surfaces. Drain pan shall be continuous metal or welded watertight. No mastic sealing of joints exposed to water will be permitted. Drain pan shall be placed on top of casing floor or integrated into casing floor assembly. Drain pan shall be pitched in all directions to drain line.
1. An intermediate, stainless-steel (304) condensate drip pan with copper downspouts shall be provided on stacked cooling coils. Use of intermediate condensate drain channel on upper casing of lower coil is permissible provided it is readily cleanable. Design of intermediate condensate drain shall prevent upper coil condensate from flowing across face of lower coil.
 2. Drain pan shall be piped to the exterior of the unit. Drain pan shall be readily cleanable.
 3. Installation, including frame, shall be designed and sealed to prevent blow-by.
- F. Plenum Fans – Multiple Fans in an Array:
1. General: Fans shall be Class II (minimum) construction with single inlet, aluminum wheel and stamped air-foil aluminum bladed. The fan wheel shall be mounted on the directly-driven motor shaft in AMCA Arrangement 4. Fans shall be dynamically balanced and internally isolated to minimize the vibrations. Provide a steel inlet cone for each wheel to match with the fan inlet. Locate fan in the air stream to assure proper flow. The fan performance shall be rated in accordance with AMCA 210 or ASHRAE 51.

2. Allowable vibration tolerances for fan shall not exceed a self-excited vibration maximum velocity of 0.005 m/s (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions or measured at equipment mounting feet if bearings are concealed. After field installation, compliance to this requirement shall be demonstrated with field test in accordance with Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT and Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC. Following fan assembly, the complete fan assembly balance shall be tested using an electronic balance analyzer with a tunable filter and stroboscope. Vibration measurements shall be taken on each motor bearing housing in the vertical, horizontal, and axial planes (5 total measurements, 2 each motor bearing and 1 axial).
3. Multiple fans shall be installed in a pre-engineered structural frame to facilitate fan stacking. All fans shall modulate in unison, above or below the synchronous speed within the limits specified by the manufacturer, by a common control sequence. Staging of the fans is not permitted. Redundancy requirement shall be met by all operating fans in an array and without the provision of an idle standby fan.
4. Fan Accessories
 - a. Fan Isolation: Provide a manual blank off plate to isolate the fan not in operation due to failure.

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

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

H. Mixing Boxes: Mixing box shall consist of casing, outdoor airflow measuring station, and return air dampers in opposed blade arrangement with damper linkage for automatic operation.

Coordinate damper operator provided in Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. Dampers shall be of ultra-low leak design with metal compressible bronze jamb seals and extruded vinyl edge seals on all blades. Blades shall rotate on stainless steel sleeve bearings or bronze bushings. Leakage rate shall not exceed 1.6 cubic meters/min/square meter (5 CFM per square foot) at 250 Pa (1 inch WG) and 2.8 cubic meters/min/square meter (9 CFM per square foot) at 995 Pa (4 inch WG).

1. Airflow measuring stations shall be provided and located in the outside and/or return air paths as indicated on the schedule and plans to measure airflow. Airflow measuring stations shall be tested per AMCA Standard 611 and licensed to bear the AMCA Ratings Seal for airflow measurement performance. Integral control damper blades shall be provided as galvanized steel and housed in a galvanized steel frame. Leakage rate shall not exceed 4 CFM/square foot at one inch water gauge complying with ASHRAE 90.1 maximum damper leakage.
 - a. The airflow measurement station shall measure up to 100 percent of the total outside air and/or return air. The airflow measurement station shall be capable of measuring down to 300 fpm. The airflow measuring device shall adjust for temperature variations. Output shall be provided from the station as a 2-10 VDC signal. Signal shall be proportional to air velocity. The accuracy of the measuring station shall be no greater than +/- 5 percent. Airflow measuring stations shall be mounted on the AHU interior.
 - b. The installing contractor shall provide duct-mounted pleated media MERV 8 filtration upstream of airflow monitoring stations requiring air straightening vanes to prevent blockage of vanes. A filter access door shall be provided for filter replacement that does not degrade the specified duct leakage class. Duct-mounted filtration section with access door for filter removal shall be tested for compliance to specified duct leakage class on the schedule and plans.

- I. Filter Section: Refer to Section 23 40 00, HVAC AIR CLEANING DEVICES, for filter requirements.
1. Filters including one complete set for temporary use at site shall be provided independent of the AHU. The AHU manufacturer shall install filter housings and racks in filter section compatible with filters furnished. The AHU manufacturer shall be responsible for furnishing temporary filters (pre-filters and after-filters, as shown on drawings) required for AHU testing.
 2. Factory-fabricated filter section shall be of the same construction and finish as the AHU casing including filter racks and hinged double wall access doors. Filter housings shall be constructed in accordance with side service or holding frame housing requirements in Section 23 40 00, HVAC AIR CLEANING DEVICES.
- J. Photo Catalytic Air Cleaning System
1. The Photo Catalytic Air Cleaner System shall be factory-engineered and factory-installed in the air handler by the air handler manufacturer and shall be covered under warranty by the air handler manufacturer.
 2. Submittal information shall include a list of reference projects, third party testing that lists reduction in colony forming units (CFU) versus time for vegetative bacteria including MRSA, viruses, and other common bioaerosols and VOCs. Data shall also include rated pressure drop at the design airflow.
 3. The Catalytic Air Cleaner System shall be a three part integral assembly for treatment of air by: (1) High Efficiency Particle Filtration (2) Ultraviolet Germicidal Irradiation (UVGI) using UV-C lamps and fixtures; and (3) Photocatalytic Oxidation (PCO) catalyst media using titanium dioxide (TiO₂).
 4. High Efficiency Particle Filters shall be rated MERV 13 or higher. Filters are positioned upstream of the PCO media.
 5. UV-C lamps and ballasts designed specifically to provide type-C ultraviolet light with a wavelength at or near 253.7 Angstroms and shall not produce any ozone. Lamps shall be imbedded in the center of the catalyst media bank, spaced no further than 6" apart, and shall achieve a minimum coverage of 5 milliwatts per square inch of UVC light across all exposed surfaces of the PCO media.
 6. The catalyst media shall consist of six-inch deep (direction of airflow) grid with face area to match casing opening, one pleat per inch (nominal), and coated with 40-200 nanometer

- TiO₂. The complete PCO media bank assembly shall be housed in a galvanized or stainless steel casing and placed in the air handler perpendicular to the airflow.
7. All UV lamps and PCO media shall be removable from outside the AHU casing through a side access door for maintenance purposes.
 8. An air flow switch shall be wired into the control circuit to disable the UV lights when the AHU fan is not running.
 9. The Catalytic Air Cleaner System shall be configured to operate electrical power that matches the power requirement in the air handler schedule. Three phase systems shall be either independent single point power or integral with the AHU main power. All necessary main fusing shall be included.
 10. Electrical fixtures shall meet the UL drip proof design criteria. Component enclosures shall be constructed of galvanized steel or stainless steel to resist corrosion. Fixtures shall have been tested and recognized by UL/C-UL under Category Code ABQK (Accessories, Air Duct Mounted), UL Standards 1995.
 11. For Line Voltage options, the CACS shall be provided with a UL 508 listed panel for power distribution and over-current protection.
 12. CACS assemble shall be capable of withstanding 750 fpm face velocity with no structural damage
 13. All polymeric materials that come into direct or indirect (reflected) contact with UV-C light shall be tested and certified as UV-C tolerant. Any non-conforming construction materials or components within the exposure zone shall be completely shielded from the UV-C light using a certified UV-C tolerant material. UV-C tolerance is defined as being capable of performing its intended duty for a minimum of 20 years.
 14. Safety
 - a. Access doors or panels shall be provided at the location of each Catalytic Air Cleaner System as indicated on the schedule. All access doors/panels shall have a mechanical safety interlock switch that disconnects the CACS power upon opening.
 - b. Each CACS shall be equipped with an externally mounted electrical disconnect switch, with lock-out capability to prevent unwanted operation for maintenance purposes.
 - c. A window shall be provided on each air handler to allow visual inspection of the Catalytic Air Cleaner System during operation. The viewing window shall be guaranteed to block UV-C light emissions below the threshold limits specified by NIOSH and/or ACGIH.

- d. Units shall have a safety warning label applied to the exterior of each section containing UV-C lights.
- e. Complete safety, maintenance and servicing instructions for the Catalytic Air Cleaner System shall be incorporated into the air handler manufacturer's standard installation, operating and maintenance manuals.

K. Coils:

1. Conform to ASTM B75 and AHRI 410.
2. Tubes: Minimum 16 mm (0.625 inch) tube diameter; Seamless copper tubing.
3. Fins: 0.1397 mm (0.0055 inch) aluminum or 0.1143 mm (0.0045 inch) copper mechanically bonded or soldered or helically wound around tubing.
4. Headers: Copper, welded steel or cast iron. Provide seamless copper tubing or resistance welded steel tube for volatile refrigerant coils.
5. "U" Bends, Where Used: Machine die-formed, silver brazed to tube ends.
6. Coil Casing: 1.6 mm (16 gage) galvanized steel with tube supports at 1200 mm (48 inch) maximum spacing. Construct casing to eliminate air bypass and moisture carry-over. Provide duct connection flanges.
7. Pressures kPa (PSIG):

Pressure	Water Coil
Test	2070 (300)
Working	1380 (200)

8. Protection: Unless protected by the coil casing, provide cardboard, plywood, or plastic material at the factory to protect tube and finned surfaces during shipping and construction activities.
9. Vents and Drain: Coils that are not vented or drainable by the piping system shall have capped vent/drain connections extended through coil casing.
10. Cooling Coil Condensate Drain Pan: Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS or Section 23 74 13, PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS.

- L. Humidifier: Provide humidification section with stainless steel drain pan of adequate length to allow complete absorption of water vapor. Provide stainless steel dispersion panel or distributors as indicated, with stainless steel supports and hardware. The humidifiers shall be of the self-generating electrode type, electrically producing atmospheric steam in a plastic cylinder without the use of immersion type electric heating elements.
1. The humidifier cabinet shall be constructed of corrosion resistant materials with all metal surfaces powder coated and designed to be aesthetically pleasing. The unit cover when removed should allow 180° access for easy maintenance.
 2. The electrodes shall be constructed of expanded low carbon steel, zinc plated and dynamically formed for precise current control, and minimization of arcing points. Electrical connection to the electrodes shall be by snap-on connectors made out of phosphorous bronze.
 3. The steam generating cylinder shall be constructed of a UL listed plastic having at least a 94HB safety rating when disposable, and 94V0 when cleanable.
 4. The steam generating cylinder shall have twin cylinder full electrodes operating as an independent circuit from the main power electrodes. No artificial neutral circuits shall be required. Additionally, the cylinder full electrodes shall be used to detect foaming of the water.
 5. The unit shall incorporate a power drain pump instead of drain solenoid to provide for more efficient flushing of the cylinder.
 6. All internal electrical controls and components shall be prewired to appropriately marked terminals for field connection. All internal components and the cabinet shall be properly grounded and shielded to prevent any line or irradiative interference.
 7. The humidifiers shall incorporate a true microprocessor control providing the following functions:
 - a. Automatic flushing of the steam generating cylinder based on conductivity, not just amperage draw, to extend the life of the electrodes. The humidifier shall read AND display the incoming water conductivity.
 - b. Pushbutton selection of drainage under power or timed drain to eliminate current leakage through the drain.
 8. The humidifier shall be programmable to empty the steam generating cylinder after an extended period of non-use, to prevent corrosion of the electrodes and contamination of the water.

9. The humidifier shall be programmable to force periodic drains to handle water with abnormal qualities that become corrosive on overconcentration.
10. The humidifier shall be programmable to allow for a modulating hi-limit humidity sensor or outdoor temperature sensor for automatic trimming of the output to avoid condensation.
11. The humidifier shall have an hour counter with programmable maintenance alarm schedules.
12. The Control may optionally remote mounted up to 600 feet.
13. Digital LCD Display of:
 - a. Incoming water conductivity
 - b. Electric current draw in Amps
 - c. Output of the humidifier
 - d. Selected output limit
 - e. Model No. and unit configuration
 - f. Sensed %RH when configured
 - g. Display of %RH set point when configured
 - h. Display of differential when configured
14. The humidifier shall have the AFS anti-foaming system to allow automatic detection and correction of water foaming. The humidifier shall be capable of operating on water qualities ranging from 75-1250 MicroMhos conductivity. Softened water should not be used.
15. The humidifier microprocessor control shall incorporate complete diagnostics, including the following alarms and pre-alarms which shall be shown on the LCD display:
 - a. High electric current in the steam cylinder
 - b. Low current electrolysis condition
 - c. Reduced steam output, unable to reach set point
 - d. High water level in cylinder
 - e. Humidity sensor defective
 - f. Water foaming in cylinder
 - g. Improper cylinder fill rate
 - h. Improper cylinder drain rate
 - i. Diagnostic memory test fail
 - j. All pre-alarms shall be self-correcting.
16. The humidifiers shall be configured for proportional control from DDC signal.

M. Discharge Section:

Provide aerodynamically designed framed discharge openings or spun bellmouth fittings to minimize pressure loss.

N. Electrical and Lighting: Wiring and equipment specifications shall conform to Division 26, ELECTRICAL.

1. Vapor-proof lights using cast aluminum base style with glass globe and cast aluminum guard shall be installed in access sections for fan, mixing box, humidifier and any section over 300 mm (12 inch) wide. A switch shall control the lights in each compartment with pilot light mounted outside the respective compartment access door. Wiring between switches and lights shall be factory installed. All wiring shall run in neatly installed electrical conduits and terminate in a junction box for field connection to the building system. Provide single point 115 volt - one phase connection at junction box.
2. Install compatible 100 watt bulb in each light fixture.
3. Provide a convenience duplex weatherproof receptacle next to the light switch.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Install air handling unit in conformance with ARI 435.
- B. Assemble air handling unit components following manufacturer's instructions for handling, testing and operation. Repair damaged galvanized areas with paint in accordance with Military Spec. DOD-P-21035. Repair painted units by touch up of all scratches with finish paint material. Vacuum the interior of air handling units clean prior to operation.
- C. Leakage test and repair:
 1. Field leakage testing shall be performed by the manufacturer.
 2. Leakage testing shall be performed for the entire air handling unit after the unit is completely assembled and installed. Positive and negative pressure tests shall be performed independently. Positive-pressure sections of units shall be tested under positive pressure and negative-pressure sections of units shall be tested under negative pressure. Unit air leakage shall not exceed 1.0% of design cfm at 1.5 times the design static pressure up to a maximum of +8" w.g. in all positive-pressure sections and -8" w.g. in all negative-pressure sections. Leakage shall be calculated by totaling all leakage either in to or out of the unit.
 3. All tests shall be performed in the presence of the Resident Engineer and the General Contractor. AHU leakage shall be measured and recorded. A report shall be provided to the Resident Engineer and Contractor to document compliance.

4. If any portion of the AHU tested fails to meet the permissible leakage level, the Contractor shall rectify sealing of unit to bring it into compliance and shall retest it until acceptable leakage is demonstrated to the Resident Engineer.
- D. Perform field mechanical (vibration) balancing in accordance with Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

3.2 STARTUP SERVICES

- A. The air handling unit shall not be operated for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings are lubricated and fan has been test run under observation.
- B. After the air handling unit is installed and tested, provide startup and operating instructions to VA personnel.
- C. An authorized factory representative should start up, test and certify the final installation and application specific calibration of control components. Items to be verified include fan performance over entire operating range, noise and vibration testing, verification of proper alignment, overall inspection of the installation, Owner/Operator training, etc.

3.3 COMMISSIONING

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

--- E N D ---

SECTION 23 74 13
PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Roof top air handling units including integral components specified herein.
- B. Definitions: Roof Top Air Handling Unit(Roof Top Units, RTU): A factory fabricated assembly consisting of fan, coils, filters, and other necessary equipment to perform one or more of the following functions of circulating, cleaning, heating, cooling, humidifying, dehumidifying, and mixing of air. Design capacities of units shall be as scheduled on the drawings.

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- B. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT: Sound and vibration requirements.
- C. Section 23 07 11, HVAC INSULATION: Piping and duct insulation.
- D. Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING: Piping and valves.
- E. Section 23 34 00, HVAC FANS: Exhaust fans.
- F. Section 23 31 00, HVAC DUCTS AND CASINGS: Requirements for flexible duct connectors, sound attenuators and sound absorbing duct lining.
- G. Section 23 40 00, HVAC AIR CLEANING DEVICES: Air filters and filters' efficiency.
- H. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: HVAC controls.
- I. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC: Testing, adjusting and balancing of air and water flows.
- J. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT: Types of motors.
- K. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS:
- L. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Refer to Article, Quality Assurance, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Air Handling Units Certification
 - 1. Air Handling Units with Plenum Fans:
 - a. Air handling Units with Multiple Fans in an Array shall be tested and rated in accordance with AHRI 430 and AHRI 260.
- C. Heating, Cooling, and Air Handling Capacity and Performance Standards: AHRI 430, AHRI 410, ASHRAE 51, and AMCA 210.
- D. Performance Criteria:
 - 1. The fan motor shall be selected within the rated nameplate capacity, without relying upon NEMA Standard Service Factor.
 - 2. Select the fan operating point as follows:
 - a. Air Foil, Backward Inclined, or Plenum Fans: At or near the peak static efficiency but at an appropriate distance from the stall line.
 - 3. Operating Limits: AMCA 99 and Manufacturer's Recommendations.
- E. Units shall be factory-fabricated, assembled, and tested by a manufacturer, in business of manufacturing similar air-handling units for at least five (5) years.

1.5 SUBMITTALS:

- A. The contractor shall, in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish a complete submission for all roof top units covered in the project. The submission shall include all information listed below. Partial and incomplete submissions shall be rejected without reviews.
- B. Manufacturer's Literature and Data:
 - 1. Submittals for RTUs shall include fans, drives, motors, coils, humidifiers, mixing box with outside/return air dampers, filter housings, and all other related accessories. The contractor shall provide custom drawings showing total air handling unit assembly including dimensions, operating weight, access sections, flexible connections, door swings, controls penetrations, electrical disconnect, lights, duplex receptacles, switches, wiring, utility connection points, unit support system, vibration isolators, drain pan, pressure drops through each component (filter, coil etc) and rigging points.
 - 2. Submittal drawings of section or component only, will not be acceptable. Contractor shall also submit performance data including performance test results, charts, curves or certified computer selection data; data sheets; fabrication and insulation details; if the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements. This data shall be submitted in hard copies and in electronic version compatible to AutoCAD version used by the VA at the time of submission.
 - 3. Submit sound power levels in each octave band for fan and at entrance and discharge of RTUs at scheduled conditions. Include sound attenuator capacities and itemized internal component attenuation. Internal lining of supply air ductwork with sound absorbing material is not permitted. In absence of sound power ratings refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
 - 4. Provide fan curves showing Liters/Second (cubic feet per minute), static pressure, efficiency, and horsepower for design point of operation and at maximum design Liters/Second (cubic feet per minute) and 110 percent of design static pressure.
 - 5. Submit total fan static pressure, external static pressure, for RTU including total, inlet and discharge pressures, and itemized specified internal losses and unspecified internal losses. Refer to air handling unit schedule on drawings.

- C. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS. Include instructions for lubrication, filter replacement, motor and drive replacement, spare part lists, and wiring diagrams.
- D. Submit written test procedures two weeks prior to factory testing. Submit written results of factory tests for approval prior to shipping.
- 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.
- F. Submit shipping information that clearly indicates how the units will be shipped in compliance with the descriptions below.
 - 1. Units shall be shipped in one (1) piece where possible and in shrink wrapping to protect the unit from dirt, moisture and/or road salt.
 - 2. If not shipped in one (1) piece, provide manufacturer approved shipping splits where required for installation or to meet shipping and/or job site rigging requirements in modular sections. Indicate clearly that the shipping splits shown in the submittals have been verified to accommodate the construction constraints for rigging as required to complete installation and removal of any section for replacement through available access without adversely affecting other sections.
 - 3. If shipping splits are provided, each component shall be individually shrink wrapped to protect the unit and all necessary hardware (e.g. bolts, gaskets etc.) will be included to assemble unit on site (see section 2.1.A4).
 - 4. Lifting lugs will be provided to facilitate rigging on shipping splits and joining of segments. If the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
 - 260-01Sound Rating of Ducted Air Moving and Conditioning Equipment
 - 410-01Standard for Forced-Circulation Air-Heating and Air-Cooling Coils

- 430-09Standard for Central Station Air Handling Units
- AHRI-DCAACPDirectory of Certified Applied Air Conditioning Products
- C. Air Moving and Conditioning Association (AMCA):
- 210-07Laboratory Methods of Testing Fans for Rating
- D. Anti-Friction Bearing Manufacturer's Association, Inc. (AFBMA):
- 9-90 (R2008).....Load Ratings and Fatigue life for Ball Bearings
- E. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):
- 51-2007Laboratory Methods of Testing Fans for Rating
- F. American Society for Testing and Materials (ASTM):
- A653/653M-02.....Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- B117-07a.....Salt Spray (Fog) Testing
- C1071-05e1.....Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
- D1654-08Standard Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
- D1735-08Water Resistance of Coatings Using Water Fog Apparatus
- D3359-08Standard Test Methods for Measuring Adhesion by Tape Test
- E84-10.....Standard Test Method for Surface Burning Characteristics of Building Materials
- G. Anti-Friction Bearing Manufacturer's Association, Inc. (AFBMA):
- 9-90Load Ratings and Fatigue life for Ball Bearings
- H. Military Specifications (Mil. Spec.):
- DOD-P-21035A-2003Paint, High Zinc Dust Content, Galvanizing Repair
- I. National Fire Protection Association (NFPA):
- NFPA 90AStandard for Installation of Air Conditioning and Ventilating Systems, 2009
- J. Energy Policy Act of 2005 (P.L.109-58)

PART 2 - PRODUCTS

2.1 ROOF TOP AIR HANDLING UNITS

A. General:

1. Roof top units (RTU) shall be fabricated from insulated, solid double-wall galvanized steel without any perforations in draw-through configuration. Casing is specified in paragraph 2.1.C. Galvanizing shall be hot dipped conforming to ASTM A525 and shall provide a minimum of 0.275 kg of zinc per square meter (0.90 oz. of zinc per square foot) (G90). Aluminum constructed units may be provided subject to VA approval and documentation that structural rigidity is equal or greater than the galvanized steel specified.
2. The contractor and the RTU manufacturer shall be responsible for insuring that the unit will not exceed the allocated space shown on the drawings, including required clearances for service and future overhaul or removal of unit components. All structural, piping, wiring, and ductwork alterations of units, which are dimensionally different than those specified, shall be the responsibility of the contractor at no additional cost to the government.
3. RTUs shall be fully assembled by the manufacturer in the factory in accordance with the arrangement shown on the drawings. The unit shall be assembled into the largest sections possible subject to shipping and rigging restrictions. The correct fit of all components and casing sections shall be verified in the factory for all units prior to shipment. All units shall be fully assembled, tested and then split to accommodate shipment and job site rigging. On units not shipped fully assembled, the manufacturer shall tag each section and include air flow direction to facilitate assembly at the job site. Lifting lugs or shipping skids shall be provided for each section to allow for field rigging and final placement of unit.
4. The RTU manufacturer shall provide the necessary gasketing, caulking, and all screws, nuts, and bolts required for assembly. The manufacturer shall provide a local representative at the job site to supervise the assembly and to assure the units are assembled to meet manufacturer's recommendations and requirements noted on the drawings. Provide documentation that this representative has provided this service on similar jobs to the Contracting Officer. If a local representative cannot be provided, the manufacturer shall provide a factory representative.

5. Gaskets: All door and casing and panel gaskets and gaskets between air handling unit components, if joined in the field, shall be high quality which seal air tight and retain their structural integrity and sealing capability after repeated assembly and disassembly of bolted panels and opening and closing of hinged components. Bolted sections may use a more permanent gasketing method provided they are not disassembled.
6. Structural Rigidity: Provide structural reinforcement when required by span or loading so that the deflection of the assembled structure shall not exceed $L/240$ of the span based on a differential static pressure of 1991 Pa (8 inches water gage) or higher.

B. Base:

1. Provide a heavy duty steel base for supporting all major RTU components. Bases shall be constructed of structural steel C channels minimum 6 inch high. Welded or bolted cross members shall be provided as required for lateral stability.
2. RTUs shall be completely self supporting for installation on roof curb.
3. The RTU bases not constructed of galvanized material shall be cleaned, primed with a rust inhibiting primer, and finished with rust inhibiting exterior enamel.

C. Casing (including wall, floor and roof):

1. General: RTU casing shall be entirely double wall insulated panels, integral of or attached to a structural frame. Construction shall be such that removal of any panel shall not affect the structural integrity of the unit. Casing finished shall meet salt-spray test as specified in paragraph 2.1.C.10. All casing and panel sections shall be tightly butted and gasketed. No gaps of double wall construction will be allowed where panels bolt to air handling unit structural member. Structural members, not covered by the double wall panels, shall have equivalent insulated double wall construction.
2. Double wall galvanized steel panels, minimum 51 mm (2 inches) thick, constructed of minimum 1.3 mm (18 gauge) outer skin and 1.0 mm (20 gauge) solid inner skin to limit wall, roof and floor deflection to not exceed an $L/240$ ratio when the unit casing is pressurized to ± 8 in. w.g.. Deflection shall be measured at the midpoint of the panel height. Total housing leakage shall not exceed 1% of rated cfm when the unit casing is pressurized to ± 8 in. w.g. The outer (skin) and inner panels shall be solid.
3. Blank-Off: Provide blank-offs as required to prevent air bypass between the AHU sections, around coils, and filters.

4. Insulation: Insulation shall be injected CFC free polyurethane foam encased in double-wall casing between exterior and interior panels such that no insulation can erode to the air stream. Insulation shall be 50 mm (2 inch) thick, and 48 kg/m³ (3.0 lb/ft³) density with a total thermal resistance (R-value) of approximately 2.3 m.K/W (13.0 hr-ft² °F/BTU). Units with less than 50 mm (2 inch) of insulation in any part of the walls, floor, roof or drain pan shall not be acceptable. The insulation shall comply with NFPA 90-A for the flame and smoke generation requirements. Also, refer to specification Section 23 07 11, HVAC INSULATION.

Table 2.1.C.4

Outer Panel	0.8 mm (22 Gage) Minimum
Inner Panel	0.8 mm (22 Gage) Minimum
Insulation	Foam
Thickness	50 mm (2 inch) Minimum
Density	48 kg/m ³ (3.0 lb/ft ³) Minimum
Total R Value	2.3 m ² .K/W (13.0 ft ² . °F.hr/Btu) Minimum

5. The thickness of insulation, mode of application, and thermal breaks shall be such that there is no visible condensation on the exterior panels of the AHU.
6. Casing panels shall be secured to the support structure with stainless steel or zinc-chromate plated screws and gaskets installed around the panel perimeter. Panels shall be completely removable to allow removal of fan, coils, and other internal components for future maintenance, repair, or modifications. Welded exterior panels are not acceptable.

7. Access Doors: Provide in each access section and where shown on drawings. Show single-sided and double-sided access doors with door swings on the floor plans. Doors shall be a minimum of 50 mm (2 inches) thick with same double wall construction as the unit casing. Doors shall be a minimum of 600 mm (24 inches) wide, unless shown of different size on drawings, and shall be the full casing height up to a maximum of 1850 mm (6 feet). Doors shall be gasketed, hinged, and latched to provide an airtight seal. The access doors for fan section, mixing box, humidifier, and coil section shall include a minimum 150 mm x 150 mm (6 inch x 6 inch) double thickness, with air space between glass panes tightly sealed, reinforced glass or Plexiglas window in a gasketed frame.
 - a. Hinges: Manufacturers standard, designed for door size, weight and pressure classifications. Hinges shall hold door completely rigid with minimum 45 kg (100 pound) weight hung on latch side of door.
 - b. Latches: Non-corrosive alloy construction, with operating levers for positive cam action, operable from either inside or outside. Doors that do not open against unit operating pressure shall allow the door to ajar and then require approximately 0.785 radian (45 degrees) further movement of the handle for complete opening. Latch shall be capable of restraining explosive opening of door with a force not less than 1991 Pa (8 inches water gage).
 - c. Gaskets: Neoprene, continuous around door, positioned for direct compression with no sliding action between the door and gasket. Secure with high quality mastic to eliminate possibility of gasket slipping or coming loose.
8. Provide sealed sleeves, metal or plastic escutcheons or grommets for penetrations through casing for power and temperature control wiring and pneumatic tubing. Coordinate with electrical and temperature control subcontractors for number and location of penetrations. Coordinate lights, switches, and duplex receptacles and disconnect switch location and mounting. All penetrations and equipment mounting may be provided in the factory or in the field. All field penetrations shall be performed neatly by drilling or saw cutting. No cutting by torches will be allowed. Neatly seal all openings airtight.
9. Roof of the unit shall be sloped to have a minimum pitch of 1/4 inch per foot. The roof shall overhang the side panels by a minimum of three inches to prevent precipitation drainage from streaming down the unit side panels.

10. Casing finished shall meet ASTM B117, 500-hour salt spray test, using 20 percent sodium chloride solution. Immediately after completion of the test, the coating shall show no sign of blistering, wrinkling, or cracking, no loss of adhesion, and the specimen shall show no sign of rust creepage beyond 1/8-inch on either side of scratch mark.
- D. Unit floor shall be level without offset space or gap and designed to support a minimum of 488 kg/square meter (100 pounds per square foot) distributed load without permanent deformation or crushing of internal insulation. Provide adequate structural base members beneath floor in service access sections to support typical service foot traffic and to prevent damage to unit floor or internal insulation.
- E. Condensate Drain Pan: Drain pan shall be designed to extend entire length of cooling coils including headers and return bends. Depth of drain pan shall be at least 43 mm (1.7 inches) and shall handle all condensate without overflowing. Drain pan shall be double wall construction, Type 304 stainless steel and have a minimum of 50 mm (2 inch) insulation, and shall be sloped to drain. Drain pan shall be continuous metal or welded watertight. No mastic sealing of joints exposed to water will be permitted. Drain pan shall be placed on top of casing floor or integrated into casing floor assembly. Drain pan shall be pitched in all directions to drain line.
 1. An intermediate condensate drip pan shall be provided on stacked cooling coils and shall be constructed of type 304 stainless steel with copper downspouts factory piped to main condensate pan. Use of intermediate condensate drain channel on upper casing of lower coil is permissible provided it is readily cleanable. Design of intermediate condensate drain shall prevent upper coil condensate from flowing across face of lower coil.
 2. Drain pan shall be piped to the exterior of the unit. Drain pan shall be readily cleanable.
 3. Installation, including frame, shall be designed and sealed to prevent blow-by.
- F. Plenum Fans – Multiple Fans in an Array
 1. General: Fans shall be Class II (minimum) construction with single inlet, aluminum wheel and stamped air-foil aluminum bladed. The fan wheel shall be mounted on the directly-driven motor shaft in AMCA Arrangement 4. Fans shall be dynamically balanced and internally isolated to minimize the vibrations. Provide a steel inlet cone for each wheel to match with the fan inlet. Locate fan in the air stream to assure proper flow. The fan performance shall be rated in accordance with AMCA 210 or ASHRAE 51.

2. Allowable vibration tolerances for fan shall not exceed a self-excited vibration maximum velocity of 0.005 m/s (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions. After field installation, compliance to this requirement shall be demonstrated with field test in accordance with Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT and Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC. The fan wheel shall meet or exceed guidelines in AMCA 801-92 for dynamic balancing requirements. The complete fan assembly balance shall be tested using an electronic balance analyzer with a tunable filter and stroboscope. Vibration measurements shall be taken on each motor bearing housing in the vertical, horizontal, and axial planes (5 total measurements, 2 each motor bearing and 1 axial).
3. Multiple fans shall be installed in a pre-engineered structural frame to facilitate fan stacking. All fans shall modulate in unison, above or below the synchronous speed within the limits specified by the manufacturer, by a common control sequence. Staging of the fans is not permitted. Redundancy requirement shall be met by all operating fans in an array and without the provision of an idle standby fan.
4. Fan Accessories
 - a. Fan Isolation: Provide a manual blank off plate to isolate the fan not in operation due to failure.
5. Fan Motor, Drive and Mounting Assembly: Fan Motors shall be premium energy efficient type, as mandated by the Energy Policy Act of 2005, with efficiencies as shown in the Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM EQUIPMENT, on drawings and suitable for use in variable frequency drive applications. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC, for additional motor and drive specifications.

G. Mixing Boxes: Mixing box shall consist of casing, outdoor airflow measuring station, and return air dampers in opposed blade arrangement with damper linkage for automatic operation.

Coordinate damper operator provided in Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. Dampers shall be of ultra-low leak design with metal compressible bronze jamb seals and extruded vinyl edge seals on all blades. Blades shall rotate on stainless steel sleeve bearings or bronze bushings. Leakage rate shall not exceed 1.6 cubic meters/min/square meter (5 cfm per square foot) at 250 Pa (1 inch water gage) and 2.8 cubic meters/min/square meter (9 cfm per square foot) at 995 Pa (4 inches water gage).

1. Airflow measuring stations shall be provided and located in the outside and/or return air paths as indicated on the schedule and plans to measure airflow. Airflow measuring stations shall be tested per AMCA Standard 611 and licensed to bear the AMCA Ratings Seal for airflow measurement performance. Integral control damper blades shall be provided as galvanized steel and housed in a galvanized steel frame. Leakage rate shall not exceed 4 CFM/square foot at one inch water gauge complying with ASHRAE 90.1 maximum damper leakage.
 - a. The airflow measurement station shall measure up to 100 percent of the total outside air and/or return air. The airflow measurement station shall be capable of measuring down to 300 fpm. The airflow measuring device shall adjust for temperature variations. Output shall be provided from the station as a 2-10 VDC signal. Signal shall be proportional to air velocity. The accuracy of the measuring station shall be no greater than +/- 5 percent. Airflow measuring stations shall be mounted on the AHU interior.
 - b. The installing contractor shall provide duct-mounted pleated media MERV 8 filtration upstream of airflow monitoring stations requiring air straightening vanes to prevent blockage of vanes. A filter access door shall be provided for filter replacement that does not degrade the specified duct leakage class. Duct-mounted filtration section with access door for filter removal shall be tested for compliance to specified duct leakage class on the schedule and plans.

H. Filter Section: Refer to Section 23 40 00, HVAC AIR CLEANING DEVICES, for filter requirements.

1. Filters including one complete set for temporary use at site shall be provided independent of the RTU. The RTU manufacturer shall install filter housings and racks in filter section compatible with filters furnished. The RTU manufacturer shall be responsible for furnishing temporary filters (pre-filters and after-filters, as shown on drawings) required for RTU testing.
2. Factory-fabricated filter section shall be of the same construction and finish as the RTU casing including filter racks and hinged double wall access doors. Filter housings shall be constructed in accordance with side service or holding frame housing requirements in Section 23 40 00, HVAC AIR CLEANING DEVICES.

I. Photo Catalytic Air Cleaning System

1. The Photo Catalytic Air Cleaner System shall be factory-engineered and factory-installed in the air handler by the air handler manufacturer and shall be covered under warranty by the air handler manufacturer.
2. Submittal information shall include a list of reference projects, third party testing that lists reduction in colony forming units (CFU) versus time for vegetative bacteria including MRSA, viruses, and other common bioaerosols and VOCs. Data shall also include rated pressure drop at the design airflow.
3. The Catalytic Air Cleaner System shall be a three part integral assembly for treatment of air by: (1) High Efficiency Particle Filtration (2) Ultraviolet Germicidal Irradiation (UVGI) using UV-C lamps and fixtures; and (3) Photocatalytic Oxidation (PCO) catalyst media using titanium dioxide (TiO₂).
4. High Efficiency Particle Filters shall be rated MERV 13 or higher. Filters are positioned upstream of the PCO media.
5. UV-C lamps and ballasts designed specifically to provide type-C ultraviolet light with a wavelength at or near 253.7 Angstroms and shall not produce any ozone. Lamps shall be imbedded in the center of the catalyst media bank, spaced no further than 6" apart, and shall achieve a minimum coverage of 5 milliwatts per square inch of UVC light across all exposed surfaces of the PCO media.

6. The catalyst media shall consist of six-inch deep (direction of airflow) grid with face area to match casing opening, one pleat per inch (nominal), and coated with 40-200 nanometer TiO₂. The complete PCO media bank assembly shall be housed in a galvanized or stainless steel casing and placed in the air handler perpendicular to the airflow.
7. All UV lamps and PCO media shall be removable from outside the AHU casing through a side access door for maintenance purposes.
8. An air flow switch shall be wired into the control circuit to disable the UV lights when the AHU fan is not running.
9. The Catalytic Air Cleaner System shall be configured to operate electrical power that matches the power requirement in the air handler schedule. Three phase systems shall be either independent single point power or integral with the AHU main power. All necessary main fusing shall be included.
10. Electrical fixtures shall meet the UL drip proof design criteria. Component enclosures shall be constructed of galvanized steel or stainless steel to resist corrosion. Fixtures shall have been tested and recognized by UL/C-UL under Category Code ABQK (Accessories, Air Duct Mounted), UL Standards 1995.
11. For Line Voltage options, the CACS shall be provided with a UL 508 listed panel for power distribution and over-current protection.
12. CACS assemble shall be capable of withstanding 750 fpm face velocity with no structural damage
13. All polymeric materials that come into direct or indirect (reflected) contact with UV-C light shall be tested and certified as UV-C tolerant. Any non-conforming construction materials or components within the exposure zone shall be completely shielded from the UV-C light using a certified UV-C tolerant material. UV-C tolerance is defined as being capable of performing its intended duty for a minimum of 20 years.
14. Safety
 - a. Access doors or panels shall be provided at the location of each Catalytic Air Cleaner System as indicated on the schedule. All access doors/panels shall have a mechanical safety interlock switch that disconnects the CACS power upon opening.
 - b. Each CACS shall be equipped with an externally mounted electrical disconnect switch, with lock-out capability to prevent unwanted operation for maintenance purposes.

- c. A window shall be provided on each air handler to allow visual inspection of the Catalytic Air Cleaner System during operation. The viewing window shall be guaranteed to block UV-C light emissions below the threshold limits specified by NIOSH and/or ACGIH.
 - d. Units shall have a safety warning label applied to the exterior of each section containing UV-C lights.
 - e. Complete safety, maintenance and servicing instructions for the Catalytic Air Cleaner System shall be incorporated into the air handler manufacturer's standard installation, operating and maintenance manuals.
- J. Coils: Coils shall be mounted on hot dipped galvanized steel supports to assure proper anchoring of coil and future maintenance. Coils shall be face or side removable for future replacement thru the access doors or removable panels. Each coil shall be removable without disturbing adjacent coil. Cooling coils shall be designed and installed to insure no condensate carry over. Provide factory installed extended supply, return, drain, and vent piping connections.
- 1. Conform to ASTM B75 and AHRI 410.
 - 2. Tubes: Minimum 16 mm (0.625 inch) tube diameter; Seamless copper tubing.
 - 3. Fins: 0.1397 mm (0.0055 inch) aluminum or 0.1143 mm (0.0045 inch) copper mechanically bonded or soldered or helically wound around tubing.
 - 4. Headers: Copper, welded steel or cast iron. Provide seamless copper tubing or resistance welded steel tube for volatile refrigerant coils.
 - 5. "U" Bends, Where Used: Machine die-formed, silver brazed to tube ends.
 - 6. Coil Casing: 1.6 mm (16 gage) galvanized steel with tube supports at 1200 mm (48 inch) maximum spacing. Construct casing to eliminate air bypass and moisture carry-over. Provide duct connection flanges.
 - 7. Pressures kPa (PSIG):

Pressure	Water Coil
Test	2070 (300)
Working	1380 (200)

- 8. Protection: Unless protected by the coil casing, provide cardboard, plywood, or plastic material at the factory to protect tube and finned surfaces during shipping and construction activities.

9. Vents and Drain: Coils that are not vented or drainable by the piping system shall have capped vent/drain connections extended through coil casing.
 10. Cooling Coil Condensate Drain Pan: Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS or Section 23 74 13, PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS.
- K. Humidifier: Provide humidification section with stainless steel drain pan of adequate length to allow complete absorption of water vapor. Provide stainless steel dispersion panel or distributors as indicated, with stainless steel supports and hardware. The humidifiers shall be of the self-generating electrode type, electrically producing atmospheric steam in a plastic cylinder without the use of immersion type electric heating elements.
1. The humidifier cabinet shall be constructed of corrosion resistant materials with all metal surfaces powder coated and designed to be aesthetically pleasing. The unit cover when removed should allow 180° access for easy maintenance.
 2. The electrodes shall be constructed of expanded low carbon steel, zinc plated and dynamically formed for precise current control, and minimization of arcing points. Electrical connection to the electrodes shall be by snap-on connectors made out of phosphorous bronze.
 3. The steam generating cylinder shall be constructed of a UL listed plastic having at least a 94HB safety rating when disposable, and 94V0 when cleanable.
 4. The steam generating cylinder shall have twin cylinder full electrodes operating as an independent circuit from the main power electrodes. No artificial neutral circuits shall be required. Additionally, the cylinder full electrodes shall be used to detect foaming of the water.
 5. The unit shall incorporate a power drain pump instead of drain solenoid to provide for more efficient flushing of the cylinder.
 6. All internal electrical controls and components shall be prewired to appropriately marked terminals for field connection. All internal components and the cabinet shall be properly grounded and shielded to prevent any line or radiative interference.
 7. The humidifiers shall incorporate a true microprocessor control providing the following functions:
 - a. Automatic flushing of the steam generating cylinder based on conductivity, not just amperage draw, to extend the life of the electrodes. The humidifier shall read AND display the incoming water conductivity.

- b. Pushbutton selection of drainage under power or timed drain to eliminate current leakage through the drain.
- 8. The humidifier shall be programmable to empty the steam generating cylinder after an extended period of non-use, to prevent corrosion of the electrodes and contamination of the water.
- 9. The humidifier shall be programmable to force periodic drains to handle water with abnormal qualities that become corrosive on overconcentration.
- 10. The humidifier shall be programmable to allow for a modulating hi-limit humidity sensor or outdoor temperature sensor for automatic trimming of the output to avoid condensation.
- 11. The humidifier shall have an hour counter with programmable maintenance alarm schedules.
- 12. The Control may optionally remote mounted up to 600 feet.
- 13. Digital LCD Display of:
 - a. Incoming water conductivity
 - b. Electric current draw in Amps
 - c. Output of the humidifier
 - d. Selected output limit
 - e. Model No. and unit configuration
 - f. Sensed %RH when configured
 - g. Display of %RH set point when configured
 - h. Display of differential when configured
- 14. The humidifier shall have the AFS anti-foaming system to allow automatic detection and correction of water foaming. The humidifier shall be capable of operating on water qualities ranging from 75-1250 MicroMhos conductivity. Softened water should not be used.
- 15. The humidifier microprocessor control shall incorporate complete diagnostics, including the following alarms and pre-alarms which shall be shown on the LCD display:
 - a. High electric current in the steam cylinder
 - b. Low current electrolysis condition
 - c. Reduced steam output, unable to reach set point
 - d. High water level in cylinder
 - e. Humidity sensor defective
 - f. Water foaming in cylinder
 - g. Improper cylinder fill rate
 - h. Improper cylinder drain rate

- i. Diagnostic memory test fail
 - j. All pre-alarms shall be self-correcting.
- 16. The humidifiers shall be configured for proportional control from DDC signal.
- L. Discharge Section: Provide aerodynamically designed framed discharge openings or spun bellmouth fittings to minimize pressure loss.
- M. Electrical and Lighting: Wiring and equipment specifications shall conform to Division 26, ELECTRICAL.
 - 1. Vapor-proof lights using cast aluminum base style with glass globe and cast aluminum guard shall be installed in access sections for fan, mixing box, humidifier and any section over 300mm (12 inch) wide. A switch shall control the lights in each compartment with pilot light mounted outside the respective compartment access door. Wiring between switches and lights shall be factory installed. All wiring shall run in neatly installed electrical conduits and terminate in a junction box for field connection to the building system. Provide single point 115 volt - one phase connection at junction box.
 - 2. Install compatible 100 watt bulb in each light fixture.
 - 3. Provide a convenience duplex weatherproof/ receptacle next to the light switch.
- N. Provide manufacturer's standard 18" roof curb.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Install roof top unit in conformance with ARI 435.
- B. Assemble roof top unit components following manufacturer's instructions for handling, testing and operation. Repair damaged galvanized areas with paint in accordance with Military Spec. DOD-P-21035A. Repair painted units by touch up of all scratches with finish paint material. Vacuum the interior of air-handling units clean prior to operation.
- C. Leakage test and repair:
 - 1. Field leakage testing shall be performed by the manufacturer.
 - 2. Leakage testing shall be performed for the entire air handling unit after the unit is completely assembled and installed. Positive and negative pressure tests shall be performed independently. Positive-pressure sections of units shall be tested under positive pressure and negative-pressure sections of units shall be tested under negative pressure. Unit air leakage shall not exceed 1.0% of design cfm at 1.5 times the design static pressure up to a maximum of +8" w.g. in all positive-pressure sections and -8" w.g. in all negative-pressure sections. Leakage shall be calculated by totaling all leakage either in to or out of the unit.

3. All tests shall be performed in the presence of the Resident Engineer and the General Contractor. AHU leakage shall be measured and recorded. A report shall be provided to the Resident Engineer and Contractor to document compliance.
 4. If any portion of the AHU tested fails to meet the permissible leakage level, the Contractor shall rectify sealing of unit to bring it into compliance and shall retest it until acceptable leakage is demonstrated to the Resident Engineer.
- D. Perform field mechanical (vibration) balancing in accordance with Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

3.2 STARTUP SERVICES

- A. The air handling unit shall not be operated for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings are lubricated and fan has been test run under observation.
- B. After the air handling unit is installed and tested, provide startup and operating instructions to VA personnel.
- C. An authorized factory representative should start up, test and certify the final installation and application specific calibration of control components. Items to be verified include fan performance over entire operating range, noise and vibration testing, verification of proper alignment, overall inspection of the installation, Owner/Operator training, etc.

3.3 COMMISSIONING

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

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SECTION 23 82 00
CONVECTION HEATING AND COOLING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

Fan coil units.

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- B. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT: Noise requirements.
- C. Section 23 21 13, HYDRONIC PIPING: Heating hot water and chilled water piping.
- D. Section 23 31 00, HVAC DUCTS AND CASINGS: Ducts and flexible connectors.
- E. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Valve operators.
- F. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC: Flow rates adjusting and balancing.
- G. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.
- H. Section 01 09 00, GENERAL COMMISSIONING REQUIREMENTS

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

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

1.5 SUBMITTALS

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

- B. Manufacturer's Literature and Data:
 - 1. Fan Coil units.
 - 2. Finned tube radiation.
- C. Certificates:
 - 1. Compliance with paragraph, QUALITY ASSURANCE.
 - 2. Compliance with specified standards.
- D. Operation and Maintenance Manuals: Submit in accordance with paragraph, INSTRUCTIONS, in Section 01 00 00, GENERAL REQUIREMENTS.
- 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.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American National Standards Institute / Air Conditioning, Heating and Refrigeration Institute (ANSI/AHRI):
 - 440-08Performance Rating of Room Fan Coils
- C. National Fire Protection Association (NFPA):
 - 90A-09Standard for the Installation of Air Conditioning and Ventilating Systems
 - 70-11National Electrical Code
- D. Underwriters Laboratories, Inc. (UL):
 - 181-08Standard for Factory-Made Air Ducts and Air Connectors
 - 1995-05Heating and Cooling Equipment

1.7 GUARANTY

- A. In accordance with FAR clause 52.246-21

PART 2 - PRODUCTS

2.1 FAN-COIL UNITS

- A. Capacity Certification: AHRI 440.
- B. Safety Compliance: NEC compliant and UL listed.

- C. Noise Levels: Operating at full cooling capacity, sound power level shall not exceed by more than 5 dB the numerical value of sound pressure levels associated with noise criteria specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT. Select units at intermediate speed, for compliance with the noise criteria.
- D. Chassis: Galvanized steel, acoustically and thermally insulated to attenuate noise and prevent condensation.
- E. Cabinet: Minimum 1.3 mm (18 gage) steel reinforced and braced. Arrange components and provide adequate space for installation of piping package and control valves. Finish shall be factory-baked enamel in manufacturer's standard color on all exposed surfaces.
 - 1. Horizontal Unit: Provide type as shown. Provide supports and vibration isolators for horizontal units as recommended by the manufacturer.
 - a. Concealed Units: Provide furred-in type with return plenum and inlet duct collar and outlet duct collar.
 - b. Recessed Units: Provide hinged access door with stamped integral air inlet grille and outlet duct collar.
 - c. Exposed Units: Fully enclosed cabinet with hinged bottom access panel with cam-lock fasteners. Provide stamped integral inlet and discharged grilles in front of cabinet.
- F. Fans: Centrifugal, forward curved, double width type wheels, galvanized steel or polyester resin construction, statically and dynamically balanced, direct driven.
 - 1. Motors: Premium efficiency, 3-speed permanent split capacitor type with integral thermal overload protection, for operation at not more than 1200 RPM.
 - 2. Provide a fan speed selector switch, with off, low, medium, and high positions. Switch shall have a set of auxiliary contacts which are open when the switch is in the "off" position and closed when the switch in any of the other positions. On vertical units, mount switch in a junction box in the cabinet of each unit. On ceiling-suspended horizontal and concealed units, switch shall be wall mounted.
- G. Cooling and Heating Coils:
 - 1. Hydronic (two separate coils for cooling and heating): Copper tubes, 10 mm (three-eighths inch) minimum inside diameter, not less than 4.3 mm (0.017 inch) thick with copper or aluminum fins. Coils shall be pressure tested for bursting and strength in accordance with Underwriters Laboratories, Inc., requirements for pressure tested coils, and shall be designed to provide adequate heat transfer capacity. Provide manual air vent at high point of each coil and drain at each low point.

- H. Piping Package: Factory furnished with unit by the manufacturer to fit control valves provided by the controls supplier. Submit manufacturer's detailed drawings of the piping in the end compartments for approval prior to fabrication of the piping packages. Provide ball stop valves on the supply and return pipes and balancing fittings on the return pipes.
- I. Drain pans: Furnish galvanized steel with solderless drain connections and molded polystyrene foam insulating liner:
 - 1. Auxiliary drain pan: Located under control valve and piping within the unit enclosure to prevent dripping.
 - 2. Secondary Drain Pan: Where shown on the drawings or where the unit is located such that drain pan overflow will damage the building, provide a secondary drain pan located underneath the unit, constructed to extend a minimum of 50 mm (2 inches) beyond the edges of the unit and be a minimum of 38 mm (1-1/2 inches deep) provided with a water detection device to deactivate the cooling in the unit.
- J. Air Filter: Manufacturer's standard throwaway type, not less than 25 mm (1 inch) thick, MERV 7, supported to be concealed from sight and be tight fitting to prevent air by-pass. Filters shall have slide out frames and be easily replaced without removing enclosure or any part thereof.
- K. Remote wall mounted space thermostats to be field installed. Provide two-way modulating control valves unless shown or specified otherwise. Refer to drawings for the location of 3-way valves.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.
- B. Handle and install units in accordance with manufacturer's written instructions.
- C. Support units rigidly so they remain stationary at all times. Cross-bracing or other means of stiffening shall be provided as necessary. Method of support shall be such that distortion and malfunction of units cannot occur.
- D. Install fiberglass blanket insulation with a minimum R value of 8 above hydronic radiant panels.

3.2 OPERATIONAL TEST

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

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 the Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.4 COMMISSIONING

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

3.5 DEMONSTRATION AND TRAINING

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

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SECTION 26 05 11
REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section applies to all sections of Division 26.
- B. Furnish and install electrical wiring, systems, equipment and accessories in accordance with the specifications and drawings. Capacities and ratings of motors, transformers, cable, switchboards, switchgear, panelboards, motor control centers, generators, automatic transfer switches, and other items and arrangements for the specified items are shown on drawings.
- C. Electrical service entrance equipment and arrangements for temporary and permanent connections to the utility's system shall conform to the utility's requirements. Coordinate fuses, circuit breakers and relays with the utility's system, and obtain utility approval for sizes and settings of these devices.
- D. Wiring ampacities specified or shown on the drawings are based on copper conductors, with the conduit and raceways accordingly sized. Aluminum conductors are prohibited.

1.2 MINIMUM REQUIREMENTS

- A. References to the International Building Code (IBC), National Electrical Code (NEC), Underwriters Laboratories, Inc. (UL) and National Fire Protection Association (NFPA) are minimum installation requirement standards.
- B. Drawings and other specification sections shall govern in those instances where requirements are greater than those specified in the above standards.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 TEST STANDARDS

- A. All materials and equipment shall be listed, labeled or certified by a nationally recognized testing laboratory to meet Underwriters Laboratories, Inc., standards where test standards have been established. Equipment and materials which are not covered by UL Standards will be accepted provided equipment and material is listed, labeled, certified or otherwise determined to meet safety requirements of a nationally recognized testing laboratory. Equipment of a class which no nationally recognized testing laboratory accepts, certifies, lists, labels, or determines to be safe, will be considered if inspected or tested in accordance with national industrial standards, such as NEMA, or ANSI. Evidence of compliance shall include certified test reports and definitive shop drawings.
- B. Definitions:
1. Listed; Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production or listed equipment or materials or periodic evaluation of services, and whose listing states that the equipment, material, or services either meets appropriate designated standards or has been tested and found suitable for a specified purpose.
 2. Labeled; Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
 3. Certified; equipment or product which:
 - a. Has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for use in a specified manner.
 - b. Production of equipment or product is periodically inspected by a nationally recognized testing laboratory.
 - c. Bears a label, tag, or other record of certification.
 4. Nationally recognized testing laboratory; laboratory which is approved, in accordance with OSHA regulations, by the Secretary of Labor.

1.5 QUALIFICATIONS (PRODUCTS AND SERVICES)

- A. Manufacturers Qualifications: The manufacturer shall regularly and presently produce, as one of the manufacturer's principal products, the equipment and material specified for this project, and shall have manufactured the item for at least three years.
- B. Product Qualification:
 - 1. Manufacturer's product shall have been in satisfactory operation, on three installations of similar size and type as this project, for approximately three years.
 - 2. The Government reserves the right to require the Contractor to submit a list of installations where the products have been in operation before approval.
- C. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within four hours of receipt of notification that service is needed. Submit name and address of service organizations.

1.6 APPLICABLE PUBLICATIONS

Applicable publications listed in all Sections of Division are the latest issue, unless otherwise noted.

1.7 MANUFACTURED PRODUCTS

- A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts shall be available.
- B. When more than one unit of the same class or type of equipment is required, such units shall be the product of a single manufacturer.
- C. Equipment Assemblies and Components:
 - 1. Components of an assembled unit need not be products of the same manufacturer.
 - 2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.
 - 3. Components shall be compatible with each other and with the total assembly for the intended service.
 - 4. Constituent parts which are similar shall be the product of a single manufacturer.
- D. Factory wiring shall be identified on the equipment being furnished and on all wiring diagrams.
- E. When Factory Testing Is Specified:
 - 1. The Government shall have the option of witnessing factory tests. The contractor shall notify the VA through the Resident Engineer a minimum of 15 working days prior to the manufacturers making the factory tests.

2. Four copies of certified test reports containing all test data shall be furnished to the Resident Engineer prior to final inspection and not more than 90 days after completion of the tests.
3. When equipment fails to meet factory test and re-inspection is required, the contractor shall be liable for all additional expenses, including expenses of the Government.

1.8 EQUIPMENT REQUIREMENTS

- A. Where variations from the contract requirements are requested in accordance with Section 00 72 00, GENERAL CONDITIONS and Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, the connecting work and related components shall include, but not be limited to additions or changes to branch circuits, circuit protective devices, conduits, wire, feeders, controls, panels and installation methods.
- B. Substitutions: When the Contractor deviates from the Owner's preferred vendor, basis of design product, or manufacturer submit to the Owner in no less than 10 days prior to bid date on alternate product or system for the Owner's approval. The submittal shall include:
 1. Detail and total price of alternate product or system proposed.
 2. 1/4" scale drawings in AutoCad format, that indicates product or system foot print with dimensions and required clearances to fit in space assigned.

1.9 EQUIPMENT PROTECTION

- A. Equipment and materials shall be protected during shipment and storage against physical damage, vermin, dirt, corrosive substances, fumes, moisture, cold and rain.
 1. Store equipment indoors in clean dry space with uniform temperature to prevent condensation. Equipment shall include but not be limited to switchgear, switchboards, panelboards, transformers, motor control centers, motor controllers, uninterruptible power systems, enclosures, controllers, circuit protective devices, cables, wire, light fixtures, electronic equipment, and accessories.
 2. During installation, equipment shall be protected against entry of foreign matter; and be vacuum-cleaned both inside and outside before testing and operating. Compressed air shall not be used to clean equipment. Remove loose packing and flammable materials from inside equipment.
 3. Damaged equipment shall be, as determined by the Resident Engineer, placed in first class operating condition or be returned to the source of supply for repair or replacement.
 4. Painted surfaces shall be protected with factory installed removable heavy kraft paper, sheet vinyl or equal.

5. Damaged paint on equipment and materials shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious.

1.10 WORK PERFORMANCE

- A. All electrical work must comply with the requirements of NFPA 70 (NEC), NFPA 70B, NFPA 70E, OSHA Part 1910 subpart J, OSHA Part 1910 subpart S and OSHA Part 1910 subpart K in addition to other references required by contract.
- B. Job site safety and worker safety is the responsibility of the contractor.
- C. Electrical work shall be accomplished with all affected circuits or equipment de-energized. When an electrical outage cannot be accomplished in this manner for the required work, the following requirements are mandatory:
 1. Electricians must use full protective equipment (i.e., certified and tested insulating material to cover exposed energized electrical components, certified and tested insulated tools, etc.) while working on energized systems in accordance with NFPA 70E.
 2. Electricians must wear personal protective equipment while working on energized systems in accordance with NFPA 70E.
 3. Before initiating any work, a job specific work plan must be developed by the contractor with a peer review conducted and documented by the Resident Engineer and Medical Center staff. The work plan must include procedures to be used on and near the live electrical equipment, barriers to be installed, safety equipment to be used and exit pathways.
 4. Work on energized circuits or equipment cannot begin until prior written approval is obtained from the Resident Engineer.
- D. For work on existing stations, arrange, phase and perform work to assure electrical service for other buildings at all times. Refer to Article OPERATIONS AND STORAGE AREAS under Section 01 00 00, GENERAL REQUIREMENTS.
- E. New work shall be installed and connected to existing work neatly, safely and professionally. Disturbed or damaged work shall be replaced or repaired to its prior conditions, as required by Section 01 00 00, GENERAL REQUIREMENTS.
- F. Coordinate location of equipment and conduit with other trades to minimize interferences.

1.11 EQUIPMENT INSTALLATION AND REQUIREMENTS

- A. Equipment location shall be as close as practical to locations shown on the drawings.
- B. Working spaces shall not be less than specified in the NEC for all voltages specified.

C. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the Government.
2. "Conveniently accessible" is defined as being capable of being reached quickly for operation, maintenance, or inspections without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to, motors, pumps, belt guards, transformers, piping, ductwork, conduit and raceways.

1.12 EQUIPMENT IDENTIFICATION

- A. In addition to the requirements of the NEC, install an identification sign which clearly indicates information required for use and maintenance of items such as switchboards and switchgear, panelboards, cabinets, motor controllers (starters), fused and unfused safety switches, automatic transfer switches, separately enclosed circuit breakers, individual breakers and controllers in switchboards, switchgear and motor control assemblies, control devices and other significant equipment.
- B. Nameplates for Normal Power System equipment shall be laminated black phenolic resin with a white core with engraved lettering. Nameplates for Essential Electrical System (EES) equipment, as defined in the NEC, shall be laminated red phenolic resin with a white core with engraved lettering. Lettering shall be a minimum of 1/2 inch [12mm] high. Nameplates shall indicate equipment designation, rated bus amperage, voltage, number of phases, number of wires, and type of EES power branch as applicable. Secure nameplates with screws.
- C. Install adhesive arc flash warning labels on all equipment as required by NFPA 70E. Label shall indicate the arc hazard boundary (inches), working distance (inches), arc flash incident energy at the working distance (calories/cm²), required PPE category and description including the glove rating, voltage rating of the equipment, limited approach distance (inches), restricted approach distance (inches), prohibited approach distance (inches), equipment/bus name, date prepared, and manufacturer name and address.

1.13 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. The Government's approval shall be obtained for all equipment and material before delivery to the job site. Delivery, storage or installation of equipment or material which has not had prior approval will not be permitted at the job site.

- C. All submittals shall include adequate descriptive literature, catalog cuts, shop drawings and other data necessary for the Government to ascertain that the proposed equipment and materials comply with specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify equipment being submitted.
- D. Submittals for individual systems and equipment assemblies which consist of more than one item or component shall be made for the system or assembly as a whole. Partial submittals will not be considered for approval.
 - 1. Mark the submittals, "SUBMITTED UNDER SECTION_____".
 - 2. Submittals shall be marked to show specification reference including the section and paragraph numbers.
 - 3. Submit each section separately.
- E. The submittals shall include the following:
 - 1. Information that confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, pictures, nameplate data and test reports as required.
 - 2. Submittals are required for all equipment anchors and supports. Submittals shall include weights, dimensions, center of gravity, standard connections, manufacturer's recommendations and behavior problems (e.g., vibration, thermal expansion,) associated with equipment or piping so that the proposed installation can be properly reviewed. Include sufficient fabrication information so that appropriate mounting and securing provisions may be designed and/or attached to the equipment.
 - 3. Elementary and interconnection wiring diagrams for communication and signal systems, control systems and equipment assemblies. All terminal points and wiring shall be identified on wiring diagrams.
 - 4. Parts list which shall include those replacement parts recommended by the equipment manufacturer.
- F. Manuals: Submit in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
 - 1. Maintenance and Operation Manuals: Submit as required for systems and equipment specified in the technical sections. Furnish four copies, bound in hardback binders, (manufacturer's standard binders) or an approved equivalent. Furnish one complete manual as specified in the technical section but in no case later than prior to performance of systems or equipment test, and furnish the remaining manuals prior to contract completion.

2. Inscribe the following identification on the cover: the words "MAINTENANCE AND OPERATION MANUAL," the name and location of the system, equipment, building, name of Contractor, and contract number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing the system or equipment and the local representatives for the system or equipment.
 3. Provide a "Table of Contents" and assemble the manual to conform to the table of contents, with tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in.
 4. The manuals shall include:
 - a. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.
 - b. A control sequence describing start-up, operation, and shutdown.
 - c. Description of the function of each principal item of equipment.
 - d. Installation instructions.
 - e. Safety precautions for operation and maintenance.
 - f. Diagrams and illustrations.
 - g. Periodic maintenance and testing procedures and frequencies, including replacement parts numbers and replacement frequencies.
 - h. Performance data.
 - i. Pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare parts, and name of servicing organization.
 - j. List of factory approved or qualified permanent servicing organizations for equipment repair and periodic testing and maintenance, including addresses and factory certification qualifications.
- G. Approvals will be based on complete submission of manuals together with shop drawings.
- H. After approval and prior to installation, furnish the Resident Engineer with one sample of each of the following:
1. A 300 mm (12 inch) length of each type and size of wire and cable along with the tag from the coils of reels from which the samples were taken.
 2. Each type of conduit coupling, bushing and termination fitting.
 3. Conduit hangers, clamps and supports.
 4. Duct sealing compound.

5. Each type of receptacle, toggle switch, occupancy sensor, outlet box, manual motor starter, device wall plate, engraved nameplate, wire and cable splicing and terminating material, and branch circuit single pole molded case circuit breaker.

1.14 SINGULAR NUMBER

Where any device or part of equipment is referred to in these specifications in the singular number (e.g., "the switch"), this reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

1.15 ACCEPTANCE CHECKS AND TESTS

The contractor shall furnish the instruments, materials and labor for field tests.

1.16 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

1.17 TRAINING

- A. Training shall be provided in accordance with Article 1.25, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS.
- B. Training shall be provided for the particular equipment or system as required in each associated specification.
- C. A training schedule shall be developed and submitted by the contractor and approved by the Resident Engineer at least 30 days prior to the planned training.

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SECTION 26 05 13 MEDIUM VOLTAGE CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation, and connection of medium voltage cables, splices, and terminations.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirement and items that are common to more than one section of Division 26.
- B. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for medium voltage cables.
- D. Section 31 20 00, EARTH MOVING: Bedding of conduits.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.5 FACTORY TESTS

Medium voltage cables shall be thoroughly tested at the factory per NEMA WC 74 to ensure that there are no electrical defects. Factory tests shall be certified.

1.6 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Clearly present sufficient information to determine compliance with drawings and specifications.
 - 2. Include product and installation information for cables, splices, terminations, and fireproofing tape.
- C. Samples: After approval and prior to installation, furnish the Resident Engineer with a minimum 12 in [300 mm] length of each type and size of cable, along with the tag from the reel from which the sample was taken. The sample shall contain the manufacturer's markings, showing all cable jacket information.
- D. Certifications:
 - 1. Factory Test Reports: Prior to installation of the cables, deliver four copies of the manufacturers certified NEMA WC 71 or WC 74 standard factory test reports to the Resident Engineer. Certified copies of test data shall show conformance with the referenced standards and shall be approved prior to delivery of cable.
 - 2. Compatibility: Provide certification from the cable manufacturer that the splices and terminations are approved for use with the cable.
 - 3. Field Test Reports: Test reports shall comply with the paragraph entitled "Acceptance Checks and Tests." After testing, submit four certified copies to the Resident Engineer of each of the graphs specified under field testing.
 - 4. After splices and terminations have been installed and tested, deliver four copies of a certificate by the contractor to the Resident Engineer which includes the following:
 - a. A statement that the materials, detail drawings, and printed instructions used are those contained in the kits approved for this contract.
 - b. A statement that each splice and each termination was completely installed in a single continuous work period by a single qualified worker without any overnight interruption.
 - c. A statement that field-made splices and terminations conform to the following requirements:
 - 1) Pencil the cable insulation precisely.

- 2) Connector installations:
 - a) Use tools that are designed for the connectors being installed.
 - b) Round and smooth the installed connectors to minimize localized voltage stressing of the insulating materials.
 - 3) Remove contaminants from all surfaces within the splices and terminations before installing the insulating materials.
 - 4) Solder block throughout stranded grounding wires that might penetrate the splicing and terminating materials.
 - 5) Use mirrors to observe the installation of materials on the backsides of the splices and terminations.
 - 6) Eliminate air voids throughout the splices and terminations.
 - 7) Stretch each layer of tape properly during installation.
 - d. List all the materials purchased and installed for the splices and terminations for this contract, including the material descriptions, manufacturers' names, catalog numbers, and total quantities.
- E. Installer Approval:
1. Employees who install splices and terminations and test the cables shall have not fewer than five years of experience splicing and terminating cables equivalent to those being spliced and terminated, including experience with the materials in the kits.
 2. Furnish satisfactory proof of such experience for each employee who splices or terminates the cables.
- F. Power Company Approval: Prior to construction, obtain written approval from the power company supplying electrical service for the following items:
1. Service entrance cables. Obtain the power company's written approval on the submittal papers for the cables before submitting them for Resident Engineer approval.
 2. A list of employees who will splice and terminate the service entrance cables.

1.7 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only:
- American Society for Testing and Materials (ASTM):
- B3-01 (R2007)Standard Specification for Soft or Annealed Copper Wire

- B. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 386-95 (R2001).....Separable Insulated Connector Systems for Power Distribution
Systems above 600 V
 - 400-01Guide for Field Testing and Evaluation of the Insulation of
Shielded Power Cable Systems
 - 400.2-05Guide for Field Testing of Shielded Power Cable Systems Using
Very Low Frequency (VLF)
 - 400.3-06Guide for Partial Discharge Testing of Shielded Power Cable
Systems in a Field Environment
 - 404-00Extruded and Laminated Dielectric Shielded Cable Joints Rated
2500-500,000 Volts
- C. National Electrical Manufacturers Association (NEMA):
 - WC 71-99.....Standard for Non-Shielded Cables Rated 2001-5000 Volts for
Use in the Distribution of Electrical Energy (ICEA S-96-659)
 - WC 74-06.....5-46 KV Shielded Power Cable for Use in the Transmission and
Distribution of Electrical Energy (ICEA S-93-969)
- D. National Fire Protection Association (NFPA):
 - 70-11National Electrical Code (NEC)
- E. Underwriters Laboratories (UL):
 - 1072-06 Medium-Voltage Power Cables

1.8 SHIPMENT AND STORAGE

- A. Cable shall be shipped on reels such that it is protected from mechanical injury. Each end of each length of cable shall be hermetically sealed with manufacturer's end caps and securely attached to the reel.
- B. Cable stored and/or cut on site shall have the ends turned down, and sealed with cable manufacturer's standard cable end seals, or field-installed heat-shrink cable end seals.

PART 2 - PRODUCTS

2.1 MEDIUM VOLTAGE CABLE

- A. Medium voltage cable shall be in accordance with the NEC and NEMA WC 71, WC 74, and UL 1072.
- B. Single conductor stranded copper conforming to ASTM B3.
- C. Voltage Rating: 15,000 V cable shall be used on all distribution systems with voltages ranging from 5,000 V to 15,000 V.

D. Insulation:

1. Insulation level shall be 133%.
2. Types of insulation:
 - a. Cable type abbreviation, EPR: Ethylene propylene rubber insulation shall be thermosetting, light and heat stabilized.
 - b. Cable type abbreviation, CCLP: Polyethylene insulation shall be thermosetting, light and heat stabilized, and chemically cross-linked.
 - c. In wet locations, anti-tree CCLP or EPR shall be used.
 - d. Cable type abbreviation, XLPE: cross-linked polyethylene insulated shielded shall be thermosetting, light and heat stabilized and chemically cross-linked.

E. Conductors and insulation shall be wrapped separately with semi-conducting tape.

F. Insulation shall be wrapped with non-magnetic, metallic shielding tape, helically-applied over semi-conducting insulation shield.

G. Heavy duty, overall protective jacket of chlorosulphonated polyethylene or polyvinyl chloride shall enclose every cable. The manufacturer's name, cable type and size, and other pertinent information shall be marked or molded clearly on the overall protective jacket.

H. Cable temperature ratings for continuous operation, emergency overload operation, and short circuit operation shall be not less than the NEC, NEMA WC 71, or NEMA WC 74 standard for the respective cable.

2.2 SPLICES AND TERMINATIONS

A. The materials shall be compatible with the cables.

B. In locations where moisture might be present, the splices shall be watertight. In manholes and handholes, the splices shall be submersible.

C. Where the Government determines that unsatisfactory splices and terminations have been installed, the contractor shall replace the unsatisfactory splices and terminations with approved material at no additional cost to the Government.

D. Splices and Terminations:

1. Materials shall be designed for the cables being spliced and terminated, and shall be suitable for the prevailing environmental conditions.
2. Splices:
 - a. Shall comply with IEEE 404. Include all components required for complete splice, with detailed instructions.
 - b. Cold-shrink splice: Premolded, cold-shrink-rubber, in-line splicing kit.

3. Terminations:

- a. Shall comply with IEEE 48. Include shield ground strap for shielded cable terminations.

2.3 FIREPROOFING TAPE

Fireproofing tape shall be flexible, non-corrosive, self-extinguishing, arcproof, and fireproof intumescent elastomer. Securing tape shall be glass cloth electrical tape not less than 7 mils [0.18 mm] thick, and 0.75 in [19 mm] wide.

PART 3 - EXECUTION

3.1 GENERAL

- A. Installation shall be in accordance with the NEC, as shown on the drawings, and per cable manufacturer's instructions.
- B. Cable shall be installed in conduit above grade and duct bank below grade. All cables of a feeder shall be pulled simultaneously.
- C. Splice the cables only in manholes and accessible pullboxes.
- D. Ground shields in accordance with Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- E. Cable maximum pull length, maximum pulling tension, and minimum bend radius shall conform with the recommendations of the cable manufacturer.
- F. Use suitable lubricating compounds on the cables to prevent pulling damage. Provide compounds that are not injurious to the cable jacket and do not harden or become adhesive.
- G. Seal the cable ends prior to pulling, to prevent the entry of moisture or lubricant.

3.2 PROTECTION DURING SPLICING OPERATIONS

Blowers shall be provided to force fresh air into manholes where free movement or circulation of air is obstructed. Waterproof protective coverings shall be available on the work site to provide protection against moisture while a splice is being made. Pumps shall be used to keep manholes dry during splicing operations. Under no conditions shall a splice or termination be made that exposes the interior of a cable to moisture. A manhole ring at least 6 in [150 mm] above ground shall be used around the manhole entrance to keep surface water from entering the manhole. Unused ducts shall be plugged and water seepage through ducts in use shall be stopped before splicing.

3.3 PULLING CABLES IN DUCTS AND MANHOLES

- A. Cables shall be pulled into ducts with equipment designed for this purpose, including power-driven winches, cable-feeding flexible tube guides, cable grips, pulling eyes, and lubricants. A sufficient number of trained personnel and equipment shall be employed to ensure the careful and proper installation of the cable.

- B. Cable reels shall be set up at the side of the manhole opening and above the duct or hatch level, allowing cables to enter through the opening without reverse bending. Flexible tube guides shall be installed through the opening in a manner that will prevent cables from rubbing on the edges of any structural member.
- C. Cable shall be unreeled from the top of the reel. Pay-out shall be carefully controlled. Cables to be pulled shall be attached through a swivel to the main pulling wire by means of a suitable cable grip and pulling eye.
- D. Woven-wire cable grips shall be used to grip the cable end when pulling small cables and short straight lengths of heavier cables.
- E. Pulling eyes shall be attached to the cable conductors to prevent damage to the cable structure.
- F. Cables shall be liberally coated with a suitable lubricant as they enter the tube guide or duct. Rollers, sheaves, or tube guides around which the cable is pulled shall conform to the minimum bending radius of the cable.
- G. Cables shall be pulled into ducts at a reasonable speed. Cable pulling using a vehicle shall not be permitted. Pulling operations shall be stopped immediately at any indication of binding or obstruction, and shall not be resumed until the potential for damage to the cable is corrected. Sufficient slack shall be provided for free movement of cable due to expansion or contraction.
- H. Splices in manholes shall be firmly supported on cable racks. No splices shall be pulled in ducts. Cable ends shall overlap at the ends of a section to provide sufficient undamaged cable for splicing.
- I. Cables cut in the field shall have the cut ends immediately sealed to prevent entrance of moisture.

3.4 SPLICES AND TERMINATIONS

- A. Install the materials as recommended by the manufacturer, including precautions pertaining to air temperature and humidity during installation.
- B. Installation shall be accomplished by qualified personnel trained to accomplish medium voltage equipment installations. All manufacturer's instructions shall be followed precisely.
- C. Splices in manholes shall be located midway between cable racks on walls of manholes, and supported with cable arms at approximately the same elevation as the enclosing duct.

3.5 FIREPROOFING

- A. Cover all cable segments exposed in manholes and pull-boxes with fireproofing tape.
- B. Apply the tape in a single layer, wrapped in a half-lap manner, or as recommended by the manufacturer. Extend the tape not less than 1 in [25 mm] into each duct.
- C. At each end of a taped cable section, secure the fireproof tape in place with glass cloth tape.

3.6 CIRCUIT IDENTIFICATION OF FEEDERS

In each manhole and pullbox, install permanent tags on each circuit's cables to clearly designate the circuit identification and voltage. The tags shall be the embossed brass type, 1.5 in [40 mm] in diameter and 40 mils thick. Attach tags with plastic ties. Position the tags so they will be easy to read after the fireproofing tape is installed.

3.7 ACCEPTANCE CHECKS AND TESTS

- A. Perform tests in accordance with the manufacturer's recommendations. Include the following visual and electrical inspections.
- B. Test equipment and labor and technical personnel shall be provided as necessary to perform the acceptance tests. Arrangements shall be made to have tests witnessed by the Resident Engineer.
- C. Visual Inspection:
 - 1. Inspect exposed sections of cables for physical damage.
 - 2. Inspect shield grounding, cable supports, splices, and terminations.
 - 3. Verify that visible cable bends meet manufacturer's minimum published bending radius.
 - 4. Verify installation of fireproofing tape and identification tags.
- D. Electrical Tests:
 - 1. Acceptance tests shall be performed on new and service-aged cables as specified herein.
 - 2. Test new cable after installation, splices, and terminations have been made, but before connection to equipment and existing cable.
- E. Service-Aged Cable Tests:
 - 1. Maintenance tests shall be performed on service-aged cable interconnected to new cable.
 - 2. After new cable test and connection to an existing cable, test the interconnected cable.
Disconnect cable from all equipment that could be damaged by the test.
- F. Insulation-Resistance Test: Test all new and service-aged cables with respect to ground and adjacent conductors.
 - 1. Test data shall include megohm readings and leakage current readings. Cable shall not be energized until insulation-resistance test results have been approved by the Resident Engineer. Test voltages and minimum acceptable resistance values shall be:

<u>Voltage Class</u>	<u>Test Voltage</u>	<u>Min. Insulation Resistance</u>
15kV	2,500 VDC	5,000 megohms

2. Provide a comprehensive report that describes the identification and location of cables tested, the test equipment used, and the date tests were performed; identifies the persons who performed the tests; and identifies the insulation resistance and leakage current results for each cable section tested. The report shall provide conclusions and recommendations for corrective action.
- G. Online Partial Discharge Test: Comply with IEEE 400 and 400.3. Test all new and service-aged cables. Perform tests after cables have passed the insulation-resistance test, and after successful energization.
1. Testing shall use a time or frequency domain detection process, incorporating radio frequency current transformer sensors with a partial discharge detection range of 10 kHz to 300 MHz.
 2. Provide a comprehensive report that describes the identification and location of cables tested, the test equipment used, and the date tests were performed; identifies the persons who performed the tests; and numerically and graphically identifies the magnitude of partial discharge detected for each cable section tested. The report shall provide conclusions and recommendations for corrective action.
- H. Final Acceptance: Final acceptance shall depend upon the satisfactory performance of the cables under test. No cable shall be energized until recorded test data have been approved by the Resident Engineer. Final test reports shall be provided to the Resident Engineer.

3.8 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 26 05 21
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
(600 VOLTS AND BELOW)

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation, and connection of the low voltage power and lighting wiring.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire-rated construction.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for cables and wiring.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.5 FACTORY TESTS

Low voltage cables shall be thoroughly tested at the factory per NEMA WC-70 to ensure that there are no electrical defects. Factory tests shall be certified.

1.6 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
 - 1. Manufacturer's Literature and Data: Showing each cable type and rating.
 - 2. Certifications: Two weeks prior to the final inspection, submit four copies of the following certifications to the Resident Engineer:
 - a. Certification by the manufacturer that the materials conform to the requirements of the drawings and specifications.
 - b. Certification by the contractor that the materials have been properly installed, connected, and tested.

1.7 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are reference in the text by designation only.
- B. American Society of Testing Material (ASTM):
 - D2301-04Standard Specification for Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape
- C. National Fire Protection Association (NFPA):
 - 70-11National Electrical Code (NEC)
- D. National Electrical Manufacturers Association (NEMA):
 - WC 70-09.....Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
- E. Underwriters Laboratories, Inc. (UL):
 - 44-05Thermoset-Insulated Wires and Cables
 - 83-08Thermoplastic-Insulated Wires and Cables
 - 467-071Electrical Grounding and Bonding Equipment
 - 486A-486B-03Wire Connectors
 - 486C-04Splicing Wire Connectors
 - 486D-05Sealed Wire Connector Systems
 - 486E-94.....Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
 - 493-07Thermoplastic-Insulated Underground Feeder and Branch Circuit Cable

514B-04Conduit, Tubing, and Cable Fittings

1479-03Fire Tests of Through-Penetration Fire Stops

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Conductors and cables shall be in accordance with NEMA WC-70 and as specified herein.
- B. Single Conductor:
 - 1. Shall be annealed copper.
 - 2. Shall be stranded for sizes No. 8 AWG and larger, solid for sizes No. 10 AWG and smaller.
 - 3. Shall be minimum size No. 12 AWG, except where smaller sizes are allowed herein.
- C. Insulation:
 - 1. XHHW-2 or THHN-THWN shall be in accordance with NEMA WC-70, UL 44, and UL 83.
- D. Color Code:
 - 1. Secondary service feeder and branch circuit conductors shall be color-coded as follows:

208/120 volt	Phase	480/277 volt
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray *
* or white with colored (other than green) tracer.		

- a. Lighting circuit “switch legs” and 3-way switch “traveling wires” shall have color coding that is unique and distinct (e.g., pink and purple) from the color coding indicated above. The unique color codes shall be solid and in accordance with the NEC. Coordinate color coding in the field with the Resident Engineer.
- 2. Use solid color insulation or solid color coating for No. 12 AWG and No. 10 AWG branch circuit phase, neutral, and ground conductors.
- 3. Conductors No. 8 AWG and larger shall be color-coded using one of the following methods:
 - a. Solid color insulation or solid color coating.
 - b. Stripes, bands, or hash marks of color specified above.
 - c. Color as specified using 0.75 in [19 mm] wide tape. Apply tape in half-overlapping turns for a minimum of 3 in [75 mm] for terminal points, and in junction boxes, pull-boxes, troughs, and manholes. Apply the last two laps of tape with no tension to prevent

possible unwinding. Where cable markings are covered by tape, apply tags to cable, stating size and insulation type.

4. For modifications and additions to existing wiring systems, color coding shall conform to the existing wiring system.

2.2 SPLICES AND JOINTS

- A. In accordance with UL 486A, C, D, E, and NEC.
- B. Aboveground Circuits (No. 10 AWG and smaller):
 1. Connectors: Solderless, screw-on, reusable pressure cable type, rated 600 V, 220° F [105° C], with integral insulation, approved for copper and aluminum conductors.
 2. The integral insulator shall have a skirt to completely cover the stripped wires.
 3. The number, size, and combination of conductors, as listed on the manufacturer's packaging, shall be strictly followed.
- C. Aboveground Circuits (No. 8 AWG and larger):
 1. Connectors shall be indent, hex screw, or bolt clamp-type of high conductivity and corrosion-resistant material, listed for use with copper and aluminum conductors.
 2. Field-installed compression connectors for cable sizes 250 kcmil and larger shall have not fewer than two clamping elements or compression indents per wire.
 3. Insulate splices and joints with materials approved for the particular use, location, voltage, and temperature. Splice and joint insulation level shall be not less than the insulation level of the conductors being joined.
 4. Plastic electrical insulating tape: Per ASTM D2304, flame-retardant, cold and weather resistant.
- D. Underground Branch Circuits and Feeders:
 1. Submersible connectors in accordance with UL 486D, rated 600 V, 190° F [90° C], with integral insulation.

2.3 CONTROL WIRING

- A. Unless otherwise specified elsewhere in these specifications, control wiring shall be as specified for power and lighting wiring, except that the minimum size shall be not less than No. 14 AWG.
- B. Control wiring shall be large enough such that the voltage drop under in-rush conditions does not adversely affect operation of the controls.

2.4 WIRE LUBRICATING COMPOUND

- A. Lubricating compound shall be suitable for the wire insulation and conduit, and shall not harden or become adhesive.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install in accordance with the NEC, and as specified.
- B. Install all wiring in raceway systems.
- C. Splice cables and wires only in outlet boxes, junction boxes, pull-boxes, manholes, or handholes.
- D. Wires of different systems (e.g., 120 V, 277 V) shall not be installed in the same conduit or junction box system.
- E. Install cable supports for all vertical feeders in accordance with the NEC. Provide split wedge type which firmly clamps each individual cable and tightens due to cable weight.
- F. For panel boards, cabinets, wireways, switches, and equipment assemblies, neatly form, train, and tie the cables in individual circuits.
- G. Seal cable and wire entering a building from underground between the wire and conduit where the cable exits the conduit, with a non-hardening approved compound.
- H. Wire Pulling:
 - 1. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling of cables. Use lubricants approved for the cable.
 - 2. Use nonmetallic ropes for pulling feeders.
 - 3. Attach pulling lines for feeders by means of either woven basket grips or pulling eyes attached directly to the conductors, as approved by the Resident Engineer.
 - 4. All cables in a single conduit shall be pulled simultaneously.
 - 5. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- I. No more than three single-phase branch circuits shall be installed in any one conduit.

3.2 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.3 INSTALLATION IN MANHOLES

- A. Install and support cables in manholes on the steel racks with porcelain or equivalent insulators. Train the cables around the manhole walls, but do not bend to a radius less than six times the overall cable diameter.

3.4 SPLICE INSTALLATION

- A. Splices and terminations shall be mechanically and electrically secure.
- B. Tighten electrical connectors and terminals according to manufacturer's published torque values.
- C. Where the Government determines that unsatisfactory splices or terminations have been installed, remove the devices and install approved devices at no additional cost to the Government.

3.5 FEEDER IDENTIFICATION

- A. In each interior pull-box and junction box, install metal tags on all circuit cables and wires to clearly designate their circuit identification and voltage. The tags shall be the embossed brass type, 1.5 in [40 mm] in diameter and 40 mils thick. Attach tags with plastic ties.
- B. In each manhole and handhole, provide tags of the embossed brass type, showing the circuit identification and voltage. The tags shall be the embossed brass type, 1.5 in [40 mm] in diameter and 40 mils thick. Attach tags with plastic ties.

3.6 EXISTING WIRING

Unless specifically indicated on the plans, existing wiring shall not be reused for a new installation.

3.7 CONTROL AND SIGNAL WIRING INSTALLATION

- A. Unless otherwise specified in other sections, install wiring and connect to equipment/devices to perform the required functions as shown and specified.
- B. Except where otherwise required, install a separate power supply circuit for each system so that malfunctions in any system will not affect other systems.
- C. Where separate power supply circuits are not shown, connect the systems to the nearest panel boards of suitable voltages, which are intended to supply such systems and have suitable spare circuit breakers or space for installation.

3.8 CONTROL AND SIGNAL SYSTEM WIRING IDENTIFICATION

- A. Install a permanent wire marker on each wire at each termination.
- B. Identifying numbers and letters on the wire markers shall correspond to those on the wiring diagrams used for installing the systems.
- C. Wire markers shall retain their markings after cleaning.

- D. In each manhole and handhole, install embossed brass tags to identify the system served and function.

3.9 ACCEPTANCE CHECKS AND TESTS

- A. Feeders and branch circuits shall have their insulation tested after installation and before connection to utilization devices, such as fixtures, motors, or appliances. Test each conductor with respect to adjacent conductors and to ground. Existing conductors to be reused shall also be tested.
- B. Applied voltage shall be 500VDC for 300-volt rated cable, and 1000VDC for 600-volt rated cable. Apply test for one minute or until reading is constant for 15 seconds, whichever is longer. Minimum insulation resistance values shall not be less than 25 megohms for 300-volt rated cable and 100 megohms for 600-volt rated cable.
- C. Perform phase rotation test on all three-phase circuits.
- D. The contractor shall furnish the instruments, materials, and labor for all tests.

- - - E N D - - -

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the general grounding and bonding requirements for electrical equipment and operations to provide a low impedance path for possible ground fault currents.
- B. "Grounding electrode system" refers to all electrodes required by NEC, as well as made, supplementary, and lightning protection system grounding electrodes.
- C. The terms "connect" and "bond" are used interchangeably in this specification and have the same meaning.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low Voltage power and lighting wiring.
- C. Section 26 13 16, MEDIUM-VOLTAGE METAL ENCLOSED LOAD INTERRUPTER SWITCHGEAR: Medium voltage distribution switchgear.
- D. Section 26 22 00, LOW-VOLTAGE TRANSFORMERS: Low voltage transformers.
- E. Section 26 23 00, LOW-VOLTAGE METAL ENCLOSED CIRCUIT BREAKER SWITCHGEAR: Low voltage switchgear.
- F. Section 26 24 13, SWITCHBOARDS: Low voltage distribution switchboards.
- G. Section 26 24 16, PANELBOARDS: Low voltage panelboards.
- H. Section 26 32 13, ENGINE GENERATORS: Engine-generators.
- I. Section 26 36 23, AUTOMATIC TRANSFER SWITCHES: Automatic transfer switches.
- J. Section 26 41 00, FACILITY LIGHTNING PROTECTION: Requirements for lightning protection.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.5 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Clearly present enough information to determine compliance with drawings and specifications.
 - 2. Include the location of system grounding electrode connections and the routing of aboveground and underground grounding electrode conductors.
- C. Test Reports: Provide certified test reports of ground resistance.
- D. Certifications: Two weeks prior to final inspection, submit four copies of the following to the Resident Engineer:
 - 1. Certification that the materials and installation are in accordance with the drawings and specifications.
 - 2. Certification by the contractor that the complete installation has been properly installed and tested.

1.6 APPLICABLE PUBLICATIONS

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

- A. American Society for Testing and Materials (ASTM):
 - B1-07Standard Specification for Hard-Drawn Copper Wire
 - B3-07Standard Specification for Soft or Annealed Copper Wire
 - B8-04Standard Specification for Concentric-Lay-Stranded Copper
Conductors, Hard, Medium-Hard, or Soft
- B. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 81-1983IEEE Guide for Measuring Earth Resistivity, Ground
Impedance, and Earth Surface Potentials of a Ground System
 - C2-07National Electrical Safety Code
- C. National Fire Protection Association (NFPA):
 - 70-11National Electrical Code (NEC)
 - 99-11Health Care Facilities
- D. Underwriters Laboratories, Inc. (UL):
 - 44-05Thermoset-Insulated Wires and Cables
 - 83-08Thermoplastic-Insulated Wires and Cables
 - 467-07Grounding and Bonding Equipment
 - 486A-486B-03Wire Connectors

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

- A. Equipment grounding conductors shall be UL 44 or UL 83 insulated stranded copper, except that sizes No. 10 AWG and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes No. 4 AWG and larger shall be identified per NEC.
- B. Bonding conductors shall be ASTM B8 bare stranded copper, except that sizes No. 10 AWG and smaller shall be ASTM B1 solid bare copper wire.
- C. Conductor sizes shall not be less than shown on the drawings, or not less than required by the NEC, whichever is greater.

2.2 GROUND RODS

- A. Steel or copper clad steel, 0.75 in diameter by 10 ft long, conforming to UL 467.
- B. Quantity of rods shall be as required to obtain the specified ground resistance, as shown on the drawings.

2.3 CONCRETE ENCASED ELECTRODE

Concrete encased electrode shall be No. 4 AWG bare copper wire, installed per NEC.

2.4 MEDIUM VOLTAGE SPLICES AND TERMINATIONS

Components shall meet or exceed UL 467 and be clearly marked with the manufacturer, catalog number, and permitted conductor size(s).

2.5 GROUND CONNECTIONS

- A. Below Grade: Exothermic-welded type connectors.
- B. Above Grade:
 - 1. Bonding Jumpers: Compression-type connectors, using zinc-plated fasteners and external tooth lockwashers.
 - 2. Connection to Building Steel: Exothermic-welded type connectors.
 - 3. Ground Busbars: Two-hole compression type lugs, using tin-plated copper or copper alloy bolts and nuts.
 - 4. Rack and Cabinet Ground Bars: One-hole compression-type lugs, using zinc-plated or copper alloy fasteners.

2.6 EQUIPMENT RACK AND CABINET GROUND BARS

Provide solid copper ground bars designed for mounting on the framework of open or cabinet-enclosed equipment racks with minimum dimensions of 0.375 in thick x 0.75 in wide.

2.7 GROUND TERMINAL BLOCKS

At any equipment mounting location (e.g., backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide screw lug-type terminal blocks.

2.8 GROUNDING BUS

Pre-drilled rectangular copper bar with stand-off insulators, minimum 0.25 in thick x 4 in high in cross-section, length as shown on drawings, with 0.281 in holes spaced 1.125 in apart.

PART 3 - EXECUTION

3.1 GENERAL

- A. Ground in accordance with the NEC, as shown on drawings, and as specified herein.
- B. System Grounding:
 - 1. Secondary service neutrals: Ground at the supply side of the secondary disconnecting means and at the related transformers.
 - 2. Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.
- C. Equipment Grounding: Metallic structures, including ductwork and building steel, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits, shall be bonded and grounded.
- D. Special Grounding: For patient care area electrical power system grounding, conform to NFPA 99 and NEC.

3.2 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.3 INACCESSIBLE GROUNDING CONNECTIONS

Make grounding connections, which are normally buried or otherwise inaccessible (except connections for which access for periodic testing is required), by exothermic weld.

3.4 MEDIUM VOLTAGE EQUIPMENT AND CIRCUITS

- A. Switchgear: Provide a bare grounding electrode conductor from the switchgear ground bus to the grounding electrode system.
- B. Duct Banks and Manholes: Provide an insulated equipment grounding conductor in each duct containing medium voltage conductors, sized per NEC except that minimum size shall be 2 AWG. Bond the equipment grounding conductors to the switchgear ground bus, to all manhole hardware and ground rods, to the cable shielding grounding provisions of medium-voltage cable splices and terminations, and to equipment enclosures.

C. Pad-Mounted Transformers:

1. Provide a driven ground rod and bond with a grounding electrode conductor to the transformer grounding pad.
2. Ground the secondary neutral.

D. Lightning Arresters: Connect lightning arresters to the equipment ground bus or ground rods as applicable.

3.5 SECONDARY VOLTAGE EQUIPMENT AND CIRCUITS

A. Main Bonding Jumper: Bond the secondary service neutral to the ground bus in the service equipment.

B. Metallic Piping, Building Steel, and Supplemental Electrode(s):

1. Provide a grounding electrode conductor sized per NEC between the service equipment ground bus and all metallic water pipe systems, building steel, and supplemental or made electrodes. Provide jumper insulating joints in the metallic piping. All connections to electrodes shall be made with fittings that conform to UL 467.
2. Provide a supplemental ground electrode and bond to the grounding electrode system.

C. Service Disconnect (Separate Individual Enclosure): Provide a ground bar bolted to the enclosure with lugs for connecting the various grounding conductors.

D. Switchgear, Switchboards, Unit Substations, Panelboards, Motor Control Centers and Panelboards, Engine-Generators, and Automatic Transfer Switches:

1. Connect the various feeder equipment grounding conductors to the ground bus in the enclosure with suitable pressure connectors.
2. For service entrance equipment, connect the grounding electrode conductor to the ground bus.
3. Provide ground bars, bolted to the housing, with sufficient lugs to terminate the equipment grounding conductors.
4. Connect metallic conduits that terminate without mechanical connection to the housing, by grounding bushings and grounding conductor to the equipment ground bus.

E. Transformers:

1. Exterior: Exterior transformers supplying interior service equipment shall have the neutral grounded at the transformer secondary. Provide a grounding electrode at the transformer.
2. Separately derived systems (transformers downstream from service equipment): Ground the secondary neutral at the transformer. Provide a grounding electrode conductor from the transformer to the ground bar at the service equipment.

3.6 RACEWAY

A. Conduit Systems:

1. Ground all metallic conduit systems. All metallic conduit systems shall contain an equipment grounding conductor.
2. Non-metallic conduit systems, except non-metallic feeder conduits that carry a grounded conductor from exterior transformers to interior or building-mounted service entrance equipment, shall contain an equipment grounding conductor.
3. Conduit that only contains a grounding conductor, and is provided for its mechanical protection, shall be bonded to that conductor at the entrance and exit from the conduit.
4. Metallic conduits which terminate without mechanical connection to an electrical equipment housing by means of locknut and bushings or adapters, shall be provided with grounding bushings. Connect bushings with a bare grounding conductor to the equipment ground bus.

B. Feeders and Branch Circuits: Install equipment grounding conductors with all feeders and power and lighting branch circuits.

C. Boxes, Cabinets, Enclosures, and Panelboards:

1. Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures through which the conductor passes (except for special grounding systems for intensive care units and other critical units shown).
2. Provide lugs in each box and enclosure for equipment grounding conductor termination.

D. Wireway Systems:

1. Bond the metallic structures of wireway to provide 100% electrical continuity throughout the wireway system, by connecting a No. 6 AWG bonding jumper at all intermediate metallic enclosures and across all section junctions.
2. Install insulated No. 6 AWG bonding jumpers between the wireway system, bonded as required above, and the closest building ground at each end and approximately every 50 ft.
3. Use insulated No. 6 AWG bonding jumpers to ground or bond metallic wireway at each end for all intermediate metallic enclosures and across all section junctions.
4. Use insulated No. 6 AWG bonding jumpers to ground cable tray to column-mounted building ground plates (pads) at each end and approximately every 49 ft.

E. Receptacles shall not be grounded through their mounting screws. Ground receptacles with a jumper from the receptacle green ground terminal to the device box ground screw and a jumper to the branch circuit equipment grounding conductor.

- F. Ground lighting fixtures to the equipment grounding conductor of the wiring system when the green ground is provided; otherwise, ground the fixtures through the conduit systems. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.
- G. Fixed electrical appliances and equipment shall be provided with a ground lug for termination of the equipment grounding conductor.
- H. Raised Floors: Provide bonding of all raised floor components. See details on the drawings.
- I. Panelboard Bonding in Patient Care Areas: The equipment grounding terminal buses of the normal and essential branch circuit panel boards serving the same individual patient vicinity shall be bonded together with an insulated continuous copper conductor not less than No. 10 AWG. These conductors shall be installed in rigid metal conduit.

3.7 OUTDOOR METALLIC FENCES AROUND ELECTRICAL EQUIPMENT

- A. Outdoor Metallic Fences Around Electrical Equipment: Fences shall be grounded as indicated. Drive ground rods until the top is 12 in below grade. Attach a No. 4 AWG copper conductor by exothermic weld to the ground rods, and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 12 in of fence mesh and fasten by two approved bronze compression fittings, one to bond the wire to post and the other to bond the wire to fence. Each gate section shall be bonded to its gatepost by a 0.375 in x 1 in flexible, braided copper strap and ground post clamps. Clamps shall be of the anti-electrolysis type.

3.8 CORROSION INHIBITORS

When making ground and ground bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.9 CONDUCTIVE PIPING

- A. Bond all conductive piping systems, interior and exterior, to the grounding electrode system. Bonding connections shall be made as close as practical to the equipment ground bus.
- B. In operating rooms and at intensive care and coronary care type beds, bond the gases and suction piping at the outlets directly to the room or patient ground bus.

3.10 LIGHTNING PROTECTION SYSTEM

Bond the lightning protection system to the electrical grounding electrode system.

3.11 ELECTRICAL ROOM GROUNDING

Building Earth Ground Busbars: Provide ground busbar and mounting hardware at each electrical room and connect to pigtail extensions of the building grounding ring.

3.12 EXTERIOR LIGHT POLES

Provide 20 ft of No. 4 bare copper coiled at bottom of pole base excavation prior to pour, plus additional unspliced length in and above foundation as required to reach pole ground stud.

3.13 GROUND RESISTANCE

- A. Grounding system resistance to ground shall not exceed 5 ohms. Make any modifications or additions to the grounding electrode system necessary for compliance without additional cost to the Government. Final tests shall ensure that this requirement is met.
- B. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not fewer than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.
- C. Services at power company interface points shall comply with the power company ground resistance requirements.
- D. Below-grade connections shall be visually inspected by the Resident Engineer prior to backfilling. The contractor shall notify the Resident Engineer 24 hours before the connections are ready for inspection.

3.14 GROUND ROD INSTALLATION

- A. For outdoor installations, drive each rod vertically in the earth, until top of rod is 24 in below final grade.
- B. For indoor installations, leave 4 in of rod exposed.
- C. Where permanently concealed ground connections are required, make the connections by the exothermic process, to form solid metal joints. Make accessible ground connections with mechanical pressure-type ground connectors.
- D. Where rock prevents the driving of vertical ground rods, install angled ground rods or grounding electrodes in horizontal trenches to achieve the specified resistance.

--- E N D ---

SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of conduit, fittings, and boxes, to form complete, coordinated, grounded raceway systems. Raceways are required for all wiring unless shown or specified otherwise.
- B. Definitions: The term conduit, as used in this specification, shall mean any or all of the raceway types specified.

1.2 RELATED WORK

- A. Section 06 10 00, ROUGH CARPENTRY: Mounting board for telephone closets.
- B. Section 07 60 00, FLASHING AND SHEET METAL: Fabrications for the deflection of water away from the building envelope at penetrations.
- C. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire rated construction.
- D. Section 07 92 00, JOINT SEALANTS: Sealing around conduit penetrations through the building envelope to prevent moisture migration into the building.
- E. Section 09 91 00, PAINTING: Identification and painting of conduit and other devices.
- F. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- G. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- H. Section 31 20 00, EARTH MOVING: Bedding of conduits.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.5 SUBMITTALS

In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:

- A. Manufacturer's Literature and Data: Showing each cable type and rating. The specific item proposed and its area of application shall be identified on the catalog cuts.
- B. Shop Drawings:
 - 1. Size and location of main feeders.
 - 2. Size and location of panels and pull-boxes.
 - 3. Layout of required conduit penetrations through structural elements.
- C. Certifications:
 - 1. Two weeks prior to the final inspection, submit four copies of the following certifications to the Resident Engineer:
 - a. Certification by the manufacturer that the material conforms to the requirements of the drawings and specifications.
 - b. Certification by the contractor that the material has been properly installed.

1.6 APPLICABLE PUBLICATIONS

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

- B. American National Standards Institute (ANSI):
 - C80.1-05Electrical Rigid Steel Conduit
 - C80.3-05Steel Electrical Metal Tubing
 - C80.6-05Electrical Intermediate Metal Conduit
- C. National Fire Protection Association (NFPA):
 - 70-11National Electrical Code (NEC)
- D. Underwriters Laboratories, Inc. (UL):
 - 1-05Flexible Metal Conduit
 - 5-04Surface Metal Raceway and Fittings
 - 6-07Electrical Rigid Metal Conduit - Steel
 - 50-95Enclosures for Electrical Equipment
 - 360-093Liquid-Tight Flexible Steel Conduit
 - 467-07Grounding and Bonding Equipment
 - 514A-04Metallic Outlet Boxes
 - 514B-04Conduit, Tubing, and Cable Fittings
 - 514C-96Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers
 - 651-05Schedule 40 and 80 Rigid PVC Conduit and Fittings
 - 651A-00Type EB and A Rigid PVC Conduit and HDPE Conduit
 - 797-07Electrical Metallic Tubing
 - 1242-06Electrical Intermediate Metal Conduit - Steel
- E. National Electrical Manufacturers Association (NEMA):
 - TC-2-03.....Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
 - TC-3-04.....PVC Fittings for Use with Rigid PVC Conduit and Tubing
 - FB1-07Fittings, Cast Metal Boxes and Conduit Bodies for Conduit,
Electrical Metallic Tubing and Cable

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Conduit Size: In accordance with the NEC, but not less than 0.5 in unless otherwise shown.
Where permitted by the NEC, 0.5 in flexible conduit may be used for tap connections to recessed lighting fixtures.
- B. Conduit:
 - 1. Rigid steel: Shall conform to UL 6 and ANSI C80.1.
 - 2. Rigid intermediate steel conduit (IMC): Shall conform to UL 1242 and ANSI C80.6.

3. Electrical metallic tubing (EMT): Shall conform to UL 797 and ANSI C80.3. Maximum size not to exceed 4 in and shall be permitted only with cable rated 600 V or less.
4. Flexible galvanized steel conduit: Shall conform to UL 1.
5. Liquid-tight flexible metal conduit: Shall conform to UL 360.
6. Direct burial plastic conduit: Shall conform to UL 651 and UL 651A, heavy wall PVC or high density polyethylene (PE).
7. Surface metal raceway: Shall conform to UL 5.

C. Conduit Fittings:

1. Rigid steel and IMC conduit fittings:
 - a. Fittings shall meet the requirements of UL 514B and NEMA FB1.
 - b. Standard threaded couplings, locknuts, bushings, conduit bodies, and elbows: Only steel or malleable iron materials are acceptable. Integral retractable type IMC couplings are also acceptable.
 - c. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure.
 - d. Bushings: Metallic insulating type, consisting of an insulating insert, molded or locked into the metallic body of the fitting. Bushings made entirely of metal or nonmetallic material are not permitted.
 - e. Erickson (union-type) and set screw type couplings: Approved for use in concrete are permitted for use to complete a conduit run where conduit is installed in concrete. Use set screws of case-hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.
 - f. Sealing fittings: Threaded cast iron type. Use continuous drain-type sealing fittings to prevent passage of water vapor. In concealed work, install fittings in flush steel boxes with blank cover plates having the same finishes as that of other electrical plates in the room.
3. Electrical metallic tubing fittings:
 - a. Fittings and conduit bodies shall meet the requirements of UL 514B, ANSI C80.3, and NEMA FB1.
 - b. Only steel or malleable iron materials are acceptable.
 - c. Indent-type connectors or couplings are prohibited.
 - d. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are prohibited.
4. Flexible steel conduit fittings:
 - a. Conform to UL 514B. Only steel or malleable iron materials are acceptable.

- b. Clamp-type, with insulated throat.
- 5. Liquid-tight flexible metal conduit fittings:
 - a. Fittings shall meet the requirements of UL 514B and NEMA FB1.
 - b. Only steel or malleable iron materials are acceptable.
 - c. Fittings must incorporate a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening. Connectors shall have insulated throats.
- 6. Direct burial plastic conduit fittings: Fittings shall meet the requirements of UL 514C and NEMA TC3.
- 7. Surface metal raceway fittings: As recommended by the raceway manufacturer. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, conduit entry fittings, accessories, and other fittings as required for complete system.
- 8. Expansion and deflection couplings:
 - a. Conform to UL 467 and UL 514B.
 - b. Accommodate a 0.75 in deflection, expansion, or contraction in any direction, and allow 30 degree angular deflections.
 - c. Include internal flexible metal braid, sized to guarantee conduit ground continuity and a low-impedance path for fault currents, in accordance with UL 467 and the NEC tables for equipment grounding conductors.
 - d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat-resistant molded rubber material with stainless steel jacket clamps.
- D. Conduit Supports:
 - 1. Parts and hardware: Zinc-coat or provide equivalent corrosion protection.
 - 2. Individual Conduit Hangers: Designed for the purpose, having a pre-assembled closure bolt and nut, and provisions for receiving a hanger rod.
 - 3. Multiple conduit (trapeze) hangers: Not less than 1.5 x 1.5 in, 12-gauge steel, cold-formed, lipped channels; with not less than 0.375 in diameter steel hanger rods.
 - 4. Solid Masonry and Concrete Anchors: Self-drilling expansion shields, or machine bolt expansion.
- E. Outlet, Junction, and Pull Boxes:
 - 1. UL-50 and UL-514A.
 - 2. Cast metal where required by the NEC or shown, and equipped with rustproof boxes.
 - 3. Sheet metal boxes: Galvanized steel, except where otherwise shown.

4. Flush-mounted wall or ceiling boxes shall be installed with raised covers so that the front face of raised cover is flush with the wall. Surface-mounted wall or ceiling boxes shall be installed with surface-style flat or raised covers.
- F. Wireways: Equip with hinged covers, except where removable covers are shown. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for a complete system.

PART 3 - EXECUTION

3.1 PENETRATIONS

- A. Cutting or Holes:
 1. Cut holes in advance where they should be placed in the structural elements, such as ribs or beams. Obtain the approval of the Resident Engineer prior to drilling through structural elements.
 2. Cut holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw. Pneumatic hammers, impact electric, hand, or manual hammer-type drills are not allowed, except where permitted by the Resident Engineer as required by limited working space.
- B. Firestop: Where conduits, wireways, and other electrical raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING.
- C. Waterproofing: At floor, exterior wall, and roof conduit penetrations, completely seal clearances around the conduit and make watertight, as specified in Section 07 92 00, JOINT SEALANTS.

3.2 INSTALLATION, GENERAL

- A. In accordance with UL, NEC, as shown, and as specified herein.
- B. Essential (Emergency) raceway systems shall be entirely independent of other raceway systems, except where shown on drawings.
- C. Install conduit as follows:
 1. In complete mechanically and electrically continuous runs before pulling in cables or wires.
 2. Unless otherwise indicated on the drawings or specified herein, installation of all conduits shall be concealed within finished walls, floors, and ceilings.
 3. Flattened, dented, or deformed conduit is not permitted. Remove and replace the damaged conduits with new undamaged material.
 4. Assure conduit installation does not encroach into the ceiling height head room, walkways, or doorways.

5. Cut square, ream, remove burrs, and draw up tight.
 6. Independently support conduit at 8 ft on centers. Do not use other supports, i.e., suspended ceilings, suspended ceiling supporting members, lighting fixtures, conduits, mechanical piping, or mechanical ducts.
 7. Support within 12 in of changes of direction, and within 12 in of each enclosure to which connected.
 8. Close ends of empty conduit with plugs or caps at the rough-in stage until wires are pulled in, to prevent entry of debris.
 9. Conduit installations under fume and vent hoods are prohibited.
 10. Secure conduits to cabinets, junction boxes, pull-boxes, and outlet boxes with bonding type locknuts. For rigid and IMC conduit installations, provide a locknut on the inside of the enclosure, made up wrench tight. Do not make conduit connections to junction box covers.
 11. Flashing of penetrations of the roof membrane is specified in Section 07 60 00, FLASHING AND SHEET METAL.
 12. Conduit bodies shall only be used for changes in direction, and shall not contain splices.
- D. Conduit Bends:
1. Make bends with standard conduit bending machines.
 2. Conduit hickey may be used for slight offsets and for straightening stubbed out conduits.
 3. Bending of conduits with a pipe tee or vise is prohibited.
- E. Layout and Homeruns:
1. Install conduit with wiring, including homeruns, as shown on drawings.
 2. Deviations: Make only where necessary to avoid interferences and only after drawings showing the proposed deviations have been submitted approved by the Resident Engineer.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.4 CONCEALED WORK INSTALLATION

A. In Concrete:

1. Conduit: Rigid steel, IMC, or EMT. Do not install EMT in concrete slabs that are in contact with soil, gravel, or vapor barriers.
2. Align and run conduit in direct lines.
3. Install conduit through concrete beams only:
 - a. Where shown on the structural drawings.
 - b. As approved by the Resident Engineer prior to construction, and after submittal of drawing showing location, size, and position of each penetration.
4. Installation of conduit in concrete that is less than 3 in thick is prohibited.
 - a. Conduit outside diameter larger than one-third of the slab thickness is prohibited.
 - b. Space between conduits in slabs: Approximately six conduit diameters apart, and one conduit diameter at conduit crossings.
 - c. Install conduits approximately in the center of the slab so that there will be a minimum of 0.75 in of concrete around the conduits.
5. Make couplings and connections watertight. Use thread compounds that are UL approved conductive type to ensure low resistance ground continuity through the conduits. Tightening setscrews with pliers is prohibited.

B. Above Furred or Suspended Ceilings and in Walls:

1. Conduit for conductors above 600 V: Rigid steel. Mixing different types of conduits indiscriminately in the same system is prohibited.
2. Conduit for conductors 600 V and below: Rigid steel, IMC, or EMT. Mixing different types of conduits indiscriminately in the same system is prohibited.
3. Align and run conduit parallel or perpendicular to the building lines.
4. Connect recessed lighting fixtures to conduit runs with maximum 6 ft of flexible metal conduit extending from a junction box to the fixture.
5. Tightening setscrews with pliers is prohibited.

3.5 EXPOSED WORK INSTALLATION

- A. Unless otherwise indicated on the drawings, exposed conduit is only permitted in mechanical and electrical rooms.
- B. Conduit for Conductors above 600 V: Rigid steel. Mixing different types of conduits indiscriminately in the system is prohibited.

- C. Conduit for Conductors 600 V and Below: Rigid steel, IMC, or EMT. Mixing different types of conduits indiscriminately in the system is prohibited.
- D. Align and run conduit parallel or perpendicular to the building lines.
- E. Install horizontal runs close to the ceiling or beams and secure with conduit straps.
- F. Support horizontal or vertical runs at not over 8 ft intervals.
- G. Surface metal raceways: Use only where shown.
- H. Painting:
 - 1. Paint exposed conduit as specified in Section 09 91 00, PAINTING.
 - 2. Paint all conduits containing cables rated over 600 V safety orange. Refer to Section 09 91 00, PAINTING for preparation, paint type, and exact color. In addition, paint legends, using 2 in high black numerals and letters, showing the cable voltage rating. Provide legends where conduits pass through walls and floors and at maximum 20 ft intervals in between.

3.6 DIRECT BURIAL INSTALLATION

Refer to Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

3.7 HAZARDOUS LOCATIONS

- A. Use rigid steel conduit only, notwithstanding requirements otherwise specified in this or other sections of these specifications.
- B. Install UL approved sealing fittings that prevent passage of explosive vapors in hazardous areas equipped with explosion-proof lighting fixtures, switches, and receptacles, as required by the NEC.

3.8 WET OR DAMP LOCATIONS

- A. Unless otherwise shown, use conduits of rigid steel or IMC.
- B. Provide sealing fittings to prevent passage of water vapor where conduits pass from warm to cold locations, i.e., refrigerated spaces, constant-temperature rooms, air-conditioned spaces, building exterior walls, roofs, or similar spaces.
- C. Unless otherwise shown, use rigid steel or IMC conduit within 5 ft of the exterior and below concrete building slabs in contact with soil, gravel, or vapor barriers. Conduit shall be half-lapped with 10 mil PVC tape before installation. After installation, completely recoat or retape any damaged areas of coating.

3.9 MOTORS AND VIBRATING EQUIPMENT

- A. Use flexible metal conduit for connections to motors and other electrical equipment subject to movement, vibration, misalignment, cramped quarters, or noise transmission.

- B. Use liquid-tight flexible metal conduit for installation in exterior locations, moisture or humidity laden atmosphere, corrosive atmosphere, water or spray wash-down operations, inside airstream of HVAC units, and locations subject to seepage or dripping of oil, grease, or water. Provide a green equipment grounding conductor with flexible metal conduit.

3.10 EXPANSION JOINTS

- A. Conduits 3 in and larger that are secured to the building structure on opposite sides of a building expansion joint require expansion and deflection couplings. Install the couplings in accordance with the manufacturer's recommendations.
- B. Provide conduits smaller than 3 in with junction boxes on both sides of the expansion joint. Connect conduits to junction boxes with sufficient slack of flexible conduit to produce 5 in vertical drop midway between the ends. Flexible conduit shall have a bonding jumper installed. In lieu of this flexible conduit, expansion and deflection couplings as specified above for conduits 15 in and larger are acceptable.
- C. Install expansion and deflection couplings where shown.
- D. Seismic Areas: In seismic areas, provide conduits rigidly secured to the building structure on opposite sides of a building expansion joint with junction boxes on both sides of the joint. Connect conduits to junction boxes with 15 in of slack flexible conduit. Flexible conduit shall have a copper green ground bonding jumper installed.

3.11 CONDUIT SUPPORTS, INSTALLATION

- A. Safe working load shall not exceed one-quarter of proof test load of fastening devices.
- B. Use pipe straps or individual conduit hangers for supporting individual conduits.
- C. Support multiple conduit runs with trapeze hangers. Use trapeze hangers that are designed to support a load equal to or greater than the sum of the weights of the conduits, wires, hanger itself, and 200 lbs. Attach each conduit with U-bolts or other approved fasteners.
- D. Support conduit independently of junction boxes, pull-boxes, fixtures, suspended ceiling T-bars, angle supports, and similar items.
- E. Fasteners and Supports in Solid Masonry and Concrete:
 - 1. New Construction: Use steel or malleable iron concrete inserts set in place prior to placing the concrete.
 - 2. Existing Construction:
 - a. Steel expansion anchors not less than 0.25 in bolt size and not less than 1.125 in embedment.

- b. Power set fasteners not less than 0.25 in diameter with depth of penetration not less than 3 in.
 - c. Use vibration and shock-resistant anchors and fasteners for attaching to concrete ceilings.
- F. Hollow Masonry: Toggle bolts.
- G. Bolts supported only by plaster or gypsum wallboard are not acceptable.
- H. Metal Structures: Use machine screw fasteners or other devices specifically designed and approved for the application.
- I. Attachment by wood plugs, rawl plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.
- J. Chain, wire, or perforated strap shall not be used to support or fasten conduit.
- K. Spring steel type supports or fasteners are prohibited for all uses except horizontal and vertical supports/fasteners within walls.
- L. Vertical Supports: Vertical conduit runs shall have riser clamps and supports in accordance with the NEC and as shown. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.

3.12 BOX INSTALLATION

- A. Boxes for Concealed Conduits:
 - 1. Flush-mounted.
 - 2. Provide raised covers for boxes to suit the wall or ceiling, construction, and finish.
- B. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling-in operations.
- C. Remove only knockouts as required and plug unused openings. Use threaded plugs for cast metal boxes and snap-in metal covers for sheet metal boxes.
- D. Outlet boxes mounted back-to-back in the same wall are prohibited. A minimum 24 in center-to-center lateral spacing shall be maintained between boxes.
- E. Minimum size of outlet boxes for ground fault interrupter (GFI) receptacles is 4 in square x 2.125 in deep, with device covers for the wall material and thickness involved.
- F. Stencil or install phenolic nameplates on covers of the boxes identified on riser diagrams; for example "SIG-FA JB No. 1."
- G. On all branch circuit junction box covers, identify the circuits with black marker.

--- E N D ---

SECTION 26 05 41
UNDERGROUND ELECTRICAL CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of precast manholes and pullboxes with ducts to form a complete underground raceway system.
- B. “Duct” and “conduit,” and “rigid metal conduit” and “rigid steel conduit” are used interchangeably in this specification.

1.2 RELATED WORK

- A. Section 07 92 00, JOINT SEALANTS: Sealing of conduit penetrations.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits, fittings and boxes for raceway systems.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project’s sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute’s Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Coordinate layout and installation of ducts, manholes, pullboxes, and pull-boxes with final arrangement of other utilities, site grading, and surface features, as determined in the field.

1.5 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Clearly present sufficient information to determine compliance with drawings and specifications.
 - 2. Include manholes, pullboxes, duct materials, and hardware. Submit plan and elevation drawings, showing openings, pulling irons, cable supports, cover, ladder, sump, and other accessories and details.
 - 3. Proposed deviations from details on the drawings shall be clearly marked on the submittals. If it is necessary to locate manholes or pullboxes at locations other than shown on the drawings, show the proposed locations accurately on scaled site drawings, and submit four copies to the Resident Engineer for approval prior to construction.
- C. Certifications: Two weeks prior to the final inspection, submit four copies of the following certifications to the Resident Engineer:
 - 1. Certification by the manufacturer that the materials conform to the requirements of the drawings and specifications.
 - 2. Certification by the contractor that the materials have been properly installed, connected, and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American Concrete Institute (ACI):
 - Building Code Requirements for Structural Concrete
 - 318/318M-05 Building Code Requirements for Structural Concrete & Commentary
 - SP-66-04 ACI Detailing Manual
- C. American National Standards Institute (ANSI):
 - 77-07 Underground Enclosure Integrity
- D. American Society for Testing and Materials (ASTM):
 - C478-09 Standard Specification for Precast Reinforced Concrete Manhole Sections
 - C858-09 Underground Precast Concrete Utility Structures

C990-09Standard Specification for Joints for Concrete Pipe, Manholes
and Precast Box Sections Using Preformed Flexible Joint
Sealants.

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

C2-07National Electrical Safety Code

F. National Electrical Manufacturers Association (NEMA):

TC 2-03Electrical Polyvinyl Chloride (PVC) Tubing And Conduit

TC 3-2004PVC Fittings for Use With Rigid PVC Conduit And Tubing

TC 6 & 8 2003PVC Plastic Utilities Duct For Underground Installations

TC 9-2004Fittings For PVC Plastic Utilities Duct For Underground
Installation

G. National Fire Protection Association (NFPA):

70-11National Electrical Code (NEC)

H. Underwriters Laboratories, Inc. (UL):

6-07Electrical Rigid Metal Conduit-Steel

467-07Grounding and Bonding Equipment

651-05Schedule 40 and 80 Rigid PVC Conduit and Fittings

651A-00Type EB and A Rigid PVC Conduit and HDPE Conduit

651B-07Continuous Length HDPE Conduit

I. U.S. General Services Administration (GSA):

A-A-60005-1998.....Frames, Covers, Gratings, Steps, Sump and Catch Basin,
Manhole

1.7 STORAGE

Lift and support pre-cast concrete structures only at designated lifting or supporting points.

PART 2 - PRODUCTS

2.1 PULLBOXES

- A. General: Size as indicated on drawings. Provide pullboxes with weatherproof, non-skid covers with recessed hook eyes, secured with corrosion- and tamper-resistant hardware. Cover material shall be identical to pullbox material. Covers shall have molded lettering, ELECTRIC or SIGNAL as applicable. Pullboxes shall comply with the requirements of ANSI/SCTE 77 Tier 15 loading. Provide pulling irons, 0.875 in diameter galvanized steel bar with exposed triangular-shaped opening.
- B. Polymer Concrete Pullboxes: Shall be molded of sand, aggregate, and polymer resin, and reinforced with steel, fiberglass, or both. Pullbox shall have open bottom.

- C. Fiberglass Pullboxes: Shall be sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
- D. Concrete Pullboxes: Shall be monolithically-poured reinforced concrete.

2.2 DUCTS

- A. Number and sizes shall be as shown on drawings.
- B. Ducts (concrete-encased):
 - 1. Plastic Duct:
 - a. NEMA TC6 & 8 and TC9 plastic utilities duct .
 - b. Duct shall be suitable for use with 194° F rated conductors.
 - 2. Conduit Spacers: Prefabricated plastic.
- C. Ducts (direct-burial):
 - 1. Plastic duct:
 - a. NEMA TC2 and TC3
 - b. UL 651, 651A, and 651B, Schedule 80 PVC or HDPE.
 - c. Duct shall be suitable for use with 167° F rated conductors.
 - 2. Rigid metal conduit: UL6 and NEMA RN1 galvanized rigid steel, threaded type, half-lapped with 10 mil PVC tape.

2.3 GROUNDING

- A. Rods: Per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- B. Ground Wire: Stranded bare copper 6 AWG minimum.

2.4 WARNING TAPE

Standard 4-mil polyethylene 3 in wide detectable tape, red with black letters, imprinted with “CAUTION - BURIED ELECTRIC CABLE BELOW” or similar.

2.5 PULL ROPE FOR SPARE DUCTS

Plastic with 200 lb minimum tensile strength.

PART 3 - EXECUTION

3.1 MANHOLE AND PULLBOX INSTALLATION

- A. Assembly and installation shall follow the printed instructions and recommendations of the manufacturer. Install manholes and pullboxes level and plumb.
 - 1. Units shall be installed on a 12 in level bed of 90% compacted granular fill, well-graded from the 1 in sieve to the No. 4 sieve. Granular fill shall be compacted with a minimum of four passes with a plate compactor.
 - 2. Seal duct terminations so they are watertight.
- B. Access: Ensure the top of frames and covers are flush with finished grade.

- C. Ground Rods in Manholes: Drive a ground rod into the earth, through the floor sleeve, after the manhole is set in place. Fill the sleeve with sealant to make a watertight seal. Rods shall protrude approximately 4 in above the manhole floor.
- D. Grounding in Manholes:
 - 1. Install a No. 3/0 AWG bare copper ring grounding conductor around the inside perimeter of the manhole and anchor to the walls with metallic cable clips.
 - 2. Connect the ring grounding conductor to the ground rod by an exothermic welding process.
 - 3. Bond the ring grounding conductor to the duct bank equipment grounding conductors, the exposed non-current carrying metal parts of racks, sump covers, and like items in the manholes with a minimum No. 6 AWG bare copper jumper.

3.2 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.3 TRENCHING

- A. Refer to Section 31 20 00, EARTH MOVING for trenching, backfilling, and compaction.
- B. Before performing trenching work at existing facilities, the Ground Penetrating Radar Survey shall be carefully performed by certified technician to reveal all existing underground ducts, conduits, cables, and other utility systems.
- C. Work with extreme care near existing ducts, conduits, cables, and other utilities to avoid damaging them.
- D. Cut the trenches neatly and uniformly.
- E. For Concrete-Encased Ducts:
 - 1. After excavation of the trench, stakes shall be driven in the bottom of the trench at 4 ft intervals to establish the grade and route of the duct bank.
 - 2. Pitch the trenches uniformly toward manholes or both ways from high points between manholes for the required duct line drainage. Avoid pitching the ducts toward buildings wherever possible.

3. The walls of the trench may be used to form the side walls of the duct bank, provided that the soil is self-supporting and that concrete envelope can be poured without soil inclusions.
Forms are required where the soil is not self-supporting.
 4. After the concrete-encased duct has sufficiently cured, the trench shall be backfilled to grade with earth, and appropriate warning tape installed.
- F. Conduits to be installed under existing paved areas and roads that cannot be disturbed shall be jacked into place. Conduits shall be heavy wall rigid steel.

3.4 DUCT INSTALLATION

A. General Requirements:

1. Ducts shall be in accordance with the NEC and IEEE C2, as shown on the drawings, and as specified.
2. Slope ducts to drain towards manholes and pullboxes, and away from building and equipment entrances. Pitch not less than 4 inches in 100 ft.
3. Underground conduit stub-ups and sweeps to equipment inside of buildings shall be taped galvanized rigid steel, and shall extend a minimum of 5 ft outside the building foundation.
Tops of conduits below building slab shall be minimum 24 in below bottom of slab.
4. Stub-ups, sweeps, and risers to equipment mounted on outdoor concrete slabs shall be taped galvanized rigid steel, and shall extend a minimum of 5 ft away from the edge of slab.
5. Install insulated grounding bushings on the terminations.
6. Radius for turns of direction shall be sufficient to accomplish pulls without damage.
Minimum radius shall be six times conduit diameter. Use manufactured long sweep bends.
7. Additional burial depth shall be required in order to accomplish NEC-required minimum bend radius of ducts.
8. All multiple conduit runs shall have conduit spacers. Spacers shall securely support and maintain uniform spacing of the duct assembly a minimum of 3 in above the bottom of the trench during the concrete pour. Spacer spacing shall not exceed 5 ft. Secure spacers to ducts and earth to prevent floating during concrete pour. Provide nonferrous tie wires to prevent displacement of the ducts during pouring of concrete. Tie wires shall not act as substitute for spacers.
9. Duct lines shall be installed no less than 12 in from other utility systems, such as water, sewer, and chilled water.

10. Clearances between individual ducts:
 - a. For like services, not less than 3 in.
 - b. For power and signal services, not less than 6 in.
 11. Duct lines shall terminate at window openings in manhole walls as shown on the drawings.
All ducts shall be fitted with end bells.
 12. Couple the ducts with proper couplings. Stagger couplings in rows and layers to ensure maximum strength and rigidity of the duct bank.
 13. Keep ducts clean of earth, sand, or gravel, and seal with tapered plugs upon completion of each portion of the work.
 14. Seal conduits, including spare conduits, at building entrances and at outdoor equipment terminations with a suitable compound to prevent entrance of moisture and gases.
- B. Concrete-Encased Ducts and Conduits:
1. Install concrete-encased ducts for medium-voltage systems, low-voltage systems, and signal systems, unless otherwise shown on the drawings.
 2. Duct lines shall consist of single or multiple duct assemblies encased in concrete. Ducts shall be uniform in size and material throughout the installation.
 3. Tops of concrete-encased ducts shall be:
 - a. Not less than 24 in and not less than shown on the drawings, below finished grade.
 - b. Not less than 30 in and not less than shown on the drawings, below roads and other paved surfaces.
 - c. Conduits crossing under grade slab construction joints shall be installed a minimum of 4 ft below slab.
 4. Extend the concrete envelope encasing the ducts not less than 3 in beyond the outside walls of the outer ducts and conduits.
 5. Within 10 ft of building manhole and pullbox wall penetrations, install reinforcing steel bars at the top and bottom of each concrete envelope to provide protection against vertical shearing.
 6. Install reinforcing steel bars at the top and bottom of each concrete envelope of all ducts underneath roadways and parking areas.
 7. Where new ducts, conduits, and concrete envelopes are to be joined to existing manholes, pullboxes, ducts, conduits, and concrete envelopes, make the joints with the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions.
 8. Conduit joints in concrete may be placed side by side horizontally, but shall be staggered at least 6 in vertically.

9. Pour each run of concrete envelope between manholes or other terminations in one continuous pour. If more than one pour is necessary, terminate each pour in a vertical plane and install 0.75 in reinforcing rod dowels extending 18 in into concrete on both sides of joint near corners of envelope.
 10. Pour concrete so that open spaces are uniformly filled. Do not agitate with power equipment unless approved by Resident Engineer.
- C. Direct-Burial Duct and Conduits:
1. Install direct-burial ducts and conduits only where shown on the drawings. Provide direct-burial ducts only for low-voltage systems.
 2. Join and terminate ducts and conduits with fittings recommended by the conduit manufacturer.
 3. Tops of ducts and conduits shall be:
 - a. Not less than 24 in and not less than shown on the drawings, below finished grade.
 - b. Not less than 30 in and not less than shown on the drawings, below roads and other paved surfaces.
 4. Do not kink the ducts or conduits. Compaction shall not deform the ducts.
- D. Concrete-Encased and Duct and Conduit Identification: Place continuous strip of warning tape approximately 12 in above ducts or conduits before backfilling trenches. Warning tape shall be preprinted with proper identification.
- E. Spare Ducts and Conduits: Where spare ducts are shown, they shall have a nylon pull rope installed. They shall be capped at each end and labeled as to location of the other end.
- F. Duct and Conduit Cleaning:
1. Upon completion of the duct installation, a standard flexible mandrel shall be pulled through each duct to loosen particles of earth, sand, or foreign material left in the duct. The mandrel shall be not less than 12 in long, and shall have a diameter not less than 0.5 in less than the inside diameter of the duct. A brush with stiff bristles shall then be pulled through each duct to remove the loosened particles. The diameter of the brush shall be the same as, or slightly larger than, the diameter of the duct.
 2. Mandrel pulls shall be witnessed by the Resident Engineer.
- G. Duct and Conduit Sealing: Seal the ducts and conduits at building entrances, and at outdoor terminations for equipment, with a suitable non-hardening compound to prevent the entrance of moisture and gases.

- H. Connections to Manholes: Ducts connecting to manholes shall be flared to have an enlarged cross-section to provide additional shear strength. Dimensions of the flared cross-section shall be larger than the corresponding manhole opening dimensions by no less than 12 inches in each direction. Perimeter of the duct bank opening in the underground structure shall be flared toward the inside or keyed to provide a positive interlock between the duct and the wall of the manhole. Use vibrators when this portion of the encasement is poured to ensure a seal between the envelope and the wall of the structure.
- I. Connections to Existing Manholes: For duct connections to existing manholes, break the structure wall out to the dimensions required and preserve the steel in the structure wall. Cut steel and extend into the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.
- J. Connections to Existing Ducts: Where connections to existing duct banks are indicated, excavate around the duct banks as necessary. Cut off the ducts and remove loose concrete from inside before installing new ducts. Provide a reinforced-concrete collar, poured monolithically with the new ducts, to take the shear at the joint of the duct banks.
- K. Partially-Completed Duct Banks: During construction, wherever a construction joint is necessary in a duct bank, prevent debris such as mud and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 2 ft back into the envelope and a minimum of 2 ft beyond the end of the envelope. Provide one No. 4 bar in each corner, 3 in from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 12 in apart. Restrain reinforcing assembly from moving during pouring of concrete.

--- E N D ---

SECTION 26 05 71
ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the requirements of the Electrical System Protective Device Study (herein, “the study”).
- B. A short-circuit and selective coordination study shall be prepared for the electrical overcurrent devices to be installed under this project.
- C. The study shall present an organized time-current analysis of each protective device in series from the and the on-site generator sources. The study shall reflect the operation of each device during normal and abnormal current conditions.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.
- B. Section 26 13 16, MEDIUM VOLTAGE METAL-ENCLOSED LOAD INTERRUPTER SWITCHGEAR: Medium-voltage distribution switchgear.
- C. Section 26 23 00, LOW-VOLTAGE METAL ENCLOSED CIRCUIT BREAKER SWITCHGEAR: Low voltage switchgear.
- D. Section 26 24 13, SWITCHBOARDS: Low-voltage distribution switchboards.
- E. Section 26 24 16, PANEL BOARDS: Low-voltage panelboards.
- F. Section 26 32 13, ENGINE GENERATORS: Engine-generators.
- G. Section 26 36 23, AUTOMATIC TRANSFER SWITCHES: Automatic transfer switches.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project’s sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute’s Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. The protective device study shall be prepared by the equipment manufacturer's qualified engineers or an approved consultant. The contractor is responsible for providing all pertinent information required by the preparers to complete the study.

1.5 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Product data on the software program to be used for the study. Software shall be in mainstream use in the industry, shall provide device settings and ratings, and shall show selective coordination by time-current drawings.
- C. Complete short-circuit and coordination study as described in paragraph 1.6.
- D. Protective equipment shop drawings shall be submitted simultaneously with or after the protective device study. Protective equipment shop drawings will not be accepted prior to protective device study.
- E. Certification: Two weeks prior to final inspection, submit four copies of the following to the Resident Engineer:
- F. Certification by the contractor that the protective devices have been adjusted and set in accordance with the approved protective device study.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 242-01Recommended Practice for Protection and Coordination of
Industrial and Commercial Power Systems
 - 399-97Recommended Practice for Power Systems Analysis
 - 1584a-04Guide for Performing Arc-Flash Hazard Calculations

1.7 REQUIREMENTS

- A. The complete study shall include a system one line diagram, short-circuit and ground fault analysis, and protective coordination plots for all overcurrent protective devices.

B. One Line Diagram:

1. On the one line diagram, show all electrical equipment and wiring to be protected by the overcurrent devices installed under this project.
2. On the one line diagram, also show the following specific information:
 - a. Calculated fault impedance, X/R ratios, and short-circuit values at each feeder and branch circuit bus.
 - b. Breaker and fuse ratings.
 - c. Generator kW and Transformer kVA and voltage ratings, percent impedance, X/R ratios, and wiring connections.
 - d. Voltage at each bus.
 - e. Identification of each bus, matching the identification on the construction drawings.
 - f. Conduit, cable, and busway material and sizes, length, and X/R ratios.

C. Short-Circuit Study:

1. Systematically calculate the fault impedance to determine the available short-circuit and ground fault currents at each bus. Incorporate the motor contribution in determining the momentary and interrupting ratings of the protective devices.
2. The study shall be calculated by means of a computer program. Pertinent data and the rationale employed in developing the calculations shall be incorporated in the introductory remarks of the study.
3. Present the data conclusions of the short-circuit study in a table format. Include the following:
 - a. Device identification.
 - b. Operating voltage.
 - c. Protective device.
 - d. Device rating.
 - e. Calculated short-circuit current.

D. Coordination Curves:

1. Prepare the coordination curves to determine the required settings of protective devices to ensure selective coordination. Graphically illustrate on log-log paper that adequate time separation exists between series devices, including the utility company upstream device. Plot the specific time-current characteristics of each protective device in such a manner that all upstream devices are clearly depicted on one sheet.
2. The following specific information shall also be shown on the coordination curves:
 - a. Device identification.

- b. Voltage and current ratio for curves.
 - c. 3-phase and 1-phase ANSI damage points for each transformer.
 - d. No-damage, melting, and clearing curves for fuses.
 - e. Cable damage curves.
 - f. Transformer in-rush points.
 - g. Maximum short-circuit cutoff point.
3. Develop a table to summarize the settings selected for the protective devices. Include the following in the table:
- a. Device identification.
 - b. Relay CT ratios, tap, time dial, and instantaneous pickup.
 - c. Circuit breaker sensor rating, long-time, short-time, and instantaneous settings, and time bands.
 - d. Fuse rating and type.
 - e. Ground fault pickup and time delay.

1.8 ANALYSIS

- A. Analyze the short-circuit calculations, and highlight any equipment determined to be underrated as specified. Propose approaches to effectively protect the underrated equipment. Provide minor modifications to conform with the study (examples of minor modifications are trip sizes within the same frame, the time-current curve characteristics of induction relays, CT ranges, etc.).
- B. After developing the coordination curves, highlight areas lacking coordination. Present a technical evaluation with a discussion of the logical compromises for best coordination.

1.9 ADJUSTMENTS, SETTINGS AND MODIFICATIONS

- A. Necessary final field adjustments, settings, and minor modifications shall be made to conform with the study without additional cost to the Government.
- B. All final circuit breaker and relay settings and fuse sizes shall be made in accordance with the recommendations of the study.

1.10 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

---END---

SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section apply to all sections of Division 26.
- 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 the electrical 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 this Division is part of the construction process. Documentation and testing of these systems, as well as training of the VA's Operation and Maintenance personnel, is required in cooperation with the VA and the Commissioning Agent.
- B. The following Electrical systems will be commissioned:
 - 1. Lighting Controls (Control system hardware and software, scene settings, zone settings, occupancy sensor interface, and unoccupied cycle control).

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 Resident Engineer prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.
- B. 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 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.
- B. Cost of Retesting: The cost associated with Pre-Functional Checklist corrections and resubmissions shall be solely the responsibility of the contractor. Any required Pre-Functional Checklist correction and resubmission by the contractor shall not be considered a justified reason for a claim of delay or for a time extension by the contractor. Time for the commissioning agent for Pre-Functional Checklist correction verifications or expanded Pre-Functional Checklist sampling verifications will be “back-charged” to the responsible subcontractor at a cost of \$3000 per man-day.

3.2 CONTRACTORS TESTS

- A. Contractor tests as required by other sections of Division 26 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. The Commissioning Agent may witness selected Contractor tests. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.3 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 execution. 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.

3.4 TRAINING OF VA PERSONNEL

- A. Training of the VA's 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. 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 01 and Division 26 Sections for additional Contractor training requirements.

----- END -----

SECTION 26 09 13
ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

- A. Furnish and install a complete Power Monitoring and Control System (PMCS) as detailed on the drawings and as described in this specification. The system is defined to include, but not be limited to, remote devices for monitoring, control and protection, device communication interface hardware, inter-communication wiring, personal computer workstations, software, printer where specified, and ancillary equipment.
- B. The manufacturer shall demonstrate the system is not a prototype and that similar systems have been field installed and successfully operated for at least five years. The PMCS vendor shall have full responsibility for insuring that the PMCS system performs as specified.
- C. The PMCS shall utilize Ethernet as the high-speed backbone network that supports direct connection of an unlimited number of personal computer workstations anywhere on the network.
- D. Each Personal Computer Workstation (PCW) connected to the network shall have equal access to information provided by the power monitoring devices for centralizing data display, data logging, alarming, event recording, and other power monitoring operations. Each PCW shall be independent of the other PCWs with its own software to allow the user to retrieve and configure the information based on the user's needs.
- E. The high-speed network shall allow direct access to data provided by the power monitoring devices for implementing automatic control.
- F. Application software for personal computer workstations shall be provided as described in Article 2.11 of this specification.
- G. The PMCS shall be POWERLOGIC as manufactured by Square D Company (Preferred Manufacturer and Basis of Design) or approved equal.
- H. All products shall not violate any U. S. patents.

1.2 REFERENCES

- A. All Power Meters and Circuit Monitors shall be UL 508 Listed, CSA approved, and have CE marking. They shall also have certified revenue accuracy as per ANSI C12.20 and IEC 60687 class 0.5S or better.
- B. The system shall comply with the applicable portions of NEMA standards. In addition, the control unit shall comply with FCC Emission Standards specified in Part 15, Sub-part J for Class A application.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. PMCS Drawings: Drawings shall show all field monitoring devices, key networking components, and cabling required to complete the system. Drawings shall identify network connections and protocols. Drawings shall identify device room location and recommended installation notations. Specific locations and mounting details are subject to the discretion and responsibilities of the installation Contractor.
- C. Product Data: Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements of each device supplied under the PMCS scope of work.

1.5 QUALITY

- A. The PMCS vendor shall be ISO 9000 registered to demonstrate quality compliance.
- B. PMCS components included within the power equipment lineups shall be factory installed, wired and tested prior to shipment to the job site.

PART 2 – PRODUCT

2.1 ENERGY METERS

- A. The Meter shall be calibrated as a system and be accurate to +/- 1% from 5 % to 100 % of the rated current over a temperature range of 0-60° C. No annual recalibration by users shall be required to maintain these accuracy's.
 - 1. The Meter shall be UL and cUL Listed per 7207. The meter module shall be rated for an operating temperature range of 0°C to 60°C.

2. The Meter shall consist of three split-core CTs hinged at both axis with the power metering electronics embedded inside of the master CT.
3. The Meter shall directly accept any voltage input from 208-480 VAC.
4. The Meter shall be internally isolated to 2000 VAC.
5. The Meter case isolation shall be 600 VAC.
6. The Meter series shall have models available for amperage ranges of 100-2400 Amps.
7. Each Meter shall have built-in RS-485 data communications using Modbus (RTU) protocol to allow multipoint communication to multiple computer workstations, programmable controllers, and other host devices, with a data rate of 9,600 baud.
8. The Meter shall be installed as part of a power monitoring and control system as indicated on the drawings. The RS-485 communications shall provide communications links up to 10,000 feet long.
9. The Meter shall communicate using the Modbus RTU protocol and connect to any host devices with a Modbus-compatible port.
10. When connected via the network to a PowerLogic computer, the Meter shall provide logging, trending, and alarming information.
11. The information and capabilities provided by the Meter shall include the following:
 - a. The basic model shall provide the following metered values:
 - 1) Real Power (kW), three-phase total
 - 2) Real Energy (kWh), three phase total
 - b. The enhanced model shall provide the following metered values:
 - 1) Current, per phase and three-phase total
 - 2) Voltage, per phase and three-phase total, phase-to-phase and phase-neutral
 - 3) Real Power (kW), per phase and three-phase total
 - 4) Reactive Power (kVAR), three phase total
 - 5) Apparent Power (kVA), three phase total
 - 6) Power Factor, per-phase and three-phase total
 - 7) Real Energy (kWh), three phase total
 - 8) Real Power Demand (kWd) readings, three phase total, present and peak
 - 9) The Meter shall a PowerLogic Enercept Meter or equal.

2.2 POWER METERS-BASIC

A. General Provisions

1. All setup parameters required by the Power Meter shall be stored in nonvolatile memory and retained in the event of a control power interruption.
2. The Power Meter may be applied in three-phase, three- or four-wire systems as well as single phase
3. The Power Meter shall be capable of being applied without modification at nominal frequencies of 45 to 65 Hz.

B. Measured Values

1. The Power Meter shall provide the following, true RMS metered quantities:
 - a. Real-Time Readings
 - b. Current (Per-Phase, N (calculated), 3-Phase Avg)
 - c. Voltage (L-L Per-Phase, L-L 3-Phase Avg, L-N Per-Phase, L-N 3-Phase Avg.)
 - d. Real Power (Per-Phase, 3-Phase Total)
 - e. Reactive Power (Per-Phase, 3-Phase Total)
 - f. Apparent Power (Per-Phase, 3-Phase Total)
 - g. Power Factor (3-Phase Total)
 - h. Frequency
 - i. THD (Current and Voltage)

C. Energy Readings

1. Accumulated Energy (Real kWh, Reactive kVARh, Apparent kVAh) (Absolute)

D. Demand Readings

1. Demand Current Calculations (Per-Phase):
 - a. Present
 - b. Peak
2. Demand Real Power Calculations (3-Phase Total):
 - a. Present
 - b. Peak
3. Demand Reactive Power Calculations (3-Phase Total):
 - a. Present
 - b. Peak

4. Demand Apparent Power Calculations (3-Phase Total):
 - a. Present
 - b. Peak
- E. Power Analysis Values
 1. THD – Voltage (Line to Line, Line to Neutral)
 2. THD -- Current (Per-Phase, Neutral)
 3. Power Factor (3-Phase)
- F. Demand
 1. All power demand calculations shall use any one of the following calculation methods, selectable by the user:
 - a. Block interval, with optional sub-intervals. The window length shall be set by the user from 1-60 minutes in 1 minute intervals. The user shall be able to set the sub-interval length from 1-60 minutes in 1-minute intervals. The following Block methods are available:
 - 1) Sliding Block that calculates demand every 15 seconds with intervals less than 15 minutes and every 60 seconds with an interval between 15 and 60 minutes.
 - 2) Fixed Block that calculates demand at the end of the interval.
- G. Sampling
 1. The current and voltage signals shall be digitally sampled at a rate high enough to provide true rms accuracy to the 15th harmonic.
 2. The Power Meter shall provide continuous sampling at a minimum of up to 32 samples/cycle, simultaneously on all voltage and current channels in the meter.
- H. Minimum and Maximum Values
 1. The Power Meter shall provide minimum and maximum values for the following parameters:
 - b. Voltage L-L
 - c. Voltage L-N
 - d. Current
 - e. Power Factor
 - f. Real Power Total
 - g. Reactive Power Total
 - h. Apparent Power Total
 - i. THD Voltage L-L
 - j. THD Voltage L-N

- k. THD Current
 - l. Frequency
- 2. For each min/max value listed above, the Power Meter shall record the following attributes:
 - a. Min/Max. Value
 - b. Phase of recorded Min/Max (for multi-phase quantities)
 - c. Minimum and maximum values shall be available via communications and display.
- I. Current Inputs
 - 1. The Power Meter shall accept current inputs from standard instrument current transformers with 5 amp secondary output and shall have a metering range of 0-6 amps with the following withstand currents: 15 amp continuous, 50 amp 10 sec per hour, 120 amp 1 sec per hour.
 - 2. Current transformer primaries through 327 kA shall be supported.
- J. Voltage Inputs
 - 1. The circuit monitor shall allow connection to circuits up to 480 volts AC without the use of potential transformers. The Power Meter shall also accept voltage inputs from standard instrument potential transformers. The Power Meter shall support PT primaries through 1.6 MV.
 - 2. The nominal full scale input of the Power Meter shall be 277 Volts AC L-N, 480 Volts AC L-L. The meter shall accept a metering over-range of 20%. The input impedance shall be greater than 2 Mohm (L-L) or 1Mohm (L-N).
- K. Accuracy
 - 1. The PM710 Power Meter shall comply with IEC62053-21 Class 1 and ANSI C12.16 Class. The PM750 Power Meter shall comply with IEC62053-22 Class 0.5S and ANSI C12.20 Class 0.5
 - 2. The Power Meter shall be accurate to 1% of reading for power and energy. Voltage and current shall be accurate to 0.5% of reading. Frequency metering shall be accurate ± 0.01 Hz at 45-65 Hz.
 - 3. These accuracy's shall be maintained for both light and full loads.
 - 4. No annual calibration shall be required to maintain this accuracy.
- L. Feature Addition
 - 1. It shall be possible to field upgrade the firmware in the Power Meter to enhance functionality. These firmware upgrades shall be done through the communication connection and shall allow upgrades of individual meters or groups. No disassembly or changing of integrated circuit chips shall be required and it will not be necessary to de-energize the circuit or the equipment to perform the upgrade.

M. Control Power

1. The Power Meter shall operate properly over a wide range of control power including 110-415 VAC, +/-10% or 125-250 VDC, +/-20%.

N. Communications

1. The Power Meter shall communicate via RS-485 Modbus or Jbus protocol with a 2-wire connection at speeds up to 19.2 kBaud.

O. Display

1. The Power Meter display shall be back lit LCD for easy viewing, display shall also be anti-glare and scratch resistant.
2. The Display shall be capable of allowing the user to view four values on one screen at the same time. A summary screen shall also be available to allow the user to view a snapshot of the system.
3. The Power Meter display shall provide local access to the following metered quantities:
 - a. Current, per phase rms and neutral (if applicable)
 - b. Voltage, phase-to-phase, phase-to-neutral
 - c. Real power, 3-phase total
 - d. Reactive power, 3-phase total
 - e. Apparent power, 3-phase total
 - f. Power factor, 3-phase total
 - g. Frequency
 - h. Demand current, per phase (if applicable)
 - i. Demand real power, three phase total (if applicable)
 - j. Demand apparent power, three phase total (if applicable)
 - k. Accumulated Energy, (kWh, kVAh, and kVARh)
 - l. THD, current and voltage, per phase (if applicable)
4. Reset of the following electrical parameters shall also be allowed from the Power Meter display:
 - a. Peak demand current
 - b. Peak demand power (kW) and peak demand apparent power (kVA)
 - c. Energy (MWh) and reactive energy (MVARh)
5. Setup for system requirements shall be allowed from the Power Meter display. Setup provisions shall include:
 - a. CT rating
 - b. PT rating (Single Phase, 2-Wire)

- c. System type three-phase, 4-wire

2.3 POWER METER – ADVANCED

A. Demand

1. All power demand calculations shall use any one of the following calculation methods, selectable by the user:
 - a. Thermal demand using a sliding window updated every second for the present demand and at the end of the interval for the last interval. The window length shall be set by the user from 1-60 minutes in one minute increments.
 - b. Block interval, with optional sub-intervals. The window length shall be set by the user from 1-60 minutes in 1 minute intervals. The user shall be able to set the sub-interval length from 1-60 minutes in 1 minute intervals. The following Block methods are available:
 - 1) Sliding Block that calculates demand every second with intervals less than 15 minutes and every 15 seconds with an interval between 15 and 60 minutes.
 - 2) Fixed Block that calculates demand at the end of the interval
 - 3) Rolling Block that a subinterval is configured. Demand is calculated at the end of each subinterval and displays at the end of the interval.
 - c. Demand can be calculated using a Synchronization signal:
 - 1) Demand can be synchronized to an input pulse from an external source. The demand period begins with every pulse. A synchronized input can be configured to either a block or rolling block calculation
 - 2) Demand can be synchronized to a communication signal. This can be configured to either a block or rolling block calculation
 - 3) Demand can be synchronized to the clock in the Power Meter.

B. Sampling

1. The current and voltage signals shall be digitally sampled at a rate high enough to provide true rms accuracy to the 63rd harmonic (fundamental of 60 Hz).
2. The Power Meter shall provide continuous sampling at a minimum of up to 128 samples/cycle, simultaneously on all voltage and current channels in the meter.

C. Minimum and Maximum Values

1. The Power Meter shall provide a monthly minimum and maximum values for the following parameters:
 - a. Voltage L-L

- b. Voltage L-N
 - c. Current per phase
 - d. Voltage L-L Unbalance
 - e. Voltage L-N Unbalance
 - f. True Power Factor
 - g. Displacement Power Factor
 - h. Real Power Total
 - i. Reactive Power Total
 - j. Apparent Power Total
 - k. THD Voltage L-L
 - l. THD Voltage L-N
 - m. THD Current
 - n. Frequency
2. For each min/max value listed above, the Power Meter shall record the following attributes:
 - a. Date/Time of the min/max value
 - b. Min/Max. Value
 - c. Phase of recorded Min/Max (for multi-phase quantities)
 3. Minimum and maximum values shall be available via communications and display.
- D. Harmonic Resolution
1. Advanced harmonic information shall be available via the Power Meter. This shall include the calculation of the harmonic magnitudes and angles for each phase voltage and current through the 63rd harmonic.
 2. Harmonic information shall be available for all three phases, current and voltage, plus the residual current. To ensure maximum accuracy for analysis, the current and voltage information for all phases shall be obtained simultaneously from the same cycle.
 3. The harmonic magnitude shall be reported as a percentage of the fundamental or as a percentage of the rms values, as selected by the user.
- E. Current Inputs
1. The Power Meter shall accept current inputs from standard instrument current transformers with 5 amp secondary output and shall have a metering range of 0-10 amps with the following withstand currents: 15 amp continuous, 50 amp 10 sec per hour, 500 amp 1 sec per hour.
 2. Current transformer primaries through 327 kA shall be supported.

F. Voltage Inputs

1. The circuit monitor shall allow connection to circuits up to 600 volts AC without the use of potential transformers. The Power Meter shall also accept voltage inputs from standard instrument potential transformers with 120 volt secondary output. The Power Meter shall support PT primaries through 3.2 MV.
2. The nominal full scale input of the circuit monitor shall be 347 Volts AC L-N, 600 Volts AC L-L. The meter shall accept a metering over-range of 50%. The input impedance shall be greater than 2 Ohm.

G. Accuracy

1. The Power Meter shall comply with ANSI C12.20 Class 0.5 and IEC 60687 Class 0.5 for revenue meters.
2. The Power Meter shall be accurate to 0.25% of reading + .025% of full scale for power and energy. Voltage and current shall be accurate to 0.075% of reading plus 0.025% of full scale. Power factor metering shall be accurate to ± 0.002 from 0.5 leading to 0.5 lagging. Frequency metering shall be accurate ± 0.01 Hz at 45-67 Hz.
3. These accuracies shall be maintained for both light and full loads.
4. No annual calibration shall be required to maintain this accuracy.

H. Waveform Capture

1. The Power Meter shall provide steady state waveform captures of the voltage and current channels. Waveform capture shall be for 3 cycles and is initiated manually using software.
2. The Power Meter shall capture, and store in internal non-volatile memory, 128 digitally sampled data points for each cycle of each phase voltage. The number of waveform captures stored onboard the circuit monitor is configurable and shall be dependent on the amount of memory available.
3. The Power Meter shall transmit the waveform samples over the network to the personal computer workstation for display, archival, and analysis.
4. Harmonic analysis performed on the captured waveforms shall resolve harmonics through the 63rd.
5. The data used for the three-cycle waveform capture display shall also be used to derive metered quantities in order to provide meaningful additional data.
6. All waveforms must reflect actual circuit performance. Waveforms synthesized or composed over time shall not be acceptable.
7. The Power Meter shall have disturbance sag/swell detection for troubleshooting and solving anomalies (PM870 only).

8. The Power Meter shall have Configurable Waveform Capture with flexible resolution permits to adapt the waveform captures according to the type of even/disturbance or channel.

I. Logging

1. The Power Meter shall provide for onboard data logging. Each Power Meter shall be able to log data, alarms and events, and waveforms. The Meter shall offer 800kB of on-board nonvolatile memory. Logged information to be stored in each Power Meter include the following:
 - a. Billing Log: The Power Meter shall store in non-volatile memory a configurable billing log that is updated every 15 minutes. Data shall be recorded by month, day and 15 minute interval. The log shall contain 24 months of monthly data, 32 days of daily data and between 2 to 52 days of 15 minute interval data depending on the number of quantities selected.
 - b. Custom Data Logs: The Power Meter shall provide up to 3 separate data logs, configurable by the user. Each log entry shall be date and time stamped to the second. Each log entry shall hold data of up to 96 parameters each. It shall be possible to set up each log to take data at a different user defined schedule interval. In addition, it shall be possible for a user to define an event. Data logs can be configured by users to be Fill & Hold or Circular (FIFO).
 - c. Alarm Log. This log shall contain time, date, event information, and coincident information for each user defined alarm or event.
 - d. Waveform Logs. This log shall store captured waveforms. Waveform logs shall be either Fill and Hold or Circular (FIFO) as defined by the user.
 - e. The Power Meter shall have default values for all logs loaded at the factory and begin on device power up.

J. Alarming

1. Alarm events shall be user definable.
 - a. The user shall be able to define over 50 alarm conditions.
 - b. The following shall be available as alarm events:
 - c. Over/under current
 - d. Over/under voltage
 - e. Current imbalance
 - f. Phase loss, current
 - g. Phase loss, voltage
 - h. Voltage imbalance

- i. Over kW Demand
- j. Phase reversal
- k. Digital Input OFF/ON
- l. End of incremental energy interval
- m. End of demand interval
 - 1) For each over/under metered value alarm, the user shall be able to define a pick-up, drop-out, and delay.
 - 2) There shall be four alarm severity levels in order make it easier for the user to respond to the most important events first.
 - 3) Indication of an alarm condition shall be given on the front panel.
 - 4) The Power Meter shall provide Boolean alarms in the form of combine up to four other alarms with NAND, NOT, OR, and XOR.

K. Output Relay Control

- 1. Relay outputs shall operate either by user command sent over the communication link, or set to operate in response to user defined alarm event.
- 2. Output relays shall close in either a momentary or latched mode as defined by the user.
- 3. Each output relay used in a momentary contact mode shall have an independent timer that can be set by the user.
- 4. It shall be possible for individual relay outputs to be controlled by multiple alarms using Boolean type logic.

L. Feature Addition

- 1. It shall be possible to field upgrade the firmware in the Power Meter to enhance functionality. These firmware upgrades shall be done through the communication connection and shall allow upgrades of individual meters or groups. No disassembly or changing of integrated circuit chips shall be required and it will not be necessary to de-energize the circuit or the equipment to perform the upgrade.

M. Control Power

- 1. The Power Meter shall operate properly over a wide range of control power including 90-457 VAC or 100-300 VDC.

N. Communications

- 1. The Power Meter shall communicate via RS-485 Modbus or Jbus protocol with a 2-wire connection.

2. Using an optional EGX Ethernet Communications device, the Power Meter shall provide Modbus communications using Modbus TCP via an Ethernet network at 10/100Mbaud using UTP or at 100 Mbaud using a Fiber connection.

O. Display

1. The Power Meter display shall allow the user to select one of three languages to view on the screen: English, French, or Spanish. The Power Meter display shall also allow the user to select a date/time format.
2. The Power Meter display shall be back lit LCD for easy viewing, display shall also be anti-glare and scratch resistant
3. The Display shall be capable of allowing the user to view four values on one screen at the same time. A summary screen shall also be available to allow the user to view a snapshot of the system.
4. The Power Meter display shall provide local access to the following metered quantities:
 - a. Current, per phase rms, 3-phase average and neutral (if applicable)
 - b. Voltage, phase-to-phase, phase-to-neutral, and 3-phase average (phase-to-phase and phase-to-neutral)
 - c. Real power, per phase and 3-phase total
 - d. Reactive power, per phase and 3-phase total
 - e. Apparent power, per phase and 3-phase total
 - f. Power factor, 3-phase total and per phase
 - g. Frequency
 - h. Demand current, per phase and three phase average
 - i. Demand real power, three phase total
 - j. Demand apparent power, three phase total
 - k. Accumulated Energy, (MWh and MVARh)
 - l. THD, current and voltage, per phase
5. Reset of the following electrical parameters shall also be allowed from the Power Meter display:
 - a. Peak demand current
 - b. Peak demand power (kW) and peak demand apparent power (kVA)
 - c. Energy (MWh) and reactive energy (MVARh)
6. Setup for system requirements shall be allowed from the Power Meter display. Setup provisions shall include:
 - a. CT rating

- b. PT rating
 - c. System type three-phase, 4-wire
 - d. Watt-hours per pulse
7. The Power Meter shall PM870 series manufactured by Square D Company or equal.
(Preferred Manufacturer and Basis of Design)

2.4 CIRCUIT MONITORS – ADVANCED

A. Measured Values

1. The following metered values shall be measured by the Circuit Monitor. In addition, the circuit monitor shall record and save in nonvolatile memory the minimum and maximum values of all listed values since last reset. The circuit monitor shall also record and save in nonvolatile memory the interval minimum, maximum, and average of any of the values pre-defined over a user specified interval.
 - a. Real-Time Readings
 - 1) Current (Per-Phase, N, G, 3-Phase Avg, Apparent rms, % Unbalanced)
 - 2) Voltage (L–L Per-Phase, L-L 3-Phase Avg, L–N Per-Phase, 3-Phase Avg, Neutral to Ground, % unbalanced)
 - 3) Real Power (Per-Phase, 3-Phase Total)
 - 4) Reactive Power (Per-Phase, 3-Phase Total)
 - 5) Apparent Power (Per-Phase, 3-Phase Total)
 - 6) Power Factor (True)(Per-Phase, 3-Phase Total)
 - 7) Power Factor (Displacement) (Per-Phase, 3-Phase Total)
 - 8) Frequency
 - 9) Temperature (Internal Ambient)
 - 10) THD (Current and Voltage)
 - 11) K-Factor (Per-Phase)
 - b. Energy Readings
 - 1) Accumulated Energy (Real kWh, Reactive kVARh, Apparent kVAh)
(Signed/Absolute)
 - 2) Incremental Energy (Real kWh, Reactive kVARh, Apparent kVAh)
(Signed/Absolute)
 - 3) Conditional Energy (Real kWh, Reactive kVARh, Apparent kVAh)
(Signed/Absolute)
 - 4) Reactive Energy by Quadrant

- c. Demand Readings
 - 1) Demand Current (Per-Phase present, 3-Phase Avg, Neutral)
 - a) Last complete interval
 - b) Peak
 - 2) Demand Voltage (L-N, L-L, Per-Phase, 3-Phase avg.)
 - a) Last complete interval
 - b) Minimum
 - c) Peak
- d. Average Power Factor (True), (3-Phase total)
 - 1) Last complete interval
 - 2) Coincident with kW peak
 - 3) Coincident with kVAR peak
 - 4) Coincident with kVA peak
- e. Demand Real Power (3-Phase Total)
 - 1) Last complete interval
 - 2) Predicted
 - 3) Peak
 - 4) Coincident kVA Demand
 - 5) Coincident kVAR Demand
- f. Demand Reactive Power (3-Phase Total)
 - 1) Last complete interval
 - 2) Predicted
 - 3) Peak
 - 4) Coincident kVA demand
 - 5) Coincident kW demand
- g. Demand Apparent Power (3-Phase Total)
 - 1) Last complete interval
 - 2) Predicted
 - 3) Peak
 - 4) Coincident kVA demand
 - 5) Coincident kW demand
- h. Power Analysis Values
 - 1) THD – Voltage, Current (3-Phase, Per-Phase, Neutral)
 - 2) THD - Voltage, Current (3-Phase, Per-Phase, Neutral)

- 3) Total Demand Distortion
 - 4) K-Factor (Per-Phase)
 - 5) Crest Factor (Per-Phase)
 - 6) Displacement Power Factor (Per-Phase, 3-Phase)
 - 7) Fundamental Voltage, Magnitude and Angle (Per-Phase)
 - 8) Fundamental Currents, Magnitude and Angle (Per-Phase)
 - 9) Fundamental Real Power (Per-Phase, 3-Phase)
 - 10) Fundamental Reactive Power (Per-Phase)
 - 11) Harmonic Power ((Per-Phase, 3-Phase)
 - 12) Phase Rotation
 - 13) Unbalance (Current and Voltage)
 - 14) Harmonic Magnitudes and Angles (Per-Phase)
 - 15) Distortion Power
 - 16) Distortion Power Factor
2. The current and voltage signals shall be digitally sampled at a rate high enough to provide true rms accuracy to the 255th harmonic (based on fundamental of 50/60 Hz).
 3. The following metered values as well as the minimum and maximum instantaneous readings since last reset shall be communicated by the Circuit Monitor:
 - a. Frequency
 - b. Temperature
 - c. Current, per phase rms and neutral (if applicable)
 - d. Current, 3-phase average rms
 - e. Current, apparent rms
 - f. Voltage, phase-to-phase and phase-to-neutral
 - g. Voltage unbalance, phase-to-phase and phase-to-neutral
 - h. Power factor, per phase
 - i. Power factor, 3-phase total
 - j. Real power, per phase and 3-phase total
 - k. Reactive power, per phase and 3-phase total
 - l. Apparent power, per phase and 3-phase total
 - m. Demand current, per phase and three-phase average
 - n. Demand real power, three-phase average
 - o. Demand reactive power, three-phase average
 - p. Demand apparent power, three-phase average

- q. Accumulated energy, (MWh, MVAH, and MVARh)
- r. Reactive energy, (VARh by quadrant)
- s. Total Harmonic Distortion (THD), voltage and current, per phase
- t. K-factor, per phase

B. Demand

1. All power demand calculations shall be done by any one of the following calculation methods, selectable by the user:
 - a. Thermal demand is calculated using a sliding window and is updated every second. The sliding window length shall be defined by the user from 1-60 minutes, with 1-minute increments.
 - b. Block interval, with optional sub-intervals. The window length shall be set by the user from 1-60 minutes in 1-minute intervals. The user shall be able to set the sub-interval length from 1-30 minutes in 1-minute intervals.
 - c. External Pulse Synchronization, utilizing a synch pulse provided externally. An optional status input shall be used to sense the pulse.
 - d. Sliding block interval with continuous sliding 1 second sub-intervals.
2. The default demand calculation method shall be a 15-minute continuous sliding block.
3. The following demand readings shall be reported by the Circuit Monitor:
 - a. Average demand current, per phase
 - b. Peak demand current, per phase
 - c. Average demand for real power, reactive power, and apparent power
 - d. Predicted demand for real power, reactive power, and apparent power
 - e. Peak demand for real power, reactive power, and apparent power
4. The Circuit Monitor shall also provide a generic demand capability to provide demand calculation on any metered parameter.
5. Each Circuit Monitor shall be capable of receiving a broadcast message over the communications network that can be used to synchronize demand calculations by several Circuit Monitors. This message need not be addressed specifically to any one Circuit Monitor.

C. Sampling

1. The current and voltage signals shall be digitally sampled at a rate high enough to provide true rms accuracy to the 255th harmonic (fundamental of 60 Hz).
2. The circuit monitor shall provide continuous sampling at a minimum of up to 512 samples/cycle, simultaneously on all voltage and current channels in the meter.

D. Harmonics

1. Advanced harmonic information shall be available via the Circuit Monitor. This shall include the calculation of the harmonic magnitudes and angles for each phase voltage and current through the 255th harmonic.
2. This information shall be available for all three phases, current and voltage, plus the neutral current. To ensure maximum accuracy for analysis, the current and voltage information for all phases shall be obtained simultaneously from the same cycle.
3. The Circuit Monitor shall have a minimum of 16k of on board memory to log harmonic magnitudes and angles.
4. The harmonic magnitude shall be reported as a percentage of the fundamental or as a percentage of any Circuit Monitor may be applied in three-phase, three- or four-wire systems. A fourth CT input shall be available to measure neutral or ground current. If the fourth CT is not used, then a residual current shall be calculated by vectoral addition of the phase currents. In four-wire connections the Circuit Monitor shall utilize the circuit neutral common reference and not earth ground, to provide metering accuracy.
5. Harmonic power flows will be provided up to the 41st harmonic for real, reactive and apparent power.

E. Transients

1. The Circuit Monitor shall be able to detect and capture transients up to 10,000 V peak line to line with a duration as short as 200 nanoseconds when equipped with a Transient Module.

F. Flicker

1. The Circuit Monitor shall detect and measure the flicker (50Hz or 60Hz) of an electrical system based on the IEC Standard 61000-4-15 (or IEEE 1453) when equipped with a Transient Module.
2. The Circuit Monitor shall measure three levels of Flicker:
 - a. Instantaneous
 - b. Short-term
 - c. Long-term
3. The user shall have the ability to view the graphical time-trend of Flicker magnitude in a semi-logarithmic format when equipped with a communications card.

G. EN50160 Evaluation

1. The Circuit Monitor shall include EN50160 evaluations. This capability is characterized by the evaluation of certain power quality parameters: frequency, magnitude of the supply voltage, supply voltage variations, rapid voltage changes, supply voltage dips, short interruptions of the supply voltage, long interruptions of the supply voltage, temporary power frequency overvoltages, transient overvoltages, supply voltage unbalance, and harmonic voltage.
2. The Circuit Monitor shall be capable of reporting EN50160 evaluation data in the following formats: summary of active evaluations, summary of evaluation status, detailed information for each evaluated parameter, detailed information for each abnormal event.
3. The user shall be able to reset EN50160 evaluations statistics as required.

H. Accuracy

1. The Circuit Monitors shall accept metering inputs of up to 600Vac direct connection or from industry standard instrument transformers (120 VAC secondary PTs and 5 A secondary CTs). Connection to 480Y/277 VAC circuits shall be possible without use of PTs.
2. PT primaries through 1.2 MV shall be supported.
3. CT primaries through 32 kA shall be supported.
4. The Circuit Monitor shall be accurate to 0.04% of reading plus/minus 0.025% of full scale for voltage and current metering and 0.08% of reading plus 0.025% for power.
5. The Circuit Monitor's energy readings shall meet the revenue accuracy requirements of ANSI C12.20 0.2 class and IEC 60687 0.2S class metering.
6. No annual re-calibration by users shall be required to maintain published accuracy.
7. Voltage and current for all phases shall be sampled simultaneously to assure high accuracy in conditions of low power factor or large waveform distortions (harmonics).

I. Waveform Capture

1. All Circuit Monitors shall include current and voltage waveform capture capability. Waveform capture shall be user selectable for 16 to 512 cycles of data. Or can be user specified up to 30 seconds.
2. Waveform capture shall be initiated either from a Personal Computer Workstation (PCW) running the Power Monitoring and Control Systems software, or by the circuit monitor as a user defined response to an alarm condition.
 - a. Waveform capture manually triggered from the Power Monitoring and Control System software shall be captured at 512 samples/cycle for one cycle providing harmonic content up to the 255th harmonic for Ia, Ib, Ic, I4, Va, Vb, Vc, Vg.

3. Three types of waveform capture shall be available for response to an alarm condition:
 - a. Steady State shall be manually initiated and provide a resolution of 512 samples/cycle
 - b. Disturbance shall be initiated manually or by an alarm condition and allow the user to select a resolution of 16 to 512 samples/cycle and a duration of 915 to 1 cycle.
 - c. Adaptive shall be initiated manually or by an alarm condition and allow the user to select a resolution of 16 to 512 samples/cycle and a duration of 1320 to 1 second.
4. The Circuit Monitor shall transmit the waveform samples over the network to the personal computer workstation for display, archival, and analysis.
5. Each voltage and current of all the phases shall be sampled concurrently so that proper phase relationships are maintained, so that harmonic flow analysis can be performed, and so that the effect of a disturbance can be observed on all phase voltages and currents.
6. Harmonic analysis performed on the captured waveforms shall resolve harmonics through the 255th using Power Monitoring and Control Software.
7. All waveforms must reflect actual circuit performance. Waveforms synthesized or composed over time shall not be acceptable.

J. Logging

1. Data logging may be accomplished either within the circuit monitor or at the PC Workstation, or both. Each circuit monitor shall be able to log data, alarms and events, and multiple waveforms. The monitors shall contain a minimum of 8MB of on-board nonvolatile memory, which can be field upgraded without requiring disassembly or removal the Circuit Monitor. On board data logs shall be communicated to the PC Workstation upon demand or at scheduled intervals. Logged information to be stored in each Circuit Monitor includes:
 - a. Up to 14 separate data logs shall be configurable by the user. Each log entry shall be date and time stamped. The type of data for the log shall be selected from a list of over 150 monitored values. Each log entry shall be user configurable to consist of from one to over 75 values of instantaneous data. It shall be possible to set up each log to record data at independent user defined intervals. In addition, it shall be possible for a user to define an event or new min/max condition that will trigger log file entries.
 - b. Data logs can be configured by users to be Fill & Hold or Circular (FIFO).
 - c. A Min/Max log file shall include the time, date, and value for the minimum and maximum of each of the instantaneous metered values since last reset. As well as a Min/Max/Avg. log that records the minimum/maximum/average readings for pre-defined quantities at a user-specified interval.

- d. An alarm and event log shall contain time, date, event information, and coincident information for each user defined alarm or event. This log shall have a capacity of up to 1,000 events.
- e. Waveform logs shall store captured waveforms as defined by the user. Waveform log entries shall be scheduled at user defined interval, externally triggered, or forced in response to a user defined event. Waveform logs shall be either Fill & Hold or Circular (FIFO) as defined by the user.
- f. The Power Monitoring and Control System software shall be available to enable the user to allocate onboard Circuit Monitor memory for each logging function.

K. Alarming

- 1. Alarm events shall be a combination of pre-configured from the factory events and user definable events. Multiple levels of alarms can be configured for each metered parameter.
- 2. The following classes of events shall be available as alarm events:
 - a. Over/under current
 - b. Over/under voltage
 - c. Current imbalance
 - d. Phase loss, current
 - e. Phase loss, voltage
 - f. Wave Shape Alarm
 - g. Voltage imbalance
 - h. Over kVA
 - i. Over kW or kVAR into/out of load
 - j. Over/under frequency
 - k. Under power factor, true or displacement
 - l. Over THD
 - m. Over K-factor
 - n. Over demand, current or power
 - o. Reverse power
 - p. Phase reversal
 - q. Status Input change
 - r. End of incremental energy interval
 - s. End of demand interval
 - t. Over/under analog inputs
 - u. Current sag/swell

- v. Voltage sag/swell
 - 3. For each over/under metered value alarm, the user shall be able to define a pick-up, drop-out, and delay.
 - 4. The user will have the ability to alarm using a Waveshape Alarm feature based on user set thresholds by defining the following parameters:
 - a. Phase Voltage
 - b. Neutral Ground Voltage
 - c. Phase Current
 - d. Neutral Current
 - 5. There shall be four alarm severity levels in order make it easier for the user to respond to the most important events first.
 - 6. Indication of an alarm condition shall be given on the local display as well as reported to the Power Monitoring and Control System software.
 - 7. The Circuit Monitor shall calculate key electrical parameters at 100ms intervals for the purpose of alarming and recording of data during an event. The recorded data shall be comprised of RMS readings for I, V, kW, kVAR, kVA, and True PF. 1-10 seconds of pre-event and up to 5 minutes of post event data can be recorded.
- L. Waveshape Alarm
- 1. The Circuit Monitor shall include waveshape alarm capability. This capability is characterized by the following features:
 - a. The Circuit Monitor shall be capable of continuously monitoring waveform anomalies in the following:
 - 1) Phase voltages
 - 2) Neutral to ground voltages
 - 3) Phase currents
 - 4) Neutral currents
 - 2. Anomalous waveshape events less than 1/2 cycle in length shall be detected.
 - 3. The user shall be able to set a threshold value and upper limit in the circuit monitor to determine if a waveshape event has occurred. The threshold and upper limit shall be user-defined values between 0-100. The threshold value is the limit at which a waveshape alarm will trigger. The upper limit defines the highest waveshape value that will trigger a waveshape alarm.

4. Upon detecting a disturbance, the Circuit Monitor shall be capable of:
 - a. Logging a waveform of the event all phase currents and voltages and/or a high-speed 100ms RMS event recording.
 - b. Recording the disturbance into an event log with a date and time stamp to the millisecond.
 - c. Causing an operator alarm at the PCW workstation.
 - d. Determining the source of the disturbance (upstream or downstream from the meter) and a statistical level of confidence (low, medium, high) of the accuracy of the source location.

M. Alarm Setpoint Learning (ASL)

1. Using SMS software (3.3.2 or greater), the user can enable the Series 4000 Circuit Monitor to learn the characteristics of normal operation of metered values and select alarm setpoints based on this data.
2. The user is able to determine the quantities to be learned and the period of time for the learning process for standard-speed and high-speed analog alarms, disturbance alarms, and waveshape alarms.
3. The user can configure this feature using one of two modes:
 - a. Fixed Learning — Initially configured user setpoints are used during the entire learning period.
 - b. Dynamic Learning — Initially configured user setpoints are temporarily replaced by learned setpoints at the interval specified by the user in SMS. The setpoints continue to be updated at the specified interval until the learning period expires.
4. The user can configure the duration of the learning period. If the learned setpoints do not change over a predefined period, the process can be stopped and the setpoints either installed or held for review.

N. Communications

1. The Circuit Monitor shall communicate via RS-232, RS-485, and Ethernet simultaneously.
2. The Circuit Monitor shall provide Modbus communications using Modbus TCP via an Ethernet network at 10/100Mbaud using UTP or Fiber connections. The Circuit Monitor shall provide the capability to communicate to 31 additional Modbus devices existing on RS-485 daisy chains and report data back to the PMCS application software or across the Ethernet network to other software applications.

3. The Circuit Monitor display shall provide an RS-232 communications port on board the metering module as well as an IR RS-232 communications port located on the display. The display port shall be completely accessible during normal operation and shall not require exposure of the operator to life-threatening voltage when in use. The operator shall be able to quickly connect a small Personal Computer (PC) to either the module port or the display port without use of tools or splices. Both the metering module port and the display port shall have all of the communication functionality of the standard hard-wired port. When a connection is made to either the metering module port or the display port, the Circuit Monitor shall continue simultaneous operation of all communication ports associated with the Circuit Monitor.
4. It shall be possible to field upgrade the firmware in the Circuit Monitor to enhance functionality. These firmware upgrades shall be done through either the display port or communication connection. No Circuit Monitor disassembly or changing of integrated circuit chips shall be required. It shall not be necessary to de-energize the circuit or the equipment to upgrade the firmware.
 - a. The circuit monitor shall allow communication to all ports simultaneously.
 - b. The circuit monitor shall have the option to serve data over the Ethernet network accessible through a standard web browser. Information shall be available from the circuit monitor and from Modbus slave devices connected downstream from the monitor. The monitor shall contain default pages from the factory and also have the ability for the user to create custom pages as needed.
5. The circuit monitor shall provide e-mail notification of any alarm condition that it detects.
6. Time synchronization to 1 millisecond between monitors via GPS synchronization.

O. I/O Options

1. Circuit Monitor Input/Output Options: Input/Output options/modules shall be field replaceable. Circuit Monitors shall provide pre-configured I/O options and also provide I/O options to be configured as applicable to each installation as shown on the project drawings:
 - a. One solid state output suitable for KYZ pulse initiation; four solid state status inputs; three (10A) mechanical output relays
 - b. Four solid state status inputs; four analog inputs (4-20 mA)
 - c. Four inputs (32Vdc); 2 solid state outputs (60Vdc); 1 analog input (0-5Vdc); 1 analog output (4-20mA)
 - d. Eight solid state status inputs (120Vac)

- e. Circuit Monitor shall provide configurable I/O options to include solid state input modules for 120Vac, 200Vac, and 32Vdc; solid state outputs modules for 120Vac, 240Vac, 60Vdc, 240Vdc; analog input modules for 0-5Vdc, 4-20mA; analog output module for 4-20mA.

P. Output Relay Control

1. Relay outputs shall operate either by user command sent over the communication link, or set to operate in response to user defined alarm event.
2. Output relays shall close in either a momentary or latched mode as defined by the user.
3. Each output relay used in a momentary contact mode shall have an independent timer that can be set by the user.
 - a. It shall be possible for individual relay outputs to be controlled by multiple alarms in a wired "OR" configuration.

Q. Disturbance Detection

1. All Circuit Monitors noted on the project drawings shall include sag and swell detection capability. This capability is characterized by the following features:
 - a. The Circuit Monitor shall continuously monitor for disturbances in the currents and incoming voltage. There shall be zero blind time; each cycle shall be individually monitored.
 - b. Disturbance events less than 1/2 cycle in length shall be detected.
 - c. The user shall be able to set a threshold and delay which shall be used by the circuit monitor to determine if an event has occurred. The threshold shall be user defined as either a fixed set point or relative set point. When using the relative set point, the Circuit Monitor will set the nominal current or voltage equal to its present average value. The Circuit Monitor will automatically adjust the nominal current and voltage values to avoid nuisance alarms caused by gradual daily variations of currents and voltages.
2. Upon detecting a disturbance, the Circuit Monitor shall be capable of :
 - a. Logging a waveform of the event all phase currents and voltages and/or a high-speed 100ms RMS event recording.
 - b. Operating any output relay on an optional I/O module.
 - c. Recording the disturbance into an event log with a date and time stamp to the millisecond.
 - d. Determining the direction of the cause of disturbance and categorize as "Upstream" from the meter or "Downstream" from the meter with an assigned confidence factor in the algorithm, then annunciate this determination through software.

- e. Causing an operator alarm at the PCW workstation.
- 3. The user shall have the ability to display the voltage sag/swell events on ITIC or SEMI graphs to quantify the event with respect to accepted industry standards. If so desired the user shall also have the ability to view this information on custom web pages over the Internet when used with a communications card.
- 4. All data and waveform logs shall be communicated over the local area network or through the front panel communications port so that the user may view and analyze the data using the PMCS software and workstation.
- 5. The location of the source of the disturbance (upstream or downstream from the meter) may be provided for each event. A statistical level of confidence (low, medium, high) will be provided of the accuracy of the source's location.

R. Display

- 1. The Circuit Monitor display shall allow the user to select one of three languages to view on the screen:
 - a. English
 - b. French
 - c. Spanish
- 2. The Circuit Monitor display shall also allow the user to select a date/time format and the ability to create additional screens for user-specified views and/or custom quantities without overwriting existing standard screens.
- 3. The Circuit Monitor display shall provide local access to the following metered quantities as well as the minimum and maximum value of each instantaneous quantity since last reset of min/max:
 - a. Current, per phase rms, 3-phase average and neutral (if applicable)
 - b. Voltage, phase-to-phase, phase-to-neutral, and 3-phase average (phase-to-phase and phase-to-neutral)
 - c. Real power, per phase and 3-phase total
 - d. Reactive power, per phase and 3-phase total
 - e. Apparent power, per phase and 3-phase total
 - f. Power factor, 3-phase total and per phase
 - g. Frequency
 - h. Demand current, per phase and three phase average
 - i. Demand real power, three phase total
 - j. Demand apparent power, three phase total

- k. Accumulated Energy, (MWh and MVARh)
 - l. THD, current and voltage, per phase
 - m. K-factor, current, per phase
- 4. Reset of the following electrical parameters shall also be allowed from the Circuit Monitor display:
 - a. Peak demand current
 - b. Peak demand power (kW) and peak demand apparent power (kVA)
 - c. Energy (MWh) and reactive energy (MVARh)
 - d. Setup for system requirements shall be allowed from the Circuit Monitor display. Setup provisions shall include
 - 1) CT rating
 - 2) PT rating
 - 3) System type three-phase, 4-wire
 - 4) Demand interval (5-60 min.)
 - 5) Watt-hours per pulse
- 5. For ease in operator viewing, two displays are offered for local viewing of Circuit Monitor data. The liquid crystal display (LCD) shall include back lighting. The enhanced vacuum fluorescent display (VFD) shall be automatically activated by a proximity sensor as the operator approaches.
- S. Current/Voltage Inputs
 - 1. The Circuit Monitors shall accept metering inputs of up to 600Vac direct connection or from industry standard instrument transformers (120 VAC secondary PTs and 5 A secondary CTs). Connection to 480Y/277 VAC circuits shall be possible without use of PTs.
 - 2. PT primaries through 1.2 MV shall be supported.
 - 3. CT primaries through 32 kA shall be supported.
 - 4. The Circuit Monitor shall be accurate to 0.04% of reading plus/minus 0.025% of full scale for voltage and current metering and 0.08% of reading plus 0.025% for power.
 - 5. The Circuit Monitor's energy readings shall meet the revenue accuracy requirements of ANSI C12.20 0.2 class metering.
 - 6. No annual re-calibration by users shall be required to maintain published accuracy.

T. Feature Additions

1. It shall be possible to field upgrade the firmware in the Circuit Monitor to enhance functionality. These firmware upgrades shall be done through the communication connection and shall allow upgrades of individual meters or groups. No disassembly or changing of integrated circuit chips shall be required and it will not be necessary to de-energize the circuit or the equipment to perform the upgrade.
 2. The Circuit Monitors shall be rated for an operating temperature range of -25° C to 70° C and have an over current withstand rating of 500 amps for 1 second.
 3. All setup parameters required by the Circuit Monitors shall be stored in nonvolatile memory and retained in the event of a control power interruption.
 4. The Circuit Monitor shall be capable of being applied without modification at nominal frequencies of 50, 60, or 400 Hz.
 5. The Circuit Monitor shall include anti-aliasing filters on both voltage and current metering inputs. These anti-aliasing filters are capable of having the corner frequency adjusted between 50Hz, 60Hz, or “off” modes.
 6. The Circuit Monitor shall have a Cat IV overvoltage withstand rating on the voltage metering inputs.
- U. The Circuit Monitor shall operate properly over a wide range of control power including 100-305 VAC or 100-300 VDC. Connections to 18-60 VDC shall also be available.
- V. Ride through capability shall be available for backup control power for up to 2 seconds, the rms values, as selected by the user.
- W. The Circuit Monitor shall provide a hardware security switch to protect all revenue related metering configuration from unauthorized/accidental changes. The Circuit Monitor shall support the use of a wire seal to further deter inadvertent configuration changes and provide visual tamper indication.
- X. The Circuit Monitor shall be a PowerLogic CM4000 series (Preferred Manufacturer and Basis of Design) manufactured by Square D Company or equal.

2.5 ETHERNET SOLUTIONS

A. Basic (Ethernet Communications Card – ECC-21)

1. The Ethernet communication card shall have an embedded web server inside the unit, capable of serving HTML pages with dynamic meter data displays.
2. The Ethernet communication card shall connect to the Ethernet backbone via standard RJ-45 port for connection of unshielded twisted pair cable (UTP) or LC fiber optic connection for multimode fiber (100BaseFX).

3. There shall be indicating LED's for the Ethernet connections to assist in trouble-shooting. Indicators are required for TRANSMIT, RECIEVE, and LINK status for Ethernet, and TRANSMIT, RECEIVE for the RS-485 communications.
4. The Ethernet communication card shall support Circuit Monitors, Power Meters, and other POWERLOGIC-compatible devices through one 2 wire or 4-wire RS-485 communication port via standard daisy-chain connections. The RS-485 serial port shall operate up to 38.4k baud.
5. The Ethernet communication card shall allow protocol conversion between standard Ethernet network protocols and PowerLogic (SY/MAX and Modbus/Jbus devices on the same daisy chain.)
6. The Ethernet communication card shall be fully TCP/IP compliant thereby allowing the power monitoring software access to power monitoring information from anywhere on the local area network (LAN) or via the Wide Area Network (WAN).
7. The protocol used over Ethernet by the Ethernet communication card shall be Modbus/TCP an international industry standard which is an open and well-defined protocol.
8. Setup of the Ethernet communication card shall be accomplished via the on-board Ethernet port and a web browser. It shall also be possible via the Ethernet port to upgrade the firmware of the Ethernet communication card in the field to accommodate new system features.
9. Web Pages shall be configurable to display data from all devices connected to the Ethernet Communication Card.
10. Data shall be displayed in tabular or trend chart format.
11. The Ethernet card shall be capable of initiating an e-mail based on alarms or custom user logic programming in the host Circuit Monitor.
 - a. Fifteen unique addresses shall be user configurable to receive e-mail notification from the Ethernet communication card
 - b. Each address shall have a user-configurable schedule assignment to only page during specific days of the week and hours of the day.
 - c. E-mail shall be initiated based on user configurable alarm priority.
 - d. E-mail shall be sent in the user-selected language of the Circuit Monitor Display (English, French, Spanish, Etc.)
 - e. The Ethernet Communication Card shall have 4 e-mail buffers.

- f. To prevent nuisance E-mails during repetitive alarms, an e-mail will only be sent on a buffered basis when one of the following conditions is met:
 - 1) One of the alarm buffers fills to 38 events OR
 - 2) A predetermined amount of time elapses.
- 12. A dedicated Ethernet communication card shall be used which requires no hardware adjustments or modifications. Standard personal computers (PCs) or programmable logic controllers (PLCs) are not acceptable as gateways to the power monitoring and control devices
- 13. The Ethernet communication card shall derive control power directly from the Circuit Monitor.
- 14. The Ethernet communication card shall be UL Listed, NOM and CE and CSA certified.
- 15. All Ethernet cabling shall be installed by a qualified data communications cable installer or the electrical contractor qualified to install data communications equipment. All communications cabling shall be Category 5 rated for 100baseT, or Fiber Optics rated for 100baseFX.
- 16. SNMP (Simple Network Management Protocol) shall be supported by the circuit monitor according to the industry standard MIB2.
- 17. SNTP (Simple Network Management Protocol) shall be supported to allow date and time to be synchronized to within 1 second between monitors.
- 18. A tool shall be provided with the ECC (Ethernet Communications Card) that allows a user to create web pages for the host meter and other monitoring and protection devices from Schneider Electric that are connected to the ECC's serial port. The tool shall be wizard based allowing the user to specify the name and address for each device and create web pages with no knowledge of HTML or Java scripting.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. PMCS components, including Circuit Monitors, Electronic Trip Units, Transformer Temperature Monitors, Motor Protection Devices, and Digital Relays, included within the power equipment lineups shall be factory installed, wired and tested prior to shipment to the job site.
- B. All control power, CT, PT and data communications wire shall be factory wired and harnessed within the equipment enclosure.
- C. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's drawings must clearly identify the interconnection requirements including wire type to be used.

- D. All wiring required to externally connect equipment lineups shall be installed by the electrical contractor.
- E. Contractor interconnection wiring requirements shall be clearly identified on the PMCS system drawings.

3.2 SYSTEM START-UP AND TRAINING

- A. On-site start-up and training of the PMCS shall be included in the project bid.
- B. Start-up shall include a complete working demonstration of the PMCS with simulation of possible operating conditions that may be encountered.
- C. Training shall include any documentation and hands-on exercises necessary to enable electrical operations personnel to assume full operating responsibility for the PMCS after completion of the training period.
- D. The project bid shall include 2 days start-up assistance and 1 days training to include 1 trip(s).
- E. The power monitoring vendor shall offer regularly scheduled factory training for customers on all aspects of power monitoring and control, including:
 - 1. Comprehensive software and hardware setup, configuration, and operation
 - 2. Advanced monitoring and data reporting
 - 3. Advanced power quality and disturbance monitoring
 - 4. The power monitoring manufacturer shall provide a full time telephone technical help center for customers.

3.3 POWER QUALITY/ENERGY MANAGEMENT SERVICES

- A. Manufacturer shall offer complete power quality and analytical services, including:
 - 1. Energy Savings
 - a. Bill and tariff analysis
 - b. Power Factor Improvement
 - c. Mechanical Equipment Optimization
 - 2. Power Quality Evaluation
 - a. IEEE-519 Harmonic Compliance
 - b. Circuit and Transformer Loading
 - c. Harmonic Mitigation
 - 3. Power System Troubleshooting
 - a. Equipment Problems
 - b. Wiring and Grounding Evaluation
 - c. Short Circuit Analysis
 - d. Load Flow and Harmonic Flow Studies

4. Engineers performing these studies shall be employees of manufacturer, have engineering degrees, and be licensed professional engineers. They shall demonstrate proficiency by demonstrating past studies and projects similar to those to be undertaken.

3.4 DESIGN SERVICES

- A. The energy monitoring system vendor shall make all alterations and changes needed to make the system perform as needed at each location. These changes may include:
 1. Custom enclosures and panels
 2. Modifications to existing switchgear and equipment, including installation
 3. Configuration of software, servers, and workstations
 4. Communication interface installation and configuration
 5. Communication network design
 6. The energy monitoring system vendor can provide development, integration, and installation services required to complete and turn over a fully functional system. This shall include:
 - a. Project management - A project manager shall be assigned to each plant EMS implementation. Typical responsibilities shall include coordination of personnel, information and on-site supervision for the various levels and functions of suppliers required for completion of the project. The Project Manager shall provide strategic direction for the entire team. Responsibilities include daily operational and tactical implementation of projects, provide logistics and ensure follow up and closure of site related issues.
 - b. All technical coordination, installation, integration and testing of all components
 - c. Detailed system design
 - d. System drawings

3.5 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

- - - E N D - - -

SECTION 26 09 23
LIGHTING CONTROLS

PART 1 – GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Digital Occupancy and Daylighting Sensor Control
 - 2. Emergency Lighting Control (if applicable)
- B. Related Section
 - 1. Section 26 27 26, WIRING DEVICES: Receptacles
 - 2. Section 26 51 00, INTERIOR LIGHTING: Fluorescent electronic dimming ballasts.
 - 3. Drawings and general provision of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to this Section
 - 4. Electrical Sections, including wiring devices, apply to the work of this Section.
- C. Control Intent – Control Intent includes, but is not limited to:
 - 1. Defaults and initial calibration settings for such items as time delay, sensitivity, fade rates, etc.
 - 2. Initial sensor and switching zones
 - 3. Initial time switch settings

1.2 REFERENCES

- A. American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE)
- B. Underwriter Laboratories of Canada (ULC)
- C. International Electrotechnical Commission
- D. International Organization for Standardization (ISO)
- E. National Electrical Manufacturers Association (NEMA)
- F. WD1 (R2005) - General Color Requirements for Wiring Devices.
- G. Underwriters Laboratories, Inc. (UL)
 - 1. 916 – Energy Management Equipment.
 - 2. 924 – Emergency Lighting

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 SYSTEM DESCRIPTION & OPERATION

A. The Lighting Control and Automation system as defined under this section covers the following equipment:

1. Digital Room Controllers – Self-configuring, digitally addressable one, two or three relays controllers with 0-10 volt control for ballasts (if applicable) and single relay application-specific plug load controllers.
2. Digital Occupancy Sensors – Self-configuring, digitally addressable and calibrated occupancy sensors with LCD display and two-way active infrared (IR) communications.
3. Digital Switches – Self-configuring, digitally addressable pushbutton switches, dimmers, and scene switches with two-way active infrared (IR) communications.
4. Digital Photosensors – Single-zone closed loop and multi-zone open loop daylighting sensors with two-way active infrared (IR) communications can provide switching or dimming control for daylight harvesting.
5. Configuration Tools – Handheld remote for room configuration provides two way infrared (IR) communications to digital devices and allows complete configuration and reconfiguration of the device / room from up to 30 feet away. Unit to have Organic LED display, simple pushbutton interface, and allow send and receive of room variables and store of occupancy sensor settings. Computer software also customizes room settings.
6. Handheld remotes for personal control – One-button dimming, two-button on/off, or five-button scene remotes provide control using infrared communications. Remote may be configured in the field to control selected loads or scenes without special tools.
7. Digital Lighting Management (DLM) local network – Free topology, plug-in wiring system (Cat 5e) for power and data to room devices.

8. Network Bridge – provides BACnet MS/TP-compliant digital networked communication between rooms, panels and the Segment Manager or building automation system (BAS).
9. Segment Manager – provides web browser-based user interface for system control, scheduling, power monitoring, room device parameter administration and reporting.
10. Emergency Lighting Control Unit (ELCU) – allows a standard lighting control device to control emergency lighting in conjunction with normal lighting in any area within a building

1.5 LIGHTING CONTROL APPLICATIONS

A. Unless relevant provisions of the applicable local Energy Codes are more stringent, provide a minimum application of lighting controls as follows:

1. Space Control Requirements – Provide occupancy/vacancy sensors with Manual-ON functionality in all spaces except toilet rooms, storerooms, or other applications where hands-free operation is desirable and Automatic-ON occupancy sensors are more appropriate. Provide Manual-ON occupancy/vacancy sensors for any enclosed office, conference room, meeting room, open plan system and training room. For spaces with multiple occupants, or where line-of-sight may be obscured, provide ceiling- or corner-mounted sensors and Manual-ON switches.
2. Bi-Level Lighting – Provide multi-level controls in all spaces as indicated on drawings.
3. Daylit Areas – Luminaires indicated on the drawings shall be controlled separately from luminaires outside of daylit zones. Luminaires closest to the daylight aperture shall be controlled separately from luminaires farther from the daylight aperture, within the daylight zone.
4. Daytime setpoints for total ambient illumination (combined daylight and electric light) level that initiate dimming shall be programmed to be not less than 125% of the nighttime maintained designed illumination levels.
5. Multiple-leveled switched daylight harvesting controls may be utilized for areas marked on drawings.
6. Provide smooth and continuous daylight dimming for areas marked on drawings. Daylighting control system may be designed to turn off electric lighting when daylight is at or above required lighting levels, only if system functions to turn lamps back on at dimmed level, rather than turning full-on prior to dimming.

B. Additional controls.

1. Provide occupancy/vacancy sensors for any enclosed office, conference room, meeting room, and training room. For spaces with multiple occupants or where line-of-sight may be obscured, provide ceiling- or corner-mounted with manual-on switches.

1.6 SUBMITTALS

- A. Submittals Package: Submit the shop drawings, and the product data specified below at the same time as a package.
- B. Shop Drawings:
 - 1. Composite wiring and/or schematic diagram of each control circuit as proposed to be installed (standard diagrams will not be accepted).
 - 2. Scale drawing for each area showing exact location of each sensor, room controller, and digital switch.
- C. Product Data: Catalog sheets, specifications and installation instructions.
- D. Include data for each device which:
 - 1. Indicates where sensor is proposed to be installed.
 - 2. Prove that the sensor is suitable for the proposed application.

1.7 QUALITY ASSURANCE

- A. Manufacturer: Minimum 10 years experience in manufacture of lighting controls.

1.8 PROJECT CONDITIONS

- A. Do not install equipment until following conditions can be maintained in spaces to receive equipment:
 - 1. Ambient temperature: 0° to 40° C (32° to 104° F).
 - 2. Relative humidity: Maximum 90 percent, non-condensing.

1.9 WARRANTY

- A. Provide a five year complete manufacturer's warranty on all products to be free of manufacturers' defects.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturer:
 - 1. WattStopper Digital Lighting Management (DLM) or subject to compliance and prior approval with specified requirements of this section, one of the following:
 - a. WattStopper Digital Lighting Management (DLM)
 - b. Hubbell Building Automation
- B. Substitutions:
 - 1. All proposed substitutions (clearly delineated as such) must be submitted in writing for approval by the design professional a minimum of 10 working days prior to the bid date and must be made available to all bidders. Proposed substitutes must be accompanied by a review of the specification noting compliance on a line-by-line basis.

2. By using pre-approved substitutions, the contractor accepts responsibility and associated costs for all required modifications to circuitry, devices, and wiring. The contractor shall provide complete engineered shop drawings (including power and control wiring) with deviations from the original design highlighted in an alternate color to the engineer for review and approval prior to rough-in.

2.2 SINGLE / DUAL RELAY WALL SWITCH OCCUPANCY SENSORS

- A. Type PW: Manual-ON, Automatic-OFF passive infrared (PIR) wall switch occupancy sensor
Furnish the Company's model which suits the electrical system parameters, and accommodates the square-foot coverage and wattage requirement for each area (and type of lighting) controlled; WattStopper PW-100, PW-200, PW-103, PW-203.

2.3 DIGITAL WALL OR CEILING MOUNTED OCCUPANCY SENSOR SYSTEM

- A. Wall or ceiling mounted (to suit installation) passive infrared (PIR), ultrasonic or dual technology digital (passive infrared and ultrasonic) occupancy sensor.
- B. Digital Occupancy Sensors shall provide graphic LCD display for digital calibration and electronic documentation. Features include the following:
 1. Digital calibration and pushbutton programming for the following variables:
 - a. Sensitivity – 0-100% in 10% increments
 - b. Time delay – 1-30 minutes in 1 minute increments
 - c. Test mode – Five second time delay
 - d. Detection technology – PIR, Ultrasonic or Dual Technology activation and/or re-activation.
 - e. Walk-through mode
 - f. Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photosensors are included in the DLM local network.
 2. One or two RJ-45 port(s) for connection to DLM local network.
 3. Two-way infrared (IR) transceiver to allow remote programming through handheld commissioning tool and control by remote personal controls.
 4. Device Status LEDs including:
 - a. PIR Detection
 - b. Ultrasonic detection
 - c. Configuration mode
 - d. Load binding
 5. Assignment of occupancy sensor to a specific load within the room without wiring or special tools.

- 6. Manual override of controlled loads.
- C. Units shall not have any dip switches or potentiometers for field settings.
- D. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required.

2.4 DIGITAL WALL SWITCHES

- A. Low voltage momentary pushbutton switches in 1, 2, 3, 4, 5 and 8 button configuration; available in white, light almond, ivory, grey and black; compatible with wall plates with decorator opening. Wall switches shall include the following features:
 - 1. Two-way infrared (IR) transceiver for use with personal and configuration remote controls.
 - 2. Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
 - 3. Red configuration LED on each switch that blinks to indicate data transmission.
 - 4. Blue Load/Scene Status LED on each switch button with the following characteristics:
 - a. Bi-level LED
 - b. Dim locator level indicates power to switch
 - c. Bright status level indicates that load or scene is active
 - 5. Dimming switches shall include seven bi-level LEDs to indicate load levels using 14 steps.
- B. Two RJ-45 ports for connection to DLM local network.
- C. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required to achieve multi-way switching.
- D. The following switch attributes may be changed or selected using a wireless configuration tool:
 - 1. Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
 - 2. Individual button function may be configured to Toggle, On only or Off only.
 - 3. Individual scenes may be locked to prevent unauthorized change.
 - 4. Fade Up and Fade Down times for individual scenes may be adjusted from 0 seconds to 18 hours.
 - 5. Ramp rate may be adjusted for each dimmer switch.
 - 6. Switch buttons may be bound to any load on a room controller and are not load type dependant; each button may be bound to multiple loads.

2.5 HANDHELD REMOTE CONTROLS

- A. Battery-operated handheld switches in 1, 2 and 5 button configuration for remote switching or dimming control. Remote controls shall include the following features:
 - 1. Two-way infrared (IR) transceiver for line of sight communication with DLM local network within up to 30 feet.
 - 2. Blue LED on each button confirms button press.
 - 3. Load buttons may be bound to any load on a room controller and are not load type dependant; each button may be bound to multiple loads.
 - 4. Inactivity timeout to save battery life.
- B. A wall mount holster and mounting hardware shall be included with each remote control

2.6 ROOM CONTROLLERS

- A. Room Controllers automatically bind the room loads to the connected devices in the space without commissioning or the use of any tools. Room Controllers shall be provided to match the room lighting load and control requirements. The controllers will be simple to install and will not have, dip switches, potentiometers or require special configuration. The control units will include the following features:
 - 1. Automatic room configuration to the most energy-efficient sequence of operation based upon the devices in the room.
 - 2. Simple replacement – Using the default automatic configuration capabilities, a room controller may be replaced with an off-the-shelf unit without requiring any configuration or setup.
 - 3. Device Status LEDs to indicate:
 - a. Data transmission
 - b. Device has power
 - c. Status for each load
 - d. Configuration status
 - 4. Quick installation features including:
 - a. Standard junction box mounting
 - b. Quick low voltage connections using standard RJ-45 patch cable
 - 5. Plenum rated
 - 6. Manual override and LED indication for each load
 - 7. Dual voltage (120/277 VAC, 60 Hz)
 - 8. Zero cross circuitry for each load.

B. On/Off Room Controllers shall include:

1. One or two relay configuration
2. Efficient 150 mA switching power supply
3. Three RJ-45 DLM local network ports
4. Discrete model listed for connection to receptacles, for occupancy-based control of plug loads within the space.
 - a. One relay configuration only
 - b. Automatic-ON/OFF configuration

C. On/Off/Dimming enhanced Room Controllers shall include:

1. Real time current monitoring
2. One, two or three relay configuration
3. Efficient 250 mA switching power supply
4. Four RJ-45 DLM local network ports.
5. One 0-10 volt analog output per relay for control of compatible ballasts and LED drivers.
6. Optional Network Bridge for BACnet MS/TP communications (LMRC-3xx).
7. The following dimming attributes may be changed or selected using a wireless configuration tool:
 - a. Establish preset level for each load from 0-100%
 - b. Set high and low trim for each load
 - c. Set lamp burn in time for each load up to 100 hours
8. Discrete model listed for connection to receptacles, for occupancy-based control of plug loads within the space.
 - a. One relay configuration only
 - b. Automatic-ON/OFF configuration

2.7 DIGITAL PHOTOSENSORS

- A. Digital photosensors work with room controllers to provide automatic switching or dimming daylight harvesting capabilities for any load type connected to a room controller. Open loop photosensors measure incoming daylight in the space, and are capable of controlling up to three lighting zones. Photosensors shall be interchangeable without the need for rewiring.

B. Digital photosensors include the following features:

1. An internal photodiode that measures only within the visible spectrum, and has a response curve that closely matches the photopic curve. The photodiode shall not measure energy in either the ultraviolet or infrared spectrums. The photocell shall have a sensitivity of less than 5% for any wavelengths less than 400 nanometers or greater than 700 nanometers.
2. Sensor light level range shall be from 1-10,000 footcandles (fc).
3. The capability of switching one-third, one-half or all lighting ON and OFF, or raising or lowering lighting levels, for each controlled zone, depending on the selection of room controller(s) and load binding to room controller(s).
4. For switching daylight harvesting, the photosensor shall provide a deadband or a separation between the “ON Setpoint” and the “OFF Setpoint” that will prevent the lights from cycling after they turn off.
5. For dimming daylight harvesting, the photosensor shall provide the option, when the daylight contribution is sufficient, of turning lights off or dimming lights to a user-selectable minimum level.
6. Optional programmable wall switch override to allow occupants to reduce lighting level to increase energy savings or, if permitted by system administrator, raise and lower lighting levels for a selected period of time or cycle of occupancy.
7. Infrared (IR) transceiver for configuration and/or commissioning with a handheld configuration tool, to transmit detected light level to wireless configuration tool, and for communication with personal remote controls.
8. Red configuration LED that blinks to indicate data transmission.
9. Blue status LED indicates test mode, override mode and load binding.
10. Recessed switch to turn controlled load(s) ON and OFF.
11. One RJ-45 port for connection to DLM local network.
12. An adjustable head and a mounting bracket to accommodate multiple mounting methods and building materials. The photosensor may be mounted on a ceiling tile, skylight light well, suspended lighting fixture or backbox.

C. Open loop digital photosensors include the following additional features:

1. An internal photodiode that measures light in a 60 degree angle cutting off the unwanted light from the interior of the room.
2. Automatically establishes setpoints following calibration using a wireless configuration tool or a PC with appropriate software.

3. A proportional control algorithm for dimming daylight harvesting with a “Setpoint” to be maintained during operation.

2.8 ROOM NETWORK (DLM Local Network)

- A. The DLM local network is a free topology lighting control physical connection and communication protocol designed to control a small area of a building. Digital room devices connect to the network using CAT 5e cables with RJ-45 connectors which provide both data and power to room devices. Features of the DLM local network include:
 1. Plug n’ Go automatic configuration and binding of occupancy sensors, switches and lighting loads to the most energy-efficient sequence of operation based upon the device attached.
 2. Simple replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.
 3. Push n’ Learn configuration to change the automatic configuration, including binding and load parameters without tools, using only the buttons on the digital devices in the local network.
 4. Two-way infrared communications for control by handheld remotes, and configuration by a handheld tool including adjusting load parameters, sensor configuration and binding, within a line of sight of up to 30 feet from a sensor, wall switch or IR receiver.

2.9 CONFIGURATIONS TOOLS

- A. A configuration tool facilitates optional customization of DLM local networks, and is used to set up open loop daylighting sensors. A wireless configuration tool features infrared communications, while PC software connects to each local network via a USB interface.
- B. Features and functionality of the wireless configuration tool shall include:
 1. Two-way infrared (IR) communication with DLM IR-enabled devices within a range of approximately 30 feet.
 2. High visibility organic LED (OLED) display, pushbutton user interface and menu-driven operation.
 3. Read, modify and send parameters for occupancy sensors, daylighting sensors, room controllers and buttons on digital wall switches.
 4. Save up to nine occupancy sensor setting profiles, and apply profiles to selected sensors.
 5. Temporarily adjust light level of any load(s) on the local network, and incorporate those levels in scene setting.
 6. Adjust or fine-tune daylighting settings established during auto-commissioning, and input light level data to complete commissioning of open loop daylighting controls.

2.10 NETWORK BRIDGE

- A. The network bridge connects a DLM local network to a BACnet-compliant network for communication between rooms, panels and a segment manager or BAS. Each local network shall include a network bridge component to provide a connection to the local network room devices. The network bridge shall use industry standard BACnet MS/TP network communication.
1. The network bridge may be incorporated directly into the room controller hardware (LMRC-3xx Room Controllers) or be provided as a separate module connected on the local network through an available RJ-45 port.
 2. Provide Plug n' Go operation to automatically discover all room devices connected to the local network and make all device parameters visible to the segment manager via the segment network. No commissioning shall be required for set up of the network bridge on the local network.
 3. The network bridge shall automatically create standard BACnet objects for selected room device parameters to allow any BACnet-compliant BAS to include lighting control and power monitoring features as provided by the DLM room devices on each local network. Standard BACnet objects shall be provided as follows:
 - a. Read/write the normal or after hours schedule state for the room
 - b. Read the detection state of the occupancy sensor
 - c. Read/write the On/Off state of loads
 - d. Read/write the dimmed light level of loads
 - e. Read the button states of switches
 - f. Read total current in amps, and total power in watts through the room controller
 - g. Read/write occupancy sensor time delay, PIR sensitivity and ultrasonic sensitivity settings
 - h. Activate a preset scene for the room
 - i. Read/write daylight sensor fade time and day and night setpoints
 - j. Read the current light level, in footcandles, from interior and exterior photosensors and photocells
 - k. Set daylight sensor operating mode
 4. Read/write wall switch lock status

2.11 SEGMENT MANAGER

- A. The Digital Lighting Management system shall include at least one segment manager to manage network communication. It shall be capable of serving up a graphical user interface via a standard web browser. Each segment manager shall have support for one, two or three segment networks as required and allow for control of a maximum of 127 local networks (rooms) and/or lighting control panels per segment network.
- B. Operational features of the Segment Manager shall include the following:
 - 1. Connection to PC or LAN via standard Ethernet TCP/IP.
 - 2. Easy to learn and use graphical user interface, compatible with Internet Explorer 8, or equal browser.
 - 3. Log in security capable of restricting some users to view-only or other limited operations.
 - 4. Automatic discovery of all DLM devices on the segment network(s). Commissioning beyond activation of the discovery function shall not be required.
 - 5. After discovery, all rooms and panels shall be presented in a standard navigation tree format. Selecting a device from the tree will allow the device settings and operational parameters to be viewed and changed by the user.
 - 6. Ability to view and modify room device operational parameters. It shall be possible to set device parameters independently for normal hours and after hours operation.
 - 7. Ability to set up schedules for rooms and panels. Schedules shall automatically set controlled zones or areas to either a normal hours or after hours mode of operation.
 - 8. Ability to group rooms and loads for common control by schedules, switches or network commands.
 - 9. Ability to monitor connected load current and display power consumption for areas equipped with room controllers incorporating the integral current monitoring feature.
 - 10. Provide seamless integration with the BAS via BACnet IP

2.12 EMERGENCY LIGHTING

- A. Emergency Lighting Control Unit – A UL 924 listed device that monitors a switched circuit providing normal lighting to an area. The unit provides normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is restored. Features include:
 - 1. 120/277 volts, 50/60 Hz., 20 amp ballast rating
 - 2. Push to test button
 - 3. Auxiliary contact for remote test or fire alarm system interface

PART 3 – EXECUTION

3.1 INSTALLATION

- A. When using wire for connections other than the DLM local network (Cat 5e with RJ-45 connectors), provide detailed point to point wiring diagrams for every termination. Provide wire specifications and wire colors to simplify contactor termination requirements
- B. Install the work of this Section in accordance with manufacturer's printed instructions unless otherwise indicated.
- C. Calibrate all sensor time delays and sensitivity to guarantee proper detection of occupants and energy savings.
 - 1. Adjust time delay so that controlled area remains lighted for 5 minutes after occupant leaves area.
- D. Provide written or computer-generated documentation on the commissioning of the system including room by room description including:
 - 1. Sensor parameters, time delays, sensitivities, and daylighting setpoints.
 - 2. Sequence of operation, (e.g. manual ON, Auto OFF. etc.)
 - 3. Load Parameters (e.g. blink warning, etc.)
- E. Re-commissioning – After 30 days from occupancy re-calibrate all sensor time delays and sensitivities to meet the Owner's Project Requirements. Provide a detailed report to the Architect / Owner of re-commissioning activity.

3.2 FACTORY COMMISSIONING

- A. Upon completion of the installation, the system shall be commissioned by the manufacturer's factory authorized representative who will verify a complete fully functional system.
- B. The electrical contractor shall provide both the manufacturer and the electrical engineer with ten working days written notice of the system startup and adjustment date.
- C. Upon completion of the system commissioning the factory-authorized technician shall provide the proper training to the owner's personnel on the adjustment and maintenance of the system.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

--- E N D ---

SECTION 26 09 25
LIGHTING CONTROL RELAY PANEL

PART 1 - GENERAL

1.1 INTRODUCTION

- A. The work covered in this section is subject to the requirements in the General Conditions of the Specifications. Contractor shall coordinate the work in this section with the trades covered in other sections of the specification to provide a complete and operable system.

1.2 SYSTEM DESCRIPTION

- A. Extent of lighting control system work is indicated by drawings and by the requirements of this section. It is the intent of this section to provide an integrated, energy saving lighting control system including Lighting Control Panels, Occupancy Sensors, and Daylighting Controls from a single supplier. Contractor is responsible for confirming that the panels and sensors interoperate as a single system.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Comply with NEC, NEMA, and FCC requirements for Class A applications.
- C. UL Approvals: Relay panels and accessory devices are to be UL listed under UL 916 Energy Management Equipment. Emergency relay panels shall be co-listed under UL 924 Emergency Lighting Equipment.

1.5 SUBMITTALS

- A. Submit manufacturer's data on lighting control system and components including shop drawings, detailed wiring diagrams, and cut sheets as required under related specification sections.

1.6 MANUFACTURERS

- A. This specification is based on products from WattStopper, Santa Clara, CA. Complete information on any other system proposed as a substitute must be submitted in writing for approval a minimum of 10 days prior to bid. Prior approval does not guarantee final approval by the electrical engineer. The contractor shall be completely responsible for providing a system meeting this specification in its entirety. All deviations from this specification must be listed and individually signed off by the consultant.

PART 2 - PRODUCTS

2.1 LIGHTING CONTROL PANELS

- A. Provide lighting control panels in the locations and capacities as indicated on the plans and schedules. Each panel shall be of modular construction and consist of the following components:
 - 1. Enclosure/Tub shall be NEMA 1, sized to accept an interior with 1 – 24 relays and 6 four-pole contactors.
 - 2. Cover shall be configured for surface or flush wall mounting of the panel as indicated on the plans. The panel cover shall have a hinged and lockable door with restricted access to line voltage section of the panel.
 - 3. Interior assembly shall be supplied as a factory assembled component specifically designed and listed for field installation. The interior construction shall provide total isolation of high voltage (Class 1) wiring from low voltage (Class 2) wiring within the assembled panel. The interior assembly shall include intelligence boards, power supply, DIN rails for mounting optional Class 2 control devices, and individually replaceable latching type relays. The panel interiors shall include the following features:
 - a. Removable, plug-in terminal blocks with screwless connections for all low voltage terminations.
 - b. Individual terminal block, override pushbutton, and LED status light for each relay.
 - c. Direct wired switch inputs associated with each relay and group channel shall support two- or three-wire, momentary or maintained contact switches or 24VDC input from occupancy sensors.

- d. Automatic support for occupancy sensor sequence of operation. Direct wired low voltage inputs automatically reconfigure when connected to a WattStopper occupancy sensor head. Occupancy sensor shall switch lighting on and off during unoccupied periods but shall not turn lighting off during scheduled occupancy periods.
- e. Digital inputs (four RJ-45 jacks) shall support 1-, 2-, 3-, 4-, and 8-button digital switches and digital occupancy sensors.
- f. Isolated contacts within each relay shall provide true relay state to the electronics. True relay state shall be indicated by the on-board LED and shall be available to external control devices and systems.
- g. Automatically sequenced operation of relays to reduce impact on the electrical distribution system when large loads are controlled simultaneously.
- h. Group, channel, and pattern control of relays shall be provided through a simple keypad interface within the panel. Any group of relays can be associated with a channel for direct on/off control or pattern (scene) control via a simple programming sequence using the relay and channel override pushbuttons and LED displays.
- i. Relay group status for each channel shall be provided through bi-color operation of the LED indicators. Solid red indicates that all relays in the group are on, solid green indicates that the group is in a mixed state, and blinking green indicates that the relays have blink warned and are currently timing out.
- j. Each relay and channel terminal block shall provide a 24V pilot light signal. It shall be possible to configure the system for support for any Class 2 pilot light voltage with the use of an auxiliary power supply.
- k. Single-pole latching relays with modular plug-in design. Relays shall provide the following ratings and features:
 - 1) Electrical:
 - a) 20 amp ballast at 277V
 - b) 20 amp ballast at 347V
 - c) 20 amp tungsten at 120V
 - d) 20 amp resistive at 347V
 - e) 1.5 HP motor at 120V
 - f) 14,000 amp short circuit current rating (SCCR) at 347V

- 2) Mechanical:
 - a) Individually replaceable, ½” KO mounting with removable Class 2 wire harness.
 - b) Actuator on relay housing provides manual override and visual status indication, accessible from Class 2 section of panel.
 - c) Dual line and load terminals each support two #14 – #12 solid or stranded conductors.
 - d) Tested to 300,000 mechanical on/off cycles.
1. Isolated low voltage contacts provide for true relay status feedback and pilot light indication.
4. Power supply shall be a multi-voltage transformer assembly with rated power to supply all electronics, occupancy sensors, switches, pilot lights, and photocells as necessary to meet the project requirements. Power supply to have internal over-current protection with automatic reset and metal oxide varistor protection.

2.2 BACnet® BASED DIGITAL COMMUNICATIONS

- A. The lighting control panel shall support digital communications to facilitate the extension of control to include interoperability with building automation systems and other intelligent field devices. Digital communications shall be RS485 master/slave token passing-based using the BACnet® protocol.
 1. The panel shall have provision for an individual BACnet device ID. The device ID description property shall be writable via the network to allow unique identification of the lighting control panel on the network.
 2. The panel shall support MS/TP MAC addresses in the range of 0 – 127 and baud rates of 9600k, 38400k and 76800k bits per second.
 3. Lighting control relays shall be controllable as binary output objects in the instance range of 1 – 48. The state of each relay shall be readable and writable by the BAS via the object present value property.
 4. Lighting control relays shall report their true on/off state as binary input objects in the instance range of 1 – 48.
 5. The eight channel groups associated with the panel shall be represented by binary value objects in the instance range of 1 – 8. The occupancy state of each channel group shall be readable and writable by the BAS via the object present value property. Commanding 1 to a channel group will put all relays associated with the channel into the occupied mode. Commanding 0 or NULL shall put the relays into the unoccupied mode.

6. Setup and commissioning of the panel shall not require manufacturer-specific software or configuration tools of any kind. All configuration of the lighting control panel shall be performed using standard BACnet objects or via the on-board LCD display and user keypad. Provide BACnet objects for panel setup and control as follows:
 - a. Binary output objects in the instance range of 1 – 24 (one per relay) for on/off control of relays.
 - b. Binary value objects in the instance range of 1 – 8 (one per channel) for normal hours/after hours schedule control.
 - c. Binary input objects in the instance range of 1 – 24 (one per relay) for reading true on/off state of the relays.
 - d. Analog value objects in the instance range of 1 – 24 (one per relay) shall assign relays to channel groups in the range of 1 – 8.
 - e. Binary value objects in the instance range of 101 – 108 (one per channel group) shall assign the channel to follow auto-on or manual-on mode when transitioning to occupied.
 - f. Analog value objects in the instance range of 101 – 108 (one per channel group) shall assign a blink warn time value to each channel. A value of 5 shall activate the blink warn feature for the channel and set a 5-minute gracetime period. A value of 250 shall activate the sweep feature for the channel and enable the use of sweep type automatic wall switches.
 - g. Analog value objects in the instance range of 211 – 208 (one per channel) shall assign an after hours time delay value to the channel in the range of 1 – 240 minutes.
 - h. Multi-state value objects in the instance range of 1 – 8 (one per channel) shall provide the state of the relays assigned to the channel. Valid states shall be ALL ON, MIXED, BLINK, and ALL OFF.
7. The description property for all objects shall be writable via the network and shall be saved in non-volatile memory within the panel.
8. The BO and BV objects shall support BACnet priority array with a relinquish default of off and after hours respectively.

2.3 USER INTERFACE

- A. Each lighting control panel shall be supplied with an integral user interface consisting of a keypad and associated OLED display screen. The user interface shall allow setup, configuration, and diagnostics of the panel without the need for software or connection of a computer. The user interface shall have the following functions as a minimum:
1. Set network parameters including panel device ID, MS/TP MAC address, baud rate and max master range.
 2. Enter meaningful names for the panel, relays, and channels.
 3. View normal hours/after hours status of each channel.
 4. Override the normal hours/after hours mode for each channel.
 5. View the 16 priority array slots for each channel and relay.
 6. Program the schedule response for each channel as:
 - a. Automatic-on or manual-on.
 - b. Enable/disable blink warn.
 - c. Enter override time delay as 0 (none) to 240 minutes.

2.4 DIGITAL NETWORK SWITCHES

- A. Provide digital wall switches with 1, 2, 3, 4, or 8 buttons, in the colors indicated on the plans. Switches shall connect to the panel via standard Cat 5e cable with RJ-45 terminations. Digital wall switches shall have the following features:
1. Available colors: white, ivory, light almond, grey or black.
 2. Single gang device shall fit standard decorator opening and use standard wall plates.
 3. LED indicator on each button for status and locator function.
 4. Concealed configuration button with LED indicator for binding buttons to relays, no software or computer shall be required.
 5. Infrared window for use with handheld two-way wireless configuration tool,
 6. Selectable function mode per button shall be momentary toggle (on/off), on only, or off only.
 7. Removable button assembly for field color change or substitution of engraved buttons.
 8. Two RJ-45 ports for connection to panel or other switches and/or occupancy sensors.
 9. Open topology digital network via Cat 5e wire.

2.5 DIGITAL OCCUPANCY SENSORS

- A. Provide digital occupancy sensors to control relays in locations as shown on the plans. Sensors shall be either passive infrared, ultrasonic, or dual technology as indicated. Sensors shall be either ceiling or wall mounded and connect to the panel using Cat 5e cable with RJ-45 terminations.

Digital occupancy sensors shall have the following features:

1. Setup and calibration shall be digital and precisely repeatable from sensor to sensor.
2. User interface with pushbuttons and illuminated LCD screen for setup and calibration.
3. Ladder-free setup and calibration with optional handheld two-way infrared commissioning tool.
4. Sensitivity, 0 – 100% in 10% increments.
5. Time delay, 1 – 30 minutes in 1 minute increments.
6. Test mode with five-second time delay for simplified walk testing.

2.6 SCHEDULE, GROUP, AND PHOTOCELL CONTROL OF RELAYS

- A. The lighting control panel shall support schedule, group, and photocell control functions via the network as configured in the optional Segment Manager controller or building automation system. The lighting control panel shall be fully compatible with building automation systems that are BACnet compliant. See related specification sections for additional information on interfacing the lighting control panel(s) to the building automation system.

2.7 BROWSER-BASED PROGRAMMING AND CONTROL

- A. The digital segment manager shall be a compact controller capable of hosting the schedule, photocell, and group relay control functions for a network of up to 96 LILM series lighting control panels. The segment manager shall provide the following features:
1. Provision for 1 to 3 separate network segments to facilitate efficient network wire routing.
 2. Compact housing with screw tab mounts for surface installation and integral DIN rail mounting slot for NEMA 1 installation in the LMSM-ENC1 enclosure.
 3. Web browser-based user interface; shall not require the installation of any lighting control software.
 4. User interface accessible from most smart phone browsers when Internet connected.
 5. Login security access control restricting some users to view-only or other limited operations.
 6. Automatic discovery of the lighting control panels.
 7. Familiar navigation-tree-based browsing to individual lighting control panels.
 8. View/override current status of channels and relays.
 9. Assign relays to channels.

10. Set channel operating parameters:
 - a. Automatic-on or manual-on operation.
 - b. Enable/disable blink warn.
 - c. Override duration time, 0 (none) to 240 minutes.
 - d. AS-100 automatic wall switch operation mode.
11. Create and run schedules:
 - a. Normal hours/after hours schedules for channels.
 - b. On/off schedules for relays.
 - c. Support for a minimum of 100 unique schedules, each with up to four time events per day.
 - d. Support annual schedules, holiday schedules and unique date-bound schedules.
12. Ethernet connectivity for user access via direct-wired connection, LAN/WAN, or Internet connection.
13. BACnet IP connectivity for connection to building automation systems.
14. Segment manager shall be WattStopper LMSM-201 with one network segment or LMSM-603 with support for three network segments.

PART 3 EXECUTION

3.1 SUPPORT SERVICES

- A. System Start Up and Commissioning
 1. Manufacturer shall provide a factory authorized technician to confirm proper installation and operation of the lighting control panels, switches, and occupancy sensors.
 2. The technician shall provide training on the lighting control features of the system and shall verify that the panel(s) is communicating with the building automation system.
 3. The system integrator or BAS vendor shall be responsible for all integration including the mapping of BACnet objects into the BAS logic, schedules and graphics.

3.2 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

--- E N D ---

SECTION 26 12 00
SUBSTATION TRANSFORMERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Power-Cast II substation transformers.

1.2 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.3 REFERENCES

- A. IEEE C57.12.00™ - Standard General Requirements For Liquid-Immersed Distribution, Power, And Regulating Transformers.
- B. IEEE C57.12.01™ - Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin-Encapsulated Windings.
- C. ANSI C57.12.10, Safety Requirements 230 kV and Below 833/958 Through 8333/10 417 kVA, Single-Phase, and 750/862 Through 60 000/80 000/100 000 kVA, Three-Phase Without Load Tap Changing; and 3750/4687 Through 60 000/80 000/100 000 kVA with Load Tap Changing.
- D. ANSI C57.12.28 - Switchgear and Transformers, Pad-Mounted Equipment - Enclosure Integrity.
- E. ANSI C57.12.50 - Requirements for Ventilated Dry-Type Distribution Transformers, 1-500 kVA Single-Phase and 15-500 kVA Three-Phase, with High Voltage 601-34,500 Volts, Low Voltage 120-600 Volts.
- F. ANSI C57.12.51 - Requirements for Ventilated Dry-Type Power Transformers, 501 kVA and Larger Three-Phase, with High Voltage 601-34,500 Volts, Low Voltage 208Y/120-4160 Volts.
- G. ANSI C57.12.55, Conformance Standard for Transformers - Dry-Type Transformers Used in Unit Installations, Including Unit Substations.
- H. IEEE C57.12.56™, Standard Test Procedure for Thermal Evaluation of Insulation Systems for Ventilated Dry-Type Power and Distribution Transformers.

- I. IEEE C57.12.58™, Guide for Conducting a Transient Voltage Analysis of a Dry-Type Transformer Coil.
- J. IEEE C57.12.59™, Guide for Dry-Type Transformer Through-Fault Current Duration.
- K. IEEE C57.12.70™, Terminal Markings and Connections for Distribution and Power Transformers.
- L. IEEE C57.12.80™, Standard Terminology for Power and Distribution Transformers.
- M. IEEE C57.12.90™ - Test Code for Liquid-Immersed Distribution Power, and Regulating Transformers.
- N. IEEE C57.12.91™, Test Code for Dry-Type Distribution and Power Transformers.
- O. IEEE C57.94™, Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers.
- P. IEEE C57.96™, Guide for Loading Dry-Type Distribution and Power Transformers.
- Q. IEEE C57.105™, Guide for Application of Transformer Connections in Three-Phase Distribution Systems.
- R. IEEE C57.109™, Guide for Liquid-Immersed Transformer Through-Fault-Current Duration.
- S. IEEE C57.111™, Guide for Acceptance of Silicone Insulating Fluid and Its Maintenance in Transformers.
- T. IEEE C57.121™ Guide for Acceptance and Maintenance of Less Flammable Hydrocarbon Fluid in Transformers.
- U. IEEE C57.124™, Recommended Practice for the Detection of Partial Discharges and the Measurement of Apparent Charge in Dry-Type Transformers.
- V. CSA-C88 - Power Transformers and Reactors.

1.4 SUBMITTALS

- A. Submit shop drawings indicating outline dimensions, connection and support points, weight, specified ratings and materials.
- B. Submit product data indicating standard model design tests and options.
- C. Submit manufacturer's installation instructions.

1.5 OPERATION AND MAINTENANCE DATA

- A. Include procedures for sampling and maintaining fluid, cleaning and maintaining unit, and replacing components.

1.6 QUALITY ASSURANCE

- A. Manufacturer: Company specializing in distribution transformers with three years documented experience.

PART 2 - PRODUCT

2.1 MANUFACTURERS

- A. Manufacturer: Square D Company or approved equal. (Preferred Manufacturer and Basis of Design)

2.2 POWER-CAST II SUBSTATION TRANSFORMER

- A. The transformer(s) shall be the substation type with side-wall mounted primary and secondary terminations.
- B. Transformer(s) shall be of solid-cast, dry-type construction, mounted in a suitable, ventilated indoor enclosure.
- C. The average temperature rise of the transformer windings shall not exceed 115° C when the transformer is operated at full nameplate AA and FA rating. The transformer(s) shall be capable of carrying 100% of nameplate kVA rating in a 40° C maximum, 30° C average ambient as defined by IEEE C57.12.01™.
- D. Terminations shall be side-wall mounted for: Close-coupling to high and low voltage switchgear sections.
- E. Primary and secondary locations shall be as indicated on drawings.
- F. The transformer(s) shall be rated 1500 kVA AA . Primary voltage 13.8 volts delta. Secondary voltage 480/277 volts wye. 4-wire, 60 Hz with two 2-1/2% full-capacity above normal and two 2-1/2% full-capacity below normal primary taps. Impedance shall be 5.75 % manufacturer's standard impedance, $\pm 7\text{-}1/2\%$. Sound level shall not exceed the maximum specified in IEEE Standard C57.12.01™ for the applicable kVA size of dry-type transformer.
- G. The impulse rating of the high voltage windings must be at least equal to the basic impulse level specified by IEEE C57.12.90™ for oil-filled transformers of the same voltage class, without the use of supplemental surge arresters.
- H. The impulse rating of the low voltage winding must be at least 30 kV for low voltage windings rated 1.2 kV and below.
- I. The transformer core shall be constructed of high grade, grain-oriented silicone steel laminations, with high magnetic permeability. Magnetic flux density is to be kept well below the saturation point. The core shall be cruciform in shape, with mitered joints to keep core losses, excitation current and noise level at a minimum. The outside surfaces of the core shall be protected against corrosion by painting with a suitable coating after assembly. Core dipping is not acceptable.
- J. The enclosure(s) shall be constructed of heavy-gauge sheet steel. All ventilating openings shall be in accordance with NEMA and NEC standards for ventilated enclosures. The cabinet shall have a minimum of four hinged doors.

- K. The base(s) shall be constructed to permit rolling or skidding in any direction, and shall be equipped with jacking pads designed to be flush with the transformer enclosure.
- L. Shall include multi-phase electronic temperature monitor controlled automatically by sensors placed in the LV air ducts. The temperature monitor must contain yellow and red indicating lights. The yellow lamp indicates fan power, while the red lamps signal that alarm and trip contacts have been activated. A 0-1 milliampere output is required for remote indication. Alarm contacts shall be provided for fans, alarm, and trip function. An audible alarm must sound when the highest phase temperature exceeds a preset point. The fans must be able to operate in either manual or automatic mode. A fan exerciser circuit must operate the cooling fans for approximately one minute every six days Fan controller must be POWERLOGIC ® system compatible.
- M. The transformer shall be pre-wired for TRANSPARENT READY web enabled communication.
- N. Provision for future forced air cooling equipment shall include mounting provision for fans, bussing sized to the fan-cooled rating and provisions for mounting the fan control system.
- O. Low voltage bus shall be silver flash plated copper throughout.
- P. The transformer shall comply with all applicable portions of NEMA TR-1, and IEEE C57.12.01™.
- Q. Testing - Testing shall be done in accordance with IEEE C57.12.91™ and shall include, as the minimum, the following tests:
 - 1. Ratio
 - 2. Polarity
 - 3. Phase Rotation
 - 4. No-Load Loss
 - 5. Excitation Current
 - 6. Impedance Voltage
 - 7. Load Loss
 - 8. Applied Potential
 - 9. Induced Potential
 - 10. The transformer windings must be free of partial discharge up to at least 1.2 times the rated line-to-ground voltage. Each winding shall be subjected to a partial discharge test to verify its partial discharge.
 - 11. Impulse Test
 - 12. Temperature Test (typical data from previous unit is acceptable)
 - 13. Sound Test (typical data from previous unit is acceptable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that pads are ready to receive work.
- B. Verify field measurements are as instructed by manufacturer.
- C. Verify that required utilities are available, in proper location and ready for use.
- D. Beginning of installation means installer accepts conditions.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install safety labels to NEMA 260.

3.3 FIELD QUALITY CONTROL

- A. Test dielectric liquid to ASTM D877, using 25,000 volts minimum breakdown voltage, after installation and before energization from system.
- B. Test transformer to IEEE C57.12.90™.
- C. Test transformer to IEEE C57.12.91™.

3.4 ADJUSTING

- A. Adjust primary taps so that secondary voltage is within 2 % of rated voltage.

3.5 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 26 13 16
MEDIUM-VOLTAGE METAL ENCLOSED LOAD INTERRUPTER SWITCHGEAR

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Medium voltage metal-enclosed switchgear with air load interrupter switches.

1.2 REFERENCES

- A. ANSI/IEEE C37.20.3 - Standard for Metal-Enclosed Interrupter Switchgear.
- B. ANSI/IEEE C37.20.4 - Standard for Indoor AC Medium Voltage Switches used in Metal-Enclosed Switchgear.
- C. NEMA

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. The metal-enclosed switchgear assembly shall be in accordance with the contract documents, applicable codes whichever is the most stringent.
- C. The manufacturer shall furnish a detailed Bill of Material and complete set of drawings.
- D. The manufacturer shall furnish comprehensive instruction manuals.

1.5 QUALITY ASSURANCE

- A. Manufacturer: The manufacturer of the switchgear must be the same as the manufacturer of the load interrupter switch.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Accept equipment on site and inspect for shipping damage.
- B. Protect equipment from weather and moisture by covering with heavy plastic or canvas and by maintaining heat within enclosure in accordance with manufacturer's instructions.

PART 2 - PRODUCT

2.1 MANUFACTURERS

- A. Switchgear: Metal-enclosed load interrupter switchgear shall be Square D type HVL or approved equal. (Preferred Manufacturer and Basis of Design)
- B. Fuses
 - 1. Current limiting
 - a. Fuses shall be current limiting, non-expulsion type of self-contained design to limit the available fault current stresses on the system.
 - b. Fuses shall be affixed in position in a non-disconnect disconnect for fuse mounting with provisions for removal and replacement from the front of the gear.
 - c. Fuse Rating: "E" rated, size to be determined by transformer manufacturer.
 - d. Voltage Class: 15.0 kV.
 - e. Interrupting Rating: As stated above to achieve the integrated interrupting rating; 22,000 amps, rms symmetrical.

2.2 LOAD INTERRUPTER SWITCHGEAR ASSEMBLY

- A. The metal-enclosed switchgear with load interrupter switches shall consist of a multiple section line-up, and be of indoor type construction. The sections shall contain the load interrupter switches and the necessary accessory components. The equipment shall be factory-assembled with necessary shipping splits and operationally checked. The assembly shall be a self-supporting, floor mounted bay and shall be securely bolted to the transformer to form an integrated structure.
- B. The integrated switchgear assembly shall withstand the effects of closing, carrying and interrupting currents up to the assigned maximum short circuit rating.
- C. A viewing window shall be installed in the switch enclosure and located so as to enable visible inspection of the switch blades and blown fuse indicators from outside the enclosure.
- D. System Voltage: 13.8 kV, 3-phase, solidly grounded, 3-phase, 3-wire.
- E. Operating Frequency: 60 Hz.
- F. Maximum Short Circuit Current: 22 kA rms symmetrical.
- G. Maximum Design Voltage: 15.0 kV.
- H. Basic Impulse Level (BIL): 95 kV.
- I. Short-Time Current (two second): 25 kA.
- J. Main Bus Ampacity: 600 amps, continuous.
- K. Integrated Short Circuit Rating: 22 kA, rms symmetrical.

2.3 COMPONENTS

- A. Load Interrupter Switch
 - 1. Over-Center Mechanism: The load interrupter switch shall be rated at 600 amperes continuous and interrupting; fixed mounted on glass reinforced polyester standoff insulators; manually operated; quick-make, quick-break with the speed of operation independent of the operator.
- B. Switches shall utilize main current carrying paths and arcing interruption path type poles.
- C. The switch operating handle shall be permanently attached to the outside front of the switchgear and ready for immediate use [except for outdoor applications where the front of the switchgear shall be covered by a full-height solid door. The handle must operate in the conventional fashion with the switch closed with the handle in the up position and the switch open with the handle in the down position. Provisions shall be available for padlocking the switch in either the open or closed position.
- D. Voltage and Short Circuit Ratings: Match ratings specified for assembly.
- E. Momentary Rating: 40 kA, rms asymmetrical.
- F. Fault Closing: 40 kA, rms asymmetrical.

2.4 ACCESSORIES

- A. Surge Arresters (metal-oxide type): Distribution class, rated 18 kV, 15.3 MCOV; one per phase.
- B. Incoming Cable Termination: Cable Lug.
- C. Provide mechanical lugs for terminating cables onto the switchgear terminal pads.
- D. Mechanical Interlocks: The high-voltage compartment door shall be interlocked to prevent opening with the load interrupter in the closed position.
- E. Key interlocks per attached drawings.
- F. Switches to be equipped with aux contacts 2NO and 2NC.
- G. Equip with P.T.'s and C.T's for meeting purposes.
- H. Provide CPT to power meter.
- I. Provide spare power fuses and spare fuse pocket in gear along with fuse handling hot stick pocket.
- J. Meter shall be Square PM870 with display.
- K. Provide Mimic bus and spare touch up paint.

PART 3 - EXECUTION

3.1 FABRICATION

- A. Construction: Indoor. Each equipment bay shall be a separately constructed cubicle assembled to form a rigid free standing unit. Minimum sheet metal thickness shall be 11 gauge steel on all exterior surfaces. Adjacent bays shall be securely bolted together to form an integrated rigid structure. To assist installation and maintenance of bus and cables, provide split rear doors with a padlockable handle and three-point latching. Each individual unit shall be braced to prevent distortion.
- B. A viewing window shall be installed in a fixed panel of the enclosure to enable visual inspection of the disconnect blades from outside the enclosure.
- C. The high voltage fuses (when required) and non-disconnect type fuse mountings, shall be accessible only through a separate door mechanically interlocked with the load interrupter switch, so the load interrupter switch is opened before the door is opened and that the switch cannot be closed when the door is open.
- D. Main Bus shall be silver-plated copper, insulated rated 600 amps, and is to be supported from the top of the enclosure on NEMA class A-20 glass reinforced polyester standoff insulators.
- E. For multiple bay lineups, include continuous ground bus through the switchgear assembly, securely connected to the steel frame of each cubicle.

3.2 FACTORY FINISHING

- A. All steel parts, shall be cleaned and a zinc-phosphate (outdoor equipment) or iron phosphate (indoor equipment) pre-treatment applied prior to paint application.
- B. Paint color shall be ANSI-49 (medium light gray) TGIC polyester powder, applied electrostatically through air. Following paint application, parts shall be baked to produce a hard durable finish. The average thickness of the paint film shall be 2.0 mils. Paint film shall be uniform in color and free from blisters, sags, flaking and peeling.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 – GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation, and connection of dry-type general-purpose transformers.

1.2 RELATED WORK

- A. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirements for seismic restraint of nonstructural components.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items common to more than one section of Division 26.
- C. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- E. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits and outlet boxes.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.5 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:
- B. Shop Drawings:
 - 1. Clearly present sufficient information to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, impedance, dimensions, weight, mounting details, decibel rating, terminations, temperature rise, no load and full load losses, and connection diagrams.
 - 3. Complete nameplate data, including manufacturer's name and catalog number.
- C. Manuals:
 - 1. When submitting the shop drawings, submit companion copies of complete maintenance and operating manuals, including technical data sheets and wiring diagrams.
 - 2. If changes have been made to the maintenance and operating manuals originally submitted, then submit four copies of the updated maintenance and operating manuals to the Resident Engineer/COTR two weeks prior to final inspection.
- D. Certifications: Two weeks prior to the final inspection, submit four copies of the following to the Resident Engineer/COTR:
 - 1. Certification by the manufacturer that the materials conform to the requirements of the drawings and specifications.
 - 2. Certification by the contractor that the equipment has been properly installed and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. National Fire Protection Association (NFPA):
 - 70-11National Electrical Code (NEC)
- C. National Electrical Manufacturers Association (NEMA):
 - ST20-92Dry-Type Transformers for General Applications
 - TP1-02Guide for Determining Energy Efficiency for Distribution Transformers
 - TR1-00Transformers, Regulators, and Reactors

PART 2 - PRODUCTS

2.1 GENERAL PURPOSE DRY-TYPE TRANSFORMERS

- A. Unless otherwise specified, dry-type transformers shall be in accordance with NEMA, NEC, and as shown on the drawings. Transformers shall be UL-listed and labeled.
- B. Dry-type transformers shall have the following features:
1. Transformers shall be self-cooled by natural convection, isolating windings, indoor dry-type. Autotransformers will not be accepted.
 2. Rating and winding connections shall be as shown on the drawings.
 3. Transformers shall have copper windings.
 4. Ratings shown on the drawings are for continuous duty without the use of cooling fans.
 5. Insulation systems:
 - a. Transformers 30 kVA and larger: UL rated 220° C system with an average maximum rise by resistance of 150 ° C in a maximum ambient of 40° C.
 - b. Transformers below 30 kVA: Same as for 30 kVA and larger or UL rated 185° C system with an average maximum rise by resistance of 115° C in a maximum ambient of 40° C.
 6. Core and coil assemblies:
 - a. Rigidly braced to withstand the stresses caused by short-circuit currents and rough handling during shipment.
 - b. Cores shall be grain-oriented, non-aging, and silicon steel.
 - c. Coils shall be continuous windings without splices except for taps.
 - d. Coil loss and core loss shall be minimized for efficient operation.
 - e. Primary and secondary tap connections shall be brazed or pressure type.
 - f. Coil windings shall have end filters or tie-downs for maximum strength.
 7. Certified sound levels determined in accordance with NEMA, shall not exceed the following:

Transformer Rating	Sound Level Rating
0 - 9 KVA	40 dB
10 - 50 KVA	45 dB
51 - 150 KVA	50 dB
151 - 300 KVA	55 dB
301 - 500 KVA	60 dB

8. If not shown on drawings, nominal impedance shall be as permitted by NEMA.

9. Single phase transformers rated 15 kVA through 25 kVA shall have two 5% full capacity taps below normal rated primary voltage. All transformers rated 30 kVA and larger shall have two 2.5% full capacity taps above, and four 2.5% full capacity taps below normal rated primary voltage.
10. Core assemblies shall be grounded to their enclosures with adequate flexible ground straps.
11. Enclosures:
 - a. Comprised of not less than code gauge steel.
 - b. Outdoor enclosures shall be NEMA 3R.
 - c. Temperature rise at hottest spot shall conform to NEMA Standards, and shall not bake and peel off the enclosure paint after the transformer has been placed in service.
 - d. Ventilation openings shall prevent accidental access to live components.
 - e. The enclosure at the factory shall be thoroughly cleaned and painted with manufacturer's prime coat and standard finish.
12. Standard NEMA features and accessories, including ground pad, lifting provisions, and nameplate with the wiring diagram and sound level indicated on it.
13. Dimensions and configurations shall conform to the spaces designated for their installations.
14. Transformers shall meet the minimum energy efficiency values per NEMA TP1 as listed below:

kVA Rating	Output efficiency (%)
15	97
30	97.5
45	97.7
75	98
112.5	98.2
150	98.3
225	98.5
300	98.6
500	98.7
750	98.8

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation of transformers shall be in accordance with the NEC, as recommended by the equipment manufacturer and as shown on the drawings.
- B. Install transformers with manufacturer's recommended clearance from wall and adjacent equipment for air circulation. Minimum clearance shall be 6 in.
- C. Install transformers on vibration pads designed to suppress transformer noise and vibrations.
- D. Use flexible metal conduit to enclose the conductors from the transformer to the raceway systems.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform tests in accordance with the manufacturer's recommendations. Include the following visual and mechanical inspections.
 - 1. Compare equipment nameplate data with specifications and approved shop drawings.
 - 2. Inspect physical and mechanical condition.
 - 3. Inspect all field-installed bolted electrical connections, using the calibrated torque-wrench method to verify tightness of accessible bolted electrical connections.
 - 4. Perform specific inspections and mechanical tests as recommended by manufacturer.
 - 5. Verify correct equipment grounding.
 - 6. Verify proper secondary phase-to-phase and phase-to-neutral voltage after energization and prior to connection to loads.

3.3 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks, settings, and tests, the contractor shall demonstrate that the transformers are in good operating condition and properly performing the intended function.

3.4 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

- - - E N D - - -

SECTION 26 23 00
LOW-VOLTAGE METAL ENCLOSED CIRCUIT BREAKER SWITCHGEAR

PART 1 GENERAL

1.1 SUMMARY

- A. This specification and associated drawings describe Power-Zone® 4 Low Voltage Draw-out Switchgear assembly constructed to ANSI C37.20.1 standards.
- B. Circuit breakers shall be drawout type MASTERPACT ® with MICROLOGIC™ electronic trip units as specified on the associated drawings. Circuit breakers shall have interrupting, close and latch, and 30-cycle withstand ratings that meet the application requirements. Interrupting rating shall be available up to 200 kA RMS amperes without fuses. Close and latch ratings to 65 kA available on all frame sizes. Thirty-cycle withstand rating available up to 100 kA to provide maximum coordination with downstream circuit breakers. Circuit breakers shall be available in 800, 1600, 2000, 3200, 4000 and 5000 A frame sizes. An adjustable rating plug (range of 0.4 to 1 times the sensor plug value) and a field-replaceable sensor plug (available in standard amperage steps from 50% to 100% of the frame size) shall determine the ampere rating of the circuit breaker.

1.2 RELATED SECTIONS

- A. Section 26 09 13, ELECTRICAL POWER MONITORING AND CONTROL
- B. Section 26 43 13, INTEGRATED SURGE PROTECTIVE DEVICES

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 STANDARDS

- A. Equipment shall be designed, tested and manufactured according to the following:
 - 1. ANSI C37.20.1 – Metal Enclosed Low Voltage Power Circuit Breaker Switchgear
 - 2. ANSI C37.51 – Testing of Metal-Enclosed Low Voltage AC Power Circuit Breaker Switchgear.

3. NEMA SG-5 – Power Switchgear Assemblies
 4. UL 1558 – Switchgear Assemblies
- B. Main and Feeder Circuit Breakers used in Power-Zone 4 shall be designed, tested and manufactured to the following:
1. ANSI C37.13- Low Voltage AC Power Circuit Breakers Used In Equipment
 2. ANSI C37.16- Preferred Rating, Related Requirement And Application Recommendations For Low Voltage Power Circuit Breakers and AC Power Circuit Protectors.
 3. ANSI C37.50- Testing of Low Voltage AC Power Circuit Breakers
 4. NEMA SG-3 - Low Voltage Power Circuit Breakers
 5. UL1066- Low Voltage Power Circuit Breakers

1.5 RATINGS

- A. The ampacity of the Low Voltage Switchgear shall be determined by the loading of the feeder circuits. System Ampacity 2000A
- B. The short circuit current rating of the system shall be determined by the available fault current at the Low Voltage Switchgear. All circuit interruption shall be accomplished by the circuit breaker and without the aid of limiter fuses. The Short time rating shall also be a function on the desired selectivity of the electrical system. Short time ratings shall be equal to interrupting ratings for systems delivering up to 85k amperes available fault current. Select RMS symmetrical amperes from the following table:

Service Voltage			Short	Close & Latch
240V	480V	600V	Time Rating	Rating
42k	42k	42k	42k	42k
65k	65k	65k	65k	65k
85k	85k	85k	85k	50k
200k	200k	130k	30k min.	22k min.

- C. The assembly is designed for use on 50Hz or 60 Hz electrical systems up to 600 Vac. The assembly shall be properly braced to the ratings of the circuit breaker installed within the assembly.
- D. Any items not specifically mentioned but which are obviously necessary for proper operation are implied in this specification.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear: Square D Power-Zone 4 using Masterpact type Low Voltage Power Circuit Breakers or approved equal. (Preferred Manufacturer and Basis of Design)

2.2 STRUCTURE

A. General

1. Each steel section shall contain one or more individual circuit breakers, or instrumentation compartments, and a rear compartment for the buses and outgoing cable connections.
2. Rigid removable steel base channel shall be provided at the front and rear of each section.
3. The finish shall be medium gray ANSI #49.

B. Dimensions

1. Section widths should be 22, 30, or 36" wide dependent on the size of the circuit breakers being installed.
2. The lineup shall provide adequate wire bending space for mains and feeders breakers using up to 750 kcmil wires.
3. Section depth shall be 54" minimum when using 800A feeders. Additional depth to the lineup shall be for the sole purpose of additional wire bending and conduit space.
4. Adequate conduit space shall be provided to allow all conductors to exit the structure at the same end.

C. Moving and Handling

1. The Lineup shall be divided into shipping splits not to exceed 88" wide and shall be capable of being lifted overhead or by a forklift.
2. Each shipping split shall be provided with removable lifting straps
3. Removable Base Channels shall be provided with prying slots for ease of final positioning at the job-site.
4. For circuit breakers, an overhead or floor mounted lifter shall be provided to ease the installation or removal of circuit breakers in excess of 75 pounds.

2.3 BREAKER COMPARTMENT

A. Circuit Breakers

1. Each circuit breaker shall be mounted in its own barriered compartment.
2. Feeder circuit breakers rated 2000A or less shall be capable of being mounted in the uppermost compartment without derating.
3. Operational buttons on the circuit breaker as well as the trip unit and the display shall be accessible without opening the breaker compartment door.
4. Circuit breakers of like sizes and rated 1600A or less shall be interchangeable as standard. Circuit breakers of lower interruption ratings shall be mechanically prohibited from being placed in the cell.
5. Prepared spaces shall be totally complete, include the racking mechanism, bussing, and secondary contacts as necessary, so that a circuit breaker of the correct frame size can be installed with no modifications required.
6. Circuit Breaker and prepared space compartments shall be “keyed” such that a breaker cannot be incorrectly installed with respect to Interrupting Rating, Frame Size, or secondary connections

B. Secondary Connections

1. All customer secondary control and communications connections shall be made from the front of the switchgear lineup.
2. A dedicated wiring area accessible from the front shall allow easy access to all control or communications terminations
3. Control Connections shall be cage clamp optional ring tongue terminals. All control wire shall be 14 gauge SIS.
4. Dedicated conduit entry for control wires shall be provided at the top and bottom of each section, capable of landing up to 3 each 1 ½” conduits and accessible from the front.
5. All interconnections between sections at shipping splits shall use locking-pull apart terminal blocks.
6. All secondary and communication wiring shall be securely fastened to the switchgear without the use of adhesive backed wire anchors.

C. Instrumentation

1. Where additional space is required for instrumentation, CPTs, metering, etc., a barriered instrumentation compartment shall be used.
2. The instrumentation compartment shall not inhibit the routing of control or communication wires.

- Individual component mounting surfaces and pans in the instrument compartments shall be painted white as standard.

2.4 BUSING AND CABLE COMPARTMENT

A. Busing

- All vertical and horizontal distribution bussing shall be rated for the full ampacity of the lineup.
- All bus joints shall consist of Grade 5 hardware and conical spring (e.g. Belleville) washers to withstand mechanical forces exerted during short circuits. All joints shall consist of a minimum of 2 bolts.
- Busing shall be plated along its entire length.
- Busing shall be braced to withstand the instantaneous interrupting rating of the main breaker(s) or 65kA minimum.
- Optional barriers shall be available to separate the busing and cable compartment.

B. Cable Compartment

- All incoming or outgoing power conductors shall be routed through this area.
- Feeder Breakers shall have adequate wire bending space regardless of the interrupting rating. See table below for additional information.
- Conduit area for each section shall be a minimum of 17" wide and provide adequate depth for all section conduits. Select depth based on the tables below:
- Optional: Barriers to separate the busing and cable compartments shall be provided. Barriers to separate the cable compartment from an adjacent cable compartment shall be provided.

Feeder Wire Bending Requirements

	54" D	60" D	72" D	80" D
Maximum Feeder Breaker	800A	4000A	4000A	4000A

Conduit Area Available

Section Width	Section Depth			
	54"	60"	72"	80"
22"	17" W x 16" D	17" W x 22" D	17" W x 34" D	17" W x 42" D
30"	25" W x 16" D	25" W x 22" D	25" W x 34" D	25" W x 42" D
36"	31" W x 16" D	31" W x 22" D	31" W x 34" D	31" W x 42" D

2.5 POWER CIRCUIT BREAKERS

A. Circuit Breakers

1. The circuit breaker shall be Square D Masterpact NW and/or NT Low Voltage Power Circuit Breaker and listed to UL 1066.
2. Circuit breakers shall be suitable for the required instantaneous rating without the use of current limiting fuses.
3. All circuit breakers shall have field interchangeable electrical accessories including shunt trip, spring release, electrical operator, auxiliary contacts, and Trip Unit.
4. All secondary connections shall be made directly to the front of the circuit breaker cradle.
5. Each Circuit breaker shall have built in contact temperature and contact wear sensors.

B. Padlocking provisions shall be furnished to receive up to three padlocks when circuit breaker is in the disconnected position, positively preventing unauthorized closing of the circuit breaker contacts.

C. Provisions for up to two key locks shall be furnished allowing locking in the disconnected position. Provisions for locking in the connected, test and disconnected positions by padlock or key lock shall be available as an option.

D. Located on the face of the circuit breaker shall be buttons, with optional lockable clear cover, to open and close the circuit breaker and indicators to show the position of the circuit breaker contacts, status of the closing springs, and circuit breaker position in the cell. An indicator shall show “charged–not OK to close” if closing springs are charged but circuit breaker is not ready to close. Circuit breaker racking system must have positive stops at the connected, test, disconnected and withdrawn positions.

E. Circuit breaker must be equipped with an interlock to discharge the stored energy spring before the circuit breaker can be withdrawn from its cell. Circuit breaker must provide a positive ground contact check between the circuit breaker and cell when the accessory cover is removed while the circuit breaker is in the connected, test or disconnected positions.

F. Circuit breaker shall provide long service life. The 3200 A circuit breaker frame and those of lower ratings must be certified to perform a minimum of 10,000 operations without maintenance. The 4000 A and 5000 A frames must be certified to 5,000 operations without maintenance.

G. Trip Units

1. Circuit breaker trip system shall be a MICROLOGIC electronic trip unit.
2. All trip units shall be removable to allow for field upgrades.
3. Trip Units shall incorporate “True RMS Sensing”, and have LED long-time pickup indications.

4. MICROLOGIC trip unit functions shall consist of adjustable long-time pickup and delay, optional short-time pickup and delay, instantaneous optional neutral protection and optional ground-fault pickup and delay.
5. Adjustable long-time pickup (I_r) and delay shall be available in an adjustable rating plug that is UL Listed as field-replaceable. Adjustable rating plug shall allow for nine long-time pickup settings from 0.4 to 1 times the sensor plug (I_n). Other adjustable rating plugs shall be available for more precise settings to match the application. Long-time delay settings shall be in nine bands from 0.5–24 seconds at six times I_r .
6. Short-time pickup shall allow for nine settings from 1.5 to 10 times I_r . Short-time delay shall be in nine bands from 0.1–0.4 $I_2 t$ ON and 0–0.4 $I_2 t$ OFF.
7. Instantaneous settings on the trip units with LSI protection shall be available in nine bands from 2 to 15 times I_n . The Instantaneous setting shall also have an OFF setting when short-time pick-up is provided.
8. All trip units shall have the capability for the adjustments to be set and read locally by rotating a switch.
9. Trip unit shall provide local trip indication and capability to indicate local and remote reason for trip, i.e., overload, short circuit or ground fault.
10. Ground-fault protection shall be available for solidly grounded three-phase, three-wire or three-phase, four-wire systems. Trip unit shall be capable of the following types of ground-fault protection: residual, source ground return, and modified differential. Ground-fault sensing systems may be changed in the field.
11. Ground-fault settings for circuit breaker sensor sizes 1200 A or below shall be in nine bands from 0.2 to 1.0 times I_n . The ground-fault settings for circuit breakers above 1200 A shall be nine bands from 500 to 1200 A.
12. Neutral current transformers shall be available for four-wire systems.
13. Trip units shall be capable of communicating on MODBUS ® networks.
14. Trip units shall be available to provide real time metering. Metering functions include current.

15. The following table indicates the standard and optional features of the Trip Units. Select the appropriate trip unit (s) for the system performance desired.

Features	Micrologic Trip Unit Series			
	Basic	A	P	H
True RMS Sensing	X	X	X	X
LI	X	X	X	X
LSI	O	O	X	X
LSIG/Ground –Fault Trip		O	O	O
Ground Fault Alarm (no trip)			X	X
Ground Fault Trip and Programming Alarm			O	O
Adjustable Rating Plugs	X	X	X	X
LED - Long-time Pickup	X	X	X	X
LED - Trip indication		X	X	X
Digital Ammeter		X	X	X
Phase loading Bar Graph		X	X	X
Zone Selective Interlocking		X	X	X
Communications		O	X	X
LCD Dot Matrix Display			X	X
Advanced User Interface			X	X
Protective Relay Functions			X	X
Thermal Imaging			X	X
Neutral Protection			X	X
Contact Wear Indication			X	X
Temperature Indication			X	X
Incremental Fine Tuning of Settings			X	X
Selectable Long-time Delay Bands			X	X
Power Measurement			X	X
Waveform Capture				X
Data Logging				X

X=Standard O=Option

- H. A test set shall be available to provide automatic function testing of the circuit breaker. No disassembly of circuit breaker shall be required.

2.6 METERING AND INSTRUMENTATION

A. Main Metering

1. Metering requirements that exceed the capabilities of the Circuit Breaker Trip Units shall use the Square D Powerlogic CM-4000 series.
2. CT's shall be appropriately sized for use on the main.
3. Separate low voltage HMI and display shall be mounted on the same door as the Main Circuit Breaker.
4. Optional I/O and Ethernet communications card shall be provided.

B. Communications

1. Equipment shall be Transparent Ready web-enabled equipment, featuring an Ethernet interface and integral web server, and have the following communications.
 - a) Ethernet Server, with Essential Monitoring: Five (5) Summary web pages shall be configured at the factory to display the most essential real-time information (load currents and demand currents per phase, demand power, energy, etc.) for each communicating device within the power equipment lineup, preprogrammed and tested.
2. A multi-point, RS485 Modbus® serial communications network shall be provided within the equipment to interconnect all breaker trip units and metering devices equipped with communications. (Note: for full functionality, these devices should be specified with power metering, when available.)
3. The serial communications network shall be wired to a PowerLogic® Ethernet Gateway / Web Server ("Ethernet Server") in the incoming section of the equipment for remote data access via customer's Local Area Network (LAN) or intranet.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine area to receive switchgear to provide adequate clearance for switchgear installation.
- B. Check that concrete pads are level and free of irregularities.
- C. Start work only after unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install switchgear in accordance with manufacturer's written guidelines, the NEC, and local codes.

3.3 FIELD QUALITY CONTROL

- A. Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.
- B. Measure, using a Megger, the insulation resistance of each bus section phase-to-phase and phase-to-ground for one minute each, at minimum test voltage of 1000 Vdc; minimum acceptable value for insulation resistance is 1 megohms. NOTE: Refer to manufacturer's literature for specific testing procedures.
- C. Check tightness of accessible bolted bus joints using calibrated torque wrench per manufacturer's recommended torque values.
- D. Physically test key interlock systems to check for proper functionality.
- E. Test ground fault systems by operating push-to-test button.

3.4 ADJUSTING

- A. Adjust all operating mechanisms for free mechanical movement per manufacturer's specifications.
- B. Tighten bolted bus connections in accordance with manufacturer's instructions.
- C. Adjust circuit breaker trip and time delay settings to values indicated.

3.5 CLEANING

- A. Touch up scratched or marred surfaces to match original finish.

3.6 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

- - - E N D - - -

SECTION 26 24 13 SWITCHBOARDS

PART 1 - GENERAL

1.1 SWITCHBOARD - GENERAL

- A. Utility Metering Compartment: The utility current transformer compartment shall comply with the local utility construction specifications.
- B. Short Circuit Current Rating: Switchboards shall be rated with a minimum short circuit current rating of 65K rms symmetrical amperes at 480 VAC maximum.
- C. Future Provisions: All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.
- D. Enclosure: Type 1 - General Purpose.
 - 1. Sections shall be aligned front and rear.
 - 2. Removable steel base channels (1.5 inch floor sills) shall be bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting.
 - 3. The switchboard enclosure shall be painted on all exterior surfaces. The paint finish shall be a medium gray, ANSI #49, applied by the electro-deposition process over an iron phosphate pre-treatment.
 - 4. All front covers shall be screw removable with a single tool and all doors shall be hinged with removable hinge pins.
 - 5. Top and bottom conduit areas shall be clearly indicated on shop drawings.
- E. Nameplates: Provide 1 inch high x 3 inches engraved laminated (Gravoply) nameplates for each device. Furnish black letters on a white background for all voltages.
- F. Bus Composition: Shall be plated copper. Plating shall be applied continuously to all bus work. The switchboard bussing shall be of sufficient cross-sectional area to meet UL Standard 891 temperature rise requirements. The phase and neutral through-bus shall have an ampacity as shown in the plans. For 4-wire systems, the neutral shall be of equivalent ampacity as the phase bus bar. Tapered bus is not acceptable. Full provisions for the addition of future sections shall be provided. Bussing shall include all necessary hardware to accommodate splicing for future additions.
- G. Ground Bus: Sized per NFPA70 and UL 891 Tables 25.1 and 25.2 and shall extend the entire length of the switchboard. Provisions for the addition of future sections shall be provided.

1.2 RELATED SECTIONS

- A. Section 26 09 13, ELECTRICAL POWER MONITORING AND CONTROL
- B. Section 26 43 13, INTEGRATED SURGE PROTECTIVE DEVICES (SPDs)
- C. Section 26 36 23, AUTOMATIC TRANSFER SWITCHES

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Square D Company (Preferred Manufacturer and Basis of Design) or approved equal.

2.2 SWITCHBOARD - INCOMING MAIN SECTION DEVICES

- A. Two-step stored energy electronic trip molded case circuit breaker(s)
 - 1. Circuit protective devices shall be two-step stored energy type circuit breakers Masterpact.
 - 2. Circuit breaker trip system shall be a microprocessor-based true rms sensing design with sensing accuracy through the thirteenth (13th) harmonic. Sensor ampere ratings shall be as indicated on the associated drawings.
 - 3. The integral trip system shall be independent of any external power source and shall contain no less than industrial grade electronic components.
 - 4. Circuit breakers shall be equipped with back-up thermal and magnetic trip system.
 - 5. The ampere rating of the circuit breaker shall be determined by the combination of an interchangeable rating plug, the sensor size and the long-time pickup adjustment on the circuit breaker. The sensor size, rating plug and switch adjustments shall be clearly marked on the face of the circuit breaker. Circuit breakers shall be UL Listed to carry 100% of their ampere rating continuously when applied in QED switchboards.

6. The following time/current response adjustments shall be provided. Each adjustment shall have discrete settings and shall be independent from all other adjustments.
 - a. Long Time Pickup & Long Time Delay
 - b. Short Time Pickup & Short Time Delay (I^2t IN & I^2t OUT)
 - c. Instantaneous Pickup
 - d. Ground Fault Alarm Only Pickup.
7. A means to seal the rating plug and trip unit adjustments in accordance with NEC Section 240-6(b) shall be provided.
8. Local visual trip indication for overload, short circuit and ground fault trip occurrences shall be provided.
9. An ammeter to individually display all phase currents flowing through the circuit breaker shall be provided. Indication of inherent ground fault current flowing in the system shall be provided on circuit breakers with integral ground fault protection. All current values shall be displayed in True rms with 2% accuracy.
10. Long Time Pickup indication to signal when loading approaches or exceeds the adjusted ampere rating of the circuit breaker shall be provided.
11. The trip system shall include a Long Time memory circuit to protect against intermittent overcurrent conditions above the long time pickup point. Means shall be provided to reset Long Time memory circuit during primary injection testing.
12. Circuit breaker trip system shall be equipped with an externally accessible test port for use with a Universal Test Set. Provide one (1) Universal Equipment Test Set for this project job for final inspection. This test set shall be suitable for testing all electric circuit breakers specified for this project. No disassembly of the circuit breaker is required for testing.
13. Communications capabilities for remote monitoring of circuit breakers trip system, to include phase and ground fault currents, pre-trip alarm indication, switch settings and trip history information shall be provided.
14. Terminations
 - a. All lugs shall be UL Listed to accept solid and/or stranded copper and aluminum conductors. Lugs shall be suitable for 90° C rated wire, sized according to the 75° C temperature rating in the NEC.
 - b. All circuit breakers shall be UL Listed to accept field installable/removable mechanical type lugs.

2.2 SWITCHBOARD - DISTRIBUTION SECTION DEVICES

A. Individually Mounted circuit breakers through 4000A.

1. Electronic trip molded/insulated case full function 100% rated circuit breaker(s) through 4000A
 - a. All electronic circuit breakers shall have the following time/current response adjustments: Long Time Pickup, Long Time Delay, Short Time Pickup, Short Time Delay, and Instantaneous settings. Each adjustment shall have discrete settings (fully adjustable) and shall be independent of all other adjustments.
 - b. Circuit breaker trip system shall be a microprocessor-based true rms sensing designed with sensing accuracy through the thirteenth (13th) harmonic. Sensor ampere ratings shall be as indicated on the associated drawing.
 - c. Local visual trip indication for overload, short circuit and ground fault trip occurrences.
 - d. Long Time Pickup indication to signal when loading approaches or exceeds the adjustable ampere rating of the circuit breaker shall be provided.

2.3 METERING (CUSTOMER)

A. Manufacturers:

1. Square D Model 870 (Preferred Manufacturer and Basis of Design) or approved equal.
2. Substitutions: substitutions shall be made only after proper verification

2.4 METERING TRANSFORMERS

- A. Manufacturer: Square D Company (Preferred Manufacturer and Basis of Design) or approved equal.
- B. Current Transformers: ANSI C57.13; 5 ampere secondary.
- C. Voltage Transformers: ANSI C57.13; 120 V single secondary. (Not required for type PM meters)

PART 3 - EXECUTION

3.1 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

--- E N D ---

SECTION 26 24 16 PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation, and connection of panelboards.

1.2 RELATED WORK

- A. Section 09 91 00, PAINTING: Identification and painting of panelboards.
- B. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirements for seismic restraint of non-structural components.
- C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one Section of Division 26.
- D. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.
- E. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- F. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits and outlet boxes.
- G. Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY: Requirements for installing the over-current protective devices to ensure proper equipment and personnel protection.
- H. Section 26 09 23, LIGHTING CONTROLS: Lighting controls integral to panelboards.
- I. Section 26 43 13, INTEGRATED SURGE PROTECTIVE DEVICES (SPDs): Surge suppressors installed in panelboards.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.5 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Sufficient information, shall be clearly presented to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, mounting details, materials, wiring diagrams, accessories, and weights of equipment. Complete nameplate data, including manufacturer's name and catalog number.
- C. Manuals:
 - 1. When submitting the shop drawings, submit companion copies of complete maintenance and operating manuals, including technical data sheets and wiring diagrams.
 - 2. If changes have been made to the maintenance and operating manuals that were originally submitted, then submit four copies of updated maintenance and operating manuals to the Resident Engineer two weeks prior to final inspection.
- D. Certification: Two weeks prior to final inspection, submit four copies of the following to the Resident Engineer:
 - 1. Certification by the manufacturer that the materials conform to the requirements of the drawings and specifications.
 - 2. Certification by the contractor that the materials have been properly installed, connected, and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. National Electrical Manufacturers Association (NEMA):
 - PB-1-06.....Panelboards
 - 250-08Enclosures for Electrical Equipment (1000V Maximum)

- C. National Fire Protection Association (NFPA):
 - 70-11National Electrical Code (NEC)
 - 70E-2004.....Standard for Electrical Life Safety in the Workplace
- D. Underwriters Laboratories, Inc. (UL):
 - 50-95Enclosures for Electrical Equipment
 - 67-09Panelboards
 - 489-09Molded Case Circuit Breakers and Circuit Breaker Enclosures

PART 2 - PRODUCTS

2.1 PANELBOARDS

- A. Panelboards shall be in accordance with UL, NEMA, NEC, and as shown on the drawings.
- B. Panelboards shall be standard manufactured products.
- C. Manufacturer: SquareD (Preferred Manufacturer and Basis of Design) or approved equal.
- D. All panelboards shall be hinged “door in door” type with:
 - 1. Interior hinged door with hand-operated latch or latches, as required to provide access only to circuit breaker operating handles, not to energized parts.
 - 2. Outer hinged door shall be securely mounted to the panelboard box with factory bolts, screws, clips, or other fasteners, requiring a tool for entry. Hand-operated latches are not acceptable.
 - 3. Push inner and outer doors shall open left to right.
- E. All panelboards shall be completely factory-assembled with molded case circuit breakers and integral accessories, such as surge protective devices per Section 26 43 13, INTEGRATED SURGE PROTECTIVE DEVICES (SPDs), metering devices per Section 26 27 13, TENANT SUB-METERING SYSTEM, lighting controls per Section 26 09 23, LIGHTING CONTROLS, and as scheduled on the drawings or specified herein. Include one-piece removable, inner dead front cover, independent of the panelboard cover.
- F. Panelboards shall have main breaker or main lugs, bus size, voltage, phase, top or bottom feed, and flush or surface mounting as scheduled on the drawings.
- G. Panelboards shall conform to NEMA PB-1, NEMA AB-1, and UL 67 and have the following features:
 - 1. Non-reduced size copper bus bars with current ratings as shown on the panel schedules, rigidly supported on molded insulators.
 - 2. Bus bar connections to the branch circuit breakers shall be the “distributed phase” or “phase sequence” type.

3. Mechanical lugs furnished with panelboards shall be cast, stamped, or machined metal alloys of sizes suitable for the conductors to which they will be connected.
4. Neutral bus shall be 100% rated, mounted on insulated supports.
5. Grounding bus bar shall be equipped with screws or lugs for the connection of grounding wires.
6. Buses shall be braced for the available short-circuit current. Bracing shall not be less than 10,000 A symmetrical for 120/208 V and 120/240 V panelboards, and 14,000 A symmetrical for 277/480 V panelboards.
7. Branch circuit panelboards shall have buses fabricated for bolt-on type circuit breakers.
8. Protective devices shall be designed so that they can easily be replaced.
9. Where designated on panel schedule "spaces," include all necessary bussing, device support, and connections. Provide blank cover for each space.
10. In two section panelboards, the main bus in each section shall be full size. The first section shall be furnished with subfeed lugs on the line side of main lugs only, or through-feed lugs for main breaker type panelboards, and have cable connections to the second section. Panelboard sections with tapped bus or crossover bus are not acceptable.
11. Series-rated panelboards are not permitted.

2.2 CABINETS AND TRIMS

A. Cabinets:

1. Provide galvanized steel cabinets to house panelboards. Cabinets for outdoor panelboards shall be factory primed and suitably treated with a corrosion-resisting paint finish meeting UL 50 and UL 67.
2. Cabinet enclosure shall not have ventilating openings.
3. Cabinets for panelboards may be of one-piece formed steel or of formed sheet steel with end and side panels welded, riveted, or bolted as required.

2.3 MOLDED CASE CIRCUIT BREAKERS FOR PANELBOARDS

- A. Circuit breakers shall be per UL 489, in accordance with the NEC, as shown on the drawings, and as specified.
- B. Circuit breakers in panelboards shall be bolt-on type.
- C. Molded case circuit breakers shall have minimum interrupting rating as required to withstand the available fault current, but not less than:
 1. 120/208 V Panelboard: 10,000 A symmetrical.
 2. 120/240 V Panelboard: 10,000 A symmetrical.
 3. 277/480 V Panelboard: 14,000 A symmetrical.

- D. Molded case circuit breakers shall have automatic, trip free, non-adjustable, inverse time, and instantaneous magnetic trips for 100 A frame or lower. Magnetic trip shall be adjustable from 3x to 10x for breakers with 600 A frames and higher. Breaker trip setting shall be set in the field, based on the approved protective device study as specified in Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY. Factory setting shall be HI, unless otherwise noted.
- E. Breaker features shall be as follows:
 - 1. A rugged, integral housing of molded insulating material.
 - 2. Silver alloy contacts.
 - 3. Arc quenchers and phase barriers for each pole.
 - 4. Quick-make, quick-break, operating mechanisms.
 - 5. A trip element for each pole, thermal magnetic type with long time delay and instantaneous characteristics, a common trip bar for all poles and a single operator.
 - 6. Electrically and mechanically trip free.
 - 7. An operating handle which indicates ON, TRIPPED, and OFF positions.
 - 8. An overload on one pole of a multipole breaker shall automatically cause all the poles of the breaker to open.
 - 9. Ground fault current interrupting breakers, shunt trip breakers, lighting control breakers (including accessories to switch line currents), or other accessory devices or functions shall be provided where indicated.

2.4 SURGE SUPPRESSION

Where shown on drawings, furnish panelboard with integral transient voltage surge suppression device. Refer to Section 26 43 13, INTEGRATED SURGE PROTECTIVE DEVICES (SPDs).

2.5 SEPARATELY ENCLOSED MOLDED CASE CIRCUIT BREAKERS

- A. Where separately enclosed molded case circuit breakers are shown on the drawings, provide circuit breakers in accordance with the applicable requirements of those specified for panelboards.
- B. Enclosures are to be of the NEMA types shown on the drawings. Where the types are not shown, they are to be the NEMA type most suitable for the environmental conditions where the circuit breakers are being installed.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the manufacturer's instructions, the NEC, as shown on the drawings, and as specified.
- B. Locate panelboards so that the present and future conduits can be conveniently connected.

- C. Install a printed schedule of circuits in each panelboard after approval by the Resident Engineer. Schedules shall be printed on the panelboard directory cards, installed in the appropriate panelboards, and incorporate all applicable contract changes. Information shall indicate outlets, lights, devices, or other equipment controlled by each circuit, and the final room numbers served by each circuit.
- D. Mount the fully-aligned panelboard such that the maximum height of the top circuit breaker above the finished floor shall not exceed 78 in. Mount panelboards that are too high such that the bottom of the cabinets will not be less than 6 in above the finished floor.
- E. Rust and scale shall be removed from the inside of existing backboxes where new panelboards are to be installed. Paint inside of backboxes with rust-preventive paint before the new panelboard interior is installed. Provide new trim and doors for these panelboards. Covers shall fit tight to the box with no gaps between the cover and the box.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. Include the following visual and mechanical inspections and electrical tests:
 - 1. Visual and Mechanical Inspection
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify appropriate anchorage and required area clearances.
 - d. Verify that circuit breaker sizes and types correspond to approved shop drawings.
 - e. To verify tightness of accessible bolted electrical connections, use the calibrated torque-wrench method or perform thermographic survey after energization.
 - f. Clean panelboard.

3.3 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks, settings, and tests, the contractor shall demonstrate that the panelboards are in good operating condition and properly performing the intended function.

3.4 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

---END---

SECTION 26 27 13
TENANT SUB-METERING SYSTEM

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

- A. Furnish and install a complete Tenant Metering System as detailed on the drawings and as described in this specification. The system shall be designed to include remote devices for utility metering, communication interface hardware, inter-communication wiring, personal computer workstation, software, printer, etc. where specified.
- B. The Tenant Metering System shall utilize Ethernet as the high-speed backbone network that supports direct connection of computer workstation with the metering devices connected to the network.
- C. Application software shall be provided as described in Article 2.05 of this specification.

1.2 REFERENCES

- A. All electric meters shall be UL and cUL Agency compliant, Listed per 7207. They shall also have +/- 1% overall system accuracy (including instrument transformer accuracy) or better from 2% to 100% of rated load. Accuracy is to meet or exceed ANSI C12.1.
- B. The water meters shall conform to AWWA Standard C-708, and NSF 61 Certified.
- C. The gas meter shall be an indoor non-compensated meter four chamber synthetic diaphragm style.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Indicate electrical & mechanical characteristics and connection requirements. Tenant Metering System components shall be installed by the power equipment manufacturer, the drawings shall clearly identify the components with the internal connections, and all contractor connections.

- C. Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements.

1.5 QUALITY

- A. The Tenant Metering System vendor shall be ISO 9000 registered to demonstrate quality compliance.
- B. Tenant Metering System components included within the power equipment lineups shall be factory installed, wired and tested prior to shipment to the job site.

PART 2 - PRODUCT

2.1 ELECTRIC METERS

- A. Electric Meters
 - 1. Meter Manufacturer: SquareD (Preferred Manufacturer and Basis of Design) or approved equal.
 - 2. The Meter shall be UL and cUL Listed per 7207. The meter module shall be rated for an operating temperature range of 0°C to 60°C minimum.
 - 3. The Meter options shall be available with standard and advance energy accuracy. Standard meters shall be calibrated as a system and be accurate to +/- 1% from 2 % to 100 % of the rated current over a temperature range of 0-60° C according to ANSI C12.1. No annual recalibration by users shall be required to maintain these accuracy's. Advanced meters shall be calibrated as a system and be accurate to +/-0.5% from 5% to 100% of the rated current over a temperature range of -10 to 60° C according to ANSI C12.20. Advanced meters shall provide a minimum of 2 digital inputs suitable for pulse metering.
 - 4. The Meter shall directly accept both single or three-phase voltage input up to and including 480 volts line to line.
 - 5. The Meter shall be capable of monitoring circuits up to 5000 Amps and shall be user configurable.
 - 6. Each Meter shall have as standard an RS-485 data port using Modbus (RTU) protocol to allow multipoint communication. The RS-485 communications shall provide communications links up to 10,000 feet in length.
 - 7. The information and capabilities provided by the Meter shall include the following. The values shall be read directly from the Meter display without the need for multipliers.
 - a. Real Energy (kWh)
 - b. Real Power Demand (kWd)
 - c. Real Power (kW)
 - d. Reactive Power (kVAR)

- e. Power Factor
 - f. Current, per phase
 - g. Voltage, per phase
8. The metering cabinet shall support optional communications interfaces including Ethernet.

2.2 COMMUNICATIONS

A. Ethernet Gateway

1. The Ethernet Gateway shall feature one 10/100baseTX Ethernet port as standard.
2. The Ethernet Gateway shall provide 512 MB of internal non-volatile memory storage to display real-time tenant metering data, and historical time/date stamped interval reading data (data logging of up to 10 parameters per metering device, and a minimum of 38 days of non-volatile data logging @ 15 minute intervals).
3. The Ethernet Gateway shall feature one serial communication port: RS-485 serial port, configurable for either RS-232 or RS-485 (support for 2-wire or 4-wire)
4. The Ethernet Gateway shall provide high speed Ethernet support for up-to 32 devices per daisy chain. It shall also support up to 64 devices utilizing Ethernet communications to Ethernet enabled devices or other gateways.
5. The Ethernet Gateway shall support the following protocols: Ethernet – MODBUS/TCP HTTP, FTP. Serial – MODBUS, JBUS, POWERLOGIC and SY/MAX.
6. The Ethernet Gateway shall be UL, CUL, CE, NOM, and FCC class A compliant.
7. The Ethernet Gateway shall be approved for use in hazardous environments according to UL Class 1, Division 2.
8. The Ethernet Gateway shall utilize Modbus/TCP protocol as its high-speed backbone network protocol.
9. The Ethernet Gateway shall be compliant to industrial temperature. It shall withstand an operating temperature range of -30 deg. C to +80 deg. C.
10. The Ethernet Gateway shall provide a multi-lingual user interface that includes English, French, and Spanish.
11. All Ethernet cabling shall be installed by a qualified data communications cable installer or the electrical contractor qualified to install data communications equipment. All communications cabling shall be Category 5 rated for 100 baseT.

12. Setup of the Ethernet Gateway shall be accomplished via the on-board Ethernet port and a web browser. Setup shall include configuring the on-board web pages for viewing real time data from the down stream devices and viewing trending of selected quantities from those devices to supplement the tenant metering system software. It shall also be possible via the Ethernet port to upgrade the firmware of the Ethernet Gateway in the field to accommodate new system features.
13. Control power shall be supplied by a 24 Vdc control power source or through Power over Ethernet with a maximum burden of 4 watts.

B. Additional Network Media Options

1. Ethernet shall be used where shown on the project drawings. Ethernet Gateways shall be provided by the TMS vendor and installed by System Installer where specified. Ethernet network connections shall be established using industry standard Ethernet protocols such TCP/IP. All components shall work with existing Ethernet Gateway, Router, and Hub technology. Use of Ethernet shall be transparent to TMS software and monitoring devices.

2.3 TENANT METERING SOFTWARE

To tie into existing Square D PowerLogic System.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All control power, CT, PT, RS485 and Ethernet data communications wire shall be field installed by System Installer.
- B. All wiring required to connect equipment lineups shall be installed by the System Installer.
- C. Contractor metering interconnection wiring requirements shall be clearly identified on the TMS network drawings, including standard product data sheets and typical wiring diagrams.

3.2 SYSTEM START-UP AND TRAINING

- A. On-site start-up and training of the TMS shall be included in the project bid. TMS vendor to include one-half day of on-site, hands-on orientation training for owner personnel with the fully commissioned TMS system.
- B. Start-up shall include a complete working demonstration of the TMS.
- C. Training shall include standard documentation and hands-on exercises for owners electrical operations personnel to become familiar with operation of the TMS.
- D. The project bid shall include 2 days start-up assistance to include 1 trip(s).
- E. The power monitoring manufacturer shall provide a dedicated telephone technical help center for customers.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

--- E N D ---

SECTION 26 27 26 WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation and connection of wiring devices.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.
- B. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits and outlets boxes.
- C. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.5 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

- B. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, mounting details, construction materials, grade and termination information.
- C. Manuals: Two weeks prior to final inspection, deliver four copies of the following to the Resident Engineer: Technical data sheets and information for ordering replacement units.
- D. Certifications: Two weeks prior to final inspection, submit four copies of the following to the Resident Engineer: Certification by the Contractor that the devices comply with the drawings and specifications, and have been properly installed, aligned, and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. National Fire Protection Association (NFPA):
 - 70-11National Electrical Code (NEC)
- C. National Electrical Manufacturers Association (NEMA):
 - WD 1General Color Requirements for Wiring Devices
 - WD 6Wiring Devices – Dimensional Requirements
- D. Underwriter’s Laboratories, Inc. (UL):
 - 5Surface Metal Raceways and Fittings
 - 20General-Use Snap Switches
 - 231Power Outlets
 - 467Grounding and Bonding Equipment
 - 498Attachment Plugs and Receptacles
 - 943Ground-Fault Circuit-Interrupters

PART 2 - PRODUCTS

2.1 RECEPTACLES

- A. General: All receptacles shall be listed by Underwriters Laboratories, Inc., and conform to NEMA WD 6.
 - 1. Mounting straps shall be plated steel, with break-off plaster ears and shall include a self-grounding feature. Terminal screws shall be brass, brass plated or a copper alloy metal.
 - 2. Receptacles shall have provisions for back wiring with separate metal clamp type terminals (four min.) and side wiring from four captively held binding screws.

- B. Duplex Receptacles: Hospital-grade, single phase, 20 ampere, 120 volts, 2-pole, 3-wire, and conform to the NEMA 5-20R configuration in NEMA WD 6. The duplex type shall have break-off feature for two-circuit operation. The ungrounded pole of each receptacle shall be provided with a separate terminal.
1. Bodies shall be ivory in color.
 2. Switched duplex receptacles shall be wired so that only the top receptacle is switched. The remaining receptacle shall be unswitched.
 3. Duplex Receptacles on Emergency Circuit:
 - a. In rooms without emergency powered general lighting, the emergency receptacles shall be of the self-illuminated type.
 4. Ground Fault Interrupter Duplex Receptacles: Shall be an integral unit, hospital-grade, suitable for mounting in a standard outlet box.
 - a. Ground fault interrupter shall be consist of a differential current transformer, solid state sensing circuitry and a circuit interrupter switch. Device shall have nominal sensitivity to ground leakage current of five milliamperes and shall function to interrupt the current supply for any value of ground leakage current above five milliamperes (+ or – 1 milliamp) on the load side of the device. Device shall have a minimum nominal tripping time of 1/30th of a second.
 - b. Ground Fault Interrupter Duplex Receptacles (not hospital-grade) shall be the same as ground fault interrupter hospital-grade receptacles except for the “hospital-grade” listing.
 5. Safety Type Duplex Receptacles:
 - a. Bodies shall be gray in color.
 - 1) Shall permit current to flow only while a standard plug is in the proper position in the receptacle.
 - 2) Screws exposed while the wall plates are in place shall be the tamperproof type.
 6. Duplex Receptacles (not hospital grade): Shall be the same as hospital grade duplex receptacles except for the "hospital grade" listing and as follows.
 - a. Bodies shall be brown phenolic compound supported by a plated steel mounting strap having plaster ears.
- C. Receptacles; 20, 30 and 50 ampere, 250 volts: Shall be complete with appropriate cord grip plug. Devices shall meet UL 231.

- D. Weatherproof Receptacles: Shall consist of a duplex receptacle, mounted in box with a gasketed, weatherproof, cast metal cover plate and cap over each receptacle opening. The cap shall be permanently attached to the cover plate by a spring-hinged flap. The weatherproof integrity shall not be affected when heavy duty specification or hospital grade attachment plug caps are inserted. Cover plates on outlet boxes mounted flush in the wall shall be gasketed to the wall in a watertight manner.

2.2 TOGGLE SWITCHES

- A. Toggle Switches: Shall be totally enclosed tumbler type with bodies of phenolic compound. Toggle handles shall be ivory in color unless otherwise specified. The rocker type switch is not acceptable and will not be approved.
1. Switches installed in hazardous areas shall be explosion proof type in accordance with the NEC and as shown on the drawings.
 2. Shall be single unit toggle, butt contact, quiet AC type, heavy-duty general-purpose use with an integral self grounding mounting strap with break-off plaster ears and provisions for back wiring with separate metal wiring clamps and side wiring with captively held binding screws.
 3. Ratings:
 - a. 120 volt circuits: 20 amperes at 120-277 volts AC.
 - b. 277 volt circuits: 20 amperes at 120-277 volts AC.

2.3 MANUAL DIMMING CONTROL

- A. Dimmer controls as shown on plans. Faceplates shall be ivory in color unless otherwise specified.
- B. Dimming controls shall be fully compatible with electronic dimming ballasts and approved by the ballast manufacturer, shall operate over full specified dimming range, and shall not degrade the performance or rated life of the electronic dimming ballast and lamp.

2.4 WALL PLATES

- A. Wall plates for switches and receptacles shall be type 302 stainless steel. Oversize plates are not acceptable.
- B. Color shall be ivory unless otherwise specified.
- C. Standard NEMA design, so that products of different manufacturers will be interchangeable. Dimensions for openings in wall plates shall be accordance with NEMA WD 6.
- D. For receptacles or switches mounted adjacent to each other, wall plates shall be common for each group of receptacles or switches.
- E. In psychiatric areas, wall plates shall be 302 stainless steel, have tamperproof screws and beveled edges.

- F. Wall plates for data, telephone or other communication outlets shall be as specified in the associated specification.
- G. Duplex Receptacles on Emergency Circuit:
 - 1. Bodies shall be red in color. Wall plates shall be red with the word "EMERGENCY" engraved in 6 mm, (1/4 inch) white letters.

2.5 SURFACE MULTIPLE-OUTLET ASSEMBLIES

- A. Assemblies shall conform to the requirements of NFPA 70 and UL 5.
- B. Shall have the following features:
 - 1. Enclosures:
 - a. Thickness of steel shall be not less than 0.040 steel for base and cover. Nominal dimension shall be 1-1/2 by 2-3/4 inches with inside cross sectional area not less than 3.5 square inches . The enclosures shall be thoroughly cleaned, phosphatized and painted at the factory with primer and the manufacturer's standard baked enamel or lacquer finish.
 - 2. Receptacles shall be duplex, hospital grade. See paragraph 'RECEPTACLES' in this section. Device cover plates shall be the manufacturer's standard corrosion resistant finish and shall not exceed the dimensions of the enclosure.
 - 3. Unless otherwise shown on drawings, spacing of the receptacles along the strip shall be 24 inches on centers.
 - 4. Wires within the assemblies shall be not less than No. 12 AWG copper, with 600 volt ratings.
 - 5. Installation fittings shall be designed for the strips being installed including bends, offsets, device brackets, inside couplings, wire clips, and elbows.
 - 6. Bond the strips to the conduit systems for their branch supply circuits.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC and as shown as on the drawings.
- B. Ground terminal of each receptacle shall be bonded to the outlet box with an approved green bonding jumper, and also connected to the green equipment grounding conductor.
- C. Outlet boxes for light and dimmer switches shall be mounted on the strike side of doors.
- D. Provide barriers in multigang outlet boxes to separate systems of different voltages, Normal Power and Emergency Power systems, and in compliance with the NEC.

- E. Coordinate with other work, including painting, electrical boxes and wiring installations, as necessary to interface installation of wiring devices with other work. Coordinate the electrical work with the work of other trades to ensure that wiring device flush outlets are positioned with box openings aligned with the face of the surrounding finish material. Pay special attention to installations in cabinet work, and in connection with laboratory equipment.
- F. Exact field locations of floors, walls, partitions, doors, windows, and equipment may vary from locations shown on the drawings. Prior to locating sleeves, boxes and chases for roughing-in of conduit and equipment, the Contractor shall coordinate exact field location of the above items with other trades. In addition, check for exact direction of door swings so that local switches are properly located on the strike side.
- G. Install wall switches 48 inches above floor, OFF position down.
- H. Install wall dimmers 48 inches above floor; derate ganged dimmers as instructed by manufacturer; do not use common neutral.
- I. Install convenience receptacles 18 inches above floor, and 6 inches above counter backsplash or workbenches. Install specific-use receptacles at heights shown on the drawings.
- J. Label device plates with a permanent adhesive label listing panel and circuit feeding the wiring device.
- K. Test wiring devices for damaged conductors, high circuit resistance, poor connections, inadequate fault current path, defective devices, or similar problems using a portable receptacle tester. Correct circuit conditions, remove malfunctioning units and replace with new, and retest as specified above.
- L. Test GFCI devices for tripping values specified in UL 1436 and UL 943.

3.2 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 26 29 21 DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation, and connection of low voltage disconnect switches.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES 600 VOLTS AND BELOW: Cables and wiring.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground faults.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for cables and wiring.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.5 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

B. Shop Drawings:

1. Clearly present sufficient information to determine compliance with drawings and specifications.
2. Include electrical ratings, dimensions, mounting details, materials, enclosure types, and fuse types and classes.
3. Show the specific switch and fuse proposed for each specific piece of equipment or circuit.

C. Manuals:

1. Provide complete maintenance and operating manuals for disconnect switches, including technical data sheets, wiring diagrams, and information for ordering replacement parts. Deliver four copies to the Resident Engineer two weeks prior to final inspection.
2. Terminals on wiring diagrams shall be identified to facilitate maintenance and operation.
3. Wiring diagrams shall indicate internal wiring and any interlocking.

D. Certifications: Two weeks prior to the final inspection, submit four copies of the following certifications to the Resident Engineer:

1. Certification by the manufacturer that the materials conform to the requirements of the drawings and specifications.
2. Certification by the contractor that the materials have been properly installed, connected, and tested.

1.6 APPLICABLE PUBLICATIONS

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

B. National Electrical Manufacturers Association (NEMA):

FU 1-07Low Voltage Cartridge Fuses

KS 1-06Enclosed and Miscellaneous Distribution Equipment Switches
(600 Volts Maximum)

C. National Fire Protection Association (NFPA):

70-11National Electrical Code (NEC)

D. Underwriters Laboratories, Inc. (UL):

98-04Enclosed and Dead-Front Switches

248-00Low Voltage Fuses

977-94Fused Power-Circuit Devices

PART 2 - PRODUCTS

2.1 LOW VOLTAGE FUSIBLE SWITCHES RATED 600 AMPERES AND LESS

- A. In accordance with UL 98, NEMA KS1, and NEC.
- B. Shall have NEMA classification General Duty (GD) for 240 V switches and NEMA classification Heavy Duty (HD) for 480 V switches.
- C. Shall be HP rated.
- D. Shall have the following features:
 - 1. Switch mechanism shall be the quick-make, quick-break type.
 - 2. Copper blades, visible in the OFF position.
 - 3. An arc chute for each pole.
 - 4. External operating handle shall indicate ON and OFF position and have lock-open padlocking provisions.
 - 5. Mechanical interlock shall permit opening of the door only when the switch is in the OFF position, defeatable to permit inspection.
 - 6. Fuse holders for the sizes and types of fuses specified.
 - 7. Electrically operated switches shall only be installed where shown on the drawings.
 - 8. Solid neutral for each switch being installed in a circuit which includes a neutral conductor.
 - 9. Ground lugs for each ground conductor.
 - 10. Enclosures:
 - a. Shall be the NEMA types shown on the drawings for the switches.
 - b. Where the types of switch enclosures are not shown, they shall be the NEMA types most suitable for the ambient environmental conditions. Unless otherwise indicated on the plans, all outdoor switches shall be NEMA 3R.
 - c. Shall be finished with manufacturer's standard gray baked enamel paint over pretreated steel (for the type of enclosure required).

2.2 LOW VOLTAGE UNFUSED SWITCHES RATED 600 AMPERES AND LESS

Shall be the same as Low Voltage Fusible Switches Rated 600 Amperes and Less, but without provisions for fuses.

2.3 LOW VOLTAGE FUSIBLE SWITCHES RATED OVER 600 AMPERES TO 1200 AMPERES

Shall be the same as Low Voltage Fusible Switches Rated 600 Amperes and Less, except for the minimum duty rating which shall be NEMA classification Heavy Duty (HD). These switches shall also be HP rated.

2.4 LOW VOLTAGE CARTRIDGE FUSES

- A. In accordance with NEMA FU1.
- B. Service Entrance: Class L, time delay.
- C. Feeders: Class RK5, time delay.
- D. Motor Branch Circuits: Class RK5, time delay.
- E. Other Branch Circuits: Class RK1, time delay.
- F. Control Circuits: Class CC, time delay.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install disconnect switches in accordance with the NEC and as shown on the drawings.
- B. Fusible disconnect switches shall be furnished complete with fuses. Arrange fuses such that rating information is readable without removing the fuse.

3.2 SPARE PARTS

Two weeks prior to the final inspection, furnish one complete set of spare fuses for each fusible disconnect switch installed on the project. Deliver the spare fuses to the Resident Engineer.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 26 32 13
ENGINE GENERATORS

PART 1 - GENERAL

1.1 SCOPE

- A. Provide complete factory assembled generator set equipment with digital (microprocessor-based) electronic generator set controls, digital governor, and digital voltage regulator.
- B. Provide factory test, startup by a supplier authorized by the equipment manufacturer(s), and on-site testing of the system.
- C. The generator set manufacturer shall warrant all equipment provided under this section, whether or not is manufactured by the generator set manufacturer, so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier shall service the generator sets.
- D. The generator set supplier shall be responsible for complete compliance to all specification requirements for the entire on site power supply system, including generator set(s), power switching equipment, and paralleling equipment (when used).
- E. Prototype testing, factory testing, site testing.

1.2 CODES AND STANDARDS

- A. The generator set installation and on-site testing shall conform to the requirements of the following codes and standards, as applicable. The generator set shall include necessary features to meet the requirements of these standards.
 - 1. ANSI S1.13-1971, Measurement of Sound Pressure Levels in Air
 - 2. CSA 282, 1989 Emergency Electrical Power Supply for Buildings
 - 3. IEEE446, Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
 - 4. NFPA 30, Flammable and Combustible Liquids
 - 5. NFPA 37, Standard For the Installation and Use of Stationary Combustion Engines and Gas Turbines
 - 6. NFPA 70, National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
 - 7. NFPA 99, Essential Electrical Systems for Health Care Facilities
 - 8. NFPA 110, Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit, component level type tests will not substitute for this requirement.

- B. The generator set and supplied accessories shall meet the requirements of the following standards:
 - 1. NEMA MG1-1998 part 32. Alternator shall comply with the requirements of this standard.
 - 2. UL142, Sub-base Tanks
 - 3. UL1236, Battery Chargers
 - 4. UL2200. The generator set shall be listed to UL2200 or submit to an independent third party certification process to verify compliance as installed.
- C. The control system for the generator set shall comply with the following requirements.
 - 1. CSA C22.2, No. 14 – M91 Industrial Control Equipment.
 - 2. EN50082-2, Electromagnetic Compatibility – Generic Immunity Requirements, Part 2: Industrial.
 - 3. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
 - 4. FCC Part 15, Subpart B.
 - 5. IEC8528 part 4. Control Systems for Generator Sets
- D. The generator set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 SUBMITTALS

- A. Shop drawings
 - 1. Manufacturer's product literature and performance data, sufficient to verify compliance to specification requirements.
 - 2. Outline drawings of assembly.
 - 3. One line diagrams and wiring diagrams for assembly and components.

4. Interconnection wiring diagrams showing all external connections required; with field wiring terminals marked in a consistent point-to-point manner.
5. Submit names, experience level, training certifications, and locations for technicians that will be responsible for servicing equipment at this site.
6. Manufacturer's certification of prototype testing.
7. Manufacturer's published warranty documents.

B. Product data

1. Technical data on all major components. Technical data must include an alternator thermal damage curve, description and operating characteristics of the alternator protection device demonstrating alternator protection, and an alternator reactive capability curve.
2. Certification of the emissions performance of the generator set engine by the engine manufacturer.
3. Seismic certification, demonstrating compliance to local requirements.
4. Factory sound data certifying compliance with sound attenuation requirements.

C. Project information

1. Test reports and certifications.
2. Factory test procedures.

D. Contract closeout information

1. Operating and maintenance data.

1.5 QUALIFICATIONS

- A. The generation set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.
- B. The manufacturer of this equipment shall have produced similar equipment for a minimum period of ten years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.6 REGULATORY REQUIREMENTS

- A. The generator set overcurrent protection shall be UL listed as a utility grade protective device under UL category NRGU or CSA equivalent.
- B. The generator set engine shall comply with all applicable emissions standards at the date of installation.

1.7 WARRANTY

- A. The manufacturer shall provide base warranty coverage on the material and workmanship of the generator set for a minimum of twenty-four (24) months for Standby product from registered commissioning and start-up.

- B. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, etc. shall be allowed during the minimum noted warranty period described in Paragraph A above.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Cummins
- B. Caterpillar Inc.
- C. Kohler

2.2 GENERATOR SET

- A. Ratings
 - 1. The generator set shall operate at 1800 rpm and at a voltage of: 277/480 Volts AC, Three phase, 4-wire, 60 hertz.
 - 2. The complete generator set shall be rated per ISO8528 as indicated on the drawings 0.8 PF, Standby rating, based on site conditions of: Altitude 4850 feet, ambient temperatures of 40 degrees C (104 degrees F), based on temperature measured at the control for indoor installations, and measured at the air inlet closest to the alternator for outdoor equipment.
 - 3. The generator set rating shall be based on emergency/standby service and marked as such per NFPA110.
- B. Performance
 - 1. Voltage regulation shall not exceed one percent for any constant load between no load and rated load for both parallel and non-parallel applications. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 0.5 percent.
 - 2. Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.25%.
 - 3. Generator sets shall be designed to allow operation at full rated load in an ambient temperature under site conditions, based on highest ambient condition. Ambient temperature shall be as measured at the air inlet to the generator set for enclosed generator sets, and at the control of the generator set for machines installed in equipment rooms.
 - 4. The engine-generator set shall be capable of single step load pick up of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature.

5. Motor starting capability shall be a minimum of 1210 kVA. The generator set shall be capable of sustaining a minimum of 90% of rated no load voltage with the specified kVA load at near zero power factor applied to the generator set.
6. The alternator shall produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic, and no 3rd order harmonics or their multiples.
7. The generator set shall be certified by the engine manufacturer to be suitable for use at the installed location and rating, and shall meet all applicable exhaust emission requirements at the time of commissioning.
8. The generator set and complete sound attenuated enclosure sound levels shall be tested by the manufacturer per ANSI S1.13. Data documenting performance shall be provided with submittal documentation.

C. Construction

1. The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails.
2. All switches, lamps, and meters in the control system shall be oil-tight and dust-tight. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts.
3. All outdoor equipment shall be enclosed with corrosion-protected materials. Steel components used in enclosures shall be powder coated and baked, and shall provide fade and corrosion resistance.

D. Connections

1. The generator set load connections shall be composed of silver or tin plated copper bus bars, drilled to accept mechanical or compression terminations of the number and type as shown on the drawings. Sufficient lug space shall be provided for use with cables of the number and size as shown on the drawings. Generator set feeder distribution shall be wall mounted and compliant to code requirements for conductor sizing, isolation of devices, and isolation of service types.
2. Power connections to auxiliary devices shall be made at the devices, with required protection located at a wall-mounted common distribution panel.
3. Generator set control interfaces to other system components shall be made on a common, permanently labeled terminal block assembly.

2.3 ENGINE AND ENGINE EQUIPMENT

- A. The engine shall be diesel, 4 cycle, radiator and fan cooled. Minimum displacement shall be 9 liters, with 6 cylinders. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. Two cycle engines are not acceptable.
- B. An electronic governor system shall provide automatic isochronous frequency regulation. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous or parallel states.
- C. Skid-mounted radiator and cooling system rated for full load operation in the ambient temperature called out in this specification as measured at the generator air inlet, based on 0.5 in H₂O external static head. Radiator shall be sized based on a core temperature which is 10C higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/fan operation in a controlled environment. Radiator shall be provided with a duct adapter flange. The cooling system shall be filled with a 50/50-ethylene glycol/water mixture by the equipment manufacturer. Rotating parts shall be guarded against accidental contact.
- D. Electric starters capable of three complete cranking cycles without overheating.
- E. Positive displacement, mechanical, full pressure, lubrication oil pump.
- F. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator.
- G. Diesel engines shall include an engine driven, mechanical, positive displacement fuel pump and fuel filter(s) with replaceable spin-on canister element(s). Fuel cooler, suitable for operation of the generator set at full rated load in the ambient temperature specified shall be provided if required for operation due to the design of the engine and the installation.
- H. Replaceable dry element air cleaner with restriction indicator.
- I. Flexible supply and return fuel lines.
- J. Engine mounted battery charging alternator, 40-ampere minimum, and solid-state voltage regulator.

K. Coolant Heater

1. Engine mounted, thermostatically controlled, coolant heater(s) for each engine. Heater voltage shall be as shown on the project drawings. The coolant heater shall be UL499 listed and labeled.
2. The coolant heater shall be installed on the engine with SAEJ20 compliant materials. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches. The coolant heater installation shall be specifically designed to provide proper venting of the system. The coolant heaters shall be installed using isolation valves to isolate the heater for replacement of the heater element. The design shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.
3. The coolant heater shall be provided with a 24VDC thermostat, installed at the engine thermostat housing. An AC power connection shall be provided for a single AC power connection to the coolant heater system.
4. The coolant heater(s) shall be sized as recommended by the engine manufacturer to warm the engine to a minimum of 40C in a 15C ambient, as a minimum, or the temperature required for starting and load pickup requirements of this specification.

L. Provide vibration isolators, spring/pad type, quantity as recommended by the generator set manufacturer. Isolators shall include seismic restraints if required by site location.

M. Starting and Control Batteries shall be lead acid type, 24 volt DC, sized as recommended by the engine manufacturer for compliance to NFPA110 starting requirements, complete with battery cables and connectors.

N. Provide exhaust silencer(s) for each engine of size and type as recommended by the generator set manufacturer and approved by the engine manufacturer to meet sound attenuation requirements of the application. Exhaust system shall be installed according to the engine manufacturer's recommendations and applicable codes and standards.

O. Provide a fully regulated, constant voltage, current limited, battery charger for each battery bank. The chargers shall be designed for heavy-duty industrial service, primarily to quickly recharge and maintain batteries that start internal combustion engines. Charger shall be rated a minimum of 10 amps, and be capable of operating in parallel with another like charger for reliability and added charging capacity.

1. Charger shall provide 4 distinct charge states: "dead battery", "bulk charge", "absorption", and "float". Charge rate shall be temperature compensated to provide proper charging in ambient conditions from -20 to +55C.

2. Provider LED indication of general charger condition, including charging, fault, and equalize. Provide a 2 line LCD display to indicate charge rate, battery voltage, faults, and provide for charger set up. Charger shall provide relay contacts for fault conditions as required by NFPA110.
 3. The charger shall operate properly during fault conditions, including battery disconnection while charging, reversed battery polarity connections, and shorted battery.
 4. The charger shall be compliant to the same RFI/EMI and voltage surge performance as are specified for the genset control.
- P. Provide and install a 20-light LED type remote alarm annunciator with horn, located as shown on the drawings or in a location that can be conveniently monitored by facility personnel. The remote annunciator shall provide all the audible and visual alarms called for by NFPA Standard 110 for level 1 systems; and in addition shall provide indications for high battery voltage, low battery voltage, loss of normal power to the charger. Spare lamps shall be provided to allow future addition of other alarm and status functions to the annunciator. Provisions for labeling of the annunciator in a fashion consistent with the specified functions shall be provided. Alarm silence and lamp test switch(es) shall be provided. LED lamps shall be replaceable, and indicating lamp color shall be capable of changes needed for specific application requirements. Alarm horn shall be switchable for all annunciation points. Alarm horn (when switched on) shall sound for first fault, and all subsequent faults, regardless of whether first fault has been cleared, in compliance with NFPA110 3-5.6.2.
- Q. Provide a UL or CSA listed sub-base fuel tank suitable for full load operation of the generator set for up to 24 hours and complying to local requirements.

2.4 LOW VOLTAGE AC ALTERNATOR

- A. The AC alternator shall be; synchronous, four pole, 2/3 pitch, brushless, revolving field, drip-proof construction, single prelubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc. The alternator design shall prevent shaft current from flowing and eliminate the need for insulated bearings. All insulation system components shall meet NEMA MG1 requirements for Class H insulation systems. Actual temperature rise measured by resistance method at full load shall not exceed **105C** in a 40C ambient. Alternator shall be provided with protection to prevent damage due to any external fault or overload condition, including short circuit, ground fault, or overload.
- B. The alternator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage up to 5 percent above or below rated voltage.

- C. The alternator shall be supplied with a dedicated, independent power source for the voltage regulation system, which provides sufficient excitation for the alternator to supply 300% of rated output current for 10 seconds.

2.5 GENERATOR SET CONTROL AND PROTECTION

- A. The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, protection and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.
- B. The control shall be mounted on the generator set. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.
- C. Control Switches
 - 1. Mode Select Switch. When in the RUN or Manual position the generator set shall start, and accelerate to rated speed and voltage as directed by the operator. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
 - 2. EMERGENCY STOP switch. Switch shall be Red "mushroom-head" push-button. Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting. The switch shall include a lockout provision for use in safely disabling the generator set for necessary service.
 - 3. RESET switch. The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
 - 4. PANEL LAMP switch. Operating the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is operated, or after the switch is operated a second time.
 - 5. Voltage and Frequency Adjustment. The genset mounted control shall include digital raise/lower switches for adjustment of voltage and frequency.

D. Generator Set AC Output Metering

1. The generator set shall be provided with a metering set including the following features and functions:
 - a. Analog voltmeter, ammeter, frequency meter, and kilowatt (KW) meter. Voltmeter and ammeter shall display all three phases. Ammeter and KW meter scales shall be color coded in the following fashion: readings from 0-90% of generator set standby rating: green; readings from 90-100% of standby rating: amber; readings in excess of 100%: red.
 - b. Digital metering set, 0.5% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three phase voltages (line to neutral or line to line) simultaneously.

E. Generator Set Alarm and Status Display

1. The generator set shall be provided with alarm and status indicating lamps to indicate non-automatic generator status, and existing warning and shutdown conditions. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of all alarm, shutdown, and status conditions associated with the generator set, including all paralleling control functions and the engine ECM on an alphanumeric display on the genset. The following alarm, shutdown, and status conditions are required, as a minimum:
 - a. low oil pressure (alarm)
 - b. low oil pressure (shutdown)
 - c. oil pressure sender failure (alarm)
 - d. low coolant temperature (alarm)
 - e. high coolant temperature (alarm)
 - f. high coolant temperature (shutdown)
 - g. engine temperature sender failure (alarm)
 - h. low coolant level (alarm or shutdown--selectable)
 - i. fail to crank (shutdown)
 - j. fail to start/overcrank (shutdown)
 - k. overspeed (shutdown)
 - l. low DC voltage (alarm)
 - m. high DC voltage (alarm)
 - n. weak battery (alarm)
 - o. low fuel (alarm)

- p. high AC voltage (shutdown)
 - q. low AC voltage (shutdown)
 - r. under frequency (shutdown)
 - s. over current (warning)
 - t. over current (shutdown)
 - u. short circuit (shutdown)
 - v. over load (alarm)
 - w. emergency stop (shutdown)
2. The generator set control shall annunciate all alarm and shutdown conditions from the engine electronic control.
 3. Provisions shall be made for indication of four customer-specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above specified conditions. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

F. Engine Status Monitoring

1. The following information shall be available from a digital status panel on the generator set control:
 - a. engine oil pressure (psi or kPA)
 - b. engine coolant temperature (degrees F or C)
 - c. engine oil temperature (degrees F or C)
 - d. engine speed (rpm)
 - e. number of hours of operation (hours)
 - f. number of start attempts
 - g. battery voltage (DC volts)
2. The control system shall also incorporate a data logging and display provision to allow logging of a minimum of the last 20 warning or shutdown indications on the generator set, the time of the last fault of each type, and the number of faults of each type, and total time of operation at various loads as a percent of the standby rating of the generator set.

G. Engine Control Functions

1. The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and number of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15-second rest period between cranking periods.

2. The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.
3. The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.
4. The control system shall include sender failure monitoring logic for oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.

H. Alternator Control Functions

1. The generator set shall include a full wave rectified automatic digital voltage regulation system that is matched and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from misoperation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase line to neutral RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below an adjustable frequency threshold. Torque matching characteristic shall be adjustable for roll-off frequency and rate, and be capable of being curve-matched to the engine torque curve with adjustments in the field. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level. Rotary potentiometers for system adjustments are not acceptable.
2. Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds.
3. Controls shall be provided to individually monitor all three phases of the output current for 1, 2, or 3-phase short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown).

4. Controls shall be provided to monitor the KW load on the generator set, and initiate an alarm condition (over load) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.
 5. An AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.
 6. A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 16VDC or more than 32 VDC (24VDC nominal) or less than 8VDC or more than 16 VDC (12VDC nominal). During engine cranking (starter engaged), the low voltage limit shall be disabled, and if DC voltage drops to less than 14.4 volts for more than two seconds a "weak battery" alarm shall be initiated.
- I. The generator set shall be provided with a network communication module to allow real time communication with the generator set control by remote devices. The control shall communicate all engine and alternator data; alarm, shutdown and status conditions; and allow starting and stopping of the generator set via the network in both test and emergency modes.
 - J. Control Interfaces for Remote Monitoring
 1. No field connections for control devices shall be made in the AC power output enclosure.
 2. Form "C" dry contact set rated 2A @ 30VDC to indicate existence of any alarm or shutdown condition on the generator set.
 3. One set of contacts rated 2A @ 30VDC to indicate generator set is ready to load. The contacts shall operate when voltage and frequency are greater than 90% of rated condition.
 4. A fused 10 amp switched 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.
 5. A fused 20 amp 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.
 6. The control shall be provided with a direct serial communication link for the communication network interface. Data shall be compatible with VA remote monitoring requirements.

2.6 SOUND ATTENUATED ENCLOSURE

- A. The generator set shall be provided with an outdoor enclosure. The package shall comply with the requirements of the National Electrical Code for all wiring materials and component spacing. The total assembly of generator set, enclosure, and sub-base fuel tank shall be designed to be lifted into place using spreader bars.
1. The enclosure shall reduce the sound level of the generator set while operating at full rated load to a maximum of 71dBA at any location 7 meters from the generator set in a free field environment. A factory analysis of sound data shall be required during submittal.
 2. Enclosure shall provide ample airflow for generator set operation at rated load in an ambient temperature of 100°F. The enclosure shall have hinged access doors as required to maintain easy access for all operating and service functions. All doors shall be lockable, and include retainers to hold the door open during service. Enclosure roof shall be designed to prevent rainwater accumulation. Openings shall be screened to limit access of rodents into the enclosure. All electrical power and control interconnections shall be made within the perimeter of the enclosure.
 3. All sheet metal shall be primed for corrosion protection and finish painted with the manufacturer's standard color using a powder coat paint process, or equal meeting the performance requirements specified below. All surfaces of all metal parts shall be primed and painted.
 4. Enclosure material shall be either steel or aluminum. Steel enclosure shall be constructed of minimum 12 gauge steel for framework and 14 gauge steel for panels. All enclosure hardware and hinges shall be stainless steel.
 5. A factory-mounted exhaust silencer shall be installed inside the enclosure, and insulated as necessary to allow generator set to operate at rated load in the maximum specified ambient temperature. Exhaust connections to the generator set shall be through seamless flexible connections.
 6. The enclosure shall include the following maintenance provisions:
 - a. Flexible coolant and lubricating oil drain lines, that extend to the exterior of the enclosure, with internal drain valves
 - b. External radiator fill provision.
 - c. Inlet ducts shall include rain hoods.

- d. Provide a mounted and wired electrical distribution panel to serve the generator set and enclosure. The provisions required include:
 - 1) 100-amp distribution panelboard connected to a 120/208VAC utility service by the installer.
 - 2) Two duplex GFI receptacles, one inside the enclosure, and a weatherproof receptacle on the outside of the enclosure.
 - 3) Two three-way switches controlling AC lamps mounted in vapor tight and gasketed fixtures.
 - 4) Normal AC service from the panelboard to the engine coolant and alternator heaters, and battery charger.

PART 3 - OTHER REQUIREMENTS

3.1 FACTORY TESTING

- A. The generator set manufacturer shall perform a complete operational test on the generator set prior to shipping from the factory. A certified test report shall be provided. All testing shall be performed with calibrated metering.
- B. Generator set factory tests on the equipment shall be performed at rated load and rated power factor, as well as 1.0 power factor. Generator sets that have not been factory tested at rated power factor will not be acceptable. Tests shall include: run at full load, maximum power, voltage regulation, transient and steady-state governing, single step load pickup, and function of safety shutdowns.
- C. A certified test report shall be provided documenting the results of these tests.

3.2 INSTALLATION

- A. Equipment shall be installed by the contractor in accordance with final submittals and contract documents. Installation shall comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions included in the listing or labeling of UL listed products.
- B. Installation of equipment shall include furnishing and installing all interconnecting wiring between all major equipment provided for the on-site power system. The contractor shall also perform interconnecting wiring between equipment sections (when required), under the supervision of the equipment supplier.
- C. Equipment shall be installed on concrete housekeeping pads. Equipment shall be permanently fastened to the pad in accordance with manufacturer's instructions and seismic requirements of the site.

- D. Equipment shall be initially started and operated by representatives of the manufacturer. All protective settings shall be adjusted as instructed by the consulting Engineer.
- E. All equipment shall be physically inspected for damage. Scratches and other installation damage shall be repaired prior to final system testing. Equipment shall be thoroughly cleaned to remove all dirt and construction debris prior to initial operation and final testing of the system.
- F. On completion of the installation by the electrical contractor, the generator set supplier shall conduct a site evaluation to verify that the equipment is installed per manufacturer's recommended practice.

3.3 ON-SITE ACCEPTANCE TEST

- A. The complete installation shall be tested to verify compliance with the performance requirements of this specification following completion of all site work. Testing shall be conducted by representatives of the manufacturer, with required fuel supplied by Contractor. The Engineer shall be notified in advance and shall have the option to witness the tests. The generator set manufacturer shall provide a site test specification covering the entire system. Tests shall include:
 - B. Prior to start of active testing, all field connections for wiring, power conductors, and bus bar connections shall be checked for proper tightening torque.
 - C. Installation acceptance tests to be conducted on-site shall include a "cold start" test, a two hour full load (resistive) test, and a one step rated load pickup test in accordance with NFPA 110. Provide a resistive load bank and make temporary connections for full load test, if necessary.
 - D. Perform a power failure test on the entire installed system. This test shall be conducted by opening the power supply from the utility service, and observing proper operation of the system for at least 2 hours. Coordinate timing and obtain approval for start of test with site personnel.

3.4 TRAINING

- A. The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided. The training program shall be not less than 4 hours in duration and the class size shall be limited to 5 persons. Training date shall be coordinated with the facility owner.

3.5 SERVICE AND SUPPORT

- A. The generator set supplier shall maintain service parts inventory for the entire power system at a central location which is accessible to the service location 24 hours per day, 365 days per year. The inventory shall have a commercial value of \$3 million or more. The manufacturer of the generator set shall maintain a central parts inventory to support the supplier, covering all the major components of the power system, including engines, alternators, control systems, paralleling electronics, and power transfer equipment.
- B. The generator set shall be serviced by a local service organization that is trained and factory certified in generator set service. The supplier shall maintain an inventory of critical power system replacement parts in the local service location. Service vehicles shall be stocked with critical replacement parts. The service organization shall be on call 24 hours per day, 365 days per year. The service organization shall be physically located within 15 miles of the site.
- C. The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.

3.6 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 26 36 23
AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes transfer switches rated 600 V and less, including the following:
 - 1. Automatic transfer switches
 - 2. Bypass/isolation switches
 - 3. Remote annunciation systems
 - 4. Remote annunciation and control systems
- B. Related Sections include the following:
 - 1. Section 26 32 13, Engine Generator.
 - 2. Section 26 00 00, Requirements for Electrical Installations.
 - 3. Section 26 05 26, Grounding and Bonding for Electrical Systems.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
 - 1. Technical data on all major components of all transfer switches and other products described in this section. Data is required for the transfer switch mechanism, control system, cabinet, and protective devices specifically listed for use with each transfer switch. Include steady state and fault current ratings, weights, operating characteristics, and furnished specialties and accessories.

2. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
1. Dimensioned outline drawings of assembly, including elevations, sections, and details including minimal clearances, conductor entry provisions, gutter space, installed features and devices and material lists for each switch specified.
 2. Internal electrical wiring and control drawings.
 3. Interconnection wiring diagrams, showing recommended conduit runs and point-to-point terminal connections to generator set.
 4. Installation and mounting instructions, including information for proper installation of equipment to meet seismic requirements.
- C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- D. Manufacturer and Supplier Qualification Data
1. The transfer switch manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.
 2. The manufacturer of this equipment shall have produced similar equipment for a minimum period of 10 years. When requested, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- E. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.
1. Features and operating sequences, both automatic and manual.
 2. List of all factory settings of relays, timers and protective devices; provide setting and calibration instructions where applicable.
- F. Warranty documents demonstrating compliance with the project's contract requirements.

1.5 QUALITY ASSURANCE

- A. Only approved bidders shall supply equipment provided under this contract.

- B. **Manufacturer Qualifications:** The equipment supplier shall maintain a service center capable of providing training, parts, maintenance and emergency repairs to equipment, including transfer switch generator sets and remote monitoring equipment at the site within a response period of less than eight hours from time of notification.
1. The transfer switch shall be serviced by technicians employed by, and specially trained and certified by, the generator set supplier and the supplier shall have a service organization that is factory-certified in both generator set and transfer switch service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.
 2. Submit names, experience level, training certifications, and locations for technicians that will be responsible for servicing equipment at this site.
 3. The manufacturer shall maintain model and serial number records of each transfer switch provided for at least 20 years.
- C. **Source Limitations:** All transfer switches are to be obtained through one source from a single manufacturer. The generator set manufacturer shall warrant transfer switches to provide a single source of responsibility for products provided.
- D. **Electrical Components, Devices, and Accessories:** Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked as suitable for use in emergency, legally required or optional standby use as appropriate for the connected load.
- E. The automatic transfer switch installation and application shall conform to the requirements of the following codes and standards:
1. Transfer switches and enclosures shall be UL 1008 listed and labeled as suitable for use in emergency, legally required, and optional standby applications.
 2. CSA 282, Emergency Electrical Power Supply for Buildings, and CSA C22.2, No. 14-M91 Industrial Control Equipment
 3. NFPA 70, National Electrical Code. Equipment shall be suitable for use in systems in compliance with Articles 700, 701 and 702.
 4. Comply with NEMA ICS 10-1993 AC Automatic Transfer Switches
 5. IBC 2006 – The transfer switches shall be prototype-tested and third-party certified to comply with the requirements of IBC group III or IV, Category D/F. The equipment shall be shipped with the installation instructions necessary to attain installation compliance

6. IEEE 446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
 7. EN55011, Class B Radiated Emissions and Class B Conducted Emissions
 8. IEC 1000-4-5 (EN 61000-4-5); AC Surge Immunity
 9. IEC 1000-4-4 (EN 61000-4-4) Fast Transients Immunity
 10. IEC 1000-4-2 (EN 61000-4-2) Electrostatic Discharge Immunity
 11. IEC 1000-4-3 (EN 61000-4-3) Radiated Field Immunity
 12. IEC 1000-4-6 Conducted Field Immunity
 13. IEC 1000-4-11 Voltage Dip Immunity
 14. IEEE 62.41, AC Voltage Surge Immunity
 15. IEEE 62.45, AC Voltage Surge Testing
- F. Comply with NFPA 99 – Essential Electrical Systems for Healthcare Facilities
- G. Comply with NFPA 110 – Emergency and Standby Power Systems. The transfer switch shall meet all requirements for Level 1 systems, regardless of the actual circuit level.
- H. The manufacturer shall warrant the material and workmanship of the transfer switch equipment for a minimum of one (1) year from registered commissioning and start-up, or eighteen (18) months from date of shipment.
- I. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, and etc. during the minimum noted warranty period described above.

1.6 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:
1. Notify Owner no fewer than 30 days in advance of proposed interruption of electrical service.
 2. Do not proceed with interruption of electrical service without Owners written permission.
 3. Do not energize any new service or distribution equipment without notification and permission of the Owner.

1.7 COORDINATION

- A. Size and location of concrete bases and anchor bolt inserts shall be coordinated. Concrete, reinforcement and formwork must meet the requirements specified in Division 03. See Section 3.1 for additional information on installation.
- B. If Project calls for bypass switches mounted on a concrete base, the base must be designed to accommodate the requirements of the drawout mechanism (extension rails and/or wheeled carriage) of the bypass switch.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cummins Power Generation
 - 2. ASCO Power Technologies
 - 3. Culter-Hammer
 - 4. Kohler
 - 5. Russelectric
- B. Equipment specifications for this Project are based on automatic transfer switches manufactured by Cummins Power Generation. Transfer switches utilizing molded case circuit breakers do not meet the requirements of this specification will not be accepted.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Provide transfer switches in the number and ratings that are shown on the drawings. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer.
- B. Fault-Current Closing and Withstand Ratings: UL 1008 WCR ratings must be specifically listed as meeting the requirements for use with protective devices at installation locations, under specified fault conditions. Withstand and closing ratings shall be based on use of the same set of contacts for the withstand test and the closing test.
- C. Solid-State Controls: All settings should be accurate to +/- 2% or better over an operating temperature range of - 40 to + 60 degrees C (- 40 to + 140 degrees F).
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplished by a non-fused, momentarily energized solenoid or electric motor operator mechanism, mechanically and electrically interlocked in both directions (except that mechanical interlock is not required for closed transition switches).
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
 - 1. Switches using molded-case switches or circuit breakers, or insulated case circuit breaker components are not acceptable.
 - 2. Transfer switches shall be double-throw, electrically and mechanically interlocked, and mechanically held in the Source 1 and Source 2 positions.

3. Main switch contacts shall be high-pressure silver alloy. Contact assemblies shall have arc chutes for positive arc extinguishing. Arc chutes shall have insulating covers to prevent inter-phase flashover.
 4. Contacts shall be operated by a high-speed electrical mechanism that causes contacts to open or close within three electrical cycles from signal.
 5. The transfer switch operation shall include the ability to switch to an open position (both sources disconnected) for the purpose of load shedding from the generator set.
 6. The power transfer mechanism shall include provisions for manual operation under load with the enclosure door closed. Manual operation may be electromechanical or mechanical, but must be coordinated with control function.
 7. Transfer switch shall be provided with flame retardant transparent covers to allow viewing of switch contact operation but prevent direct contact with components that could be operating at line voltage levels.
 8. The transfer switch shall include the mechanical and control provisions necessary to allow the device to be field-configured for operating speed. Transfer switch operation with motor loads shall be as is recommended in NEMA MG1.
 - a. Phase angle monitoring/timing equipment is not an acceptable substitute for this functionality.
 9. Transfer switches designated on the drawings as “4-pole” shall be provided with a switched neutral pole switched which is switched simultaneously with phase poles.
 10. Transfer switches designated on the drawings as “isolation-bypass” switches shall meet the requirements of section 2.4 of this specification.
- G. Control: Transfer switch control shall be capable of communicating with the genset control, other switches and remote programming devices over a high-speed network interface.
- H. Factory wiring: Transfer switch internal wiring shall be composed of pre-manufactured harnesses that are permanently marked for source and destination. Harnesses shall be connected to the control system by means of locking disconnect plug(s), to allow the control system to be easily disconnected and serviced without disconnecting power from the transfer switch mechanism
- I. Terminals: Terminals shall be pressure type and appropriate for all field wiring. Terminal arrangement and cabinet space must be such that feeder conductors can enter from the top, side or bottom of the switch, at the installer’s discretion. Control wiring shall be equipped with suitable lugs, for connection to terminal strips.

- J. Enclosures: All enclosures shall be third-party certified for compliance to NEMA ICS 6 and UL 508, unless otherwise indicated:
1. The enclosure shall provide wire bend space in compliance to the latest version of NFPA70, regardless of the direction from which the conduit enters the enclosure.
 2. Exterior cabinet doors shall provide complete protection for the system's internal components. Doors must have permanently mounted key-type latches. Bolted covers or doors are not acceptable.
 3. Transfer switches shall be provided in enclosures that are third party certified for their intended environment per NEMA requirements.
 - a. Transfer switches mounted in a controlled indoor environment shall be provided in NEMA Type 1 enclosures (IEC type IP30).
 - b. Transfer switches installed indoors shall be NEMA Type 12 (IEC type IP61) if the Project environment requires dust-proof and/or drip-proof equipment.
 - c. Transfer switches located outdoors shall be supplied in NEMA Type 3R (IEC IP34) when dust-proof and/or rain-proof enclosures are required.
 - d. Transfer switches that are installed outdoors or in any other uncontrolled environment shall be supplied with NEMA Type 4 or 4X (stainless steel) enclosures (IEC IP65).

2.3 AUTOMATIC TRANSFER SWITCHES

- A. Comply with requirements for Level 1 equipment according to NFPA 110.
- B. Indicated current ratings:
1. Refer to the Project drawings for specifications on the sizes and types of transfer switch equipment, withstand and closing ratings, number of poles, voltage and ampere ratings, enclosure type, and accessories.
 2. Main contacts shall be rated for 600 VAC minimum.
 3. Transfer switches shall be rated to carry 100% of rated current continuously in the enclosure supplied, in ambient temperatures of -40 to +60 degrees C (-40 to +140 degrees F), relative humidity up to 95% (non-condensing), and altitudes up to 10,000 feet (3000 meters).
- C. Manual Switch Operation: The power transfer mechanism shall include provisions for manual operation under load with the enclosure door closed. Manual operation may be electromechanical or mechanical, but must be coordinated with control function
- D. Relay Signal: Control shall include provisions for addition of a pre-transfer relay signal, adjustable from 0 to 60 seconds, to be provided if necessary for elevator operation, based on equipment provided for the project.

- E. Control: Transfer switch control shall be provided with necessary equipment and software to communicate with the genset control, other transfer switches, remote annunciation equipment, and other devices over a high speed control network.
- F. Neutral Switching: Transfer switches designated on the drawings as 4-pole shall be provided with a switched neutral pole. The neutral pole shall be of the same construction and have the same ratings as the phase poles. All poles shall be switched simultaneously using a common crossbar. Substitute equipment using overlapping neutral contacts is not acceptable.
- G. Transfer switches that are designated on the drawings as 3-pole shall be provided with a neutral bus and lugs. The neutral bus shall be sized to carry 100% of the current designated on the switch rating.
- H. Automatic Transfer Switch Control Features
 - 1. The transfer switch control system shall be configurable in the field for any operating voltage level up to 600 VAC. Voltage sensing shall be monitored based on the normal voltage at the site. Systems that utilize voltage monitoring based on standard voltage conditions that are not field configurable are not acceptable.
 - 2. All transfer switch sensing shall be configurable from an operator panel or from a Windows XP or later PC-based service tool. Designs utilizing DIP switches or other electromechanical devices are not acceptable.
 - 3. The transfer switch shall be configurable to accept a relay contact signal and a network signal from an external device for load shedding purposes. On receipt of this signal, the transfer switch shall switch to a neutral position when connected to Source 2. If Source 1 is available when the load-shed signal is received, the transfer switch shall connect to Source 1.
 - 4. The transfer switch shall be configurable to accept a relay contact signal and a network signal from an external device to prevent transfer to the generator service.
 - 5. The transfer switch shall provide a relay contact signal prior to transfer or re-transfer. The time period before and after transfer shall be adjustable in a range of 0 to 50 seconds.
 - 6. The control system shall be designed and prototype tested for operation in ambient temperatures from - 40 degrees C to + 60 degrees C (- 40 to +140 degrees F). It shall be designed and tested to comply with the requirements of the noted voltage and RFI/EMI standards.
 - 7. The control shall have optically isolated logic inputs, high isolation transformers for AC inputs and relays on all outputs, to provide optimum protection from line voltage surges, RFI and EMI.

8. The transfer switch network monitoring equipment, when supplied, shall be provided with a battery-based auxiliary power supply to allow monitoring of the transfer switch when both AC power sources are non-operational. The battery power supply shall be monitored for proper condition, and the transfer switch shall include an alarm condition to indicate low battery condition.
- I. Transfer Switch Control Panel: The transfer switch shall have a microprocessor-based control with a sealed membrane panel incorporating pushbuttons for operator-controlled functions, and LED lamps for system status indicators. The panel shall also include an alphanumeric display for detailed system information. Panel display and indicating lamps shall include permanent labels.
 1. The indicator panel LEDs shall display:
 - a. Which source the load is connected to (Source 1 or Source 2)
 - b. Which source or sources are available
 - c. When switch is not set for automatic operation, because the control is disabled or the bypass switch is in use
 - d. When the switch is in test/exercise mode
 2. The indicator shall have pushbuttons that allow the operator to activate the following functions:
 - a. Activate pre-programmed test sequence
 - b. Override programmed delays, and immediately go to the next operation
 - c. Reset the control by clearing any faults
 - d. Test all of the LEDs by lighting them simultaneously
 3. The alphanumeric digital display shall be vacuum fluorescent-type, clearly visible in both bright sunlight and no-light conditions over an angle of 120 degrees, and shall display the following:
 - a. AC voltage for all phases, normal and emergency
 - b. Source status: connected or not connected
 - c. Load data, including voltage, AC current, frequency, KW, KVA, and power factor.
 4. The display panel shall be password-protected, and allow the operator to view and make adjustments:
 - a. Set nominal voltage and frequency for the transfer switch
 - b. Adjust voltage and frequency sensor operation set points
 - c. Set up time clock functions
 - d. Set up load sequence functions
 - e. Enable or disable control functions including program transition

- f. View real-time clock data, operation log (hours connected, times transferred, failures) and service history
- J. Control Functions: Functions managed by the control shall include:
 - 1. Software adjustable time delays:
 - a. Engine start (prevents nuisance genset starts in the event of momentary power fluctuation): 0 to 120 seconds (default 3 sec)
 - b. Transfer normal to emergency (allows genset to stabilize before load is transferred): 0 to 120 seconds (default 3 sec)
 - c. Re-transfer emergency to normal (allows utility to stabilize before load is transferred from genset): 0 to 30 minutes (default 3 sec)
 - d. Engine cooldown: 0 to 30 minutes (default 10 min)
 - e. Programmed transition: 0 to 60 seconds (default 3 sec)
 - 2. Undervoltage sensing: three-phase normal, three-phase emergency source.
 - a. Pickup: 85 to 98% of nominal voltage (default 90%)
 - b. Dropout: 75 to 98% of nominal voltage (default 90%)
 - c. Dropout time delay: 0.1 to 1.0 seconds (default 0.5 sec)
 - d. Accurate to within +/- 1% of nominal voltage
 - 3. Over-voltage sensing: three-phase normal, three-phase emergency source.
 - a. Pickup: 95 to 99% of dropout setting (default 95%)
 - b. Dropout: 105 to 135% of nominal voltage (default 110%)
 - c. Dropout time delay: 0.5 to 120 seconds (default 3 sec)
 - d. Accurate to within +/- 1% of nominal voltage
 - 4. Over/under frequency sensing:
 - a. Pickup: +/- 5 to +/-20% of nominal frequency (default 10%)
 - b. Dropout: +/-1% beyond pickup (default 1%)
 - c. Dropout time delay: 0.1 to 15.0 seconds (default 5 sec)
 - d. Accurate to within +/- 0.2%
 - 5. Voltage imbalance sensing:
 - a. Dropout: 2 to 10% (default 4%)
 - b. Pickup: 90% of dropout
 - c. Time delay: 2.0 to 20 seconds (default 5 sec)
 - 6. Phase rotation sensing:
 - a. Time delay: 100 msec

7. Loss of single-phase detection:

- a. Time delay: 100 msec

K. Control features shall include:

1. Programmable genset exerciser: A field-programmable control shall periodically start the generator, transfer the load to generator for a preset time, then re-transfer and shut down the generator after a preset cool-down period.
 - a. Push-button programming control shall have a selection of eight different schedules for exercising generator, with or without load.
2. In event of a loss of power to the control, all control settings, real-time clock setting and the engine start-time delay setting will be retained.
3. The system continuously logs information including the number of hours each source has been connected to the load, the number of times transferred, and the total number of times each source has failed. An event recorder stores information, including time and date-stamp, for up to 50 events.
4. Transfer Override Switch: Overrides automatic re-transfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light to indicate override status.

L. Control Interface

1. Provide one set Form C auxiliary contacts on both sides, operated by transfer switch position, rated 10 amps 250 VAC.
2. The transfer switch shall be provided with a network communication card, and configured to allow network-based communication with the transfer switch and other network system components, including the generator set(s) provided for the Project.
3. Unassigned Auxiliary Contacts: Two normally open, 1-pole, double-throw contacts for each switch position, rated 10A at 240 VAC.

M. Engine Starting Contacts

1. One isolated and normally closed, and one isolated and normally open; rated 10A at 32 VDC minimum.

2.4 BYPASS/ISOLATION SWITCHES

- A. Comply with requirements for Level 1 equipment according to NFPA 110.

- B. Description: Transfer switches that are designated on the drawings as “bypass isolation” transfer switches shall be provided with a manually-operated bypass switch arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
1. The bypass switch shall be enclosed in the same cabinet as the automatic transfer switch, and UL-listed as an assembled product.
 2. The bypass-isolation switch shall provide a means for manually bypassing the transfer switch from either source (Normal or Emergency) to the load, while under load if necessary, and to isolate the transfer switch from both sources for maintenance or repair without a power interruption or disturbance.
 - a. The design shall allow connection to the alternate source with a power interruption of at least 0.5 seconds.
 - b. Designs that bypass to only one source are not acceptable under this specification.
 3. The bypass switch shall be operable without the use of tools, and shall include the ability to remove the automatic switch mechanism without the use of tools and without opening the exterior cabinet door(s).
 4. Operability: Switch shall be constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations, in 15 seconds or less.
 5. Bypass-isolation switch equipment shall be UL listed per Standard 1008 and CSA approved, with continuous current rating, voltage and frequency ratings, and withstand and closing ratings equal to the transfer switch ratings at the specified conditions of ambient temperature, humidity, and altitude.
 6. The bypass-isolation and transfer switches shall be mechanically held in each position. Switching mechanisms shall be break-before-make on all poles, including the neutral pole on 4-pole switches. The switch mechanism shall be an over-center toggle device which provides stored energy contact operation during both opening and closing. The speed of contact operation shall be independent of the force applied to the operating handles, which permit manual operation under load.
 7. Provide means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks shall prevent transfer-switch operation, except for testing or maintenance.

8. Bypass switch shall be a fully-rated, manually-operated switch, rated for the same loads as the automatic transfer switch. Bypass switch shall provide bypass to either normal or emergency source by use of a door-mounted, keyed source selector switch and a permanently mounted external operating handle. Equipment shall provide manual bypass without disturbance of the power supply to the load.
 - a. Equipment requiring load isolation before bypass is not acceptable for use on this Project.
9. Equipment shall provide for manual bypass operation to the source opposite that to which the transfer switch is connected. This shall cause the transfer switch to automatically go to a position disconnected from both sources.
 - a. Equipment that does not provide a rapid means of opposite source bypass is not acceptable under this specification.
10. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
11. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
12. Positive mechanical interlocks shall prevent all possible source-to-source interconnections. The interlock system shall assure a properly sequenced, mechanically guided bypass and isolation action.
 - a. Designs which depend on electrical interlocks to prevent source to source interconnections, or which intentionally interconnect the sources, are not acceptable.
13. The equipment shall utilize automatic, mechanical stops to prevent manually bypassing to a dead source.
 - a. Equipment that does not prevent dead source bypass is not acceptable.
14. A drawout isolation mechanism shall provide closed-door isolation of the transfer switch, using a permanently mounted, external handle. The isolation mechanism shall be interlocked so that either the transfer switch must be bypassed or the transfer switch must be open before the mechanism will permit isolation of the transfer switch. Drawout arrangement must provide physical separation from live parts and accessibility for testing and maintenance operations.

15. The isolation mechanism shall provide for three-position operation: Connected, Test, and Isolated. In the Connected position, isolation contacts shall be fully engaged and closed, with the transfer switch control cable connected. In the Test position, isolation contacts shall be open and the transfer switch control cable connected. The Test position shall allow operational testing of transfer switch and controls without power disruption to the load. In the Isolated position, the transfer switch and control shall be completely isolated from all power sources. In the isolated position, safety shutters shall close to cover bypass switch power terminals, thus minimizing the possibility of accidental contact with energized parts. In the Isolated position, the transfer switch shall be capable of being withdrawn from the cabinet, and removed using overhead lifting equipment.
 - a. Mechanisms that do not allow for drawout and removal for servicing using overhead lifting equipment are not acceptable under this specification.
 16. The bypass and isolation process for the automatic transfer switch shall be capable of being fully accomplished without opening the cabinet door.
 17. Interconnection of bypass/isolation switch with automatic transfer switch shall consist of factory-installed copper bus bars, plated at connection points and braced for the indicated available short-circuit current.
 18. Note the size and access requirements for the transfer switch with bypass isolation and provide equipment that will fit into the space allowed as well as complying with code-specified access requirements.
 19. Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
- C. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars, plated at connection points and braced for the indicated available short-circuit current.

2.5 REMOTE ANNUNCIATOR SYSTEM

- A. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:
1. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 2. Switch position.
 3. Switch in test mode.
 4. Failure of communication link.

- B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
 - 1. Indicating Lights: Grouped for each transfer switch monitored.
 - 2. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
 - 3. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
 - 4. Lamp Test: Push-to-test or lamp-test switch on front panel.
- C. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically reverts to stand-alone, self-contained operation.
- D. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation. The remote annunciation system shall not prevent transfer to the alternate source when the primary power source fails, nor prevent return to the primary source if the alternate source fails.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- B. Floor-Mounting Switch: Anchor to floor by bolting.
 - 1. Floor-mounted transfer switches (except drawout switches supported by wheeled carriages, which must be rolled out at floor level) shall be mounted on concrete bases complying with the following requirements:
 - a. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support.
- C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
- D. Identify components according to Section 26 00 00, REQUIREMENTS FOR ELECTRICAL INSTALLATION.
- E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

- B. Field control connections shall be made on a common terminal block that is clearly and permanently labeled.
- C. Transfer switch shall be provided with AL/CU mechanical lugs sized to accept the full output rating of the switch. Lugs shall be suitable for the number and size of conductors shown on the drawings.
- D. Ground equipment according to Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- E. Connect wiring according to Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

3.3 SOURCE QUALITY CONTROL

- A. Prior to shipping, factory shall test and inspect components, assembled switches, and associated equipment to ensure proper operation.
- B. Factory shall check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements.
- C. Factory shall perform dielectric strength test complying with NEMA ICS 1.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: The supplier of the transfer switches and associated equipment shall inspect, test, and adjust components, assemblies, and equipment installations, including connections, and report results in writing.
- B. Manufacturer's representative shall perform tests and inspections and prepare test reports.
- C. After installing equipment and after electrical circuitry has been energized, installer shall test for compliance with requirements.
 - 1. Perform recommended installation tests as recommended in manufacturer's installation and service manuals.
 - 2. After energizing circuits, demonstrate interlocking sequence and operational function for each switch.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Verify time-delay settings.
 - c. Verify that the transfer switch is accurately metering AC voltage and current (when provided).
 - d. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.

- e. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
- 3. Ground-Fault Tests (if integral to transfer switch): Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a. Verify grounding connections and locations and ratings of sensors.
- D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
 - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 DEMONSTRATION

- A. After generator set installation, the generator and transfer switch supplier shall conduct a complete operation, basic maintenance, and emergency service seminar covering generator set and transfer switch equipment, for up to 10 people employed by the Owner.
 - 1. The seminar shall include instruction on operation of the transfer equipment, normal testing and exercise, adjustments to the control system, use of the PC based service and maintenance tools provided under this contract, and emergency operation procedures.
 - 2. The class duration shall be at least 8 hours in length, and include practical operation with the installed equipment.

3.6 SERVICE AND SUPPORT

- A. The manufacturer shall supply the Owner with a complete set of the service and maintenance software required to support the product. The software shall be provided at a training class attended by the user, to qualify the user in proper use of the software. The software shall have the following features and capabilities:
 - 1. The software shall be 32 bit and shall be XP and Vista compatible.
 - 2. The software shall use the Windows Explorer format, for ease of use and commonality with other software in use at the facility.

3. The software shall allow adjustment of all functions described herein, adjustment of operating levels of all protective functions, and programming of all optional functions in the controller. Adjustments shall be possible over modem from a facility that is remote from the generator set.
4. The software shall be capable of storing and displaying data for any function monitored by the generator set control. This data shall be available in common file formats, and on graphical “strip chart” displays.
5. The software shall automatically record all control operations and adjustments performed by any operator or software user, for tracking of changes to the control.
6. The software shall display all warning, shutdown, and status changes programmed into transfer switch controller. For each event, the control shall provide information on the nature of the event, when it last occurred, and how many times it has occurred.

3.7 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

- - - E N D - - -

SECTION 26 41 00
FACILITY LIGHTNING PROTECTION

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing and installation of a complete master labeled lightning protection system, complying with NFPA 780, UL 96 and UL 96A.

1.2 RELATED WORK

- A. Section 07 60 00, FLASHING AND SHEET METAL: penetrations through the roof.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path to ground for possible ground faults.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™
CERTIFICATION.

1.4 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.5 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Isometric and plan views showing layout and connections to the required metal surfaces.
 - 2. Show the methods of mounting the system to the adjacent construction.

- C. Qualifications: Submit proof that the installer of the lightning protection system is a certified Lightning Protection Institute (LPI) installer, and has had suitable and adequate experience installing other lightning protection systems, and is capable of installing the system as recommended by the manufacturer of the equipment.
- D. Certification: Two weeks prior to final inspection, submit four copies of the following certifications to the Resident Engineer:
 - 1. Certification that the lightning protection system has been properly installed and tested.
 - 2. Certification that the lightning protection system has been inspected by a UL representative and has been approved by UL without variation.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. National Fire Protection Association (NFPA):
 - 70-11National Electrical Code (NEC)
 - 780-11Standard for the Installation of Lightning Protection Systems
- C. Underwriters Laboratories, Inc. (UL):
 - 96Lightning Protection Components
 - 96A.....Installation Requirements for Lightning Protection Systems
 - UL 467Standard for Grounding and Bonding Equipment

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Attach master labels to each item by its manufacturer as evidence that the materials have been manufactured in conformance with the UL Standards for master label lightning protection materials.
- B. In addition to conformance to UL 96, the component material requirements are as follows:
 - 1. Conductors: Electrical grade copper. Conductors shall be in accordance with NFPA 780 and UL 96 for Class I, Class II, or Class II modified materials as applicable.
 - 2. Air terminals: Solid copper, 18 inches long, not less than 3/8 inch diameter, with sharp nickel-plated points.
 - 3. Ground rods: Copper clad steel, not less than 1/2 inch diameter by 8 feet long. Rods made of copper-clad steel shall conform to UL 467 and galvanized ferrous rods shall conform to IEEE C135.30. Ground rods of copper-clad steel, steel, stainless steel, galvanized ferrous, and solid copper shall not be mixed on the project.

4. Ground plates: Solid copper, not less than 1/16 inch thick.
 5. Tubing: Stiff copper or brass.
- C. Anchors and fasteners: Bolt type which are most suitable for the specific anchor and fastener installations. Clamp-type connectors for splicing conductors shall conform to UL 96, class as applicable, and, Class 2, style and size as required for the installation. Clamp-type connectors shall only be used for the connection of the roof conductor to the air terminal and to the guttering. All other connections, bonds, and splices shall be done by exothermic welds or by high compression fittings. The exothermic welds and high compression fittings shall be listed for the purpose. The high compression fittings shall be the type which require a hydraulically operated mechanism to apply a minimum of 10,000 psi.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be coordinated with the roofing manufacturer and installer.
- B. Install the conductors as inconspicuously as practical and with the proper bends.
- C. Install the vertical conductors within the concealed cavity of exterior walls. Run the conductors to the exterior at elevations below the finished grade and make the ground connections to the earth outside of the building or stack perimeter.
- D. Make connections of dissimilar metal with bimetallic type fittings to prevent electrolytic action.
- E. Use the exothermic welding type connections that form solid metal joints in the main vertical and horizontal conductors, and for connections that are not exposed in the finish work.
- F. Protect copper conductors with stiff copper or brass tubing, which enclose the conductors from the top to the bottom of the tubing, between one foot below and seven feet above the finished grade. The conductor shall be bonded to the top and bottom of the tubing.
- G. Sheath copper conductors, which pass over cast stone, cut stone, architectural concrete and masonry surfaces, with not less than a 1/16 inch thickness of lead to prevent staining of the exterior finish surfaces.
- H. For the earth connections, install ground rods and ground plates, and the conductor connections to them and the main water pipes in the presence of the Resident Engineer. For the conductors located outside of the building or stack, install the conductors not less than two feet below the finished grade.
- I. For structural steel buildings, connect the steel framework of the buildings to the main water pipe near the water system entrance to the building.
- J. Connect lightning protection cables to all metallic projections, equipment, and components above the roof as indicated on the drawings.

- K. Connect exterior metal surfaces, located within three feet of the lightning protection system conductors, to the lightning protection system conductors to prevent flashovers.
- L. Maintain horizontal or downward coursing of main conductor and insure that all bends have at least an 8-inch radius and do not exceed 90 degrees.
- M. Conductors shall be rigidly fastened every three feet along the roof and down to the building to ground.
- N. Air terminals shall be secured against overturning either by attachment to the object to be protected or by means of a substantial tripod or other braces permanently and rigidly attached to the building or structure. Install air terminal bases, cable holders and other roof-system supporting means without piercing roof metal.
- O. Use clamp supports to secure supporting means to roof standing seams only.
- P. Use through-roof connectors for down-conductor attachment to roof system. Provide flashing in accordance with Section 07 60 00, FLASHING AND SHEET METAL.
- Q. Down-conductors coursed on or in reinforced concrete columns or on structural steel columns shall be connected to the reinforcing steel or the structural steel member at its upper and lower extremities. In the case of long vertical members an additional connection shall be made at intervals not exceeding 100 feet.
- R. A counterpoise, where shown, shall be of No. 1/0 copper cable or equivalent material having suitable resistance to corrosion and shall be laid around the perimeter of the structure in a trench not less than 2 feet deep at a distance not less than 3 feet nor more than 8 feet from the nearest point of the structure.
- S. On construction utilizing post tensioning systems to secure precast concrete sections, the post tension rods shall not be used as a path for lightning to ground. Down conductors shall be provided on structures using post tensioning systems. Down conductors shall have sufficient separation from post tension rods to prevent side-flashing. Post tension rods shall be bonded to the lightning protection and grounding systems only at the base of the structure; this bonding shall be performed in strict accordance with the recommendations of the post tension rod manufacturer, and shall be done by, or in the presence of, a representative of the manufacturer.
- T. Grounding: Test the ground resistance to earth by standard methods and conform to the ground resistance requirements specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- U. Where shown, use the structural steel framework or reinforcing steel as the main conductor:
 - 1. Weld or bond the non-electrically-continuous sections together and make them electrically continuous.

2. Verify the electrical continuity by measuring the ground resistances to earth at the ground level, at the top of the building or stack, and at intermediate points with a sensitive ohmmeter. Compare the resistance readings.
 3. Connect the air terminals together with an exterior conductor connected to the structural steel framework at not more than 60 foot intervals.
 4. Install ground connections to earth at not more than 60 foot intervals around the perimeter of the building.
 5. Weld or braze bonding plates, not less than 8 inches square, to cleaned sections of the steel and connect the conductors to the plates.
 6. Do not pierce the structural steel in any manner. Connections to the structural steel shall conform to UL Publication No. 96A.
- V. For smoke stacks, the following additional requirements shall apply:
1. Extend air terminals from approximately three feet below the top of the smoke stacks to approximately three feet above the top of the stacks.
 2. Securely seat and rivet the vertical conductors into bronze cable connectors. Cross-connect the vertical conductors at approximately the midpoint between the top and bottom of the smoke stacks.
- W. When the lightning protection systems have been installed, have the systems inspected by a UL representative. Obtain and install a UL numbered master label for each of the lightning protection systems at the location directed by the UL representative and the Resident Engineer.
- X. Where the drawings show the new lightning protection system connected to an existing lightning protection system without a UL master label, the new portion of the lightning system still requires inspection and labels as specified above for new work.
- Y. Metal fences that are electrically continuous with metal posts extending at least 2 feet into the ground require no additional grounding. Other fences shall be grounded on each side of every gate. Fences shall be grounded by means of ground rods every 1000 to 1500 feet of length when fences are located in isolated places, and every 500 to 750 feet when in proximity (100 feet or less) to public roads, highways, and buildings.

3.2 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 26 43 13
INTEGRATED SURGE PROTECTIVE DEVICES (SPDs)

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. This section describes the materials and installation requirements for a Surge Protective Device (SPD), previously referred to as a Transient Voltage Surge Suppressor (TVSS). These devices are used to protect AC electrical circuits from the effect of lightning induced currents, substation switching transients and internally generated transients resulting from inductive and or capacitive load switching

1.2 REFERENCES

- A. ANSI/UL 1449- 2006 - Surge Protective Devices
- B. UL 1283 - Electromagnetic Interference Filters
- C. ANSI/IEEE C62.41.1-2002 - IEEE Guide on the Surge Environment in Low Voltage (1000 V and Less) AC Power Circuits; C62.41.2-2002 - IEEE Recommended Practice on Characterization of Surge Voltages in Low Voltage AC Power Circuits; and C62.45-2002 - IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.
- D. NEC 2011, Article 285 (Or current to your AHJ)

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATION
- B. Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
- D. Section 26 41 00, FACILITY LIGHTNING PROTECTION

1.5 SUBMITTALS

- A. Product data and manufacturer's installation instructions for non-approved manufacturers shall be submitted for review ten days prior to the bid date.
- B. The submittals shall also include:
 - 1. Dimensional drawing of each SPD type.
 - 2. ANSI/UL 1449-2006 Listing, Standard for Safety, Surge Protective Devices, documentation.
 - 3. UL 1283 Listing, Electromagnetic Interference Filters, documentation.
 - 4. ANSI/IEEE C62.41.2 and C62.45, Category C_{High} (20kV-1.2/50, 10kA-8/20μs waveform) clamping voltage test results.

PART 2 – PRODUCT

2.1 MANUFACTURERS

- A. Equivalent to Square D/Schneider Electric, Surgeloc.IMA Series. (Preferred Manufacturer and Basis of Design)

2.2 INTEGRAL SURGE SUPPRESSORS

- A. SPD shall be listed to ANSI/UL 1449- Third Edition and UL 1283, Electromagnetic Interference Filters.
- B. Integrated surge protective devices (SPD) shall be Component Recognized in accordance with UL 1449 Third Edition, Section 37.3.2 and 37.4 at the standard's highest short circuit current rating (SCCR) of 200 kA.
- C. SPD shall be tested with the ANSI/IEEE Category C_{High} exposure waveform (20kV-1.2/50μs, 10kA-8/20μs).
- D. Pulse life test: Capable of protecting against and surviving 20,000 ANSI/IEEE Category C_{High} transients without failure or degradation of clamping voltage by more than 10%.
- E. SPD shall provide suppression for all modes of protection: L-L, L-N, L-G, and N-G in WYE systems.
- F. The manufacturer of the SPD shall be the same as the manufacturer of the service entrance and distribution equipment in which the devices are installed and shipped. Also, this distribution equipment shall be fully tested and certified to the following UL standards:
 - 1. UL 67 = Panelboards
 - 2. UL 845 = Motor Control Centers
 - 3. UL 857 = Busway
 - 4. UL 891 = Switchboards
 - 5. UL 1558 = Low Voltage Switchgear

G. Recommended SPD ratings:

1. Minimum surge current rating shall be 240 kA per phase (120 kA per mode) for service entrance and 120 kA per phase (60 kA per mode) for distribution applications.
2. UL 1449 clamping voltage must not exceed the following:

<u>VOLTAGE</u>	<u>L-N</u>	<u>L-G</u>	<u>N-G</u>	<u>L-L</u>
240/120	800/400V	800/400V	400V	1200V
208Y/120	400V	400V	400V	1200V
480Y/277	800V	800V	800V	2000V
600Y/347	1200V	1200V	1200V	2500V

H. Minimum ANSI/UL 1449-2006 withstand (In) rating to be 20kA per mode

- I. SPD shall be designed to withstand a maximum continuous operating voltage (MCOV) of not less than 115% for 277/480V and 125% for 120/208V nominal RMS operating system voltages.
- J. SPD shall be constructed of one self-contained suppression module per phase.
- K. Visible indication of proper SPD connection and operation shall be provided. The indicator lights shall indicate which phase as well as which module is fully operable. The status of each SPD module shall be monitored on the front cover of the enclosure as well as on the module. A push-to-test button shall be provided to test each phase indicator. Push-to-test button shall activate a state change of dry contacts for testing purposes.
- L. SPD shall be equipped with an audible alarm which shall activate when any one of the surge current modules has reached an end-of-life condition. An alarm on/off switch shall be provided to silence the alarm. The switches and alarm shall be located on the front cover of the enclosure.
- M. A surge counter shall be located on the diagnostic panel on the front cover of the enclosure. The counter shall be equipped with a manual reset and battery backup to retain memory upon loss of AC power.
- N. A connector shall be provided along with dry contacts (normally open or normally closed) to allow connection to a remote monitor or other system. The output of the dry contacts shall indicate an end-of-life condition for the complete SPD or module.
- O. Terminals shall be provided for necessary power and ground connections.
- P. The SPD may be equipped the following optional items:
- Q. A remote monitoring device shall be provided to directly connect to the SPD with a dry contact connector for simple installation. The device will have indicator lights and an audible alarm to monitor for normal and fault conditions.

- R. SPD shall have a warranty for a period of ten (10) years from date of invoice. Warranty shall be the responsibility of the electrical distribution equipment manufacturer and shall be supported by their respective field service division.

PART 3 - EXECUTION

3.1 SERVICE ENTRANCE AND DISTRIBUTION EQUIPMENT

- A. Manufacturer shall install SPD in the power distribution equipment for use at the utility service entrance to the facility and in each distribution panel to be protected.
- B. The SPD shall be installed on the load side of a service disconnect overcurrent device per NEC.
- C. Where the internal SPD is connected to the power system with cables, keep the conductors as short as possible with no sharp bends.
- D. The SPD ground shall be connected to the power system ground.

3.2 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 26 51 00 INTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies the furnishing, installation and connection of the interior lighting systems.

1.2 RELATED WORK

- A. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirement for seismic restraint for nonstructural Components.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General requirements that are common to more than one section of Division 26.
- C. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
- E. Section 26 27 26, WIRING DEVICES: Wiring devices used for control of the lighting systems.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.5 SUBMITTALS

- A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Product Data: For each type of lighting fixture (luminaire) designated on the Lighting Fixture Schedule, arranged in order of fixture designation, submit the following information.
 - 1. Material and construction details include information on housing, optics system and lens/diffuser.
 - 2. Physical dimensions and description.
 - 3. Wiring schematic and connection diagram.
 - 4. Installation details.
 - 5. Energy efficiency data.
 - 6. Photometric data based on laboratory tests complying with IESNA Lighting Measurements, testing and calculation guides.
 - 7. Lamp data including lumen output (initial and mean), color rendition index (CRI), rated life (hours) and color temperature (degrees Kelvin).
 - 8. Ballast data including ballast type, starting method, ambient temperature, ballast factor, sound rating, system watts and total harmonic distortion (THD).
- C. Manuals:
 - 1. Submit, simultaneously with the shop drawings companion copies of complete maintenance and operating manuals including technical data sheets, and information for ordering replacement parts.
 - 2. Two weeks prior to the final inspection, submit four copies of the final updated maintenance and operating manuals, including any changes, to the Resident Engineer.
- D. Certifications:
 - 1. Two weeks prior to final inspection, submit four copies of the following certifications to the Resident Engineer:
 - a. Certification by the Contractor that the equipment has been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. Institute of Electrical and Electronic Engineers (IEEE):
C62.41-91Guide on the Surge Environment in Low Voltage (1000V and less) AC Power Circuits
- C. National Fire Protection Association (NFPA):
70-11National Electrical Code (NEC)
101-11Life Safety Code
- D. National Electrical Manufacturer's Association (NEMA):
C82.1-97Ballasts for Fluorescent Lamps - Specifications
C82.2-02Method of Measurement of Fluorescent Lamp Ballasts
C82.4-02Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps
C82.11-02High Frequency Fluorescent Lamp Ballasts
- E. Underwriters Laboratories, Inc. (UL):
496-96Edison-Base Lampholders
542-99Lampholders, Starters, and Starter Holders for Fluorescent Lamps
844-95Electric Lighting Fixtures for Use in Hazardous (Classified) Locations
924-95Emergency Lighting and Power Equipment
935-01Fluorescent-Lamp Ballasts
1029-94High-Intensity-Discharge Lamp Ballasts
1029A-06Ignitors and Related Auxiliaries for HID Lamp Ballasts
1598-00Luminaires
1574-04Standard for Track Lighting Systems
2108-04Standard for Low-Voltage Lighting Systems
8750-08Light Emitting Diode (LED) Light Sources for Use in Lighting Products
- F. Federal Communications Commission (FCC):
Code of Federal Regulations (CFR), Title 47, Part 18

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES (LUMINAIRES)

- A. Shall be in accordance with NFPA 70 and UL 1598, as shown on drawings, and as specified.
- B. Sheet Metal:
 - 1. Shall be formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved) and parallel to each other as designed.
 - 2. Wireways and fittings shall be free of burrs and sharp edges and shall accommodate internal and branch circuit wiring without damage to the wiring.
 - 3. When installed, any exposed fixture housing surface, trim frame, door frame and lens frame shall be free of light leaks; lens doors shall close in a light tight manner.
 - 4. Hinged door closure frames shall operate smoothly without binding when the fixture is in the installed position, latches shall function easily by finger action without the use of tools.
- C. Ballasts shall be serviceable while the fixture is in its normally installed position, and shall not be mounted to removable reflectors or wireway covers unless so specified.
- D. Lamp Sockets:
 - 1. Fluorescent: Lampholder contacts shall be the biting edge type or phosphorous-bronze with silver flash contact surface type and shall conform to the applicable requirements of UL 542. Lamp holders for bi-pin lamps shall be of the telescoping compression type, or of the single slot entry type requiring a one-quarter turn of the lamp after insertion.
 - 2. High Intensity Discharge (H.I.D.): Shall have porcelain enclosures.
- E. Recessed fixtures mounted in an insulated ceiling shall be listed for use in insulated ceilings.
- F. Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, captive hinges or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.
- G. Metal Finishes:
 - 1. The manufacturer shall apply standard finish (unless otherwise specified) over a corrosion resistant primer, after cleaning to free the metal surfaces of rust, grease, dirt and other deposits. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion resistant manner to match the adjacent surface(s). Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking, and shall be applied after fabrication.
 - 2. Interior light reflecting finishes shall be white with not less than 85 percent reflectances, except where otherwise shown on the drawing.
 - 3. Exterior finishes shall be as shown on the drawings.

- H. Lighting fixtures shall have a specific means for grounding metallic wireways and housings to an equipment grounding conductor.
- I. Light Transmitting Components for Fluorescent Fixtures:
 - 1. Shall be 100 percent virgin acrylic.
 - 2. Flat lens panels shall have not less than 1/8 inch of average thickness. The average thickness shall be determined by adding the maximum thickness to the minimum unpenetrated thickness and dividing the sum by 2.
 - 3. Unless otherwise specified, lenses, diffusers and louvers shall be retained firmly in a metal frame by clips or clamping ring in such a manner as to allow expansion and contraction of the lens without distortion or cracking.
- J. Lighting fixtures in hazardous areas shall be suitable for installation in Class and Group areas as defined in NFPA 70, and shall comply with UL 844.
- K. Compact fluorescent fixtures shall be manufactured specifically for compact fluorescent lamps with ballast integral to the fixture. Assemblies designed to retrofit incandescent fixtures are prohibited except when specifically indicated for renovation of existing fixtures (not the lamp). Fixtures shall be designed for lamps as specified.

2.2 BALLASTS

- A. Linear Fluorescent Lamp Ballasts: Multi-voltage (120 – 277V) electronic programmed-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated; including the following features:
 - 1. Lamp end-of-life detection and shutdown circuit (T5 lamps only).
 - 2. Automatic lamp starting after lamp replacement.
 - 3. Sound Rating: Class A.
 - 4. Total Harmonic Distortion Rating: 10 percent or less.
 - 5. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 - 6. Operating Frequency: 20 kHz or higher.
 - 7. Lamp Current Crest Factor: 1.7 or less.
 - 8. Ballast Factor: 0.87 or higher unless otherwise indicated.
 - 9. Power Factor: 0.98 or higher.
- 10. Interference: Comply with 47 CFT 18, Ch.1, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.

11. To facilitate multi-level lamp switching, lamps within fixture shall be wired with the outermost lamp at both sides of the fixture on the same ballast, the next inward pair on another ballast and so on to the innermost lamp (or pair of lamps). Within a given room, each switch shall uniformly control the same corresponding lamp (or lamp pairs) in all fixture units that are being controlled.
 12. Where three-lamp fixtures are indicated, unless switching arrangements dictate otherwise, utilize a common two-lamp ballast to operate the center lamp in pairs of adjacent units that are mounted in a continuous row. The ballast fixture and slave-lamp fixture shall be factory wired with leads or plug devices to facilitate this circuiting. Individually mounted fixtures and the odd fixture in a row shall utilize a single-lamp ballast for operation of the center lamp.
 13. Dimming ballasts shall be as per above, except dimmable from 100% to 5% of rated lamp lumens.
- B. Compact Fluorescent Lamp Ballasts: Multi-voltage (120 – 277V), electronic-programmed rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated; including the following features:
1. Lamp end-of-life detection and shutdown circuit.
 2. Automatic lamp starting after lamp replacement.
 3. Sound Rating: Class A.
 4. Total Harmonic Distortion Rating: 10 percent or less.
 5. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 6. Operating Frequency: 20 kHz or higher.
 7. Lamp Current Crest Factor: 1.7 or less.
 8. Ballast Factor: 0.95 or higher unless otherwise indicated.
 9. Power Factor: 0.98 or higher.
 10. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
 11. Dimming ballasts shall be as per above, except dimmable from 100% to 5% of rated lamp lumens.

- C. Ballasts for high intensity discharge fixtures: Multi-tap voltage (120- 480v) electromagnetic ballast for high intensity discharge lamps. Comply with ANSI C82.4 and UL 1029. Include the following features unless otherwise indicated:
1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
 2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single-lamp ballasts.
 3. Rated Ambient Operating Temperature: 104 deg F (40 deg C).
 4. Open-circuit operation that will not reduce average life.
 5. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.
- D. Electronic ballast for high intensity discharge metal-halide lamps shall include the following features unless otherwise indicated:
1. Minimum Starting Temperature: Minus 20 deg F (Minus 29 deg C) for single-lamp ballasts.
 2. Rated Ambient Operating Temperature: 130 deg F (54 deg C).
 3. Lamp end-of-life detection and shutdown circuit.
 4. Sound Rating: Class A.
 5. Total Harmonic Distortion Rating: 20 percent or less.
 6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 7. Lamp Current Crest Factor: 1.5 or less.
 8. Power Factor: 0.90 or higher.
 9. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for non-consumer equipment.
 10. Protection: Class P thermal cut.

2.3 FLUORESCENT EMERGENCY BALLAST

- A. Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.
1. Emergency Connection: Operate one fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.

2. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
 - a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
3. Battery: Sealed, maintenance-free, nickel-cadmium type.
4. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
5. Integral Self-Test: Automatically initiates test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing LED.

2.4 LAMPS

A. Linear and U-shaped T5 and T8 Fluorescent Lamps:

1. Rapid start fluorescent lamps shall comply with ANSI C78.1; and instant-start lamps shall comply with ANSI C78.3.
2. Chromacity of fluorescent lamps shall comply with ANSI C78.376.
3. Except as indicated below, lamps shall be low-mercury energy saving type, have a color temperature between 3500° and 4100°K, a Color Rendering Index (CRI) of greater than 70, average rated life of 20,000 hours, and be suitable for use with dimming ballasts, unless otherwise indicated. Low mercury lamps shall have passed the EPA Toxicity Characteristic Leachate Procedure (TCLP) for mercury by using the lamp sample preparation procedure described in NEMA LL 1.
 - a. Over the beds in Intensive Care, Coronary Care, Recovery, Life Support, and Observation and Treatment areas; Electromyographic, Autopsy (Necropsy), Surgery, and certain dental rooms (Examination, Oral Hygiene, Oral Surgery, Recovery, Labs, Treatment, and X-Ray) use color corrected lamps having a CRI of 85 or above and a correlated color temperature between 5000 and 6000°K.
 - b. Other areas as indicated on the drawings.

B. Compact Fluorescent Lamps:

1. T4, CRI 80 (minimum), color temperature 3500 K, and suitable for use with dimming ballasts, unless otherwise indicated.

C. Long Twin-Tube Fluorescent Lamps:

1. T5, CRI 80 (minimum), color temperature between 3500° and 4100°K, 20,000 hours average rated life.

D. High Intensity Discharge Lamps:

1. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000°K.
2. Ceramic, Pulse-Start, Metal-Halide Lamps: CRI 80 (minimum), and color temperature 4000°K.
3. Low-Pressure Sodium Lamps: ANSI 78.41, CRI 0, and color temperature 1800°K.

2.5 EXIT LIGHT FIXTURES

A. Exit light fixtures shall meet applicable requirements of NFPA 101 and UL 924.

B. Housing and Canopy:

1. Shall be made of die-cast aluminum.
2. Optional steel housing shall be a minimum 20 gauge thick or equivalent strength aluminum.
3. Steel housing shall have baked enamel over corrosion resistant, matte black or ivory white primer.

C. Door frame shall be cast or extruded aluminum, and hinged with latch.

D. Finish shall be satin or fine-grain brushed aluminum.

E. There shall be no radioactive material used in the fixtures.

F. Fixtures:

1. Maximum fixture wattage shall be 1 watt or less.
2. Inscription panels shall be cast or stamped aluminum a minimum of 0.090 inch thick, stenciled with 6 inch high letters, baked with red color stable plastic or fiberglass. Lamps shall be luminous Light Emitting Diodes (LED) mounted in center of letters on red color stable plastic or fiberglass. The LED shall be rated minimum 25 years life.
3. Double-Faced Fixtures: Provide double-faced fixtures where required or as shown on drawings.
4. Directional Arrows: Provide directional arrows as part of the inscription panel where required or as shown on drawings. Directional arrows shall be the "chevron-type" of similar size and width as the letters and meet the requirements of NFPA 101.

G. Voltages: Refer to Lighting Fixture Schedule.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC, manufacturer's instructions and as shown on the drawings or specified.
- B. Align, mount and level the lighting fixtures uniformly.
- C. Fluorescent bed light fixtures shall be attached to the studs in the walls. Attachment to gypsum board only is not acceptable.

D. Lighting Fixture Supports:

1. Shall provide support for all of the fixtures. Supports may be anchored to channels of the ceiling construction, to the structural slab or to structural members within a partition, or above a suspended ceiling.
2. Shall maintain the fixture positions after cleaning and relamping.
3. Shall support the lighting fixtures without causing the ceiling or partition to deflect.
4. Hardware for recessed lighting fixtures:
 - a. All fixture mounting devices connecting fixtures to the ceiling system or building structure shall have a capacity for a horizontal force of 100 percent of the fixture weight and a vertical force of 400 percent of the fixture weight.
 - b. Mounting devices shall clamp the fixture to the ceiling system structure (main grid runners or fixture framing cross runners) at four points in such a manner as to resist spreading of these supporting members. Each support point device shall utilize a screw or approved hardware to "lock" the fixture housing to the ceiling system, restraining the fixture from movement in any direction relative to the ceiling. The screw (size No. 10 minimum) or approved hardware shall pass through the ceiling member (T-bar, channel or spline), or it may extend over the inside of the flange of the channel (or spline) that faces away from the fixture, in a manner that prevents any fixture movement.
 - c. In addition to the above, the following is required for fixtures exceeding 20 pounds in weight.
 - 1) Where fixtures mounted in ASTM Standard C635-69 "Intermediate" and "Heavy Duty" ceilings and weigh between 20 pounds and 56 pounds provide two 12 gauge safety hangers hung slack between diagonal corners of the fixture and the building structure.
 - 2) Where fixtures weigh over 56 pounds they shall be independently supported from the building structure by approved hangers. Two-way angular bracing of hangers shall be provided to prevent lateral motion.
 - d. Where ceiling cross runners are installed for support of lighting fixtures, they must have a carrying capacity equal to that of the main ceiling runners and be rigidly secured to the main runners.

5. Surface mounted lighting fixtures:
 - a. Fixtures shall be bolted against the ceiling independent of the outlet box at four points spaced near the corners of each unit. The bolts (or stud-clips) shall be minimum 1/4-20 bolt, secured to main ceiling runners and/or secured to cross runners. Non-turning studs may be attached to the main ceiling runners and cross runners with special non-friction clip devices designed for the purpose, provided they bolt through the runner, or are also secured to the building structure by 12 gauge safety hangers. Studs or bolts securing fixtures weighing in excess of 56 pounds shall be supported directly from the building structure.
 - b. Where ceiling cross runners are installed for support of lighting fixtures they must have a carrying capacity equal to that of the main ceiling runners and be rigidly secured to the main runners.
 - c. Fixtures less than 15 pounds in weight and occupying less than two square feet of ceiling area may, (when designed for the purpose) be supported directly from the outlet box when all the following conditions are met.
 - 1) Screws attaching the fixture to the outlet box pass through round holes (not key-hole slots) in the fixture body.
 - 2) The outlet box is attached to a main ceiling runner (or cross runner) with approved hardware.
 - 3) The outlet box is supported vertically from the building structure.
 - d. Fixtures mounted in open construction shall be secured directly to the building structure with approved bolting and clamping devices.
6. Single or double pendant-mounted lighting fixtures:
 - a. Each stem shall be supported by an approved outlet box, mounted swivel joint and canopy which holds the stem captive and provides spring load (or approved equivalent) dampening of fixture oscillations. Outlet box shall be supported vertically from the building structure.
7. Outlet boxes for support of lighting fixtures (where permitted) shall be secured directly to the building structure with approved devices or supported vertically in a hung ceiling from the building structure with a nine gauge wire hanger, and be secured by an approved device to a main ceiling runner or cross runner to prevent any horizontal movement relative to the ceiling.
- E. Furnish and install the specified lamps for all lighting fixtures installed and all existing lighting fixtures reinstalled under this project.

- F. Coordinate between the electrical and ceiling trades to ascertain that approved lighting fixtures are furnished in the proper sizes and installed with the proper devices (hangers, clips, trim frames, flanges), to match the ceiling system being installed.
- G. Bond lighting fixtures and metal accessories to the grounding system as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- H. Exercise electronic dimming ballasts over full range of dimming capability by operating the control devices(s) in the presence of the Resident Engineer. Observe for visually detectable flicker over full dimming range.
- I. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Government. Burn-in period to be 40 hours minimum, unless a lesser period is specifically recommended by lamp manufacturer. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage. Replace any lamps and ballasts which fail during burn-in.
- J. At completion of project, relamp/reballast fixtures which have failed lamps/ballasts. Clean fixtures, lenses, diffusers and louvers that have accumulated dust/dirt/fingerprints during construction. Replace damaged lenses, diffusers and louvers with new.
- K. Dispose of lamps.

3.2 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 26 56 00
EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation, and connection of exterior luminaires, poles, and supports.

1.2 RELATED WORK

- A. Section 09 06 00, SCHEDULE FOR FINISHES: Finishes for exterior light poles and luminaires.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- C. Section 26 05 13, MEDIUM-VOLTAGE CABLES: Medium voltage cables for series-connected street lighting.
- D. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low voltage power and lighting wiring.
- E. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- F. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits, fittings, and boxes for raceway systems.
- G. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Underground handholes and conduits.
- H. Section 26 09 23, LIGHTING CONTROLS: Controls for exterior lighting.

1.3 SUSTAINABILITY CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's sustainability considerations and goals. These considerations and goals are to establish a facility which maximizes sustainability, profitability, and the health of all occupants. In order to fulfill these goals, this project is pursuing a Green Building Institute's Green Globes™ certification of Two Globes. Refer to sections listed below for sustainability considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

- A. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS for GREEN GLOBES™ CERTIFICATION.

1.4 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.5 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Clearly present sufficient information to determine compliance with drawings and specifications.
 - 2. Include electrical ratings, dimensions, mounting, details, materials, required clearances, terminations, wiring and connection diagrams, photometric data, ballasts, poles, luminaires, lamps, and accessories. Include electronic photometric files in IES format, or provide link (URL) to manufacturer's website that contains photometric data for each specific fixture used, excluding wallpack fixtures.
- C. Manuals: Two weeks prior to final inspection, submit four copies of operating and maintenance manuals to the Resident Engineer. Include technical data sheets, wiring and connection diagrams, and information for ordering replacement lamps, ballasts, and parts.
- D. Certifications: Two weeks prior to final inspection, submit four copies of the following to the Resident Engineer:
 - 1. Certification by the manufacturer that the materials are in accordance with the drawings and specifications.
 - 2. Certification by the contractor that the complete installation has been properly installed and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. Aluminum Association Inc. (AA):
 - AAH35.1-06Alloy and Temper Designation Systems for Aluminum
- C. American Association of State Highway and Transportation Officials (AASHTO):
 - LTS-5-09Structural Supports for Highway Signs, Luminaires and Traffic Signals
- D. American Concrete Institute (ACI):
 - 318-05Building Code Requirements for Structural Concrete

- E. American National Standards Institute (ANSI):
 - C81.61-09Electrical Lamp Bases – Specifications for Bases (Caps) for Electric Lamps
- F. American Society for Testing and Materials (ASTM):
 - A123/A123M-09Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - A153/A153M-09.....Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - B108-03a-08Aluminum-Alloy Permanent Mold Castings
 - C1089-06Spun Cast Prestressed Concrete Poles
- G. Federal Aviation Administration (FAA):
 - AC 70/7460-IK-07Obstruction Lighting and Marking
 - AC 150/5345-43F-06Obstruction Lighting Equipment
- H. Illuminating Engineering Society of North America (IESNA)
 - HB-9-00Lighting Handbook
 - RP-8-05Roadway Lighting
 - RP-20-98Lighting for Parking Facilities
 - RP-33-99Lighting for Exterior Environments
 - LM-5-96.....Photometric Measurements of Area and Sports Lighting Installations
 - LM-50-99.....Photometric Measurements of Roadway Lighting Installations
 - LM-52-99.....Photometric Measurements of Roadway Sign Installations
 - LM-64-01Photometric Measurements of Parking Areas
 - LM-72-97.....Directional Positioning of Photometric Data
 - LM-79-08.....Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products
 - LM-80-08.....Approved Method for Measuring Lumen Maintenance of LED Light Sources
- I. National Electrical Manufacturers Association (NEMA):
 - C78.41-06Electric Lamps – Guidelines for Low-Pressure Sodium Lamps
 - C78.42-07Electric Lamps – Guidelines for High-Pressure Sodium Lamps
 - C78.43-07Electric Lamps – Single-Ended Metal-Halide Lamps
 - C78.1381-98Electric Lamps – 70-Watt M85 Double-Ended Metal-Halide Lamps
 - C82.4-02Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)

- C136.3-05For Roadway and Area Lighting Equipment – Luminaire Attachments
- C136.17-05Roadway and Area Lighting Equipment – Enclosed Side-Mounted Luminaires for Horizontal-Burning High-Intensity-Discharge Lamps – Mechanical Interchangeability of Refractors
- ICS 2-00 (R2005)Controllers, Contactors and Overload Relays Rated 600 Volts
- ICS 6-93 (R2006)Enclosures
- J. National Fire Protection Association (NFPA):
 - 70-11National Electrical Code (NEC)
- K. Underwriters Laboratories, Inc. (UL):
 - 496-08Lampholders
 - 773-95Plug-In, Locking Type Photocontrols for Use with Area Lighting
 - 773A-06Nonindustrial Photoelectric Switches for Lighting Control
 - 1029-94High-Intensity-Discharge Lamp Ballasts
 - 1598-08Luminaires
 - 8750-08Light Emitting Diode (LED) Light Sources for Use in Lighting Products

1.7 DELIVERY, STORAGE, AND HANDLING

Provide manufacturer’s standard provisions for protecting pole finishes during transport, storage, and installation. Do not store poles on ground. Store poles so they are at least 12 in above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Materials and equipment shall be in accordance with NEC, UL, ANSI, and as shown on the drawings and specified.

2.2 POLES

- A. General:
 - 1. Poles shall be as shown on the drawings, and as specified. Finish shall be as specified on the drawings.
 - 2. The pole and arm assembly shall be designed for wind loading of 100 mph, with an additional 30% gust factor, supporting luminaire(s) and accessories such as shields, banner arms, and banners that have the effective projected areas indicated. The effective projected area of the pole shall be applied at the height of the pole base, as shown on the drawings.

3. Poles shall be anchor-bolt type designed for use with underground supply conductors. Poles shall have handhole having a minimum clear opening of 2.5 x 5 in. Handhole covers shall be secured by stainless steel captive screws.
4. Provide a steel-grounding stud opposite handhole openings, designed to prevent electrolysis when used with copper wire.
5. Provide a base cover that matches the pole in material and color to conceal the mounting hardware pole-base welds and anchor bolts.
6. Hardware and Accessories: All necessary hardware and specified accessories shall be the product of the pole manufacturer.
7. Provide manufacturer's standard finish, as scheduled on the drawings. Where indicated on drawings, provide finishes as indicated in Section 09 06 00, SCHEDULE FOR FINISHES.

B. Types:

1. Steel: Provide square steel poles having minimum 11-gauge steel with minimum yield/strength of 48,000 psi and hot-dipped galvanized factory finish. Galvanized steel poles shall comply with ASTM A123 and A153.

2.3 FOUNDATIONS FOR POLES

- A. Foundations shall be cast-in-place concrete, having 3000 psi minimum 28-day compressive strength.
- B. Foundations shall support the effective projected area of the specified pole, arm(s), luminaire(s), and accessories, such as shields, banner arms, and banners, under wind conditions previously specified in this section.
- C. Place concrete in spirally-wrapped treated paper forms for round foundations, and construct forms for square foundations.
- D. Rub-finish and round all above-grade concrete edges to approximately 0.25 in radius.
- E. Anchor bolt assemblies and reinforcing of concrete foundations shall be as shown on the drawings. Anchor bolts shall be in a welded cage or properly positioned by the tie wire to stirrups.
- F. Prior to concrete pour, install electrode per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

2.4 LUMINAIRES

- A. Per UL 1598 and NEMA C136.17. Luminaires shall be weatherproof, heavy duty, outdoor types designed for efficient light utilization, adequate dissipation of lamp and ballast heat, and safe cleaning and relamping.
- B. Light distribution pattern types shall be as shown on the drawings.
- C. Incorporate ballasts in the luminaire housing, except where otherwise shown on the drawings.

- D. Lenses shall be frame-mounted, heat-resistant, borosilicate glass, with prismatic refractors, unless otherwise shown on the drawings. Attach the frame to the luminaire housing by hinges or chain. Use heat and aging-resistant, resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- E. Lamp sockets for high intensity discharge (H.I.D) fixture shall have locking-type porcelain enclosures in conformance to the applicable requirements of ANSI C81.61 and UL 496.
- F. Pre-wire internal components to terminal strips at the factory.
- G. Bracket-mounted luminaires shall have leveling provisions and clamp-type adjustable slip-fitters with locking screws.
- H. Materials shall be rustproof. Latches and fittings shall be non-ferrous metal.
- I. Provide manufacturer's standard finish, as scheduled on the drawings. Where indicated on drawings, match finish process and color of pole or support materials. Where indicated on drawings, provide finishes as indicated in Section 09 06 00, SCHEDULE FOR FINISHES.
- J. Luminaires shall carry factory labels, showing complete, specific lamp and ballast information.

2.5 LAMPS

- A. Install the proper lamps in every luminaire installed.
- B. Lamps shall be general-service, outdoor lighting types.
- C. Metal-Halide Lamps: NEMA C78.43 or NEMA C78.1381.

2.6 METAL HALIDE ELECTRONIC BALLASTS

- A. Ballast shall be low-frequency electronic type, and shall operate pulse start and ceramic metal halide lamps at a frequency of 90 to 200 Hz square wave.
- B. Ballast shall be labeled Type '1' outdoor, suitable for recessed use, Class 'P'.
- C. Ballast shall have auto-resetting thermal protector to shut off ballast when operating temperatures reach unacceptable levels.
- D. Ballast shall have an end of lamp life detection and shut-down circuit.
- E. Lamp current crest factor shall be 1.5 or less.
- F. Ballasts shall comply with FCC Title 47 CFR Part 18 Non-consumer RFI/EMI Standards.
- G. Ballast shall have a minimum ballast factor of 1.0.
- H. Input current THD shall not exceed 20% for the primary lamp.
- I. Ballasts shall have ANSI C62.41, category 'A' transient protection.
- J. Ballasts shall have power factor greater than 90%.
- K. Ballast shall have a Class 'A' sound rating.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lighting in accordance with the NEC, as shown on the drawings, and in accordance with manufacturer's recommendations.
- B. Pole Foundations:
 - 1. Excavate only as necessary to provide sufficient working clearance for installation of forms and proper use of tamper to the full depth of the excavation. Prevent surface water from flowing into the excavation. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath, and the end of conduit.
 - 2. Set anchor bolts according to anchor-bolt templates furnished by the pole manufacturer.
 - 3. Install poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.
 - 4. After the poles have been installed, shimmed, and plumbed, grout the spaces between the pole bases and the concrete base with non-shrink concrete grout material. Provide a plastic or copper tube, of not less than 0.375 in inside diameter through the grout, tight to the top of the concrete base to prevent moisture weeping from the interior of the pole.
- C. Install lamps in each luminaire.
- D. Adjust luminaires that require field adjustment or aiming.

3.2 GROUNDING

Ground noncurrent-carrying parts of equipment, including metal poles, luminaires, mounting arms, brackets, and metallic enclosures, as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS. Where copper grounding conductor is connected to a metal other than copper, provide specially-treated or lined connectors suitable and listed for this purpose.

3.3 ACCEPTANCE CHECKS AND TESTS

Verify operation after installing luminaires and energizing circuits.

3.4 WATER TANKS AND COOLING TOWERS

Mount the luminaires at the extreme top of tank and tower.

3.5 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of 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 specifications will be tested as part of a larger system. Refer to Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS and related sections for contractor responsibilities for system commissioning.

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