DEPARTMENT OF VETERANS AFFAIRS
VHA MASTER SPECIFICATIONS

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Section 00 01 10

SECTION 23 00 60
MECHANICAL DEMOLITION

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the demolition and removal of automatic control components, valves, ductwork insulation and accessories in existing building.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

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

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify field measurements and existing ductwork arrangements are as shown on Drawings.

B. Verify that abandoned equipment serve only abandoned facilities.

C. Demolition drawings are based on casual field observation and existing record documents. The demolition drawings are diagrammatic and show the general scope of demolition work and do not show all the construction detail of the original record drawings. Report discrepancies to the VA Project Engineer before disturbing existing installation.

D. The contractor shall visit the existing building and grounds and review the existing building record drawings for details of existing installation to familiarize himself with existing conditions prior to submitting bid. No allowance will be made subsequently, in this connection, on behalf of the contractor for any error or negligence on his part.

E. Beginning of demolition means the contractor accepts existing conditions.

3.2 PREPARATION

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

3.3 DEMOLITION AND EXTENSION OF EXISTING MECHANICAL WORK

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

B. Unless otherwise noted on the drawings, all salvage items removed in connection with this Contract are to become the property of the contractor. Salvage items noted to remain the property of the VA shall be delivered to a location to be designated by the VA Project Engineer. Contractor shall remove from construction areas all trash or debris as it accumulates and dispose of it off campus at no additional cost to the VA. All construction areas shall be kept clean, safe, and orderly at all times. At the completion and acceptance for work, contractor shall remove from the site all debris and surplus materials resulting from this work and dispose of them off campus at no additional cost to the VA.

C. Remove, relocate, and extend existing installations to accommodate new construction as required for proper installation and system operation.

D. Remove all accessories above grade.

E. Seal all existing roof penetrations, which will not be reused.

F. Remove, relocate or provide brackets, hangers, and other accessories as required.

G. Repair adjacent construction and finishes damaged during demolition and extension work.

H. Maintain access to existing mechanical installations, which remain active.

I. The contractor shall remove diffusers, ductwork, and their appurtenances no longer required unless otherwise noted. The mixing boxes shall be refurbished and reused as noted in drawings.

3.4 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment, which remain or are to be returned to the VA Project Engineer.

B. All building surfaces damaged and openings left by new work or the removal or relocation of mechanical equipment, shall be repaired to original condition and painted by the contractor.

C. All ductwork identified as remaining shall be reinsulated with ductwrap per specification section 23 07 11.

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SECTION 23 05 11
COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 23.

B. Definitions:

1. Exposed: Piping, ductwork, and equipment exposed to view in finished rooms.
2. Option or optional: Contractor's choice of an alternate material or method.
3. PE: VA Project Engineer
4. 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 07 84 00, FIRESTOPPING.

E. Section 23 07 11, HVAC, PLUMBING, and Boiler Plant Insulation

F. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

G. Section 23 21 13, HYDRONIC PIPING

H. Section 23 22 13, STEAM and CONDENSATE HEATING PIPING

I. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training

J. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

1.3 QUALITY ASSURANCE

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

B. Products Criteria:

1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years. The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However,

digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other specification sections for any exceptions 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 then those specified. Refer any conflicts to the VA Project Engineer (PE)/Contracting Officers Technical Representative (COTR).
4. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.
5. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.
6. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
7. Asbestos products or equipment or materials containing asbestos shall not be used.

C. 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 reasonably close to the site.

D. 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.

E. Execution (Installation, Construction) Quality:

1. Apply and install all items in accordance with manufacturer's written instructions. Refer conflicts between the manufacturer's instructions and the contract drawings and specifications to the PE for resolution. Provide written hard copies or computer files of manufacturer’s installation instructions to the PE 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.
3. Upon request by Government, provide lists of previous installations for selected items of equipment. Include contact persons who will serve as references, with telephone numbers and e-mail addresses.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, and with requirements in the individual specification sections.

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

C. If equipment is submitted which differs in arrangement from that shown, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.

D. Prior to submitting shop drawings for approval, contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.

E. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient installation. Final review and approvals will be made only by groups.

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

1. Equipment and materials identification.

2. Fire-stopping materials.

G. 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.

1.5 APPLICABLE PUBLICATIONS

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

B. Air Conditioning, Heating and Refrigeration Institute (AHRI):

430-2009.....Central Station Air-Handling Units

C. American National Standard Institute (ANSI):

B31.1-2007.....Power Piping

D. Rubber Manufacturers Association (ANSI/RMA):

IP-20-2007.....Drives Using Classical V-Belts and Sheaves

IP-21-2009.....Drives Using Double-V (Hexagonal) Belts

IP-22-2007.....Drives Using Narrow V-Belts and Sheaves

E. Air Movement and Control Association (AMCA):

410-96.....Recommended Safety Practices for Air Moving Devices

F. American Society of Mechanical Engineers (ASME):

Boiler and Pressure Vessel Code (BPVC):

Section I-2007.....Power Boilers

Section IX-2007.....Welding and Brazing Qualifications

Code for Pressure Piping:

B31.1-2007.....Power Piping

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

A36/A36M-08.....Standard Specification for Carbon Structural Steel

A575-96(2007).....Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades

E84-10.....Standard Test Method for Burning Characteristics of Building Materials

E119-09c.....Standard Test Method for Fire Tests of Building Construction and Materials

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

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

SP 69-2003.....Pipe Hangers and Supports-Selection and Application

SP 127-2001.....Bracing for Piping Systems, Seismic – Wind – Dynamic, Design, Selection, Application

I. National Electrical Manufacturers Association (NEMA):

MG-1-2009.....Motors and Generators

J. National Fire Protection Association (NFPA):

31-06.....Standard for Installation of Oil-Burning Equipment

54-09.....National Fuel Gas Code

70-08.....National Electrical Code

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

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

101-09.....Life Safety Code

1.6 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

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

B. Cleanliness of Piping and Equipment Systems:

1. Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.

2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.
3. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.7 JOB CONDITIONS – WORK IN EXISTING BUILDING

A. Building Operation: Government employees will be continuously operating and managing all facilities, including temporary facilities, that serve the medical center.

B. Maintenance of Service: Schedule all work to permit continuous service as required by the Medical Center.

C. Steam and Condensate Service Interruptions: Limited steam and condensate service interruptions, as required for interconnections of new and existing systems, will be permitted by the Resident Engineer during periods when the demands are not critical to the operation of the Medical Center. These non-critical periods are limited to between 8 pm and 5 am in the appropriate off-season (if applicable). Provide at least one week advance notice to the VA Project 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 22 degrees C (72 degrees F) minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. No storm water or ground water leakage permitted. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA.

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

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

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

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

C. Components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.

D. Major items of equipment, which serve the same function, must be the same make and model. Exceptions will be permitted if performance requirements cannot be met.

2.2 COMPATIBILITY OF RELATED EQUIPMENT

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 LIFTING ATTACHMENTS

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

2.4 EQUIPMENT AND MATERIALS IDENTIFICATION

A. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 48 mm (3/16-inch) high of brass with black-filled letters, or rigid black plastic with white letters permanently fastened to the equipment. Identify unit components such as coils, filters, fans, etc.

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. Additionally, provide a hardcopy drawing and AutoCADD copy (version compatible with Fargo VA current version of CADD) of valve locations.

2.5 FIRESTOPPING

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

2.6 GALVANIZED REPAIR COMPOUND

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

2.7 HVAC PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

A. 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 VA Project 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 VA Project Engineer for each job condition.

B. 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.

C. Attachment to Wood Construction: Wood screws or lag bolts.

D. Hanger Rods: Hot-rolled steel, ASTM A36 or A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 38 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.

E. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (No. 12 gage), designed to accept special spring held, hardened steel nuts. 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.

F. Supports for Piping Systems:
   1. Select hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or preinsulated calcium silicate shields. Provide Type 40 insulation shield or preinsulated calcium silicate shield at all other types of supports and hangers including those for preinsulated piping.
   2. Piping Systems except High and Medium Pressure Steam (MSS SP-58):
      a. Standard clevis hanger: Type 1; provide locknut.
      b. Riser clamps: Type 8.
      c. Wall brackets: Types 31, 32 or 33.
      d. Roller supports: Type 41, 43, 44 and 46.
      e. Saddle support: Type 36, 37 or 38.
      f. Turnbuckle: Types 13 or 15. Preinsulate.
      g. U-bolt clamp: Type 24.
      h. Copper Tube:
         1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with non adhesive isolation tape to prevent electrolysis.
         2) For vertical runs use epoxy painted or plastic coated riser clamps.
         3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.
         4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.
   3. High and Medium Pressure Steam (MSS SP-58):
      a. Provide eye rod or Type 17 eye nut near the upper attachment.

b. Piping 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.

2.8 SPECIAL TOOLS AND LUBRICANTS

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

2.9 ASBESTOS

A. Materials containing asbestos are not permitted.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

A. Coordinate location of piping, sleeves, inserts, hangers, 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. Cutting Holes:

1. Cut holes through concrete and masonry by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by PE/COTR where working area space is limited.
2. Locate holes to avoid interference with structural members such as beams or grade beams.
3. Do not penetrate membrane waterproofing.

E. Interconnection of Instrumentation or Control Devices: Generally, electrical and pneumatic interconnections are not shown but must be provided.

F. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.

G. Electrical and Pneumatic Interconnection of Controls and Instruments: This generally not shown but must be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments and computer workstations. Comply with NFPA-70.

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 VA Project Engineer. Damaged or defective items in the opinion of the VA Project Engineer shall be replaced.
2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and equipment against dirt, water, chemical, or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.

I. 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.

J. Work in Existing Building:

1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00 00, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).
2. As specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will least interfere with normal operation of the facility.
3. Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills, will be permitted only with approval of the VA Project

Engineer. Locate openings that will not affect structural slabs, columns, ribs or beams.

K. Switchgear and IRM/HUB Rooms and Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear. If this is not possible, drip pans shall be installed below piping to protect electrical and telephone switchgear.

L. Inaccessible Equipment:

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

3.2 PIPE AND EQUIPMENT SUPPORTS

A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Do not drill or burn holes in structural steel.

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. 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.

3.3 MECHANICAL DEMOLITION

A. Rigging access, other than indicated on the drawings, shall be provided by the Contractor after approval for structural integrity by the A/E. Such access shall be provided without additional cost or time to the Government. Where work is in an operating building, provide approved protection from dust and debris at all times for the safety of personnel and maintenance of operation and environment of the building.

B. 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.

3.4 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.

B. In addition, the following special conditions apply:

1. Cleaning shall be thorough. Use solvents, cleaning materials and methods recommended by the manufacturers for the specific tasks. Remove all rust prior to painting and from surfaces to remain unpainted. Repair scratches, scuffs, and abrasions prior to applying prime and finish coats.
2. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.
3. Pumps, motors, steel and cast iron bases, and coupling guards shall be cleaned, and shall be touched-up with the same color as utilized by the pump manufacturer

3.5 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.

3.6 LUBRICATION

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

B. Equip all devices with required lubrication fittings or devices.

C. Provide any specialized grease gun(s) with attachments for applicable fittings for each type of grease applied.

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

3.7 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.

3.8 STARTUP AND TEMPORARY OPERATION

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

3.9 OPERATING AND PERFORMANCE TESTS

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

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.

3.10 INSTRUCTIONS TO VA PERSONNEL

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

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SECTION 23 07 11
HVAC AND BOILER PLANT INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Field applied insulation for thermal efficiency and condensation control for:
   1. HVAC piping, ductwork, and equipment.

B. Definitions
   1. ASJ: All service jacket, white finish facing or jacket.
   2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.
   3. Cold: Equipment, ductwork or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.
   4. Concealed: Ductwork and piping above ceilings and in chases, interstitial space, and pipe spaces.
   5. Exposed: Piping, ductwork, and equipment exposed to view in finished areas including mechanical and electrical equipment rooms or exposed to outdoor weather. Attics and crawl spaces where air handling units are located are considered to be mechanical rooms. Shafts, chases, interstitial spaces, unfinished attics, crawl spaces and pipe basements are not considered finished areas.
   6. FSK: Foil-scrim-kraft facing.
   7. Hot: HVAC Ductwork handling air at design temperature above 16 degrees C (60 degrees F); HVAC equipment or piping handling media above 41 degrees C (105 degrees F).
   8. Density: kg/m3 - kilograms per cubic meter (Pcf - pounds per cubic foot).
   9. Runouts: Branch pipe connections up to 25-mm (one-inch) nominal size to fan coil units or reheat coils for terminal units.
   10. Thermal conductance: Heat flow rate through materials.
      a. Flat surface: Watt per square meter (BTU per hour per square foot).
      b. Pipe or Cylinder: Watt per square meter (BTU per hour per linear foot).
   11. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).

12. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.
13. MPS: Medium pressure steam (110 kPa [16 psig] thru 414 kPa [59 psig].
14. MPR: Medium pressure steam condensate return.
15. LPS: Low pressure steam (103 kPa [15 psig] and below).
16. LPR: Low pressure steam condensate gravity return.
17. HWH: Hot water heating supply.
18. HWHR: Hot water heating return.
19. GH: Hot glycol-water heating supply.
20. GHR: Hot glycol-water heating return.
21. GC: Chilled glycol-water supply.
22. GCR: Chilled glycol-water return.

1.2 RELATED WORK

A. Section 07 84 00, FIRESTOPPING: Mineral fiber and bond breaker behind sealant.
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
D. Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM and CONDENSATE HEATING PIPING: Piping and equipment.
E. Section 23 21 13, HYDRONIC PIPING: Hot water, chilled water, and glycol piping.
F. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS. Requirements for commissioning, systems readiness checklists, and training.

1.3 QUALITY ASSURANCE

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

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

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

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

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

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

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

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

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

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

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

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

4.3.10.2.6.1 Electrical wires and cables and optical fiber cables shall be listed as noncombustible or limited combustible and have a maximum smoke developed index of 50 or shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance

with NFPA 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

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

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

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

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

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

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

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

1.4 SUBMITTALS

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

B. Shop Drawings:

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

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

1.5 STORAGE AND HANDLING OF MATERIAL

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

1.6 APPLICABLE PUBLICATIONS

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

B. Federal Specifications (Fed. Spec.):

L-P-535E (2)- 99.....Plastic Sheet (Sheeting): Plastic Strip; Poly (Vinyl Chloride) and Poly (Vinyl Chloride - Vinyl Acetate), Rigid.

C. Military Specifications (Mil. Spec.):

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

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

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

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

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

A167-99(2004).....Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

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

C411-05.....Standard test method for Hot-Surface Performance of High-Temperature Thermal Insulation

C449-07.....Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement

C533-09.....Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation

C534-08.....Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

C547-07.....Standard Specification for Mineral Fiber pipe Insulation

C552-07.....Standard Specification for Cellular Glass Thermal Insulation

C553-08.....Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

C585-09.....Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System) R (1998)

C612-10.....Standard Specification for Mineral Fiber Block and Board Thermal Insulation

C1126-04.....Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation

C1136-10.....Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation

D1668-97a (2006).....Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing

E84-10.....Standard Test Method for Surface Burning Characteristics of Building Materials

E119-09c.....Standard Test Method for Fire Tests of Building Construction and Materials

E136-09b.....Standard Test Methods for Behavior of Materials in a Vertical Tube Furnace at 750 degrees C (1380 F)

E. National Fire Protection Association (NFPA):

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

101-09.....Life Safety Code

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

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

F. Underwriters Laboratories, Inc (UL):

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

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

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

PART 2 - PRODUCTS

2.1 MINERAL FIBER OR FIBER GLASS

A. ASTM C612 (Board, Block), Class 1 or 2, density 48 kg/m3 (3 pcf), k = 0.037 (0.26) at 24 degrees C (75 degrees F), external insulation for temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.

B. ASTM C553 (Blanket, Flexible) Type I, Class B-5, Density 32 kg/m3 (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) 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 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/ ft3)	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

2.3 INSULATION FACINGS AND JACKETS

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

B. ASJ jacket shall be white kraft bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for

painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 75 mm (3 inch) butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.

C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK) or PVDC vapor retarder jacketing type for concealed ductwork and equipment.

D. Factory composite materials may be used provided that they have been tested and certified by the manufacturer.

E. Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be polyvinyl chloride (PVC) conforming to Fed Spec L-P-335, composition A, Type II Grade GU, and Type III, minimum thickness 0.7 mm (0.03 inches). Provide color matching vapor retarder pressure sensitive tape.

2.4 PIPE COVERING PROTECTION SADDLES

A. Cold pipe support: Premolded pipe insulation 180 degrees (half-shells) on bottom half of pipe at supports. Material shall be calcium silicate 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).

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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]) or calcium silicate. Insulation at supports shall have same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m3 (3.0 pcf).

2.5 ADHESIVE, MASTIC, CEMENT

A. Mil. Spec. MIL-A-3316, Class 1: Jacket and lap adhesive and protective finish coating for insulation.

B. Mil. Spec. MIL-A-3316, Class 2: Adhesive for laps and for adhering insulation to metal surfaces.

C. Mil. Spec. MIL-A-24179, Type II Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.

D. Mil. Spec. MIL-C-19565, Type I: 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.

2.6 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.

2.7 REINFORCEMENT AND FINISHES

A. Hexagonal wire netting: 25 mm (one inch) mesh, 0.85 mm thick (22 gage) galvanized steel.

B. Corner beads: 50 mm (2 inch) by 50 mm (2 inch), 0.55 mm thick (26 gage) galvanized steel; or, 25 mm (1 inch) by 25 mm (1 inch), 0.47 mm thick (28 gage) aluminum angle adhered to 50 mm (2 inch) by 50 mm (2 inch) Kraft paper.

2.8 FIRESTOPPING MATERIAL

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

2.9 FLAME AND SMOKE

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

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

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

B. Except for specific exceptions, insulate entire specified equipment, piping (pipe, fittings, valves, accessories), and duct systems. Insulate each pipe and duct individually. Do not use scrap pieces of insulation where a full length section will fit.

C. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. 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. 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.

F. HVAC work not to be insulated:

1. Air handling units.
2. In hot piping: Unions, flexible connectors, 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.

G. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.

H. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. 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.

I. 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. Partitions

3.2 INSULATION INSTALLATION

A. Mineral Fiber Board:

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

3. Exposed ductwork and equipment in unfinished areas, mechanical and electrical equipment rooms and attics, interstitial spaces and duct work exposed to outdoor weather:
   a. 40 mm (1-1/2 inch) thick insulation faced with ASJ (white all service jacket): Supply air duct, return air duct, exhaust air duct, relief air duct, and afterfilter housing.
   b. Outside air intake ducts: 75 mm (three inch) thick insulation faced with ASJ.

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.
      c. Above ceilings level: 40 mm (1 ½ inch) thick insulation faced with FSK.
   4. Exhaust, relief, and return air: 40 mm (1-1/2 inch) thick insulation faced with FSK.

C. Molded Mineral Fiber Pipe and Tubing Covering:
   1. Fit insulation to pipe or duct, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.

2. Contractor's options for fitting, flange and valve insulation:
   a. Insulating and finishing cement for sizes less than 100 mm (4 inches) operating at surface temperature of 16 degrees C (61 degrees F) or more.
   a. 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.
   b. 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.
   c. 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.

3.3 PIPE INSULATION SCHEDULE

A. Provide insulation for piping systems as scheduled below:

Insulation Thickness Millimeters (Inches)					
		Nominal Pipe Size Millimeters (Inches)			
Operating Temperature Range/Service	Insulation Material	Less than 25 (1)	25 – 32 (1 – 1¼)	38 – 75 (1½ - 3)	100 (4) and Above
122-177 degrees C (251-350 degrees F) (MPS)	Mineral Fiber (Above ground piping only)	75 (3)	100 (4)	113 (4.5)	113 (4.5)
100-121 degrees C (212-250 degrees F) (MPR, LPS, vent piping from PRV Safety Valves, Condensate receivers and flash tanks)	Mineral Fiber (Above ground piping only)	62 (2.5)	62 (2.5)	75 (3.0)	75 (3.0)
38-94 degrees C (100-200 degrees F)	Mineral Fiber (Above ground	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)

(LPR, GH and GHR)	piping only)				
4-16 degrees C (40-60 degrees F) (GC, GCR)	Mineral Fiber (Above ground piping only)	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)

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SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide (a) direct-digital control system(s) as indicated on the project documents, point list, interoperability tables, drawings and as described in these specifications. Include a complete and working direct-digital control system. Include all engineering, programming, controls and installation materials, installation labor, commissioning and start-up, training, final project documentation and warranty.

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

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

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

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

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

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

1. Fire alarm systems. If zoned fire alarm is required by the project-specific requirements, this interface shall require multiple relays, which are provided and installed by the fire alarm system contractor, to be monitored.

D. Responsibility Table:

Work/Item/System	**Furnish**	**Install**	**Low Voltage Wiring**	**Line Power**
Control system low voltage and communication wiring	23 09 23	23 09 23	23 09 23	N/A
LAN conduits and raceway	23 09 23	23 09 23	N/A	N/A
Automatic damper actuators	23 09 23	23 09 23	23 09 23	23 09 23
Manual valves	23	23	N/A	N/A
Automatic valves	23 09 23	23	23 09 23	23 09 23

Work/Item/System	Furnish	Install	Low Voltage Wiring	Line Power
Pipe insertion devices and taps, flow and pressure stations.	23	23	N/A	N/A
Thermowells	23 09 23	23	N/A	N/A
Current Switches	23 09 23	23 09 23	23 09 23	N/A
Control Relays	23 09 23	23 09 23	23 09 23	N/A
All control system nodes, equipment, housings, enclosures and panels.	23 09 23	23 09 23	23 09 23	26

E. This facility's existing direct-digital control system and its ECC is located at the mechanical shop. The contractor administered by this Section of the technical specifications shall observe the capabilities, communication network, services, spare capacity of the existing control system and its ECC prior to beginning work.

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

F. This campus has standardized on an existing standard ASHRAE Standard 135, BACnet/IP Control System supported by a preselected controls service company (G & R Controls – Siemens). This entity is referred to as the "Control System Integrator" in this Section of the technical specifications. The Control system integrator is responsible for ECC system graphics and expansion. It also prescribes control system-specific commissioning/ verification procedures to the contractor administered by this Section of the technical specification. It lastly provides limited assistance to the contractor administered by this Section of the technical specification in its commissioning/verification work. The Control System Integrator shall be removed under Deduct Alternate No. 3. If the deduct alternate is accepted, each controls contractor shall be responsible for its own

ECC, system graphics and expansion. All of the items in the "Control System Integrator" column (of the responsibility table on the next page) would turn into the responsibility of the controls contractor (Section 23 09 23 Contractor) if the alternate is accepted.

1. The General Contractor of this project shall directly hire the Control System Integrator in a contract separate from the contract procuring the controls contractor administered by this Section of the technical specifications.
2. The contractor administered by this Section of the technical specifications shall coordinate all work with the Control System Integrator. The contractor administered by this Section of the technical specifications shall integrate the ASHRAE Standard 135, BACnet/IP control network(s) with the Control System Integrator's area control through an Ethernet connection provided by the Control System Integrator.
3. The contractor administered by this Section of the technical specifications shall provide a peer-to-peer networked, stand-alone, distributed control system. This direct digital control (DDC) system shall include one portable operator terminal - laptop, one digital display unit, microprocessor-based controllers, instrumentation, end control devices, wiring, piping, software, and related systems. This contractor is responsible for all device mounting and wiring.
4. Responsibility Table:

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

Overall system verification		X	
Controller and LAN system verification	X		

1.2 RELATED WORK

A. Section 23 21 13, Hydronic Piping.

B. Section 23 22 13, Steam and Condensate Heating Piping.

C. Section 26 05 11, Requirements for Electrical Installations.

D. Section 26 05 21, Low-Voltage Electrical Power Conductors and Cables (600 Volts and Below).

E. Section 26 05 26, Grounding and Bonding for Electrical Systems.

F. Section 26 05 33, Raceway and Boxes for Electrical Systems.

G. Section 26 27 26, Wiring Devices.

H. Section 27 10 05, Computer Network and Telephone Wiring System

1.3 DEFINITION

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

B. Analog: A continuously varying signal value (e.g., temperature, current, velocity etc.

C. BACnet: A Data Communication Protocol for Building Automation and Control Networks , ANSI/ASHRAE Standard 135. This communications protocol allows diverse building automation devices to communicate data over and services over a network.

D. BACnet/IP: Annex J of Standard 135. It defines and allows for using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP sub-networks that share the same BACnet network number.

E. BACnet Internetwork: Two or more BACnet networks connected with routers. The two networks may sue different LAN technologies.

F. BACnet Network: One or more BACnet segments that have the same network address and are interconnected by bridges at the physical and data link layers.

G. BACnet Segment: One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.

H. BACnet Broadcast Management Device (BBMD): A communications device which broadcasts BACnet messages to all BACnet/IP devices and other BBMDs connected to the same BACnet/IP network.

I. BACnet Interoperability Building Blocks (BIBBs): BACnet Interoperability Building Blocks (BIBBs) are collections of one or more

BACnet services. These are prescribed in terms of an "A" and a "B" device. Both of these devices are nodes on a BACnet internetwork.

J. BACnet Testing Laboratories (BTL). The organization responsible for testing products for compliance with the BACnet standard, operated under the direction of BACnet International.

K. Baud: It is a signal change in a communication link. One signal change can represent one or more bits of information depending on type of transmission scheme. Simple peripheral communication is normally one bit per Baud. (e.g., Baud rate = 78,000 Baud/sec is 78,000 bits/sec, if one signal change = 1 bit).

L. Binary: A two-state system where a high signal level represents an "ON" condition and an "OFF" condition is represented by a low signal level.

M. BMP or bmp: Suffix, computerized image file, used after the period in a DOS-based computer file to show that the file is an image stored as a series of pixels.

N. Bus Topology: A network topology that physically interconnects workstations and network devices in parallel on a network segment.

O. Control Unit (CU): Generic term for any controlling unit, stand-alone, microprocessor based, digital controller residing on secondary LAN or Primary LAN, used for local controls or global controls

P. Deadband: A temperature range over which no heating or cooling is supplied, i.e., 22-25 degrees C (72-78 degrees F), as opposed to a single point change over or overlap).

Q. Device: a control system component that contains a BACnet Device Object and uses BACnet to communicate with other devices.

R. Device Object: Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet internetwork. This number is often referred to as the device instance.

S. Device Profile: A specific group of services describing BACnet capabilities of a device, as defined in ASHRAE Standard 135-2008, Annex L. Standard device profiles include BACnet Operator Workstations (B-OWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS). Each device used in new construction is required to have a PICS statement listing which service and BIBBs are supported by the device.

T. Diagnostic Program: A software test program, which is used to detect and report system or peripheral malfunctions and failures. Generally, this system is performed at the initial startup of the system.

U. Direct Digital Control (DDC): Microprocessor based control including Analog/Digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices in order to achieve a set of predefined conditions.

V. Distributed Control System: A system in which the processing of system data is decentralized and control decisions can and are made at the subsystem level. System operational programs and information are provided to the remote subsystems and status is reported back to the Engineering Control Center. Upon the loss of communication with the Engineering Control center, the subsystems shall be capable of operating in a stand-alone mode using the last best available data.

W. Download: The electronic transfer of programs and data files from a central computer or operation workstation with secondary memory devices to remote computers in a network (distributed) system.

X. DXF: An AutoCAD 2-D graphics file format. Many CAD systems import and export the DXF format for graphics interchange.

Y. Electrical Control: A control circuit that operates on line or low voltage and uses a mechanical means, such as a temperature sensitive bimetal or bellows, to perform control functions, such as actuating a switch or positioning a potentiometer.

Z. Electronic Control: A control circuit that operates on low voltage and uses a solid-state components to amplify input signals and perform control functions, such as operating a relay or providing an output signal to position an actuator.

AA. Engineering Control Center (ECC): The centralized control point for the intelligent control network. The ECC comprises of personal computer and connected devices to form a single workstation.

BB. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.

CC. Firmware: Firmware is software programmed into read only memory (ROM) chips. Software may not be changed without physically altering the chip.

DD. Gateway: Communication hardware connecting two or more different protocols. It translates one protocol into equivalent concepts for the other protocol. In BACnet applications, a gateway has BACnet on one side and non-BACnet (usually proprietary) protocols on the other side.

EE. GIF: Abbreviation of Graphic interchange format.

FF. Graphic Program (GP): Program used to produce images of air handler systems, fans, chillers, pumps, and building spaces. These images can be animated and/or color-coded to indicate operation of the equipment.

GG. Graphic Sequence of Operation: It is a graphical representation of the sequence of operation, showing all inputs and output logical blocks.

HH. I/O Unit: The section of a digital control system through which information is received and transmitted. I/O refers to analog input (AI, digital input (DI), analog output (AO) and digital output (DO). Analog signals are continuous and represent temperature, pressure, flow rate etc, whereas digital signals convert electronic signals to digital pulses (values), represent motor status, filter status, on-off equipment etc.

II. I/P: a method for conveying and routing packets of information over LAN paths. User Datagram Protocol (UDP) conveys information to “sockets” without confirmation of receipt. Transmission Control Protocol (TCP) establishes "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.

JJ. JPEG: A standardized image compression mechanism stands for Joint Photographic Experts Group, the original name of the committee that wrote the standard.

KK. Local Area Network (LAN): A communication bus that interconnects operator workstation and digital controllers for peer-to-peer communications, sharing resources and exchanging information.

LL. Network Repeater: A device that receives data packet from one network and rebroadcasts to another network. No routing information is added to the protocol.

MM. Native BACnet Device: A device that uses BACnet as its primary method of communication with other BACnet devices without intermediary gateways. A system that uses native BACnet devices at all levels is a native BACnet system.

NN. Network Number: A site-specific number assigned to each network segment to identify for routing. This network number must be unique throughout the BACnet internetwork.

OO. Object: The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.

PP. Object Identifier: An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.

QQ. Object Properties: Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in ASHRAE 135; some are optional and some are required. Objects are controlled by reading from and writing to object properties.

RR. Operating system (OS): Software, which controls the execution of computer application programs.

SS. PCX: File type for an image file. When photographs are scanned onto a personal computer they can be saved as PCX files and viewed or changed by a special application program as Photo Shop.

TT. Peripheral: Different components that make the control system function as one unit. Peripherals include monitor, printer, and I/O unit.

UU. Peer-to-Peer: A networking architecture that treats all network stations as equal partners- any device can initiate and respond to communication with other devices.

VV. PICS: Protocol Implementation Conformance Statement, describing the BACnet capabilities of a device. All BACnet devices have published PICS.

WW. PID: Proportional, integral, and derivative control, used to control modulating equipment to maintain a setpoint.

XX. Repeater: A network component that connects two or more physical segments at the physical layer.

YY. Router: a component that joins together two or more networks using different LAN technologies. Examples include joining a BACnet Ethernet LAN to a BACnet MS/TP LAN.

ZZ. Sensors: devices measuring state points or flows, which are then transmitted back to the DDC system.

AAA. Thermostats : devices measuring temperatures, which are used in control of standalone or unitary systems and equipment not attached to the DDC system.

1.4 QUALITY ASSURANCE

A. Criteria:

1. Single Source Responsibility of subcontractor: The Contractor shall obtain hardware and software supplied under this Section and delegate the responsibility to a single source controls installation subcontractor. The controls subcontractor shall be responsible for the complete design, installation, and commissioning of the system. The controls subcontractor shall be in the business of design, installation and service of such building automation control systems similar in size and complexity.
2. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in production and installation of HVAC control systems. Products shall be manufacturer’s latest standard design and have been tested and proven in actual use.
3. The controls subcontractor shall provide a list of no less than five similar projects which have building control systems as specified in this Section. These projects must be on-line and functional such that the Department of Veterans Affairs (VA) representative would observe the control systems in full operation.
4. The controls subcontractor shall have in-place facility within 50 miles with technical staff, spare parts inventory for the next five (5) years, and necessary test and diagnostic equipment to support the control systems.
5. The controls subcontractor shall have minimum of three years experience in design and installation of building automation systems similar in performance to those specified in this Section. Provide evidence of experience by submitting resumes of the project manager, the local branch manager, project engineer, the application engineering staff, and the electronic technicians who would be involved with the supervision, the engineering, and the installation of the control systems. Training and experience of these personnel shall not be less than three years. Failure to disclose this information will be a ground for disqualification of the supplier.

6. Provide a competent and experienced Project Manager employed by the Controls Contractor. The Project Manager shall be supported as necessary by other Contractor employees in order to provide professional engineering, technical and management service for the work. The Project Manager shall attend scheduled Project Meetings as required and shall be empowered to make technical, scheduling and related decisions on behalf of the Controls Contractor.

B. Codes and Standards:

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

1.5 PERFORMANCE

A. The system shall conform to the following:

1. Graphic Display: The system shall display up to four (4) graphics on a single screen with a minimum of twenty (20) dynamic points per graphic. All current data shall be displayed within ten (10) seconds of the request.
2. Graphic Refresh: The system shall update all dynamic points with current data within eight (8) seconds. Data refresh shall be automatic, without operator intervention.
3. Object Command: The maximum time between the command of a binary object by the operator and the reaction by the device shall be two(2) seconds. Analog objects shall start to adjust within two (2) seconds.
4. Object Scan: All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or work-station will be current, within the prior six (6) seconds.
5. Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed (10) seconds.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every (5) seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
7. Multiple Alarm Annunciations: All workstations on the network shall receive alarms within five (5) seconds of each other.

8. Performance: Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every one (1) second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
9. Reporting Accuracy: Listed below are minimum acceptable reporting end-to-end accuracies for all values reported by the specified system:

Measured Variable	**Reported Accuracy**
Space temperature	±0.5°C (±1°F)
Ducted air temperature	±0.5°C [±1°F]
Outdoor air temperature	±1.0°C [±2°F]
Dew Point	±1.5°C [±3°F]
Water temperature	±0.5°C [±1°F]
Relative humidity	±2% RH
Air pressure (ducts)	±25 Pa [±0.1"w.c.]
Air pressure (space)	±0.3 Pa [±0.001"w.c.]
Electrical Power	±0.5% of reading

Note 1: for both absolute and differential pressure

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

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

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

1.6 WARRANTY

A. Labor and materials for control systems shall be warranted for a period as specified under Warranty in FAR clause 52.246-21.

B. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no cost or reduction in service to the owner.

The system includes all computer equipment, transmission equipment, and all sensors and control devices.

C. Controls and Instrumentation subcontractor shall be responsible for temporary operations and maintenance of the control systems during the construction period until final commissioning, training of facility operators and acceptance of the project by VA. All existing equipment shall be kept functional during construction. Coordinate all work affecting building systems with the VA.

1.7 SUBMITTALS

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

B. Manufacturer’s literature and data for all components including the following:

1. A wiring diagram for each type of input device and output device including DDC controllers, modems, repeaters, etc. Diagram shall show how the device is wired and powered, showing typical connections at the digital controllers and each power supply, as well as the device itself. Show for all field connected devices, including but not limited to, control relays, motor starters, electric or electronic actuators, and temperature pressure, flow and humidity sensors and transmitters.
2. A diagram of each terminal strip, including digital controller terminal strips, terminal strip location, termination numbers and the associated point names.
3. Control dampers and control valves schedule, including the size and pressure drop.
4. Catalog cut sheets of all equipment used. This includes, but is not limited to software (by manufacturer and by third parties), DDC controllers, panels, peripherals, airflow measuring stations and associated components, and auxiliary control devices such as sensors, actuators, and control dampers. When manufacturer’s cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted. Each submitted piece of literature and drawings should clearly reference the specification and/or drawings that it supposed to represent.

5. Sequence of operations for each HVAC system and the associated control diagrams. Equipment and control labels shall correspond to those shown on the drawings.
6. Color prints of proposed graphics with a list of points for display.
7. Furnish a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet-compliant device.
8. Schematic wiring diagrams for all control, communication and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.
9. An instrumentation list for each controlled system. Each element of the controlled system shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.
10. Riser diagrams of wiring between central control unit and all control panels.
11. Scaled plan drawings showing routing of LAN and locations of control panels, controllers, routers, gateways, ECC, and larger controlled devices.
12. Construction details for all installed conduit, cabling, raceway, cabinets, and similar. Construction details of all penetrations and their protection.
13. Quantities of submitted items may be reviewed but are the responsibility of the contractor administered by this Section of the technical specifications.

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

D. Licenses: Provide licenses for all software residing on and used by the Controls Systems and transfer these licenses to the Owner prior to completion.

E. As Built Control Drawings:
1. Furnish three (3) copies of as-built drawings for each control system. The documents shall be submitted for approval prior to final completion.
2. Furnish one (1) stick set of applicable control system prints for each mechanical system for wall mounting. The documents shall be submitted for approval prior to final completion.

3. Furnish one (1) CD-ROM in CAD DWG format for the drawings noted in subparagraphs above. CAD version utilized must be compatible with version currently used at the Fargo VA Medical Center.

F. Operation and Maintenance (O/M) Manuals):
   1. Submit in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS. Provide hardcopy and PDF version on CD or DVD.
   2. Include the following documentation:
      a. General description and specifications for all components, including logging on/off, alarm handling, producing trend reports, overriding computer control, and changing set points and other variables.
      b. Detailed illustrations of all the control systems specified for ease of maintenance and repair/replacement procedures, and complete calibration procedures.
      c. One copy of the final version of all software provided including operating systems, programming language, operator workstation software, and graphics software.
      d. Complete troubleshooting procedures and guidelines for all systems.
      e. Complete operating instructions for all systems.
      f. Recommended preventive maintenance procedures for all system components including a schedule of tasks for inspection, cleaning and calibration. Provide a list of recommended spare parts needed to minimize downtime.
      g. Licenses, guaranty, and other pertaining documents for all equipment and systems.

G. Submit Performance Report to VA Project Engineer prior to final inspection.

1.8 INSTRUCTIONS

A. Instructions to VA operations personnel: Perform in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS, and as noted below.
   1. Training shall comprise of on the job training during start-up, checkout period, and performance test period. VA facilities personnel will work with the Contractor’s installation and test personnel on a daily basis during start-up and checkout period. During the performance test period, controls subcontractor will

provide 8 hours of instructions, given in multiple training sessions (each no longer than four hours in length), to the VA facilities personnel.

2. The O/M Manuals shall contain approved submittals as outlined in Article 1.7, SUBMITTALS. The Controls subcontractor will review the manual contents with VA facilities personnel during second phase of training.
3. Training shall be given by direct employees of the controls system subcontractor.

1.9 PROJECT CONDITIONS (ENVIRONMENTAL CONDITIONS OF OPERATION)

A. The ECC and peripheral devices and system support equipment shall be designed to operate in ambient condition of 20 to 35°C (65 to 90°F) at a relative humidity of 20 to 80% non-condensing.

B. All electronic equipment shall operate properly with power fluctuations of plus 10 percent to minus 15 percent of nominal supply voltage.

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

1.10 APPLICABLE PUBLICATIONS

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

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

Standard 135-10.....BACNET Building Automation and Control Networks

C. American Society of Mechanical Engineers (ASME):

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

D. American Society of Testing Materials (ASTM):

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

E. Federal Communication Commission (FCC):

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

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

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

G. National Fire Protection Association (NFPA):

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

H. Underwriter Laboratories Inc (UL):

94-10.....Tests for Flammability of Plastic Materials for Parts and Devices and Appliances
294-10.....Access Control System Units
486A/486B-10.....Wire Connectors
555S-11.....Standard for Smoke Dampers
916-10.....Energy Management Equipment
1076-10.....Proprietary Burglar Alarm Units and Systems

PART 2 - PRODUCTS

2.1 MATERIALS

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

2.2 CONTROLS SYSTEM ARCHITECTURE

A. General

1. The Controls Systems shall consist of multiple Nodes and associated equipment connected by industry standard digital and communication network arrangements.
2. The building controllers and principal communications network equipment shall be standard products of recognized major manufacturers available through normal PC and computer vendor channels – not "Clones" assembled by a third-party subcontractor.
3. The networks shall, at minimum, comprise, as necessary, the following:
   a. Active processing BACnet-compliant building controllers connected to other BACNet-compliant controllers together with their power supplies and associated equipment.
   b. Addressable elements, sensors, transducers and end devices.

c. Third-party equipment interfaces and gateways as described and required by the Contract Documents.

d. Other components required for a complete and working Control Systems as specified.

B. The Specifications for the individual elements and component subsystems shall be minimum requirements and shall be augmented as necessary by the Contractor to achieve both compliance with all applicable codes, standards and to meet all requirements of the Contract Documents.

C. Network Architecture

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

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

D. Third Party Interfaces:

1. The contractor administered by this Section of the technical specifications shall include necessary hardware, equipment, software and programming to allow data communications between the controls systems and building systems supplied by other trades.

2. Other manufacturers and contractors supplying other associated systems and equipment shall provide their necessary hardware, software and start-up at their cost and shall cooperate fully with the contractor administered by this Section of the technical specifications in a timely manner and at their cost to ensure complete functional integration.

E. Servers:

1. Provide data storage server(s) to archive historical data including trends, alarm and event histories and transaction logs. Include any additional servers as needed for system expansion.

2. Equip these server(s) with the same software tool set that is located in the BACnet building controllers for system configuration and custom logic definition and color graphic configuration or provide upgrade to all at no extra cost.

3. Access to all information on the data storage server(s) shall be through the same browser functionality used to access individual nodes. When logged onto a server the operator will be able to also interact with any other controller on the control system as required

for the functional operation of the controls systems. The contractor administered by this Section of the technical specifications shall provide all necessary digital processor programmable data storage server(s).

4. These server(s) shall be utilized for controls systems application configuration, for archiving, reporting and trending of data, for operator transaction archiving and reporting, for network information management, for alarm annunciation, for operator interface tasks, for controls application management and similar. These server(s) shall utilize IT industry standard data base platforms which utilize a database declarative language designed for managing data in relational database management systems (RDBMS) such as SQL.

2.3 COMMUNICATION

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

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

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

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

1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, reports, system software, and custom programs shall be viewable and editable from each internetwork controller.

2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute specified control system operation. An authorized operator shall be able to edit cross-controller links by typing a standard object address.

D. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and

wiring. Expansion shall not require operator interface hardware additions or software revisions.

E. ECCs and Controllers with real-time clocks shall use the BACnet Time Synchronization service. The system shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight savings and standard time as applicable. After power outages, the system components shall automatically restart.

2.4 ENGINEERING CONTROL CENTER (ECC)

A. The controls contractor shall utilize the existing Operator’s Workstation in the Mechanical Shop. If the software currently installed on the workstation does not match the controls contractor’s software, new software shall be provided. Any workstation upgrades to the existing computer hardware or software shall be completed by this contractor at this time if required.

B. The ECC shall reside on a high-speed network with controllers as shown on system drawings. The ECC and each standard browser connected to server shall be able to access all system information.

C. ECC and controllers shall communicate using BACnet protocol. ECC and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ASHRAE/ANSI 135-2008, BACnet Annex J. After power outages, the system components shall automatically restart.

A. ECC Software:

1. Provide for automatic system database save and restore on the ECC’s hard disk a copy of the current database of each Controller. This database shall be updated whenever a change is made in any system panel. In the event of a database loss in a building management panel, the ECC shall automatically restore the database for that panel. This capability may be disabled by the operator.
2. Provide for manual database save and restore. An operator with proper clearance shall be able to save the database from any system panel. The operator also shall be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
3. Provide a method of configuring the system. This shall allow for future system changes or additions by users with proper clearance.

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

operating system shall be Windows XP or better, and shall support the third party software.

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

f. Real-time graphical viewing and control of environment.
g. Scheduling trend reports.
h. Program editing.
i. Operating activity log and system security.
j. Transfer data to third party software.

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

operator intervention and without pre-defined screen refresh values.

d. Color shall be used to indicate status and change in status of the equipment. The state colors shall be user definable.

e. A clipart library of HVAC equipment, such as chillers, boilers, air handling units, fans, terminal units, pumps, coils, standard ductwork, piping, valves and laboratory symbols shall be provided in the system. The operator shall have the ability to add custom symbols to the clipart library.

f. A dynamic display of the site-specific architecture showing status of the controllers, the ECC and network shall be provided.

g. The windowing environment of the workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of graphic associated with an alarm to be viewed without interrupting work in progress. The graphic system software shall also have the capability to split screen, half portion of the screen with graphical representation and the other half with sequence of operation of the same HVAC system.

16. Trend reports shall be generated on demand or pre-defined schedule and directed to monitor display, printers or disk. As a minimum, the system shall allow the operator to easily obtain the following types of reports:

a. A general list of all selected points in the network.

b. List of all points in the alarm.

c. List of all points in the override status.

d. List of all disabled points.

e. List of all points currently locked out.

f. List of user accounts and password access levels.

g. List of weekly schedules.

h. List of holiday programming.

i. List of limits and dead bands.

j. Custom reports.

k. System diagnostic reports, including, list of digital controllers on the network.

l. List of programs.

17. Weather Reports

m. Weather Data Report: Provide a monthly report showing the daily minimum, maximum, and average outdoor air temperature, as well as the number of heating and cooling degree-days for each day. Provide an annual (12-month) report showing the minimum, maximum, and average outdoor air temperature for the month, as well as the number of heating and cooling degree-days for the month.

18. Scheduling and Override:
    a. Provide override access through menu selection from the graphical interface and through a function key.
    b. Provide a calendar type format for time-of-day scheduling and overrides of building control systems. Schedules reside in the ECC. The digital controllers shall ensure equipment time scheduling when the ECC is off-line. The ECC shall not be required to execute time scheduling. Provide the following spreadsheet graphics as a minimum:
        1) Weekly schedules.
        2) Zone schedules, minimum of 100 zones.
        3) Scheduling up to 365 days in advance.
        4) Scheduled reports to print at workstation.
19. Collection and Analysis of Historical Data:
    a. Provide trending capabilities that will allow the operator to monitor and store records of system activity over an extended period of time. Points may be trended automatically on time based intervals or change of value, both of which shall be user definable. The trend interval could be five (5) minutes to 120 hours. Trend data may be stored on hard disk for future diagnostic and reporting. Additionally trend data may be archived to network drives or removable disk media for off-site retrieval.
    b. Reports may be customized to include individual points or predefined groups of at least six points. Provide additional functionality to allow pre-defined groups of up to 250 trended points to be easily accessible by other industry standard word processing and spreadsheet packages. The reports shall be time and date stamped and shall contain a report title and the name of the facility.
    c. System shall have the set up to generate spreadsheet reports to track energy usage and cost based on weekly or monthly interval,

equipment run times, equipment efficiency, and/or building environmental conditions.

d. Provide additional functionality that will allow the operator to view real time trend data on trend graph displays. A minimum of 20 points may be graphed regardless of whether they have been predefined for trending. In addition, the user may pause the graph and take snapshots of the screens to be stored on the workstation disk for future reference and trend analysis. Exact point values may be viewed and the graph may be printed. Operator shall be able to command points directly on the trend plot by double clicking on the point.

20. Alarm Management:

a. Alarm routing shall allow the operator to send alarm notification to selected printers or operator workstation based on time of day, alarm severity, or point type.

b. Alarm notification shall be provided via two alarm icons, to distinguish between routine, maintenance type alarms and critical alarms. The critical alarms shall display on the screen at the time of its occurrence, while others shall display by clicking on their icon.

c. Alarm display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message in English language. The operator shall be able to sort out the alarms.

d. Alarm messages shall be customized for each point to display detailed instructions to the operator regarding actions to take in the event of an alarm.

e. An operator with proper security level access may acknowledge and clear the alarm. All that have not been cleared shall be archived at workstation disk.

2.5 BACNET PROTOCOL ANALYZER

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

2.6 NETWORK AND DEVICE NAMING CONVENTION

A. Network Numbers

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

B. Device Instances

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

C. Device Names

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

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

2.7 BACNET DEVICES

A. All BACnet Devices – controllers, gateways, routers, actuators and sensors shall conform to BACnet Device Profiles and shall be BACnet Testing Laboratories (BTL) -Listed as conforming to those Device Profiles. Protocol Implementation Conformance Statements (PICSs), describing the BACnet capabilities of the Devices shall be published and available of the Devices through links in the BTL website.

1. BACnet Building Controllers, historically referred to as NACs, shall conform to the BACnet B-BC Device Profile, and shall be BTL-Listed as conforming to the B-BC Device Profile. The Device’s PICS shall be submitted.
2. BACnet Advanced Application Controllers shall conform to the BACnet B-AAC Device Profile, and shall be BTL-Listed as conforming to the B-AAC Device Profile. The Device’s PICS shall be submitted.
3. BACnet Application Specific Controllers shall conform to the BACnet B-ASC Device Profile, and shall be BTL-Listed as conforming to the B-ASC Device Profile. The Device’s PICS shall be submitted.
4. BACnet Smart Actuators shall conform to the BACnet B-SA Device Profile, and shall be BTL-Listed as conforming to the B-SA Device Profile. The Device’s PICS shall be submitted.
5. BACnet Smart Sensors shall conform to the BACnet B-SS Device Profile, and shall be BTL-Listed as conforming to the B-SS Device Profile. The Device’s PICS shall be submitted.
6. BACnet routers and gateways shall conform to the BACnet B-OTH Device Profile, and shall be BTL-Listed as conforming to the B-OTH Device Profile. The Device’s PICS shall be submitted.

2.8 CONTROLLERS

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

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

9. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
10. Memory. The controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
11. The controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Controller operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
12. Provide a minimum of 10% extra spare points for future use in each panel.

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

shutdown below 80%. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

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

C. Direct Digital Controller Software

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

6. System Security: Operator access shall be secured using individual password and operator’s name. Passwords shall restrict the operator to the level of object, applications, and system functions assigned to him. A minimum of six (6) levels of security for operator access shall be provided.
7. Application Software: The controllers shall provide the following programs as a minimum for the purpose of optimizing energy consumption while maintaining comfortable environment for occupants. All application software shall reside and run in the system digital controllers. Editing of the application shall occur at the ECC or via a portable operator’s terminal, when it is necessary, to access directly the programmable unit.
   a. Power Demand Limiting (PDL): Power demand limiting program shall monitor the building power consumption and limit the consumption of electricity to prevent peak demand charges. PDL shall continuously track the electricity consumption from a pulse input generated at the kilowatt-hour/demand electric meter. PDL shall sample the meter data to continuously forecast the electric demand likely to be used during successive time intervals. If the forecast demand indicates that electricity usage will likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads. Once the demand load has met, loads that have been shed shall be restored and returned to normal mode. Control system shall be capable of demand limiting by resetting the HVAC system set points to reduce load while maintaining indoor air quality.
   b. Economizer: An economizer program shall be provided for VAV systems. This program shall control the position of air handler relief, return, and outdoors dampers. If the outdoor air dry bulb temperature and humidity fall below changeover set point the energy control center will modulate the dampers to provide 100 percent outdoor air. The operator shall be able to override the economizer cycle and return to minimum outdoor air operation at any time.
   c. Night Setback/Morning Warm up Control: The system shall provide the ability to automatically adjust set points for this mode of operation.

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

e. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or a group of points according to a stored time. This program shall provide the capability to individually command a point or group of points. When points are assigned to one common load group it shall be possible to assign variable time advances/delays between each successive start or stop within that group. Scheduling shall be calendar based and advance schedules may be defined up to one year in advance. Advance schedule shall override the day-to-day schedule. The operator shall be able to define the following information:
   1) Time, day.
   2) Commands such as on, off, auto.
   3) Time delays between successive commands.
   4) Manual overriding of each schedule.
   5) Allow operator intervention.

f. Alarm Reporting: The operator shall be able to determine the action to be taken in the event of an alarm. Alarms shall be routed to the ECC based on time and events. An alarm shall be able to start programs, login the event, print and display the

messages. The system shall allow the operator to prioritize the alarms to minimize nuisance reporting and to speed operator's response to critical alarms. A minimum of six (6) priority levels of alarms shall be provided for each point.

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

2.9 SENSORS (AIR, WATER AND STEAM)

A. Sensors' measurements shall be read back to the DDC system, and shall be visible by the ECC.

B. Temperature and Humidity Sensors shall be electronic, vibration and corrosion resistant for wall, immersion, and/or duct mounting. Provide all remote sensors as required for the systems.

1. Temperature Sensors: thermistor type for terminal units and Resistance Temperature Device (RTD) with an integral transmitter type for all other sensors.

a. Duct sensors shall be rigid or averaging type as shown on drawings. Averaging sensor shall be a minimum of 1 linear ft of sensing element for each sq ft of cooling coil face area.

1) Rigid duct temperature sensors shall be provided with ranges of -40 to 240 degrees F.

2) Averaging temperature sensors shall be provided with ranges of 20 to 120 degrees F.

b. Space sensors shall be equipped with in-space User set-point adjustment, override switch, numerical temperature display on sensor cover, and communication port. Match room thermostats. Provide a tooled-access cover.

1) Public space sensor: setpoint adjustment shall be only through the ECC or through the DDC system's diagnostic device/laptop. Do not provide in-space User set-point adjustment. Provide an opaque keyed-entry cover if needed to restrict in-space User set-point adjustment.

c. Wire: Twisted, shielded-pair cable.

d. Output Signal: 4-20 ma.

2. Humidity Sensors: Bulk polymer sensing element type.

a. Duct and room sensors shall have a sensing range of 20 to 80 percent with accuracy of ± 2 to ± 5 percent RH, including hysteresis, linearity, and repeatability.

b. Outdoor humidity sensors shall be furnished with element guard and mounting plate and have a sensing range of 0 to 100 percent RH.

c. 4-20 ma continuous output signal.

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

1. 4-20 ma output signal.

2. -2.5 to 2.5 inches wg for duct static pressure range.

3. 0 to 0.25 inch wg for Building static pressure range.

2.10 CONTROL CABLES

A. General:

1. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments. Comply with Section 26 05 26.

2. Cable conductors to provide protection against induction in circuits. Crosstalk attenuation within the System shall be in excess of -80 dB throughout the frequency ranges specified.

3. Minimize the radiation of RF noise generated by the System equipment so as not to interfere with any audio, video, data, computer main distribution frame (MDF), telephone customer service unit (CSU), and electronic private branch exchange (EPBX) equipment the System may service.

4. The as-installed drawings shall identify each cable as labeled, used cable, and bad cable pairs.

5. Label system’s cables on each end. Test and certify cables in writing to the VA before conducting proof-of-performance testing. Minimum cable test requirements are for impedance compliance, inductance, capacitance, signal level compliance, opens, shorts, cross talk, noise, and distortion, and split pairs on all cables in the frequency ranges used. Make available all cable installation and test records at demonstration to the VA. All changes (used pair,

failed pair, etc.) shall be posted in these records as the change occurs.

6. Power wiring shall not be run in conduit with communications trunk wiring or signal or control wiring operating at 100 volts or less.

B. Analogue control cabling shall be not less than No. 18 AWG solid, with thermoplastic insulated conductors as specified in Section 26 05 21.

C. Copper digital communication cable between the ECC and the B-BC and B-AAC controllers shall be 100BASE-TX Ethernet, Category 5e or 6, not less than minimum 24 American Wire Gauge (AWG) solid, Shielded Twisted Pair (STP) or Unshielded Twisted Pair (UTP), with thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, as specified in Section 27 10 05.

1. Other types of media commonly used within IEEE Std 802.3 LANs (e.g., 10Base-T and 10Base-2) shall be used only in cases to interconnect with existing media.

D. Optical digital communication fiber, if used, shall be Multimode or Singlemode fiber, 62.5/125 micron for multimode or 10/125 micron for singlemode micron with SC or ST connectors as specified in TIA-568-C.1. Terminations, patch panels, and other hardware shall be compatible with the specified fiber and shall be as specified in Section 27 10 05. Fiber-optic cable shall be suitable for use with the 100Base-FX or the 100Base-SX standard (as applicable) as defined in IEEE Std 802.3.

2.11 THERMOSTATS AND HUMIDISTATS

A. Freezestats shall have a minimum of 300 mm (one linear foot) of sensing element for each 0.093 square meter (one square foot) of coil area. A freezing condition at any increment of 300 mm (one foot) anywhere along the sensing element shall be sufficient to operate the thermostatic element. Freezestats shall be manually-reset.

2.12 FINAL CONTROL ELEMENTS AND OPERATORS

A. Fail Safe Operation: Control valves and dampers shall provide "fail safe" operation in either the normally open or normally closed position as required for freeze, moisture, and smoke or fire protection.

B. Spring Ranges: Range as required for system sequencing and to provide tight shut-off.

C. Power Operated Control Dampers (other than VAV Boxes): Factory fabricated, balanced type dampers. All modulating dampers shall be opposed blade type and gasketed. Blades for two-position, duct-mounted

dampers shall be parallel, airfoil (streamlined) type for minimum noise generation and pressure drop.

1. Leakage: Except as specified in subparagraph 2 below, maximum leakage in closed position shall not exceed 7 L/S (15 CFMs) differential pressure for outside air and exhaust dampers and 200 L/S/ square meter (40 CFM/sq. ft.) at 50 mm (2 inches) differential pressure for other dampers.
2. Frame shall be galvanized steel channel with seals as required to meet leakage criteria.
3. Blades shall be galvanized steel or aluminum, 200 mm (8 inch) maximum width, with edges sealed as required.
4. Bearing shall be nylon, bronze sleeve or ball type.
5. Hardware shall be zinc-plated steel. Connected rods and linkage shall be non-slip. Working parts of joints shall be brass, bronze, nylon or stainless steel.
6. Maximum air velocity and pressure drop through free area the dampers:
   h. Duct mounted damper: 600 meter per minute (2000 fpm).
   i. Maximum static pressure loss: 50 Pascal (0.20 inches water gage).

D. Control Valves:

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

d. Modulating Steam Control: 80 percent of inlet gauge pressure (acoustic velocity limitation).
e. Modulating water flow control, 3 meters (10 feet) of water.

7. Two position water valves shall be line size.

E. Damper and Valve Operators and Relays:

1. Electronic operator shall provide full modulating control of dampers and valves. A linkage and pushrod shall be furnished for mounting the actuator on the damper frame internally in the duct or externally in the duct or externally on the duct wall, or shall be furnished with a direct-coupled design. Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.
   a. Minimum valve close-off pressure shall be equal to the system pump’s dead-head pressure, minimum 50 psig for valves smaller than 4 inches.
2. Electronic damper operators: Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.
   a. For dampers called out to include end-switches, blade end contacts shall be used in lieu of actuator mounted endswitches.
3. See drawings for required control operation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Examine project plans for control devices and equipment locations; and report any discrepancies, conflicts, or omissions to Project VA Engineer for resolution before proceeding for installation.
2. Install equipment, piping, wiring/conduit parallel to or at right angles to building lines.

3. Install all equipment and piping in readily accessible locations. Do not run conduit concealed under insulation or inside ducts.
4. Mount control devices and conduit located on ducts and apparatus with external insulation on standoff support to avoid interference with insulation.
5. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
6. Run wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing.
7. Install equipment level and plum.

B. Electrical Wiring Installation:

1. All wiring cabling shall be installed in conduits. Install conduits and wiring in accordance with Specification Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS. Conduits carrying control wiring and cabling shall be dedicated to the control wiring and cabling: these conduits shall not carry power wiring. Provide plastic end sleeves at all conduit terminations to protect wiring from burrs.
2. Install analog signal and communication cables in conduit and in accordance with Specification Section 26 05 21. Install digital communication cables in conduit and in accordance with Specification Section 27 10 05, Computer Network and Telephone Wiring System.
3. Install conduit and wiring between operator workstation(s), digital controllers, electrical panels, indicating devices, instrumentation, miscellaneous alarm points, thermostats, and relays as shown on the drawings or as required under this section.
4. Install all electrical work required for a fully functional system and not shown on electrical plans or required by electrical specifications. Where low voltage (less than 50 volt) power is required, provide suitable Class B transformers.
5. Install all system components in accordance with local Building Code and National Electric Code.
   a. Splices: Splices in shielded and coaxial cables shall consist of terminations and the use of shielded cable couplers. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties.
   b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 300 mm (12 inches) long.

Equipment for fiber optics system shall be rack mounted, as applicable, in ventilated, self-supporting, code gauge steel enclosure. Cables shall be supported for minimum sag.

c. Cable Runs: Keep cable runs as short as possible. Allow extra length for connecting to the terminal board. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.

d. Use vinyl tape, sleeves, or grommets to protect cables from vibration at points where they pass around sharp corners, through walls, panel cabinets, etc.

6. Conceal cables, except in mechanical rooms and areas where other conduits and piping are exposed.

7. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.

8. Grounding: ground electrical systems per manufacturer’s written requirements for proper and safe operation.

C. Install Sensors and Controls:

1. Temperature Sensors:

a. Install all sensors and instrumentation according to manufacturer’s written instructions. Temperature sensor locations shall be readily accessible, permitting quick replacement and servicing of them without special skills and tools.

b. Calibrate sensors to accuracy specified, if not factory calibrated.

c. Use of sensors shall be limited to its duty, e.g., duct sensor shall not be used in lieu of room sensor.

d. Install room sensors permanently supported on wall frame. They shall be mounted at 1.5 meter (5.0 feet) above the finished floor.

e. Mount sensors rigidly and adequately for the environment within which the sensor operates. Separate extended-bulb sensors form contact with metal casings and coils using insulated standoffs.

f. Sensors used in mixing plenum, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.

g. All pipe mounted temperature sensors shall be installed in wells.

h. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor reading.

i. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.

2. Pressure Sensors:

a. Install duct static pressure sensor tips facing directly downstream of airflow.

b. Install high-pressure side of the differential switch between the pump discharge and the check valve.

c. Install snubbers and isolation valves on steam pressure sensing devices.

3. Actuators:

a. Mount and link damper and valve actuators according to manufacturer’s written instructions.

b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed position.

c. Check operation of valve/actuator combination to confirm that actuator modulates valve smoothly in both open and closed position.

D. Installation of network:

1. Ethernet:

a. The network shall employ Ethernet LAN architecture, as defined by IEEE 802.3. The Network Interface shall be fully Internet Protocol (IP) compliant allowing connection to currently installed IEEE 802.3, Compliant Ethernet Networks.

b. The network shall directly support connectivity to a variety of cabling types. As a minimum provide the following connectivity: 100 Base TX (Category 5e cabling) for the communications between the ECC and the B-BC and the B-AAC controllers.

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

E. Installation of digital controllers and programming:

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

3.2 SYSTEM VALIDATION AND DEMONSTRATION

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

B. Validation

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

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

C. Demonstration

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

properly through the complete sequence of operation, e.g., seasonal change, occupied/unoccupied mode, and warm-up condition.

g. Demonstrate hardware interlocks and safeties functions, and that the control systems perform the correct sequence of operation after power loss and resumption of power loss.

h. Prepare and deliver to the VA graphed trends of all control loops to demonstrate that each control loop is stable and the set points are maintained.

i. Demonstrate that each control loop responds to set point adjustment and stabilizes within one (1) minute. Control loop trend data shall be instantaneous and the time between data points shall not be greater than one (1) minute.

5. Witnessed demonstration of ECC functions shall consist of:

a. Running each specified report.

b. Display and demonstrate each data entry to show site specific customizing capability. Demonstrate parameter changes.

c. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.

d. Execute digital and analog commands in graphic mode.

e. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs (6 loops minimum).

f. Demonstrate EMS performance via trend logs and command trace.

g. Demonstrate scan, update, and alarm responsiveness.

h. Demonstrate spreadsheet/curve plot software, and its integration with database.

i. Demonstrate on-line user guide, and help function and mail facility.

j. Demonstrate digital system configuration graphics with interactive upline and downline load, and demonstrate specified diagnostics.

k. Demonstrate multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.

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

PART 4 - CONTROL SEQUENCES

4.1 M-AHU-11

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 and D-3 shall be fully closed. When the unit is "On", D-1, D-2 and D-3 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 and D-2 or V-4 in sequence. The supply air temperature set point shall be varied from 55 to 60 degrees F (adjustable) as the return air temperature varies from 78 to 72 degrees F (adjustable). D-3 shall be positioned opposite D-2 either through a mechanical linkage or through a separate actuator from the same DDC output.
   a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1, D-2 and D-3 and shall assume the minimum outside air position. The DCP shall modulate V-1 to maintain the supply air temperature sensed by T-1.
   b. ECONOMIZER CONTROL: When the temperature of the outside air is between 65 deg. F (adjustable) and the supply air temperature, sensed by T-1, dampers D-1, D-2, and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. The DCP shall modulate V-1 to maintain the supply air temperature, sensed by T-1 as required.
   c. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, dampers D-2 and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. D-1 shall be positioned opposite D-2. If D-1 is closed to minimum outside air, D-2 is open, and D-3 is closed to minimum relief air in this mode then valve V-4 shall be modulated to maintain the supply air temperature.
2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply air flow shall be controlled by the DCP modulating the supply fan variable speed motor controller (VSMC) to maintain the

duct static pressure setpoint (set at 1.00" static pressure - adjustable) as sensed by SPS-1 (see plans for location).

2. The DCP shall reset the return air fan VSMC to maintain a constant speed difference between the speed for the supply fan and the speed for the return fan.
3. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

E. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan and return fans shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply and return fans shall restart when fire alarm circuit is reset.

F. EMERGENCY CONSTANT SPEED OPERATION

1. On all VSMC fans in VAV systems upon failure of the VSMC, the fans shall be started/stopped manually at the DCP or the ECC through the by-pass starter. Fans shall then be operated at constant speed.

G. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

H. UNIT START-UP

1. On unit start-up, enable supply and return fans for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

I. OUTSIDE AIR DAMPER AT LOUVER

1. When the air handler is called to run, the damper shall be open/under control. If the air handler is turned off, the outside air damper shall be closed.

4.2 M-AHU-14

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 and D-3 shall be fully closed. When the unit is "On", D-1, D-2 and D-3 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 and D-2 or V-4 in sequence. The supply air temperature set point shall be varied in order to maintain the space temperature set point. D-3 shall be positioned opposite D-2 either through a mechanical linkage or through a separate actuator from the same DDC output.

   a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1, D-2 and D-3 and shall assume the minimum outside air position. The DCP shall modulate V-1 to maintain the space set point.

   b. ECONOMIZER CONTROL: When the temperature of the outside air is between 65 deg. F (adjustable) and the supply air temperature, sensed by T-1, dampers D-1, D-2, and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. The DCP shall modulate V-1 to maintain the space set point.

   c. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, dampers D-2 and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. D-1 shall be positioned opposite D-2. If D-1 is closed to minimum outside air, D-2 is open, and D-3 is closed to minimum relief air in this mode then valve V-4 shall be modulated to maintain the space set point.

2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply air flow shall be controlled by the DCP modulating the supply fan variable speed motor controller (VSMC) to maintain the duct static pressure setpoint (set at 1.00" static pressure - adjustable) as sensed by SPS-1 (see plans for location).
2. The DCP shall reset the return air fan VSMC to maintain a constant speed difference between the speed for the supply fan and the speed for the return fan.
3. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. HUMIDITY CONTROL

1. When the DCP is not calling for humidity, sensed by H-1, “On-Off" two way control valve V-2 shall remain closed. When the DCP is calling for humidity V-2 shall remain open.
2. The return air humidity, sensed by H-1, shall be maintained at set point by the DCP modulating humidity control valve V-3 to maintain the desired relative humidity. The DCP shall override this control to maintain maximum humidity of 80% (adjustable) as sensed by H-2. DCP shall close valve V-2 whenever the supply fan is off. Valve V-3 shall be interlocked with a temperature switch to keep the humidifier off until condensate temperature approaches steam temperature.

E. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

F. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan and return fans shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply and return fans shall restart when fire alarm circuit is reset.

G. EMERGENCY CONSTANT SPEED OPERATION

1. On all VSMC fans in VAV systems upon failure of the VSMC, the fans shall be started/stopped manually at the DCP or the ECC through the by-pass starter. Fans shall then be operated at constant speed.

H. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

I. UNIT START-UP

1. On unit start-up, enable supply and return fans for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

J. OUTSIDE AIR DAMPER AT LOUVER

1. When the air handler is called to run, the damper shall be open/under control. If the air handler is turned off, the outside air damper shall be closed.

4.3 M-AHU-25

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 shall be fully closed.

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or V-4 in sequence. The supply air temperature set point shall be varied in order to maintain the space temperature set point.

a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, D-1 shall assume the minimum outside air position. The DCP shall modulate V-1 to maintain the space set point.

b. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, then valve V-4 (Pre-Heat) and V-5 (Heating) shall be modulated to maintain the space set point. Bypass dampers for steam heating coils shall be controlled as follows: Modulate the steam valve as required to maintain set point and close the bypass damper above an outside temperature of 30 degrees (adjustable). Below an outside air temperature of zero degrees,

the control valve shall be fully open and the bypass damper shall modulate in order to maintain the set point.

2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply air fan shall be controlled by the DCP.
2. The status of existing exhaust fans M-EF-47, M-EF-48, and Tray Assembly Exhaust Fan shall be monitored. When no fans are running or the tray assembly fan only is running, the supply fan VFD shall be set to 50% (adjustable). If M-EF-47 or M-EF-48 is running by itself, the supply fan VFD shall be set to 75% (adjustable). If M-EF-47 or 48 are running along with the tray assembly fan, the supply fan VFD shall be set to 85% (adjustable). When all three fans are running, the supply fan VFD shall be set to 100% (adjustable).
3. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply fan shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

E. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply fan shall restart when fire alarm circuit is reset.

F. EMERGENCY CONSTANT SPEED OPERATION

1. On all VSMC fans in systems upon failure of the VSMC, the fans shall be started/stopped manually at the DCP or the ECC through the by-pass starter. Fans shall then be operated at constant speed.

G. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

H. UNIT START-UP

1. On unit start-up, enable supply fan for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

I. OUTSIDE AIR DAMPER AT LOUVER

1. When the air handler is called to run, the damper shall be open/under control. If the air handler is turned off, the outside air damper shall be closed. The outside air damper shall be proven open via endswitch before the supply fan is called to start.

4.4 M-AHU-6

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 and D-3 shall be fully closed. When the unit is "On", D-1, D-2, D-3, and D-4 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 and D-2 or V-4 in sequence. The supply air temperature set point shall be varied from 55 to 60 degrees F (adjustable) as the return air temperature varies from 78 to 72 degrees F (adjustable). D-3 shall be positioned opposite D-2 either through a mechanical linkage or through a separate actuator from the same DDC output. When the unit is running, D-4 shall assume the fully open minimum outside air position.

a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1 and D-2. The DCP shall modulate V-1 to maintain the supply air temperature sensed by T-1.

b. ECONOMIZER CONTROL: When the temperature of the outside air is between 65 deg. F (adjustable) and the supply air temperature, sensed by T-1, dampers D-1, D-2, and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. The DCP shall modulate V-1 to maintain the supply air temperature, sensed by T-1 as required.

c. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, dampers D-1, D-2 and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. D-1 shall be positioned opposite D-2. If D-1 is closed to minimum outside air, D-2 is open, and D-3 is closed to minimum relief air in this mode then valve V-4 shall be modulated to maintain the supply air temperature.

2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply air flow shall be controlled by the DCP modulating the supply fan variable speed motor controller (VSMC) to maintain the duct static pressure setpoint (set at 1.00" static pressure - adjustable) as sensed by SPS-1 (see plans for location).
2. The DCP shall reset the return air fan VSMC to maintain a constant speed difference between the speed for the supply fan and the speed for the return fan.
3. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. HUMIDITY CONTROL

1. When the DCP is not calling for humidity, sensed by H-1, “On-Off" two way control valve V-2 shall remain closed. When the DCP is calling for humidity V-2 shall remain open.
2. The return air humidity, sensed by H-1, shall be maintained at set point by the DCP modulating humidity control valve V-3 to maintain the desired relative humidity. The DCP shall override this control to maintain maximum humidity of 80% (adjustable) as sensed by H-2. DCP shall close valve V-2 whenever the supply fan is off. Valve V-3 shall be interlocked with a temperature switch to keep the humidifier off until condensate temperature approaches steam temperature.

E. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

F. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan and return fans shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply and return fans shall restart when fire alarm circuit is reset.

G. EMERGENCY CONSTANT SPEED OPERATION

1. On all VSMC fans in VAV systems upon failure of the VSMC, the fans shall be started/stopped manually at the DCP or the ECC through the by-pass starter. Fans shall then be operated at constant speed.

H. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

I. UNIT START-UP

1. On unit start-up, enable supply and return fans for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

J. OUTSIDE AIR DAMPER AT LOUVER

1. When the air handler is called to run, the minimum air damper shall be open. During economizer mode, the maximum air damper shall open as required to maintain the set point as described in the economizer control paragraph above. If the air handler is turned off, both outside air dampers shall be closed.

4.5 M-AHU-22

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 shall be fully closed. When the unit is "On", D-1 shall open in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or V-4 in sequence. The supply air temperature set point shall be varied from 55 to 60 degrees F (adjustable) as the return air temperature varies from 78 to 72 degrees F (adjustable).
   a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall shall assume the standard outside air position. The DCP shall modulate V-1 to maintain the supply air temperature sensed by T-1.
   b. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, then valve V-4 shall be modulated to maintain the supply air temperature. Bypass dampers for steam heating coils shall be controlled as follows: Modulate the steam valve as required to maintain set point and close the bypass damper above an outside temperature of 30 degrees (adjustable). Below an outside air temperature of zero degrees, the control valve shall be fully open and the bypass damper shall modulate in order to maintain the set point.
2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply air flow shall be controlled by the DCP modulating the supply fan variable speed motor controller (VSMC) to maintain the duct static pressure setpoint (set at 1.00" static pressure - adjustable) as sensed by SPS-1 (see plans for location).
2. When the supply fan is started, the Lab Exhaust Fan (M-EF-17) shall be interlocked to start. Provide status of the lab exhaust fan.
3. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. HUMIDITY CONTROL

1. When the DCP is not calling for humidity, sensed by H-1, “On-Off" two way control valve V-2 shall remain closed. When the DCP is calling for humidity V-2 shall remain open.

2. The return air humidity, sensed by H-1, shall be maintained at set point by the DCP modulating humidity control valve V-3 to maintain the desired relative humidity. The DCP shall override this control to maintain maximum humidity of 80% (adjustable) as sensed by H-2. DCP shall close valve V-2 whenever the supply fan is off. Valve V-3 shall be interlocked with a temperature switch to keep the humidifier off until condensate temperature approaches steam temperature.

E. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

F. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply fan shall restart when fire alarm circuit is reset.

G. EMERGENCY CONSTANT SPEED OPERATION

1. On all VSMC fans in VAV systems upon failure of the VSMC, the fans shall be started/stopped manually at the DCP or the ECC through the by-pass starter. Fans shall then be operated at constant speed.

H. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

I. UNIT START-UP

1. On unit start-up, enable supply fan for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

J. OUTSIDE AIR DAMPER AT LOUVER

1. When the air handler is called to run, the damper shall be open/under control. If the air handler is turned off, the outside air damper shall be closed.

4.6 M-AHU-27

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 shall be fully closed. When the unit is "On", D-1 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 in sequence. The supply air temperature set point shall be varied in order to maintain the space temperature set point.
   a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1 and shall assume the minimum outside air position. The DCP shall modulate V-1 to maintain the space set point.
   b. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, damper D-1 shall assume the minimum outside air position.

C. AIR FLOW CONTROL

1. The supply air fan shall be controlled by the DCP.
2. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

E. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply fan shall restart when fire alarm circuit is reset.

F. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

G. UNIT START-UP

1. On unit start-up, enable supply fan for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

H. OUTSIDE AIR DAMPER AT LOUVER

1. When the air handler is called to run, the damper shall be open/under control. If the air handler is turned off, the outside air damper shall be closed.

4.7 M-AHU-28

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 and D-3 shall be fully closed. When the unit is "On", D-1, D-2 and D-3 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 and D-2 or V-4 in sequence. The supply air temperature set point shall be varied from 55 to 60 degrees F (adjustable) as the return air temperature varies from 78 to 72 degrees F (adjustable). D-3 shall be positioned opposite D-2 either through a mechanical linkage or through a separate actuator from the same DDC output.
   a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1, D-2 and D-3 and shall assume the minimum outside air position. The DCP shall modulate V-1 to maintain the supply air temperature sensed by T-1.
   b. ECONOMIZER CONTROL: When the temperature of the outside air is between 65 deg. F (adjustable) and the supply air temperature, sensed by T-1, dampers D-1, D-2, and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. The DCP shall modulate V-1 to maintain the supply air temperature, sensed by T-1 as required.
   c. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature,

sensed by T-1, dampers D-2 and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. D-1 shall be positioned opposite D-2. If D-1 is closed to minimum outside air, D-2 is open, and D-3 is closed to minimum relief air in this mode then valve V-4 shall be modulated to maintain the supply air temperature.

2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply air flow shall be controlled by the DCP modulating the supply fan variable speed motor controller (VSMC) to maintain the duct static pressure setpoint (set at 1.00" static pressure - adjustable) as sensed by SPS-1 (see plans for location).
2. The DCP shall reset the return air fan VSMC to maintain a constant speed difference between the speed for the supply fan and the speed for the return fan.
3. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. HUMIDITY CONTROL

1. When the DCP is not calling for humidity, sensed by H-1, “On-Off" two way control valve V-2 shall remain closed. When the DCP is calling for humidity V-2 shall remain open.
2. The return air humidity, sensed by H-1, shall be maintained at set point by the DCP modulating humidity control valve V-3 to maintain the desired relative humidity. The DCP shall override this control to maintain maximum humidity of 80% (adjustable) as sensed by H-2. DCP shall close valve V-2 whenever the supply fan is off. Valve V-3 shall be interlocked with a temperature switch to keep the humidifier off until condensate temperature approaches steam temperature.

E. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be

indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

F. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan and return fans shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply and return fans shall restart when fire alarm circuit is reset.

G. EMERGENCY CONSTANT SPEED OPERATION

1. On all VSMC fans in VAV systems upon failure of the VSMC, the fans shall be started/stopped manually at the DCP or the ECC through the by-pass starter. Fans shall then be operated at constant speed.

H. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

I. UNIT START-UP

1. On unit start-up, enable supply and return fans for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

J. OUTSIDE AIR DAMPER AT LOUVER

1. When the air handler is called to run, the damper shall be open/under control. If the air handler is turned off, the outside air damper shall be closed.

4.8 M-AHU-29

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 and D-3 shall be fully closed. When the unit is "On", D-1, D-2 and D-3 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 and D-2 or V-4 in sequence. The supply air temperature set point shall be varied in order to maintain the space temperature set point. D-3 shall be positioned opposite D-2 either through a mechanical linkage or through a separate actuator from the same DDC output.

a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1, D-2 and D-3 and shall assume the minimum outside air position. The DCP shall modulate V-1 to maintain the space set point.

b. ECONOMIZER CONTROL: When the temperature of the outside air is between 65 deg. F (adjustable) and the supply air temperature, sensed by T-1, dampers D-1, D-2, and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. The DCP shall modulate V-1 to maintain the space set point.

c. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, dampers D-2 and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. D-1 shall be positioned opposite D-2. If D-1 is closed to minimum outside air, D-2 is open, and D-3 is closed to minimum relief air in this mode then valve V-4 shall be modulated to maintain the space set point. Bypass dampers for steam heating coils shall be controlled as follows: Modulate the steam valve as required to maintain set point and close the bypass damper above an outside temperature of 30 degrees (adjustable). Below an outside air temperature of zero degrees, the control valve shall be fully open and the bypass damper shall modulate in order to maintain the space set point.

2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply air and return air fans shall be controlled by the DCP.
2. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. HUMIDITY CONTROL

1. When the DCP is not calling for humidity, sensed by H-1, “On-Off" two way control valve V-3 shall remain closed. When the DCP is calling for humidity V-3 shall remain open.

2. The return air humidity, sensed by H-1, shall be maintained at set point by the DCP modulating humidity control valve V-3 to maintain the desired relative humidity. The DCP shall override this control to maintain maximum humidity of 80% (adjustable) as sensed by H-2. DCP shall close valve V-2 whenever the supply fan is off.

E. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

F. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan and return fans shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply and return fans shall restart when fire alarm circuit is reset.

G. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

H. UNIT START-UP

1. On unit start-up, enable supply and return fans for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

I. RELIEF AIR DAMPER AT LOUVER

1. When the air handler is called to run, the relief air damper at the louver shall modulate to match the percentage of the relief air damper position in the ductwork. The percentage of position for this damper shall be adjustable for field modifications. If the air handler is turned off, the relief air damper at the louver shall be closed. The relief damper at the unit shall be under control as described above in the economizer sequence.

4.9 M-AHU-30

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1

and D-3 shall be fully closed. When the unit is "On", D-1, D-2 and D-3 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The zone supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 and D-2 or V-4 in sequence. The supply air temperature set point for each zone shall be varied in order to maintain the zone temperature set point. D-3 shall be positioned opposite D-2 either through a mechanical linkage or through a separate actuator from the same DDC output.
   a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1, D-2 and D-3 and shall assume the minimum outside air position. The DCP shall modulate V-1 to maintain the cold deck set point.
   b. ECONOMIZER CONTROL: When the temperature of the outside air is between 65 deg. F (adjustable) and the cold deck temperature, dampers D-1, D-2, and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled cold deck temperature. The DCP shall modulate V-1 to maintain the cold deck set point.
   c. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, dampers D-2 and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the cold deck temperature. D-1 shall be positioned opposite D-2. If D-1 is closed to minimum outside air, D-2 is open, and D-3 is closed to minimum relief air in this mode then valve V-4 shall be modulated to maintain the hot deck temperature.
   d. ZONE CONTROL: Each zone thermostat shall control the hot deck and cold deck control dampers to maintain a discharge temperature set point that varies to meet the zone set point. The hot and cold deck dampers shall be positioned opposite of each other. The hot deck temperature shall be maintained to satisfy the zone with the greatest heating needs. The cold deck temperature shall be maintained at 55 degrees (adjustable).
2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply and return fans shall be controlled by the DCP.
2. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. HUMIDITY CONTROL

1. When the DCP is not calling for humidity, sensed by H-1, “On-Off" two way control valve V-3 shall remain closed. When the DCP is calling for humidity V-3 shall remain open.
2. The return air humidity, sensed by H-1, shall be maintained at set point by the DCP modulating humidity control valve V-3 to maintain the desired relative humidity. The DCP shall override this control to maintain maximum humidity of 80% (adjustable) as sensed by H-2. DCP shall close valve V-2 whenever the supply fan is off.

E. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

F. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan and return fans shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply and return fans shall restart when fire alarm circuit is reset.

G. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

H. UNIT START-UP

1. On unit start-up, enable supply and return fans for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

I. RELIEF AIR DAMPER AT LOUVER

1. When the air handler is called to run, the relief air damper at the louver shall modulate to match the percentage of the relief air

damper position in the ductwork. The percentage of position for this damper shall be adjustable for field modifications. If the air handler is turned off, the relief air damper at the louver shall be closed. The relief damper at the unit shall be under control as described above in the economizer sequence.

4.10 M-AHU-31

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 and D-3 shall be fully closed. When the unit is "On", D-1, D-2 and D-3 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The zone supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 and D-2 or V-4 in sequence. The supply air temperature set point for each zone shall be varied in order to maintain the zone temperature set point. D-3 shall be positioned opposite D-2 either through a mechanical linkage or through a separate actuator from the same DDC output.

a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1, D-2 and D-3 and shall assume the minimum outside air position. The DCP shall modulate V-1 to maintain the cold deck set point.

b. ECONOMIZER CONTROL: When the temperature of the outside air is between 65 deg. F (adjustable) and the cold deck temperature, dampers D-1, D-2, and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled cold deck temperature. The DCP shall modulate V-1 to maintain the cold deck set point.

c. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, dampers D-2 and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the cold deck temperature. D-1 shall be positioned opposite D-2. If D-1 is closed to minimum outside air, D-2 is open, and D-3 is closed to minimum relief air in this mode then valve V-4 shall be modulated to maintain the hot deck temperature.

d. ZONE CONTROL: Each zone thermostat shall control the hot deck and cold deck control dampers to maintain a discharge temperature set point that varies to meet the zone set point. The hot and cold deck dampers shall be positioned opposite of each other. The hot deck temperature shall be maintained to satisfy the zone with the greatest heating needs. The cold deck temperature shall be maintained at 55 degrees (adjustable).

2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply and return fans shall be controlled by the DCP.
2. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. HUMIDITY CONTROL

1. When the DCP is not calling for humidity, sensed by H-1, “On-Off" two way control valve V-3 shall remain closed. When the DCP is calling for humidity V-3 shall remain open.
2. The return air humidity, sensed by H-1, shall be maintained at set point by the DCP modulating humidity control valve V-3 to maintain the desired relative humidity. The DCP shall override this control to maintain maximum humidity of 80% (adjustable) as sensed by H-2. DCP shall close valve V-2 whenever the supply fan is off.

E. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

F. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan and return fans shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply and return fans shall restart when fire alarm circuit is reset.

G. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

H. UNIT START-UP

1. On unit start-up, enable supply and return fans for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

I. RELIEF AIR DAMPER AT LOUVER

1. When the air handler is called to run, the relief air damper at the louver shall modulate to match the percentage of the relief air damper position in the ductwork. The percentage of position for this damper shall be adjustable for field modifications. If the air handler is turned off, the relief air damper at the louver shall be closed. The relief damper at the unit shall be under control as described above in the economizer sequence.

4.11 M-AHU-49

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 and D-3 shall be fully closed. When the unit is "On", D-1, D-2 and D-3 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 and D-2 or V-4 in sequence. The supply air temperature set point shall be varied from 55 to 60 degrees F (adjustable) as the return air temperature varies from 78 to 72 degrees F (adjustable). D-3 shall be positioned opposite D-2 either through a mechanical linkage or through a separate actuator from the same DDC output.

a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1, D-2 and D-3 and shall assume the minimum outside air position. The DCP shall modulate V-1 to maintain the supply air temperature sensed by T-1.

b. ECONOMIZER CONTROL: When the temperature of the outside air is between 65 deg. F (adjustable) and the supply air temperature, sensed by T-1, dampers D-1, D-2, and D-3 shall modulate to

maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. The DCP shall modulate V-1 to maintain the supply air temperature, sensed by T-1 as required.

c. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, dampers D-2 and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. D-1 shall be positioned opposite D-2. If D-1 is closed to minimum outside air, D-2 is open, and D-3 is closed to minimum relief air in this mode then valve V-4 shall be modulated to maintain the supply air temperature.

2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply air flow shall be controlled by the DCP modulating the supply fan variable speed motor controller (VSMC) to maintain the duct static pressure setpoint (set at 1.00" static pressure - adjustable) as sensed by SPS-1 (see plans for location).
2. The DCP shall reset the return air fan VSMC to maintain a constant speed difference between the speed for the supply fan and the speed for the return fan.
3. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. HUMIDITY CONTROL

1. When the DCP is not calling for humidity, sensed by H-1, “On-Off" two way control valve V-2 shall remain closed. When the DCP is calling for humidity V-2 shall remain open.
2. The return air humidity, sensed by H-1, shall be maintained at set point by the DCP modulating humidity control valve V-3 to maintain the desired relative humidity. The DCP shall override this control to maintain maximum humidity of 80% (adjustable) as sensed by H-2. DCP shall close valve V-2 whenever the supply fan is off. Valve V-3 shall be interlocked with a temperature switch to keep the humidifier off until condensate temperature approaches steam temperature.

E. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

F. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan and return fans shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply and return fans shall restart when fire alarm circuit is reset.

G. EMERGENCY CONSTANT SPEED OPERATION

1. On all VSMC fans in VAV systems upon failure of the VSMC, the fans shall be started/stopped manually at the DCP or the ECC through the by-pass starter. Fans shall then be operated at constant speed.

H. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

I. UNIT START-UP

1. On unit start-up, enable supply and return fans for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

J. OUTSIDE AIR DAMPER AT LOUVER

1. When the air handler is called to run, the damper shall be open/under control. If the air handler is turned off, the outside air damper shall be closed.

4.12 M-AHU-50

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 and D-3 shall be fully closed. When the unit is "On", D-1, D-2 and D-3 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 and D-2 or V-4 in sequence.

The supply air temperature set point shall be varied from 55 to 60 degrees F (adjustable) as the return air temperature varies from 78 to 72 degrees F (adjustable). D-3 shall be positioned opposite D-2 either through a mechanical linkage or through a separate actuator from the same DDC output.

a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1, D-2 and D-3 and shall assume the minimum outside air position. The DCP shall modulate V-1 to maintain the supply air temperature sensed by T-1.

b. ECONOMIZER CONTROL: When the temperature of the outside air is between 65 deg. F (adjustable) and the supply air temperature, sensed by T-1, dampers D-1, D-2, and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. The DCP shall modulate V-1 to maintain the supply air temperature, sensed by T-1 as required.

c. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, dampers D-2 and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. D-1 shall be positioned opposite D-2. If D-1 is closed to minimum outside air, D-2 is open, and D-3 is closed to minimum relief air in this mode then valve V-4 shall be modulated to maintain the supply air temperature.

2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply air flow shall be controlled by the DCP modulating the supply fan variable speed motor controller (VSMC) to maintain the duct static pressure setpoint (set at 1.00" static pressure - adjustable) as sensed by SPS-1 (see plans for location).
2. The DCP shall reset the return air fan VSMC to maintain a constant speed difference between the speed for the supply fan and the speed for the return fan.
3. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three

inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. HUMIDITY CONTROL

1. When the DCP is not calling for humidity, sensed by H-1, “On-Off" two way control valve V-2 shall remain closed. When the DCP is calling for humidity V-2 shall remain open.
2. The return air humidity, sensed by H-1, shall be maintained at set point by the DCP modulating humidity control valve V-3 to maintain the desired relative humidity. The DCP shall override this control to maintain maximum humidity of 80% (adjustable) as sensed by H-2. DCP shall close valve V-2 whenever the supply fan is off. Valve V-3 shall be interlocked with a temperature switch to keep the humidifier off until condensate temperature approaches steam temperature.

E. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

F. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan and return fans shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply and return fans shall restart when fire alarm circuit is reset.

G. EMERGENCY CONSTANT SPEED OPERATION

1. On all VSMC fans in VAV systems upon failure of the VSMC, the fans shall be started/stopped manually at the DCP or the ECC through the by-pass starter. Fans shall then be operated at constant speed.

H. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

I. UNIT START-UP

1. On unit start-up, enable supply and return fans for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

J. OUTSIDE AIR DAMPER AT LOUVER

1. When the air handler is called to run, the damper shall be open/under control. If the air handler is turned off, the outside air damper shall be closed.

4.13 M-AHU-4

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 and D-3 shall be fully closed. When the unit is "On", D-1, D-2, D-3, and D-4 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 and D-2 or V-4 in sequence. The supply air temperature set point shall be varied from 55 to 60 degrees F (adjustable) as the return air temperature varies from 78 to 72 degrees F (adjustable). D-3 shall be positioned opposite D-2 either through a mechanical linkage or through a separate actuator from the same DDC output. When the unit is running, D-4 shall assume the fully open minimum outside air position.

a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1 and D-2. The DCP shall modulate V-1 to maintain the supply air temperature sensed by T-1.

b. ECONOMIZER CONTROL: When the temperature of the outside air is between 65 deg. F (adjustable) and the supply air temperature, sensed by T-1, dampers D-1, D-2, and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. The DCP shall modulate V-1 to maintain the supply air temperature, sensed by T-1 as required.

c. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, dampers D-1, D-2 and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. D-1 shall be positioned opposite D-2. If D-1 is closed to minimum outside air, D-2 is open, and D-3 is closed to minimum relief air in this mode then

valve V-4 shall be modulated to maintain the supply air temperature.

2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply air flow shall be controlled by the DCP modulating the supply fan variable speed motor controller (VSMC) to maintain the duct static pressure setpoint (set at 1.00" static pressure - adjustable) as sensed by SPS-1 (see plans for location).
2. The DCP shall reset the return air fan VSMC to maintain a constant speed difference between the speed for the supply fan and the speed for the return fan.
3. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. HUMIDITY CONTROL

1. When the DCP is not calling for humidity, sensed by H-1, “On-Off" two way control valve V-2 shall remain closed. When the DCP is calling for humidity V-2 shall remain open.
2. The return air humidity, sensed by H-1, shall be maintained at set point by the DCP modulating humidity control valve V-3 to maintain the desired relative humidity. The DCP shall override this control to maintain maximum humidity of 80% (adjustable) as sensed by H-2. DCP shall close valve V-2 whenever the supply fan is off. Valve V-3 shall be interlocked with a temperature switch to keep the humidifier off until condensate temperature approaches steam temperature.

E. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

F. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan and return fans shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply and return fans shall restart when fire alarm circuit is reset.

G. EMERGENCY CONSTANT SPEED OPERATION

1. On all VSMC fans in VAV systems upon failure of the VSMC, the fans shall be started/stopped manually at the DCP or the ECC through the by-pass starter. Fans shall then be operated at constant speed.

H. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

I. UNIT START-UP

1. On unit start-up, enable supply and return fans for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

J. OUTSIDE AIR DAMPER AT LOUVER

1. When the air handler is called to run, the minimum air damper shall be open. During economizer mode, the maximum air damper shall open as required to maintain the set point as described in the economizer control paragraph above. If the air handler is turned off, both outside air dampers shall be closed.

4.14 M-AHU-7

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 and D-3 shall be fully closed. When the unit is "On", D-1, D-2, D-3, and D-4 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 and D-2 or V-4 in sequence. The supply air temperature set point shall be varied from 55 to 60 degrees F (adjustable) as the return air temperature varies from 78 to 72 degrees F (adjustable). D-3 shall be positioned opposite D-2 either through a mechanical linkage or through a separate actuator from the same DDC output. When the unit is running, D-4 shall assume the fully open minimum outside air position.

a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1 and D-2. The DCP shall modulate V-1 to maintain the supply air temperature sensed by T-1.

b. ECONOMIZER CONTROL: When the temperature of the outside air is between 65 deg. F (adjustable) and the supply air temperature, sensed by T-1, dampers D-1, D-2, and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. The DCP shall modulate V-1 to maintain the supply air temperature, sensed by T-1 as required.

c. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, dampers D-1, D-2 and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. D-1 shall be positioned opposite D-2. If D-1 is closed to minimum outside air, D-2 is open, and D-3 is closed to minimum relief air in this mode then valve V-4 shall be modulated to maintain the supply air temperature.

2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply air flow shall be controlled by the DCP modulating the supply fan variable speed motor controller (VSMC) to maintain the duct static pressure setpoint (set at 1.00" static pressure - adjustable) as sensed by SPS-1 (see plans for location).
2. The DCP shall reset the return air fan VSMC to maintain a constant speed difference between the speed for the supply fan and the speed for the return fan.
3. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. HUMIDITY CONTROL

1. When the DCP is not calling for humidity, sensed by H-1, “On-Off" two way control valve V-2 shall remain closed. When the DCP is calling for humidity V-2 shall remain open.

2. The return air humidity, sensed by H-1, shall be maintained at set point by the DCP modulating humidity control valve V-3 to maintain the desired relative humidity. The DCP shall override this control to maintain maximum humidity of 80% (adjustable) as sensed by H-2. DCP shall close valve V-2 whenever the supply fan is off. Valve V-3 shall be interlocked with a temperature switch to keep the humidifier off until condensate temperature approaches steam temperature.

E. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

F. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan and return fans shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply and return fans shall restart when fire alarm circuit is reset.

G. EMERGENCY CONSTANT SPEED OPERATION

1. On all VSMC fans in VAV systems upon failure of the VSMC, the fans shall be started/stopped manually at the DCP or the ECC through the by-pass starter. Fans shall then be operated at constant speed.

H. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

I. UNIT START-UP

1. On unit start-up, enable supply and return fans for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

J. OUTSIDE AIR DAMPER AT LOUVER

1. When the air handler is called to run, the minimum air damper shall be open. During economizer mode, the maximum air damper shall open as required to maintain the set point as described in the economizer control paragraph above. If the air handler is turned off, both outside air dampers shall be closed.

4.15 M-AHU-51

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 and D-3 shall be fully closed. When the unit is "On", D-1, D-2 and D-3 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 and D-2 or V-4 in sequence. The supply air temperature set point shall be varied from 55 to 60 degrees F (adjustable) as the return air temperature varies from 78 to 72 degrees F (adjustable). D-3 shall be positioned opposite D-2 either through a mechanical linkage or through a separate actuator from the same DDC output.

   a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1, D-2 and D-3 and shall assume the minimum outside air position. The DCP shall modulate V-1 to maintain the supply air temperature sensed by T-1.

   b. ECONOMIZER CONTROL: When the temperature of the outside air is between 65 deg. F (adjustable) and the supply air temperature, sensed by T-1, dampers D-1, D-2, and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. The DCP shall modulate V-1 to maintain the supply air temperature, sensed by T-1 as required.

   c. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, dampers D-2 and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. D-1 shall be positioned opposite D-2. If D-1 is closed to minimum outside air, D-2 is open, and D-3 is closed to minimum relief air in this mode then valve V-4 shall be modulated to maintain the supply air temperature.

2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply air flow shall be controlled by the DCP modulating the supply fan variable speed motor controller (VSMC) to maintain the duct static pressure setpoint (set at 1.00" static pressure - adjustable) as sensed by SPS-1 (see plans for location).
2. The DCP shall reset the return air fan VSMC to maintain a constant speed difference between the speed for the supply fan and the speed for the return fan.
3. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. HUMIDITY CONTROL

1. When the DCP is not calling for humidity, sensed by H-1, “On-Off" two way control valve V-2 shall remain closed. When the DCP is calling for humidity V-2 shall remain open.
2. The return air humidity, sensed by H-1, shall be maintained at set point by the DCP modulating humidity control valve V-3 to maintain the desired relative humidity. The DCP shall override this control to maintain maximum humidity of 80% (adjustable) as sensed by H-2. DCP shall close valve V-2 whenever the supply fan is off. Valve V-3 shall be interlocked with a temperature switch to keep the humidifier off until condensate temperature approaches steam temperature.

E. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

F. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan and return fans shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply and return fans shall restart when fire alarm circuit is reset.

G. EMERGENCY CONSTANT SPEED OPERATION

1. On all VSMC fans in VAV systems upon failure of the VSMC, the fans shall be started/stopped manually at the DCP or the ECC through the by-pass starter. Fans shall then be operated at constant speed.

H. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

I. UNIT START-UP

1. On unit start-up, enable supply and return fans for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

J. OUTSIDE AIR DAMPER AT LOUVER

1. When the air handler is called to run, the damper shall be open/under control. If the air handler is turned off, the outside air damper shall be closed.

4.16 M-AHU-55

A. GENERAL

1. Unit is normally started and stopped by the DCP or remotely at the ECC. H-O-A switch shall be kept in the "Auto" position. "Hand" and "Off" shall be used only for maintenance. When the unit is "Off" D-1 and D-3 shall be fully closed. When the unit is "On", D-1, D-2 and D-3 shall modulate in accordance with the following sequence:

B. TEMPERATURE CONTROL

1. The supply air temperature, sensed by T-1, shall be maintained at set point by DCP modulating V-1 or D-1 and D-2 or V-4 in sequence. The supply air temperature set point shall be varied from 55 to 60 degrees F (adjustable) as the return air temperature varies from 78 to 72 degrees F (adjustable). D-3 shall be positioned opposite D-2 either through a mechanical linkage or through a separate actuator from the same DDC output.

a. COOLING CONTROL: When the temperature of the outside air, sensed by T-2, is above 65 deg. f, the DCP shall prevent the modulation of D-1, D-2 and D-3 and shall assume the minimum outside air position. The DCP shall modulate V-1 to maintain the supply air temperature sensed by T-1.

b. ECONOMIZER CONTROL: When the temperature of the outside air is between 65 deg. F (adjustable) and the supply air temperature, sensed by T-1, dampers D-1, D-2, and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the

scheduled supply air temperature. The DCP shall modulate V-1 to maintain the supply air temperature, sensed by T-1 as required.

c. HEATING AND ECONOMIZER CONTROL: When the temperature of the outside air, sensed by T-2, is below the supply air temperature, sensed by T-1, dampers D-2 and D-3 shall modulate to maintain the mixed air temperature at 2 degrees less than the scheduled supply air temperature. D-1 shall be positioned opposite D-2. If D-1 is closed to minimum outside air, D-2 is open, and D-3 is closed to minimum relief air in this mode then valve V-4 shall be modulated to maintain the supply air temperature.

2. Upon loss of air flow sensor by SPS-2, V-4 shall modulate to maintain 55 deg. F (adjustable) unit casing temperature monitored by T-2.

C. AIR FLOW CONTROL

1. The supply air flow shall be controlled by the DCP modulating the supply fan variable speed motor controller (VSMC) to maintain the duct static pressure setpoint (set at 1.00" static pressure - adjustable) as sensed by SPS-1 (see plans for location).
2. The DCP shall reset the return air fan VSMC to maintain a constant speed difference between the speed for the supply fan and the speed for the return fan.
3. The DCP using high pressure sensor SPS-2 located at the supply fan discharge shall prevent the supply fan from developing over three inches of static pressure. If static pressure at SPS-2 exceeds three inches (adjustable) the supply fan shall shut "Off".

D. HUMIDITY CONTROL

1. When the DCP is not calling for humidity, sensed by H-1, “On-Off" two way control valve V-2 shall remain closed. When the DCP is calling for humidity V-2 shall remain open.
2. The return air humidity, sensed by H-1, shall be maintained at set point by the DCP modulating humidity control valve V-3 to maintain the desired relative humidity. The DCP shall override this control to maintain maximum humidity of 80% (adjustable) as sensed by H-2. DCP shall close valve V-2 whenever the supply fan is off. Valve V-3 shall be interlocked with a temperature switch to keep the humidifier off until condensate temperature approaches steam temperature.

E. FREEZE PROTECTION

1. If the air temperature as sensed by TS-1 falls below 45 deg. F (adjustable), an alarm signal shall be indicated at the DCP and ECC. If this temperature falls below 40 deg. F (adjustable) the unit supply and return fans shall shut down and a critical alarm shall be indicated at the DCP and ECC. The freezestat shall be manually reset at the unit.

F. AUTOMATIC SHUTDOWN/RESTART

1. When smoke is detected by duct smoke detector, the supply fan and return fans shall shut "Off" and an alarm signal shall be transmitted to the fire alarm system. Exhaust fans serving space of the supply fan shall continue to run. Supply and return fans shall restart when fire alarm circuit is reset.

G. EMERGENCY CONSTANT SPEED OPERATION

1. On all VSMC fans in VAV systems upon failure of the VSMC, the fans shall be started/stopped manually at the DCP or the ECC through the by-pass starter. Fans shall then be operated at constant speed.

H. POWER OUTAGE OPERATION

1. On the event of a power outage air handling unit shall automatically restart when power has been re-established.

I. UNIT START-UP

1. On unit start-up, enable supply and return fans for a minimum of 5 minutes (adjustable) before starting program in order to equalize all unit sensors.

J. OUTSIDE AIR DAMPER AT LOUVER

1. When the air handler is called to run, the damper shall be open/under control. If the air handler is turned off, the outside air damper shall be closed.

----- END -----

SECTION 23 21 13
HYDRONIC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.
B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION: General mechanical requirements and items, which are common to more than one section of Division 23.
D. Section 23 07 11, HVAC AND BOILER PLANT INSULATION: Piping insulation.
E. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Temperature and pressure sensors and valve operators.

1.3 QUALITY ASSURANCE

A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION, which includes welding qualifications.
B. Submit prior to welding of steel piping a certificate of Welder’s certification. The certificate shall be current and not more than one year old.

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.
C. Submit prior to welding of steel piping a certificate of welder’s certification. The certificate shall be current and not more than one year old.
D. Coordination Drawings: Refer to Article, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

E. As-Built Piping Diagrams: Provide drawing as follows for the chilled water, 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 in the same size as contract documents.
   3. One complete set of drawings in electronic format (Autocad version compatible with the version currently in use at the Fargo VA Medical Center).

1.5 APPLICABLE PUBLICATIONS

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

B. American Society of Mechanical Engineers (ASME):

B1.20.1-83.....Pipe Threads, General Purpose (Inch)
B16.1-98.....Cast Iron Pipe Flanges and Flanged Fittings
B16.3-98.....Malleable Iron Threaded Fittings
B16.4-98.....Gray Iron Threaded Fittings
B16.5-03.....Pipe Flanges and Flanged Fittings
B16.9-03.....Factory-Made Wrought Buttwelding Fittings
B16.11-05.....Forged Fittings, Socket-Welding and Threaded
B16.14-91.....Ferrous Pipe Plugs, Bushings, and Locknuts with Pipe Threads
B16.22-01.....Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
B16.23-02.....Cast Copper Alloy Solder Joint Drainage Fittings
B16.24-01.....Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150, 300, 400, 600, 900, 1500 and 2500
B16.39-98.....Malleable Iron Threaded Pipe Unions, Classes 150, 250, and 300
B16.42-98.....Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300
B31.1-01.....Power Piping
B31.9-04.....Building Services Piping
B40.100-05.....Pressure Gauges and Gauge Attachments

C. American National Standards Institute, Inc. (ANSI):

B16.1 00.....Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125 and 250

B16.3 00.....Malleable Iron Threaded Fittings Classes 150 and 300

B16.5 03.....Pipe Flanges and Flanged Fittings NPS ½ through NPS 24

B16.9 03.....Factory Made Wrought Butt Welding Fittings

B16.11 01.....Forged Fittings, Socket Welding and Threaded

B16.14 91.....Ferrous Pipe Plugs, Bushings and Locknuts with Pipe Threads

B16.18-01.....Cast Copper Alloy Solder joint Pressure fittings

B16.22 00.....Wrought Copper and Bronze Solder Joint Pressure Fittings

B16.24 01.....Cast Copper Alloy Pipe Fittings and Flanged Fittings: Class 150, 300, 400, 600, 900, 1500 and 2500

B31.1 01.....Power Piping

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

A47/A47M-99 (2004).....Ferritic Malleable Iron Castings

A53/A53M-06.....Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A106/A106M-06.....Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

A126-04.....Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

A181/A181M-01.....Standard Specification for Carbon Steel Forgings, for General-Purpose Piping

A183-03.....Standard Specification for Carbon Steel Track Bolts and Nuts

A216/A216M-04 ..... Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service

A234/A234M 04 ..... Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

A307-04 ..... Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength

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

A 615/A 615M-04 ..... Deformed and Plain Carbon Steel Bars for Concrete Reinforcement

A653/A 653M-04 ..... Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) By the Hot-Dip Process

B32-04 ..... Standard Specification for Solder Metal

B61-02 ..... Standard Specification for Steam or Valve Bronze Castings

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

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

B209 04 ..... Aluminum and Aluminum Alloy Sheet and Plate

C177 97 ..... Standard Test Method for Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus

C478-03 ..... Precast Reinforced Concrete Manhole Sections

C533 03 ..... Calcium Silicate Block and Pipe Thermal Insulation

C552 03 ..... Cellular Glass Thermal Insulation

C591-01 ..... Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation

E. American Water Works Association (AWWA):

C110/03.....Ductile Iron and Grey Iron Fittings for Water

C203 00.....Coal Tar Protective Coatings and Linings for Steel Water Pipe Lines Enamel and Tape Hot Applied

F. American Welding Society (AWS):

A5.8/A5.8M-04.....Specification for Filler Metals for Brazing and Braze Welding

B2.1-02.....Standard Welding Procedure Specification

G. Copper Development Association, Inc. (CDA):

CDA A4015-95.....Copper Tube Handbook

H. Expansion Joint Manufacturer's Association, Inc. (EJMA):
EMJA-2003.....Expansion Joint Manufacturer's Association Standards, Eighth Edition

I. Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry, Inc.:
SP-70-06.....Gray Iron Gate Valves, Flanged and Threaded Ends
SP-71-05.....Gray Iron Swing Check Valves, Flanged and Threaded Ends
SP-72-99.....Ball Valves with Flanged or Butt-Welding Ends for General Service
SP-78-05.....Cast Iron Plug Valves, Flanged and Threaded Ends
SP-80-03.....Bronze Gate, Globe, Angle and Check Valves
SP-85-02.....Cast Iron Globe and Angle Valves, Flanged and Threaded Ends

J. Tubular Exchanger Manufacturers Association: TEMA 8th Edition, 2000

K. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
HVAC Duct Construction Standards, 2nd Edition 1997

1.6 SPARE PARTS

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

PART 2 - PRODUCTS

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

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

2.2 PIPE AND TUBING

A. Chilled Water (above ground), 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. Pipe supports, including insulation shields, for above ground piping: Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

2.3 FITTINGS FOR STEEL PIPE

A. 65 mm (2-1/2 inches) and Larger: Welded or flanged joints. Mechanical couplings and fittings are optional for water piping only.

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

B. 50 mm (2 inches) and Smaller: Screwed or welded. Mechanical couplings are optional for water piping only.
   1. Butt welding: ASME B16.9 with same wall thickness as connecting piping.
   2. Forged steel, socket welding or threaded: ASME B16.11.
   3. Screwed: 150 pound malleable iron, ASME B16.3. 125 pound cast iron, ASME B16.4, may be used in lieu of malleable iron. Bushing reduction of a single pipe size, or use of close nipples, is not acceptable.
   4. Unions: ASME B16.39.
   5. Water hose connection adapter: Brass, pipe thread to 20 mm (3/4 inch) garden hose thread, with hose cap nut.

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

D. Mechanical Pipe Couplings and Fittings: May be used, with cut or roll grooved pipe, in water service up to 110 degrees C (230 degrees F) in lieu of welded, screwed or flanged connections.
   1. Grooved mechanical couplings: Malleable iron, ASTM A47 or ductile iron, ASTM A536, fabricated in two or more parts, securely held together by two or more track-head, square, or oval-neck bolts, ASTM A183.
   2. Gaskets: Rubber product recommended by the coupling manufacturer for the intended service.
   3. Grooved end fittings: Malleable iron, ASTM A47; ductile iron, ASTM A536; or steel, ASTM A53 or A106, designed to accept grooved mechanical couplings. Tap-in type branch connections are acceptable.

2.4 FITTINGS FOR COPPER TUBING

A. Solder Joint:

1. Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.
2. Contractor’s Option: Mechanical press sealed fittings, double pressed type, NSF 50/61 approved, with EPDM (ethylene propylene diene monomer) non-toxic synthetic rubber sealing elements for up 65 mm (2-1/2 inch) and below are optional for above ground water piping only.
3. Mechanically formed tee connection in water and drain piping: Form mechanically extracted collars in a continuous operation by drilling pilot hole and drawing out tube surface to form collar, having a height of not less than three times the thickness of tube wall. Adjustable collaring device shall insure proper tolerance and complete uniformity of the joint. Notch and dimple joining branch tube in a single process to provide free flow where the branch tube penetrates the fitting.

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

2.5 DIELECTRIC FITTINGS

A. Provide where copper tubing and ferrous metal pipe are joined.

B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.

C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.

D. Temperature Rating, 99 degrees C (210 degrees F).

2.6 SCREWED JOINTS

A. Pipe Thread: ANSI B1.20.

B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

2.7 VALVES

A. Asbestos packing shall not be allowed.

B. All valves of the same type shall be products of a single manufacturer. Provide gate and globe valves with packing that can be replaced with the valve under full working pressure.

C. Gate Valves:

1. 50 mm (2 inches) and smaller: MSS-SP80, Bronze, 1725 kPa (250 lb.), wedge disc, rising stem, union bonnet.
2. 65 mm (2 1/2 inches) and larger: Flanged, outside screw and yoke.

a. MSS-SP 70, iron body, bronze mounted, 1725 kPa (250 psig) wedge disc.

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

2.8 FIRESTOPPING MATERIAL

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

PART 3 - EXECUTION

3.1 GENERAL

A. The drawings show the general arrangement of pipe and equipment but do not show all required fittings and offsets that may be necessary to connect pipes to equipment, fan-coils, coils, radiators, etc., and to coordinate with other trades. Provide all necessary fittings, offsets and pipe runs based on field measurements and at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.

B. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping relatively clean during installation and protect open ends when work is not in progress.

C. Support piping securely. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION. Install convertors and other heat exchangers at height sufficient to provide gravity flow of condensate to the flash tank and condensate pump.

D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (one inch) minimum clearance between adjacent piping or other surface. Unless shown otherwise, slope drain piping down in the direction of flow not less than 25 mm (one inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.

E. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one

end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing.

F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs.

G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.

H. Provide manual air vent at all piping system high points and drain valves at all low points.

I. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:

   1. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.

J. Thermometer Wells: In pipes 65 mm (2-1/2 inches) and smaller increase the pipe size to provide free area equal to the upstream pipe area.

K. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION.

L. Where copper piping is connected to steel piping, provide dielectric connections.

3.2 PIPE JOINTS

A. Welded: Beveling, spacing and other details shall conform to ASME B31.1 and AWS B2.1. See Welder’s qualification requirements under "Quality Assurance" in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

B. Screwed: Threads shall conform to ASME B1.20; joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.

C. Mechanical Joint: Pipe grooving shall be in accordance with joint manufacturer's specifications. Lubricate gasket exterior including lips, pipe ends and housing interiors to prevent pinching the gasket during installation. Lubricant shall be as recommended by coupling manufacturer.

D. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.

3.3 LEAK TESTING ABOVEGROUND PIPING

A. Inspect all joints and connections for leaks and workmanship and make corrections as necessary, to the satisfaction of the VA Project Engineer. Tests may be either of those below, or a combination, as approved by the VA Project Engineer.

B. An operating test at design pressure, and for hot systems, design maximum temperature.

C. A hydrostatic test at 1.5 times design pressure. For water systems the design maximum pressure would usually be the static head, or expansion tank maximum pressure, plus pump head. Factory tested equipment (convertors, exchangers, coils, etc.) need not be field tested. Isolate equipment where necessary to avoid excessive pressure on mechanical seals and safety devices.

3.4 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

A. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

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SECTION 23 22 13
STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Steam and condensate piping inside buildings.

1.2 RELATED WORK

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

B. Piping insulation: Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

C. Temperature and pressure sensors and valve operators: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

1.3 QUALITY ASSURANCE

A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION, which includes welding qualifications.

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. Valves of all types.

C. Coordination Drawings: Refer to Article, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

1.5 APPLICABLE PUBLICATIONS

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

B. American National Institute Standard (ANSI):

B1.20.1-01.....Pipe Threads, General Purpose (Inch)

C. American Society of Mechanical Engineers (ASME):

B16.1-2005.....Cast 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

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-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 AND STEAM GENERATION.

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 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 thredolets 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. Provide gate and globe valves with packing that can be replaced with the valve under full working pressure.

C. Shut-off Valves

1. Ball Valves: Brass or bronze body with chrome-plated ball with full port and Teflon seat at 4140 kPa (600 psig) working pressure rating. Screwed or solder connections. Provide stem extension to allow operation without interfering with pipe insulation.

2. Gate Valves:

a. 50 mm (2 inches) and smaller: MSS-SP80, Bronze, 250 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, 250 psig at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel solid disc and seats. Provide 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.

2.8 STEAM HUMIDIFIERS

A. For all existing steam humidifiers serving the air handlers on this project, provide a new temperature switch on the condensate piping and all wiring required to activate the modulating control valve. See the control sequences for more information on operation.

2.9 FIRESTOPPING MATERIAL

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

PART 3 - EXECUTION

3.1 GENERAL

A. The drawings show the general arrangement of pipe and equipment but do not show all required fittings and offsets that may be necessary to connect pipes to equipment, fan-coils, coils, radiators, etc., and to coordinate with other trades. Provide all necessary fittings, offsets and pipe runs based on field measurements and at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.

B. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping relatively clean during installation and protect open ends when work is not in progress.

C. Support piping securely. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION. Install 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.

F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs.

G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.

H. 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 walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION.

J. Where copper piping is connected to steel piping, provide dielectric connections.

3.2 PIPE JOINTS

A. Welded: Beveling, spacing and other details shall conform to ASME B31.1 and AWS B2.1. See Welder’s qualification requirements under "Quality Assurance" in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

B. Screwed: Threads shall conform to ASME B1.20; joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.

C. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.

D. Solvent Welded Joints: As recommended by the manufacturer.

3.3 LEAK TESTING

A. Inspect all joints and connections for leaks and workmanship and make corrections as necessary, to the satisfaction of the VA Project Engineer. Tests may be either of those below, or a combination, as approved by the VA Project Engineer. Tests shall be witnessed by the VA Project Engineer in their entirety.

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.

3.4 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.

3.5 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

A. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

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