Engineering Technologies Inc

ADDENDUM

DATE ISSUED	4/26/2016	ADDENDUM #	1
ENGINEER	Engineering Technologies, Inc. 825 M Street, Suite 200 Lincoln, NE 68508	PROJECT	FES VAV UPGRADE
		ETI PROJECT #	2014-174

The Engineer issues this Addendum to all known bidders before receipt of proposals. Bidder shall acknowledge the receipt of this addendum on their proposal sheet and all information contained herein shall become a part of the contract documents.

ADDENDUM:

GENERAL ITEMS

1. See attached for Pre-Bid Meeting - Attendance sheet.

SPECIFICATIONS – MECHANICAL

1. See attached for mechanical specifications to be included for this project.

DRAWINGS – MECHANICAL

1. Sheet M1.1 Basement HVAC and Mechanical Demolition
   A. Radiant heater to be removed along with other two radiant heaters in Open Office 008/010. See attachment 1M for approximate location of third heater to be removed. Patch and repair ceiling to match existing.

DRAWINGS – ELECTRICAL

1. Sheet E1.1 Basement and First Floor Electrical Demolition
   A. Radiant heater existing 120V circuit to be removed back to nearest junction box, along with the other two radiant heaters shown. See attachment 1M for approximate location of third heater.

END OF ADDENDUM

LINCOLN: 825 M Street, Suite 200, Lincoln, NE 68508 P 402.476.1273 F 402.476.1274
OMAHA: 1111 N.13th Street, Suite 216, Omaha, NE 68102 P 402.330.2772 F 402.330.2630

Pre-Bid Meeting - Attendance

April 26, 2016 at 11:00 A.M. CDT
Foundation for Educational Services
*VAV System Upgrade
ETI Project No. 2014-174

NAME	COMPANY	PHONE	EMAIL
Scott W. Bahm	NAI FNA Realty	402-441-5820	sbahm@NAIFNA.com
John Schuler	Vifco Mechanical	402-477-0666	Jschuler@Vifcomechanical.com
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Andy Monson	HEP	402-423-4800	andyhep@neb.rr.com
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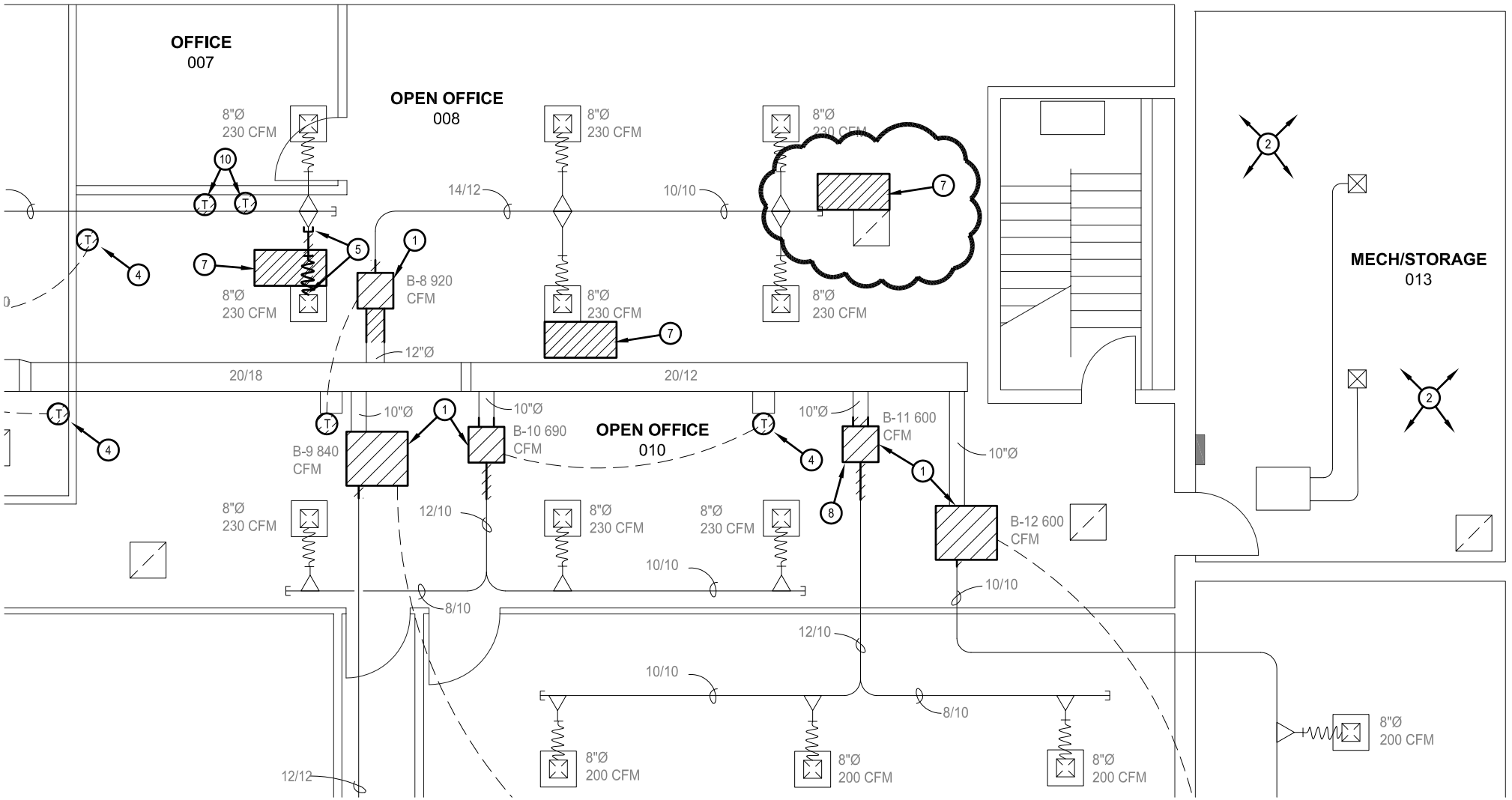

SHEET NOTES

7. REMOVE EXISTING RADIANT HEATING PANELS. PATCH AND REPAIR CEILING TO MATCH EXISTING.

FOUNDATION FOR EDUCATIONAL SERVICES
VAV UPGRADE - BASEMENT DEMOLITION

SCALE: 1/8" = 1'-0"

TJM

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ETI Project No: (2014-174)

ADD #1

SHEET
M1.1

ATTACHMENT NO.
1M

4/26/2016

SECTION 23 0050

GENERAL MECHANICAL PROVISIONS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. The work required under Heating, Ventilating, and Air Conditioning Contract shall include all material, labor, equipment and services necessary and reasonably incidental to the proper completion of the systems, and all special work as hereinafter specified and indicated on the drawings.

B. All work shall be executed in such a manner as to interfere as little as possible with the normal functioning of the facility, including operations of all utility services and any equipment, and with work being done by others. Roads shall be kept clear of materials, etc., at all times so that there will be no interference with the usual traffic. Where necessary, on account of new work connecting to existing pipes, where utility services are required to be cut, they shall be cut and capped at suitable places where indicated by drawings, or in the absence of such indication, where directed by the Architect/Engineer. No road traffic or utility service such as water, gas, or steam shall be interrupted without prior approval of the Owner, and all arrangements for work which will involve such interference shall be made in advance with the Owner so that same can be effected in a minimum of time and interference.

1.02 RELATED SECTIONS

A. Section 01 0000 - Summary

B. Section 00 7200 - General Conditions: Performance bond and labor and material payment bonds, warranty, and correction of work.

C. Section 01 3000 - Administrative Requirements: Submittals procedures, shop drawings, product data, and samples.

D. Section 01 7000 - Execution and Closeout Requirements: Contract closeout procedures.

E. Individual Product Sections: Specific requirements for operation and maintenance data.

F. Individual Product Sections: Warranties required for specific products or Work.

1.03 INTERPRETATION OF DRAWINGS AND SPECIFICATIONS

A. Drawings and specifications shall be taken together. Provide work specified and not indicated, or work indicated and not specified as though mentioned in both.

B. In case of discrepancy between drawings and specifications, or within either document, the greater quantity of work and/or better quality shall be used for estimating and the matter brought to the Engineer's attention for a written decision.

C. Drawings are to be interpreted as diagrammatic only, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment. It should be understood that the Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of pipes and ducts so as to best fit the layout of the job. Scaling of the drawings will not be sufficient or accurate for determining these locations. Contractor shall refer to the Architectural drawing for dimensions of walls, foundations, structural beams, and other structural building members. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.

D. Because of the scale of the drawings, certain basic items, such as fittings, boxes, valves, unions, etc., may not be shown, but where such items are required by other sections of the specifications or where they are required for proper installation of the work, such items shall be furnished and installed.

E. The determination of quantities of material and equipment required shall be made by the Contractor from the drawings. Schedules on the drawings and in the specifications are completed as an aid to the Contractor but where discrepancies arise, the greater number shall govern.

F. Where words "provide", "install", or "furnished" are used on the drawings or in the specifications, it shall be taken to mean, to furnish, install and connect up complete and ready for operation, the items mentioned.

1.04 COOPERATION AND PROGRESS

A. Keep informed about the work of all other trades engaged in the project and execute the work in such a manner as not to delay or interfere with the progress of other contractors. This contractor shall schedule his work so that no other contractor is delayed in the execution of his work. Complete cooperation of all trades is expected. Employ a competent foreman on job throughout the entire project to ensure that coordination is maintained.

B. Schedule and coordinate the work of this Division with the schedule of the contractor to progress the work expeditiously, and to avoid unnecessary delays.

C. Examine fully the drawings and specifications for other contractors for other trades, and coordinate the installation of this work with the work of the other contractors. Consult and cooperate with other contractors for determining space requirements and for determining that adequate clearance is allowed with respect to his equipment, other equipment, and the building. The Owner's representative reserves the right to determine space priority in the event of interference between piping, conduit, ducts, and equipment of the various contractors.

D. Conflicts between the drawings and the specification shall be called to the attention of the Owner's representative and Engineer. If clarification is not asked for prior to the taking of bids, it will be assumed that none is required and that the contractor is in agreement with the drawings and specifications as issued. If clarification is required after the Contract is awarded, such clarification will be made by the Engineer and his decision will be final.

E. Coordinate the installation of all mechanical system components with all other trades, including structural components and electrical trades. Allocate space in the different areas to allow for the installation of ductwork, piping, sprinklers, waste and vents, and mechanical equipment above ceilings and in equipment spaces. Recommend rerouting, resizing or relocation of mechanical components, if necessary, so all trades can install their systems in the space allotted. Any proposed changes from the systems layout, on the drawings, shall be done in accordance with the design criteria specified in the applicable codes and shall be subject to the review and acceptance of the Engineer.

F. After award of the Contract, and prior to start of construction, the Prime Contractor shall schedule a meeting with all subcontractors responsible of the work items listed above. The purpose of the meeting is to introduce the coordination program and to determine its implementation in relation to the progress schedule.

G. The prime contractor and subcontractors shall participate in the coordination process. Participation is mandatory. If a contractor or subcontractor fails to participate in the coordination process, the Owner reserves the right to do the following:
   1. Stop any and all construction progress payments for any work performed by the contractor. Such payments will be reinstated only after the contractor or subcontractor resumes participation in the coordination drawing process.
   2. Relocate and resize contractor's work components as necessary to ensure all components will be installed as intended. In the event the contractor did not participate in the coordination process, he will not be entitled to any contract cost increases or time extensions due to Owner initiated changes in the work.

H. The contractor shall also be held responsible for any unnecessary rework by other trade contractors that is attributable to his failure to participate in the coordination process.

I. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility because of the scale of the drawings. Each contractor is expected to have included in his bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process. The contractor will not be allowed any contract cost extra or time extension for changes dictated by the coordination process.

J. Utility installation in congested areas is dependent on the sequence of utility installation as much as it is dependent on the physical size of the utilities. The contractors shall use the coordination process to properly sequence the installation of utilities as appropriate to ensure the above ceiling and congested area utility installation is satisfactory.

1.05 GUARANTEE

A. The Contractor, by the acceptance of this specification and the signing of the Contract, acknowledges his acquaintance with all the requirements and guarantees that every part going to make up the system, will be the best of its respective kind and will be erected in a most thorough and substantial manner by none but experienced labor.

B. The Contractor guarantees that all piping as provided in this specification will be free from all obstructions, and that all piping will be tight and drip free.

C. The Contractor guarantees that the entire system of ductwork will provide free circulation of air without objectionable noise and that all air distribution within the conditioned space will be draftless and reasonably quiet.

D. The Contractor guarantees that all equipment and appliances will successfully and acceptably perform the work for which they are installed and that each will operate smoothly and quietly up to its rated capacity.

E. The Contractor further guarantees himself responsible for any defects which may develop in any part of the system, including equipment, piping, fixtures and appliances, due to faulty workmanship, design or material; and to replace and make good, without cost to the Owner, any such faulty parts or construction which develop defects at any time within one (1) year from the date of substantial completion. The date of substantial completion shall be as defined in the Contract Documents. Any repairs or replacement required on account of defects, as outlined in this paragraph shall be made promptly upon written notice from the Architect.

F. Natural wear, accident, or carelessness on the part of others, however, shall not be made good by the Contractor.

1.06 PROTECTION OF INSTALLED WORK AND MATERIAL STORED ON SITE

A. The Contractor is responsible for all work installed by him until his contract is complete and shall protect it from injury by others.

B. All piping, fittings, equipment and material to be stored on the jobsite for any period of time shall be protected from the weather in a manner that is acceptable to the Architect.

1.07 SITE VISIT

A. Bidders are advised to visit the site and inform themselves as to all conditions, and failure to do so will in no way relieve the successful bidder from the necessity of furnishing any material or performing any work that may be required to complete the work in accordance with the true intent and meaning of the drawings and specifications without additional cost to the Owner.

B. Before bidding the job, investigate, determine and verify locations and invert elevations of sanitary and storm sewers, city water mains and any other buried or overhead utilities on or near site. Determine such locations in conjunction with all public and private utility companies and with all authorities having jurisdiction.

C. On projects where remodeling of an existing structure is in the scope of the project, the contractor shall field verify locations of existing piping and ductwork. The contractor shall verify the exact locations of existing piping and ductwork to which the new ductwork and new piping are to connect and if the locations of the existing piping and ductwork are different than that shown on the drawings, the contractor shall include the additional cost in his bid proposal. The contractor shall also field verify the locations of existing piping and ductwork that are in conflict with the routing of the new work, and include in his bid proposal monies for the rerouting of the existing work in order to accommodate the new work.

1.08 RULES, REGULATIONS AND CODES

A. The Contractor shall become acquainted with the local codes, and in case of a discrepancy between plans or specifications and the local codes, the Contractor shall use the code requirements. The greater quantity of work and material and/or better quality shall be used for estimating and the matter brought to the Architect's attention for a written decision.

B. Perform all work in strict accordance with all rules, regulations, codes, ordinances, or laws of Local, State, and Federal governments, or of other authorities having lawful jurisdiction. Comply therewith. Such rules, regulations, codes, ordinances, or laws include, but are not necessarily limited to, the following:
   1. City building and fire codes.
   2. City plumbing and mechanical codes.
   3. National Electric Code.
   4. National Fire Protection Association.
   5. Occupation Safety and Health Act.

C. If the Contractor notes, at the time of bidding, any parts of the plans and specifications which are not in accord with the applicable codes or regulations, he shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time to follow this procedure, he shall submit with his proposal a separate price required to make the system shown on the drawings comply with the codes and regulations.

D. All changes to the system made after the letting of the contract, in order to comply with the applicable codes or the requirements of the inspector, shall be made by the Contractor without cost to the Owner.

1.09 SUBSTITUTIONS

A. The Engineer shall be the sole and final judge as to the suitability of items substituted for those specified.

B. The entire cost of all changes of any type due to substitutions for materials specified shall be borne by the Contractor at no extra cost to the Owner.

C. Unsolicited and voluntary deducts, on the part of the Contractor for substituting unapproved equipment, shall not be considered for the purpose of awarding the Contract.

D. When the drawings and/or specifications refer to any item, article, material, method, fabrication, assembly or construction by means of one or more manufacturer's trade name, catalog reference or similar means of identification of manufacturer, the Contractor shall furnish one of the makes so identified without substitution unless other make or makes have been approved by addendum to the contract documents prior to the receipt of bids. Requests for the approval of items of equal quality are requested to be made in writing to the Engineer five days prior to the date of the receipt of bids so that a list of acceptable equal quality items can be made known to all bidders by an addendum. If substitution for names items, articles, materials, methods, fabrications, assembly or construction are approved, the Contractor assumes all responsibility for coordination and performing the related changes in the work necessitated by such substitutions and shall include in his bid all costs involved therein.

1.10 SHOP DRAWING REVIEW

A. Shop drawings will be reviewed only to extent of information indicated. This check is only for review of general conformance with the design concept of the project and general compliance with the information given the contract documents. The contractor is responsible for confirming and correlating all quantities and dimensions, selecting fabrication processes techniques of construction, coordinating his work in a safe and satisfactory manner.

B. Review of shop drawings shall not relieve Contractor of responsibility for providing all controls, wiring, components, etc., which are shown or specified, or all additional controls, wiring, components, etc., required to provide complete and correctly operating mechanical systems.

C. In cases where substituted equipment has been installed in place of specified equipment the Contractor shall bear the entire cost of all changes of any type due to the substitution, even though the shop drawings have been reviewed by the Architect/Engineer.

D. Shop drawings in no way relieve the contractor from performing on the job as to the intent of the construction documents.

1.11 CONNECTING NEW WORK TO EXISTING WORK

A. Connect new work to existing work in a neat workmanlike manner. In every case where any part of the existing work must be cut to install new work, or is damaged, same must be patched and repaired in a manner satisfactory to the Engineer. Where relocation of existing equipment and piping systems is necessary in areas providing uninterruptible services, schedule work during slack periods. Anticipate scheduling work at a period which will result in additional construction cost, such as overtime for work to be done at night or on weekends. Include cost in the bid proposal.

B. Do not cut into existing services without first informing the Owners representative as to the time and duration of shutdown of the existing services.

C. Perform work that interrupts any service at a time that will cause least interference to the operation of the building.

D. Maintain all existing services and equipment unless indicated to be removed.

1.12 ACCESS TO EQUIPMENT FOR MAINTENANCE

A. Install all equipment, piping, etc., to permit access for normal maintenance. Maintain easy access to filters, motors, drive compressors, coils, etc. Install all such equipment and accessories to facilitate maintenance. Perform any relocation of pipes, ducts, etc. required to permit access at request of Engineer at no additional cost to Owner.

1.13 FIRE AND SMOKE STOPPAGE

A. It shall be the responsibility of this Contractor to maintained and fire and smoke integrity of all walls, ceilings, floors, etc., through which this work passes through or into. Fire and smoke barriers shall be provided in and around as required by Codes.

B. Where holes are required to be patched, or conduit, piping, ducts, etc., are required to be patched around, it shall be filled with a material that is UL Classified Standard 1479 for this use and Factory Mutual System approved.

C. Fire and smoke stoppage material shall be water based with intumescent properties. Material may be in the form of caulking, putty pads or wrap strips. Materials shall be installed in accordance to manufacturers and UL standards.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION- NOT USED

END OF SECTION 23 0050

SECTION 23 0519

METERS AND GAGES FOR HVAC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pressure gages and pressure gage taps.

B. Thermometers and thermometer wells.

1.02 RELATED REQUIREMENTS

A. Section 23 0993 - Sequence of Operations for HVAC Controls.

B. Section 23 2113 - Hydronic Piping.

1.03 REFERENCE STANDARDS

A. ASME B40.100 - Pressure Gauges and Gauge Attachments; The American Society of Mechanical Engineers; 2013.

B. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers; 2014.

C. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers; 2014.

D. UL 393 - Indicating Pressure Gauges for Fire-Protection Service; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

1.04 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

PART 2 PRODUCTS

2.01 PRESSURE GAGES

A. Pressure Gages: ASME B40.100, UL 393 drawn steel case, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
   1. Case: Steel with brass bourdon tube.
   2. Size: 4-1/2 inch diameter.
   3. Mid-Scale Accuracy: One percent.
   4. Scale: Psi.

2.02 PRESSURE GAGE TAPPINGS

A. Gage Cock: Tee or lever handle, brass for maximum 150 psi.

2.03 STEM TYPE THERMOMETERS

A. Thermometers - Adjustable Angle: Red- or blue-appearing non-toxic liquid in glass; ASTM E1; lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device; adjustable 360 degrees in horizontal plane, 180 degrees in vertical plane.
   1. Size: 9 inch scale.
   2. Window: Clear Lexan.
   3. Stem: 3/4 inch NPT brass.
   4. Accuracy: 2 percent, per ASTM E77.
   5. Calibration: Degrees F.

2.04 TEST PLUGS

A. Test Plug: 1/4 inch or 1/2 inch brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with neoprene core for temperatures up to 200 degrees F.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch for installation of thermometer sockets. Ensure sockets allow clearance from insulation.

B. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets. Refer to Section 23 0943. Where thermometers are provided on local panels, duct or pipe mounted thermometers are provided on local panels, duct or pipe mounted thermometers are not required.

C. Provide instruments with scale ranges selected according to service with largest appropriate scale.

D. Install gages and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

E. Locate test plugs adjacent to control device sockets.

END OF SECTION 23 0519

SECTION 23 0553

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Nameplates.

B. Pipe Markers.

1.02 REFERENCE STANDARDS

A. ASME A13.1 - Scheme for the Identification of Piping Systems; The American Society of Mechanical Engineers; 2007.

1.03 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

PART 2 PRODUCTS

2.01 IDENTIFICATION APPLICATIONS

A. Variable Air Volume Boxes: nameplates, ceiling tacks where located above lay-in ceiling.

B. Control Panels: Nameplates.

C. Dampers: Ceiling tacks where located above lay-in ceiling.

D. Piping: Pipe markers.

E. Valves: Ceiling tacks where located above lay-in ceiling.

2.02 NAMEPLATES

A. Manufacturers:
   1. Advanced Graphic Engraving.
   2. Brimar Industries, Inc..
   3. Kolbi Pipe Marker Co..
   4. Seton Identification Products.

2.03 PIPE MARKERS

A. Manufacturers:
   1. Brady Corporation.
   2. Brimar Industries, Inc..
   3. Kolbi Pipe Marker Co..
   4. MIFAB, Inc..
   5. Seton Identification Products.

B. Color: Conform to ASME A13.1.

C. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

E. Color code as follows:
   1. Heating, Cooling, and Boiler Feedwater: Green with white letters.

2.04 CEILING TACKS

A. Manufacturers:
   1. Craftmark.

B. Description: Steel with 3/4 inch diameter color coded head.

C. Color code as follows:
   1. HVAC Equipment: Yellow.

2. Heating/Cooling Valves: Blue.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.

C. Identify service, flow direction, and pressure.

D. Install in clear view and align with axis of piping.

E. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

END OF SECTION 23 0553

SECTION 23 0593

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Testing, adjustment, and balancing of air systems.

B. Testing, adjustment, and balancing of hot water heating system systems.

1.02 REFERENCE STANDARDS

A. ASHRAE Std 111 - Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2008.

B. NEBB (TAB) - Procedural Standards for Testing Adjusting Balancing of Environmental Systems; National Environmental Balancing Bureau; 2005, Seventh Edition.

1.03 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
   1. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Engineer and for inclusion in operating and maintenance manuals.
   2. Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
   3. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
   4. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
   5. Units of Measure: Report data in I-P (inch-pound) units only.

C. Project Record Documents: Record actual locations of flow measuring stations and balancing valves and rough setting.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Perform total system balance in accordance with one of the following:
   1. ASHRAE Std 111, Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.
   2. NEBB Procedural Standards for Testing Adjusting Balancing of Environmental Systems.

B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.

C. TAB Agency Qualifications:
   1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.

3.02 EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
   1. Systems are started and operating in a safe and normal condition.
   2. Temperature control systems are installed complete and operable.
   3. Fans are rotating correctly.
   4. Fire and volume dampers are in place and open.

5. Access doors are closed and duct end caps are in place.
6. Air outlets are installed and connected.
7. Duct system leakage is minimized.
8. Hydronic systems are flushed, filled, and vented.
9. Proper strainer baskets are clean and in place.
10. Service and balance valves are open.

B. Beginning of work means acceptance of existing conditions.

3.03 ADJUSTMENT TOLERANCES

A. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

B. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

C. If system cannot be balanced per design documents, Contractors shall work together towards a solution on the site and be prepared to remedy work as required. If requirements cannot still be attained, the Contractor shall contact Engineer prior to submitting report.

3.04 RECORDING AND ADJUSTING

A. Ensure recorded data represents actual measured or observed conditions.

B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.05 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities .

B. Measure air quantities at air inlets and outlets.

C. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

D. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.

E. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

F. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

G. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

H. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

I. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.

J. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.

3.06 WATER SYSTEM PROCEDURE

A. Adjust water systems to provide required or design quantities.

B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.

C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

D. Effect system balance with automatic control valves fully open to heat transfer elements.

E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

3.07 SCOPE

A. Test, adjust, and balance the following:
   1. Variable Air Volume Boxes.
   2. Air Flow Stations.
   3. Exhaust Fans
   4. Air Inlets and Outlets
   5. Hot Water Heating Piping

3.08 MINIMUM DATA TO BE REPORTED

A. VAV Reheat Coils:
   1. Identification/number
   2. Location
   3. Service
   4. Air flow, design and actual
   5. Water flow, design and actual
   6. Water pressure drop, design and actual
   7. Entering water temperature, design and actual
   8. Leaving water temperature, design and actual
   9. Entering air temperature, design and actual
   10. Leaving air temperature, design and actual
   11. Air pressure drop, design and actual

B. Return Air/Outside Air:
   1. Identification/location
   2. Design air flow
   3. Actual air flow
   4. Return air temperature
   5. Outside air temperature
   6. Actual mixed air temperature

C. Exhaust Fans:
   1. Location
   2. Manufacturer
   3. Model number
   4. Serial number
   5. Air flow, specified and actual
   6. Total static pressure (total external), specified and actual
   7. Sheave Make/Size/Bore
   8. Number of Belts/Make/Size
   9. Fan RPM

D. Duct Traverses:
   1. System zone/branch
   2. Duct size
   3. Area
   4. Design velocity

5. Design air flow
6. Test velocity
7. Test air flow
8. Duct static pressure

E. Flow Measuring Stations:
1. Identification/number
2. Location
3. Size
4. Manufacturer
5. Model number
6. Serial number
7. Design Flow rate
8. Design pressure drop
9. Actual/final pressure drop
10. Actual/final flow rate
11. Station calibrated setting

F. Air Distribution Tests:
1. Air terminal number
2. Room number/location
3. Terminal type
4. Terminal size
5. Area factor
6. Design velocity
7. Design air flow
8. Test (final) velocity
9. Test (final) air flow
10. Percent of design air flow

END OF SECTION 23 0593

SECTION 23 0713
DUCT INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Duct insulation.

B. Duct Liner.

1.02 RELATED REQUIREMENTS

A. Section 23 3100 - HVAC Ducts and Casings.

1.03 REFERENCE STANDARDS

A. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation; 2014.

B. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2015a.

C. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials; 2014.

D. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials; National Fire Protection Association; 2006.

E. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; Sheet Metal and Air Conditioning Contractors' National Association; 2005.

F. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

1.04 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.

B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.02 GLASS FIBER, FLEXIBLE

A. Manufacturer:
   1. Knauf Fiber Glass.
   2. Johns Manville Corporation.
   3. Owens Corning Corp.
   4. CertainTeed Corporation.;

B. Vapor Barrier Jacket:
   1. Kraft paper with glass fiber yarn and bonded to aluminized film.
   2. Moisture Vapor Permeability: 0.029 ng/Pa s m (0.02 perm inch), when tested in accordance with ASTM E96/E96M.
   3. Secure with pressure sensitive tape.

2.03 DUCT LINER

A. Manufacturers:
   1. Knauf Fiber Glass.

2. Johns Manville Corporation.
3. Owens Corning Corp.
4. CertainTeed Corporation; .

B. Insulation: Incombustible glass fiber complying with ASTM C 1071; flexible blanket; impregnated surface and edges coated with poly vinyl acetate polymer or acrylic polymer shown to be fungus and bacteria resistant by testing to ASTM G 21.
1. Apparent Thermal Conductivity: Maximum of 0.31 at 75 degrees F.
2. Rated Velocity on Coated Air Side for Air Erosion: 5,000 fpm, minimum.
3. Minimum Noise Reduction Coefficients:
   a. 1 inch Thickness: 0.45.
   b. 2 inch Thickness: 0.90.

C. Adhesive: Waterproof, fire-retardant type, ASTM C916.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that ducts have been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Insulated ducts conveying air below ambient temperature:
1. Provide insulation with vapor barrier jackets.
2. Finish with tape and vapor barrier jacket.
3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.

C. External Duct Insulation Application:
1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
2. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers.
3. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
4. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

D. Duct and Plenum Liner Application:
1. Adhere insulation with adhesive for 100 percent coverage.
2. Secure insulation with mechanical liner fasteners. Refer to SMACNA (DCS) for spacing.
3. Seal and smooth joints. Seal and coat transverse joints.
4. Seal liner surface penetrations with adhesive.
5. Duct dimensions indicated are net inside dimensions required for air flow. Increase duct size to allow for insulation thickness.

3.03 SCHEDULES

A. Supply Ducts: 1/2 inch thick liner on rectangular ducts and 1-1/2" inch thick duct wrap insulation on round ducts.

END OF SECTION 23 0713

SECTION 23 0719

HVAC PIPING INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Piping insulation.

B. Jackets and accessories.

1.02 RELATED REQUIREMENTS

A. Section 07 8400 - Firestopping.

B. Section 23 2113 - Hydronic Piping: Placement of hangers and hanger inserts.

1.03 REFERENCE STANDARDS

A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus; 2013.

B. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation; 2015.

C. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel; 2008 (Reapproved 2013).

D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2015a.

E. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials; 2014.

F. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

1.04 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.02 GLASS FIBER

A. Manufacturers:
   1. CertainTeed Corporation.
   2. Johns Manville Corporation.
   3. Knauf Insulation.
   4. Owens Corning Corporation.

B. Insulation: ASTM C547 and ASTM C795; semi-rigid, noncombustible, end grain adhered to jacket.
   1. 'K' Value: ASTM C177, 0.24 at 75 degrees F.
   2. Maximum Service Temperature: 650 degrees F.
   3. Maximum Moisture Absorption: 0.2 percent by volume.

C. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.

D. Vapor Barrier Lap Adhesive: Compatible with insulation.

2.03 JACKETS

A. PVC Plastic.
   1. Manufacturers:
      a. Johns Manville Corporation.
   2. Jacket: One piece molded type fitting covers and sheet material, off-white color.
      a. Minimum Service Temperature: 0 degrees F.
      b. Maximum Service Temperature: 150 degrees F.
      c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
      d. Thickness: 10 mil.
      e. Connections: Brush on welding adhesive.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.

C. Glass fiber insulated pipes conveying fluids above ambient temperature.
   1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
   2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with PVC fitting covers.

D. Inserts and Shields:
   1. Application: Piping 1 inches diameter or larger.
   2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
   3. Insert location: Between support shield and piping and under the finish jacket.
   4. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
   5. Insert Material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

E. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, refer to Section 07 8400.

3.02 SCHEDULE

A. Heating Systems:
   1. Heating Water Supply and Return:
      a. Glass Fiber Insulation:
         1) Pipe Size Range: Up to 1-1/2", 1-1/2 inch thickness.
         2) Pipe Size Range: 2" and over, 2 inch thickness.

END OF SECTION 23 0719

SECTION 23 0913

HVAC INSTRUMENTATION AND CONTROLS

SUMMARY

1.01 GENERAL

A. A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. See Division 15 Section "Sequence of Operation" for requirements that relate to this Section.

C. HVAC INSTRUMENTATION AND CONTROLS WILL BE CONTRACTED UNDER THE MECHANICAL CONTRACTOR.

1.02 SUBMITTALS

A. Product Data: For each control device indicated.

B. Shop Drawings:
   1. Schematic flow diagrams.
   2. Power, signal, and control wiring diagrams.
   3. Details of control panel faces.
   4. Damper schedule.
   5. Valve schedule.
   6. DDC System Hardware: Wiring diagrams, schematic floor plans, and schematic control diagrams.
   7. Control System Software: Schematic diagrams, written descriptions, and points list.

C. Software and firmware operational documentation.

D. Field quality-control test reports.

E. Operation and maintenance data.

1.03 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide electric control systems of the following:

   Provide Alerton control software and hardware by Control Management, Inc (CMI). CMI Bid contact is Frederick Lerouge (402) 779-6109.

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.

C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics

2.02 DDC EQUIPMENT

A. Operator Workstation: Access to the system shall be via a standard web browser on the owner provided Internet Router. Access will be restricted with password protection.

B. APPLICATION CONTROLLERS
   1. Provide one or more native BACnet application controllers for each air handler that adequately cover all objects listed in object list. All controllers shall interface to building

controller through either MS/TP LAN using BACnet protocol, or Ethernet LAN using BACnet over Ethernet or BACnet TCP/IP. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of units. Controllers shall be fully programmable using graphical programming blocks. Programming tool shall be resident on operator workstation and be the same tool as used for the building controller. No auxiliary or non-BACnet controllers shall be used.

2. BACnet Conformance
   a. Application controllers shall be approved by the BTL as meeting the BACnet Advanced Application Controller requirements.
3. Application controllers shall include universal inputs with 12-bit resolution that accept 3K and 10K thermistors, 0–10VDC, Platinum 1000 ohm RTD, 0–5VDC, 4–20mA and dry contact signals. Any input on a controller may be either analog or digital with a minimum of three inputs that accept pulses. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall include binary and analog outputs on board. Analog outputs with 12-bit resolution shall support either 0–10VDC or 0–20mA. Binary outputs shall have LED indication of status. Software shall include scaling features for analog outputs. Application controller shall include 20VDC voltage supply for use as power supply to external sensors.
4. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller up to 20 times per second (minimum of 10 times per second) and capable of multiple PID loops for control of multiple devices. All calculations shall be completed using floating-point math and system shall support display of all information in floating-point nomenclature at operator's terminal.
5. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely using modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using programming tools as described in operator's terminal section.
6. Application controller shall include support for intelligent room sensor (see sensor section.) Display on intelligent room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode, based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.
7. The controller processor shall be a 32-bit processor.

2.03 TERMINAL UNIT APPLICATION CONTROLLERS (AC UNITS, FAN-COILS)

A. Provide one native BACnet application controller for each piece of unitary mechanical equipment that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.

B. BACnet Conformance
   1. Application controllers shall, as a minimum, support MS/TP BACnet LAN types. They shall communicate directly using this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be approved by the BTL as meeting the BACnet Application Specific Controller requirements and support all BACnet services necessary to provide the following BACnet functional groups:
      a. Files Functional Group
      b. Reinitialize Functional Group
      c. Device Communications Functional Group

C. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5VDC, 4–20mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and

modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.

D. All program sequences shall be stored on board controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely through modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section.

E. Application controller shall include support for intelligent room sensor (see sensor section) Display on room sensor shall be programmable at controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

2.04 VAV BOX CONTROLLERS—SINGLE DUCT

A. Provide one native BACnet application controller for each VAV box that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include on board CFM flow sensor, inputs, outputs and programmable, self-contained logic program as needed for control of units.

B. BACnet Conformance
   1. Application controllers shall, at a minimum, support MS/TP BACnet LAN types. They shall communicate directly through this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be approved by the BTL as meeting the BACnet Application Specific Controller requirements.
   2. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5 VDC, and dry contact signals. Inputs on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall also include binary outputs on board. For applications using variable speed parallel fans, provide a single analog output selectable for 0-10 V or 0-20 mA control signals. Application controller shall include microprocessor driven flow sensor for use in pressure independent control logic. All boxes shall be controlled using pressure-independent control algorithms and all flow readings shall be in CFM (LPS if metric).

D. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely using modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using the same programming tool as Building Controller and as described in operator’s workstation section.

E. Application controller shall include support for intelligent room sensor (see sensor section) Display on room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed

on the sensor. See sequence of operations for specific display requirements for intelligent room sensor.

F. On board flow sensor shall be microprocessor-driven and pre-calibrated at the factory. Pre-calibration shall be at 16 flow points as a minimum. All factory calibration data shall be stored in non-volatile memory. Calibration data shall be field adjustable to compensate for variations in VAV box type and installation. All calibration parameters shall be adjustable through intelligent room sensor. Operator's workstation, portable computers, and special hand-held field tools shall not be needed for field calibration.

G. Provide duct temperature sensor at discharge of each VAV box that is connected to controller for reporting back to operator's workstation.

2.05 AUXILIARY CONTROL DEVICES

A. Temperature Sensors
   1. All temperature sensors to be solid-state electronic, interchangeable with housing appropriate for application. Wall sensors to be installed as indicated on drawings. Mount 48 inches above finished floor. Duct sensors to be installed such that the sensing element is in the main air stream. Immersion sensors to be installed in wells provided by control contractor, but installed by mechanical contractor. Immersion wells shall be filled with thermal compound before installation of immersion sensors. Outside air sensors shall be installed away from exhaust or relief vents, not in an outside air intake, and in a location that is in the shade most of the day.
   2. Intelligent Room Sensor with LCD Readout
      a. Sensor shall contain a backlit LCD digital display and user function keys along with temperature sensor. Controller shall function as room control unit and allow occupant to raise and lower setpoint, and activate terminal unit for override use—all within limits as programmed by building operator. Sensor shall also allow service technician access to hidden functions as described in sequence of operation.
      b. The intelligent room sensor shall simultaneously display room setpoint, room temperature, outside temperature, and fan status (if applicable) at each controller. This unit shall be programmable, allowing site developers the flexibility to configure the display to match their application. The site developer should be able to program the unit to display time-of-day, room humidity and outdoor humidity. Unit must have the capability to show temperatures in degrees Fahrenheit or Centigrade.
      c. Override time may be set and viewed in half-hour increments. Override time countdown shall be automatic, but may be reset to zero by occupant from the sensor. Time remaining shall be displayed. Display shall show the word "OFF" in unoccupied mode unless a function button is pressed.
      d. See sequence of operation for specific operation of LCD displays and function keys in field service mode and in normal occupant mode. Provide intelligent room sensors as specified in point list.
      e. Field service mode shall be customizable to fit different applications. If intelligent room sensor is connected to VAV controller, VAV box shall be balanced and all air flow parameters shall be viewed and set from the intelligent room sensor with no computer or other field service tool needed.
   3. Wall Sensor
      a. Standard wall sensor shall use solid-state sensor identical to intelligent room sensor and shall be packaged in aesthetically pleasing enclosure. Sensor shall provide override function, warmer/cooler lever for set point adjustment and port for plug-in of Field Service Tool for field adjustments. Override time shall be stored in controller and be adjustable on a zone-by-zone basis. Adjustment range for warmer/cooler lever shall also be stored in EEPROM on controller. All programmable variables shall be available to field service tool through wall sensor port.
   4. Wireless Wall Sensor
      a. Wireless wall sensor shall use solid-state sensor and shall be packaged in aesthetically pleasing enclosure. Sensor shall provide override function,

warmer/cooler dial for set point adjustment. Override time shall be stored in controller and be adjustable on a zone-by-zone basis. Adjustment range for warmer/cooler lever shall also be stored in EEPROM on controller. All programmable variables shall be available to field service tool through wall sensor port. There shall be a mechanical means the lock the wall sensor to the base to prevent theft and vandalism.

b. Wireless wall sensor shall have a battery life of 5 year with alkaline batteries and 7.5 years with lithium batteries. A low battery indication shall be signaled to the controller prior to the battery being exhausted. The wireless sensor shall run on industry standard AA style batteries.

c. The wireless range in open air shall meet or exceed 3000 ft. The strength of the wireless signal must be indicated at the wireless sensor to aid in placement and trouble shooting. The receiver shall have a wireless communications received light that indicates the proper communication is occurring.

d. The wireless wall sensor and receiver must be paired in an addressable mean to facilitate easy replacement and reassignment.

2.06 ELECTRONIC ACTUATORS AND VALVES

A. Quality Assurance for Actuators and Valves
   1. UL Listed Standard 873 and C.S.A. Class 4813 02 certified.
   2. NEMA 2 rated enclosures for inside mounting, provide with weather shield for outside mounting.
   3. Five-year manufacturer's warranty. Two-year unconditional and three-year product defect from date of installation.
   4. All electric/electronic valve and damper actuators shall be Honeywell or Belimo manufactured.

B. Execution Details for Actuators and Valves
   1. For AHU hot water coils: Furnish a Freeze-stat and install "Hard Wire" interlock to disconnect the mechanical spring return actuator power circuit for fail-safe operation. Use of the control signal to drive the actuators closed is not acceptable.
   2. VAV box damper and valve actuation shall be floating type or analog (2–10VDC, 4–20mA). Mechanical Spring is not required.
   3. Booster-heat valve actuation shall be floating type or analog (2-10vdc, 4-20ma).
   4. Primary valve control shall be analog (2–10VDC, 4–20mA).
   5. Actuators for damper and control valves 0.5–6 inches shall be electric unless otherwise specified, provide actuators as follows:
      a. UL Listed Standard 873 and Canadian Standards association Class 481302 shall certify actuators.
      b. NEMA 2 rated actuator enclosures for inside mounting. Use additional weather shield to protect actuator when mounted outside.
      c. One-year manufacturer's warranty.
      d. Mechanical spring shall be provided when specified. Capacitors or other non-mechanical forms of fail-safe are not acceptable.
      e. Position indicator device shall be installed and made visible to the exposed side of the actuator. For damper short shaft mounting, a separate indicator shall be provided to the exposed side of the actuator.
      f. Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for butterfly valve actuators.
      g. A Pushbutton gearbox release shall be provided for all non-spring actuators.
      h. Modulating actuators shall be 24VAC and consume 10VA power or less.
      i. Conduit connectors are required when specified and when code requires it.

C. Damper Actuators:

1. Outside air and exhaust air damper actuators shall be mechanical spring return. capacitors or other non-mechanical forms of fail-safe are not acceptable. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the damper as required.
2. Economizer actuators shall utilize analog control 2–10VDC, floating control is not acceptable.
3. Electric damper actuators (including VAV box actuators) shall be direct shaft-mounted and use a V-bolt and toothed V-clamp causing a cold weld effect for positive gripping. Single bolt or set-screw type fasteners are not acceptable.
4. One electronic actuator shall be direct shaft-mounted per damper section. No connecting rods or jackshafts shall be needed. Small outside air and return air economizer dampers may be mechanically linked together if one actuator has sufficient torque to drive both and damper drive shafts are both horizontal installed.
5. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft-mounted per damper section. (See below execution section for more installation details.)

D. Valve Actuators 0.5–6 inches
1. Mechanical spring shall be provided on all actuators for pre-heat coil and actuators for AHU heating or cooling coil when units are mounted outside. See plans for fail-safe flow function: Normal Open or Normal Closed. Capacitors or other non-mechanical forms of fail-safe are not acceptable.
2. All zone service actuators shall be non-spring return unless otherwise specified.
3. The valve actuator shall be capable of providing the minimum torque required for proper valve close-off for the required application.
4. All control valves actuators shall have an attached 3-foot cable for easy installation to a junction box.
5. Override handle and gearbox release shall be provided for all non-spring return valve actuators.

E. Control Dampers.
1. The BAS contractor shall furnish and size all automatic control dampers unless provided with packaged equipment. The sheet metal contractor shall install all dampers unless provided with packaged equipment.
2. All dampers used for modulating service shall be opposed blade type and arranged for normally open or normally closed operation as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop for effective throttling.
3. All dampers used for two-position or open-close control shall be parallel blade type arranged for normally open or closed operation as required.
4. Damper linkage hardware shall be constructed of aluminum or corrosion-resistant zinc and nickel-plated steel and furnished as follows:
    a. Bearing support bracket and drive blade pin extension shall be provided for each damper section. Sheet metal contractor shall install bearing support bracket and drive blade pin extension. Sheet metal contractor shall provide permanent indication of blade position by scratching or marking the visible end of the drive blade pin extension.
    b. Drive pin may be round only if V-bolt and toothed V-clamp is used to cause a cold weld effect for positive gripping. For single bolt or set-screw type actuator fasteners, round damper pin shafts must be milled with at least one side flat to avoid slippage.
    c. Damper manufacturer shall supply alignment plates for all multi-section dampers.
    d. Dampers shall be Ruskin Model CD60 or Honeywell equal

F. Control Valves 0.5–6” inches
1. The BAS contractor shall furnish all specified motorized control valves and actuators. BAS contractor shall furnish all control wiring to actuators. The plumbing contractor shall install all valves. Equal percentage control characteristic shall be provided for all water coil

control valves. Linear valve characteristic is acceptable for 3-way valves that are 2.5 inches and above.

2. Characterized control valves shall be used for hydronic heating or cooling applications and small to medium AHU water-coil applications to 100GPM. Actuators are non-spring return for terminal unit coil control unless otherwise noted. If the coil is exposed to the outside air stream, see plans for spring return requirement.
   a. Leakage is aero percent, close-off is 200psi, maximum differential is 30psi; rangeablity is 500:1.
   b. Valves 0.5–2 inches shall be nickel-plated forged brass body, NPT screw type connections.
   c. Valves 0.5–1.25 inches shall be rated for ANSI Class 600 working pressure. Valves 1.5 and 2 inches shall be rated for ANSI Class 400 working pressure.
   d. The operating temperature range shall be 0–250 degrees F.
   e. Stainless steel ball and stem shall be furnished on all modulating valves.
   f. Seats shall be fiberglass reinforced Teflon.
   g. Two-way and three-way valves shall have an equal percentage control port. Full stem rotation is required for maximum flow to insure stable BTU control of the coil.
   h. Three-way valve shall be applicable for both mixing and diverting.
   i. The characterizing disc is made of TEFZEL and shall be keyed and held secure by a retaining ring.
   j. The valves shall have a blow-out proof stem design.
   k. The stem packing shall consist of 2 lubricated O-rings designed for on-off or modulating service and require no maintenance.
   l. The valves shall have an ISO type, 4-bolt flange for mounting actuator in any orientation parallel or perpendicular to the pipe.
   m. A non-metallic thermal isolation adapter shall separate valve flange from actuator.
   n. One fastening screw shall secure the direct coupling of the thermal isolation adapter between the actuator and the valve. This will prevent all lateral or rotational forces from affecting the stem and its packing O-rings.
3. Globe valves 0.5–2 inches shall be used for steam control or water flow applications.
   a. Valves shall be bronze body, NPT screw type, and shall be rated for ANSI Class 250 working pressure.
   b. Valves 0.5 inches (DN15) through 2 inches (DN50) with spring return actuators shall close off against 50 psi pressure differential with Class III leakage (0.1%).
   c. The operating temperature range shall be 20–280 degrees F.
   d. Spring loaded TFE packing shall protect against leakage at the stem.
   e. Two-way valves shall have an equal percentage control port.
   f. Three-way valves shall have a linear control and bypass port.
   g. Mixing and diverting valves must be installed specific to the valve design.
4. Globe Valve 2.5–6 inches
   a. Valves 2.5 inches (DN65) through 6 inches (DN50) shall be iron body, 125 lb. flanged with Class III (0.1%) close-off leakage at 50 psi differential.
   b. Valves with spring return actuators shall close off against 50 psi pressure differential with Class III leakage (0.1%).
   c. Flow type for two-way valves shall be equal percentage. Flow type for three-way valves shall be linear.
   d. Mixing and diverting valves must be installed specific to the valve design.
5. Butterfly valves
   a. Butterfly valves shall be sized for modulating service at 60–70 degree stem rotation. Isolation valves shall be line-size. Design velocity shall be less than 12 feet per second when used with standard EPDM seats.
   b. Body is cast iron.
   c. Disc is aluminum bronze standard.
   d. Seat is EPDM standard.
   e. Body Pressure is 200 psi, -30–275 degrees F.

f. Flange is ANSI 125/250.
g. Media Temperature Range is -22–240 degree F.
h. Maximum Differential Pressure is 200 psi for 2- to 6- inch size.

6. Performance Verification Test
   a. Control loops shall cause productive actuation with each movement of the actuator and actuators shall modulate at a rate that is stable and responsive. Actuator movement shall not occur before the effects of previous movement have affected the sensor.
   b. Actuator shall have capability of signaling a trouble alarm when the actuator Stop-Go Ratio exceeds 30%.
7. Actuator mounting for damper and valve arrangements shall comply to the following:
   a. Damper actuators: Shall not be installed in the air stream
   b. A weather shield shall be used if actuators are located outside. For damper actuators, use clear plastic enclosure.
   c. Damper or valve actuator ambient temperature shall not exceed 122 degrees F through any combination of medium temperature or surrounding air. Appropriate air gaps, thermal isolation washers or spacers, standoff legs, or insulation shall be provided as necessary.
   d. Actuator cords or conduit shall incorporate a drip leg if condensation is possible. Water shall not be allowed to contact actuator or internal parts. Location of conduits in temperatures dropping below dew point shall be avoided to prevent water from condensing in conduit and running into actuator.
8. Damper mounting arrangements shall comply to the following:
   a. The ventilation subcontractor shall furnish and install damper channel supports and sheet metal collars.
   b. No jack shafting of damper sections shall be allowed.
   c. Multi-section dampers shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per section.
9. Size damper sections based on actuator manufacturer's specific recommendations for face velocity, differential pressure and damper type. In general:
   a. Damper section shall not exceed 24 ft-sq. with face velocity >1500 FPM.
   b. Damper section shall not exceed 18 ft-sq. with face velocity > 2500 FPM.
   c. Damper section shall not exceed 13 ft-sq. with face velocity > 3000 FPM.
10. Multiple section dampers of two or more shall be arranged to allow actuators to be direct shaft mounted on the outside of the duct.
11. Multiple section dampers of three or more sections wide shall be arranged with a 3-sided vertical channel (8 inches wide by 6 inches deep) within the duct or fan housing and between adjacent damper sections. Vertical channel shall be anchored at the top and bottom to the fan housing or building structure for support. The sides of each damper frame shall be connected to the channels. Holes in the channel shall allow damper drive blade shafts to pass through channel for direct shaft-mounting of actuators. Open side of channel shall be faced downstream of the airflow, except for exhaust air dampers.
12. Multiple section dampers to be mounted flush within a wall or housing opening shall receive either vertical channel supports as described above or sheet metal standout collars. Sheet metal collars (12-inch minimum) shall bring each damper section out of the wall to allow direct shaft-mounting of the actuator on the side of the collar.

G. Valve Sizing for Water Coil
1. On/Off control valves shall be line size.
2. Modulating control valve body size may be reduced, at most, two pipe sizes from the line size or not less than half the pipe size. The BAS contractor shall size all water coil control valves for the application as follows:
   a. Booster-heat valves shall be sized not to exceed 4–9psi differential pressure. Size valve for 50% valve authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.

b. Primary valves shall be sized not to exceed 5–15psi differential pressure. Size valve for 50% valve authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.
c. Butterfly valves shall be sized for modulating service at 60–70 degree rotation. Design velocity shall be 12 feet per second or less when used with standard EPDM seats.

3. Valve mounting arrangements shall comply to the following:
   a. Unions shall be provided on all ports of two-way and three-way valves.
   b. Install three-way equal percentage characterized control valves in a mixing configuration with the “A” port piped to the coil.
   c. Install 2.5 inches and above, three-way globe valves, as manufactured for mixing or diverting service to the coil.

2.07 CARBON DIOXIDE SENSOR

A. Provide a space or duct carbon dioxide gas detection sensor as indicated within the field termination schedules and/or control diagrams. Carbon dioxide detection sensors shall meet, at minimum, the following requirements:
   1. Set-up to be fully microprocessor based c/w LCD.
   2. 4-20 mA, 0-10 or 0-5 Vdc output compatible with BMS proportional to 0 to 2000 ppm of carbon dioxide concentration
   3. Power supply to be 20-28Vac/dc @ 140 mA max for 24 Vac and 80 mA avg. @24 Vdc.
   4. No maintenance or periodic sensor replacement needed. The sensor shall have a 5-year calibration interval, utilizing the Automatic Calibration Logic Program (ACLP).
   5. Standard accuracy to be 3% of reading or 75 ppm, whichever is greater.
   6. Optional integral humidity and temperature transmitter or temperature sensor (thermistor or RTD)
   7. BACnet communications
   8. Optional setpoint adjustment, override switch and relay.
   9. Operating temperature of 0°C to 50°C.
   10. Operating temperature of 32°F to 122°F.

2.08 AIRFLOW MEASUREMENT DEVICES (AMD) WITH TEMPERATURE AND AIRFLOW ALARMING CAPABILITY

A. Airflow measurement devices shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node.
   1. Thermal dispersion devices that indirectly heat a thermistor are not acceptable.

B. General
   1. Provide one AMD for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature at each measurement location.
   2. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes.
      a. Devices that have electronic signal processing components on or in the sensor probe are not acceptable.
   3. Airflow measurement shall be field configurable to determine the average actual or standard mass airflow rate.
      a. Actual airflow rate calculations shall have the capability of being adjusted automatically by the transmitter for altitudes other than sea level.
   4. Temperature measurement shall be field configurable to determine the velocity weighted temperate or simple arithmetic average temperature.

C. Sensor Probes
   1. Sensor probes shall be constructed of gold anodized, 6063 aluminum alloy tube
   2. Sensor probe mounting brackets shall be constructed of 304 stainless steel.
   3. Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper.

a. PVC jacketed internal wiring is not acceptable.

4. Probe internal wiring connections shall consist of solder joints and spot welds.
   a. Connectors of any type within the probe are not acceptable.
   b. Printed circuit boards within the probe are not acceptable.
5. Probe internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.
6. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -67°F to 392 °F (-55° C to 200° C) and continuous and direct UV exposure.
   a. Plenum rated PVC jacket cables are not acceptable.
7. Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
8. Each sensor probe shall contain one or more independently wired sensing nodes.
9. Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter.
10. Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy.
    a. Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.
11. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
12. Each sensor node shall be individually calibrated to NIST-traceable airflow standards at a minimum of 16 calibration points.
    a. The number of independent sensor nodes provided shall be as follows:

Area ft2	# Sensor Nodes
<= 0.5	1
> 0.5 & <= 1	2
> 1 & <= 2	4
> 2 & <= 4	6
> 4 & <= 8	8
> 8 & <= 12	12
> 12 & <= 14	14
> 14	16

       1) A total of 4 probes shall be required for openings with an aspect ratio <= 1.5 and with an area >= 25 ft2.

D. Transmitter
1. A remotely located microprocessor-based transmitter shall be provided for each measurement location.
2. The transmitter shall be comprised of a main circuit board and interchangeable interface card.
3. All printed circuit board interconnects, edge fingers, and test points shall be gold plated.
4. All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
5. All receptacle plug pins shall be gold plated.
6. The transmitter shall be capable of determining the average airflow rate and temperature of the sensor nodes.
   a. Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (IR-interface).
7. The transmitter shall be capable of providing a high and/or low airflow alarm.
8. The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
9. The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.

a. The airflow rate, temperature, airflow alarm and system status alarm shall be visible on the display.

10. The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals and one or both of the following:
    a. one isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU) network connection; or
    b. one isolated Ethernet (simultaneously supported BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection.
11. Analog output signals shall provide the total airflow rate and be field configurable to output one of the following:
    a. temperature
    b. airflow alarm; or
    c. system status alarm
12. Network communications shall provide the average airflow rate, temperature, airflow alarm, system status alarm, individual sensor node airflow rates and individual sensor node temperatures.
13. Provide an infra-red I/O card mounted on the transmitter PCB for communication to a handheld retrieval device that can download individual sensor node airflow and temperature data in real time.
14. The transmitter shall be powered by 24 VAC and use a switching power supply that is over-current and over-voltage protected.
15. The transmitter shall use a “watchdog” timer circuit to ensure continuous operation in the event of brown-out and/or power failure.

E. Performance
1. Each sensing node shall have an airflow accuracy of ±2% of reading over an operating range of 0 to 5,000 FPM (25.4 m/s).
    a. Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.
        1) Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.
    b. Each sensing node shall have a temperature accuracy of ±0.15° F (0.1° C) over an operating range of -20° F to 160° F. (-28.9° C to 71° C).

F. Listings and Certifications
1. The AMD shall be UL873 Listed as an assembly.
    a. Devices claiming compliance with the UL Listing based on individual UL component listing are not acceptable.
2. The AMD shall be BTL Listed.

G. Basis of Design: EBTRON, Inc. model GTx116-P+.

H. The airflow stations will be mounted by the Sheet Metal Contractor and wired by the Temperature Control Contractor.

2.09 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 16 Section "Voice and Data Communication Cabling."

PART 3 EXECUTION

3.01 INSTALLATION

A. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices [48 inches (1220 mm)] [60 inches (1530 mm)] <Insert dimension> above the floor.
1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

B. Install automatic dampers according to Division 15 Section "Duct Accessories."

C. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

D. Install labels and nameplates to identify control components according to Division 15 Section "Mechanical Identification."

E. Install hydronic instrument wells, valves, and other accessories according to Division 15 Section "Hydronic Piping."

F. Install refrigerant instrument wells, valves, and other accessories according to Division 15 Section "Refrigerant Piping."

G. Install duct volume-control dampers according to Division 15 Sections specifying air ducts.

H. Install electronic and fiber-optic cables according to Division 16 Section "Voice and Data Communication Cabling."

3.02 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 16 Section "Raceways and Boxes."

B. Install building wire and cable according to Division 16 Section "Conductors and Cables."

C. Install signal and communication cable according to Division 16 Section "Voice and Data Communication Cabling."
   1. Plenum cabling is acceptable above ceiling space except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   3. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   4. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
   5. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
   2. Test and adjust controls and safeties.
   3. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
   4. Test each point through its full operating range to verify that safety and operating control set points are as required.
   5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
   6. Test each system for compliance with sequence of operation.
   7. Test software and hardware interlocks.

C. DDC Verification:
   1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
   2. Check instruments for proper location and accessibility.
   3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
   4. Check instrument tubing for proper fittings, slope, material, and support.

5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature instruments and material and length of sensing elements.
7. Check control valves. Verify that they are in correct direction.
8. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
9. Check DDC system as follows:
    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.04 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls.

END OF SECTION 23 0913

SECTION 23 0993

SEQUENCE OF OPERATIONS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

B. See Division 23 Section "Building Management System" for control equipment and devices and for submittal requirements.

1.02 WORK INCLUDED

A. Sequence of operation is hereby defined as the manner and method by which controls function. Requirements for each type of control system operation are specified in this section.

1.03 CONTROL SEQUENCES

A. VAV Air Handling Units.

B. VAV Terminal Units.

C. Cabinet Unit Heaters.

D. Exhaust Fans.

1.04 SUBMITTALS

A. Shop Drawings: Submit Shop Drawings for each system automatically controlled, containing the following information:
   1. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves and control devices.
   2. Label each control device with setting or adjustable range of control.
   3. Indicate factory and field wiring.
   4. Indicate each control panel required, with internal and external wiring clearly indicated. Provide detail of panel face, including controls, instruments and labeling. Include verbal description of sequence of operation.
   5. Maintenance Data: Include copy of Shop Drawings in each Maintenance Manual.

PART 2 PRODUCTS

2.01 GENERAL

A. Building Management System equipment shall be as specified in Division 23 Section "Building Management System".

B. Provide dynamic color graphics for all systems including but not limited to those identified in sequence of operation. Refer to Drawings for Building Management System components and equipment.

PART 3 EXECUTION

3.01 CONTROL SEQUENCES

A. VAV Air Handling Unit.
   1. Supply Fans and Return Fans: Fans shall be enabled through the building management system via a BACnet MSTP interface to the “Fanwall Control System”.
      a. Supply fan shall be enabled when a minimum of 20% of VAVs are in occupied mode. If supply fan does not start, an alarm shall be generated.
      b. Return fan shall be enabled when supply fan is enabled. If return fan does not start, an alarm shall be generated.
      c. When fans are enabled, control sequence shall commence.
      d. Air handling unit shall operate in 100% return air mode at start-up for five minutes, or until mixed air temperature is above adjustable 40 deg F.
      e. Duct mounted averaging thermostat shall notify BMS of mixed air temperature. Alarm system when air temperature falls below 40 deg F

f. The fire alarm system AHU shutdown shall be wired directly into the “Fanwall Control System”. The electrical contractor shall provide the fire alarm related work and the equipment provider shall provide the programming necessary for the factory controls. The “Fanwall Systems” shall automatically restart if the fire alarm returns to normal and the BMS system has the system in occupied mode.

g. Supply fan variable frequency drive shall modulate fan to maintain duct pressure 2/3 down supply ductwork.
   1) The supply and return fans shall run continuously. The BAS shall modulate the supply fan to maintain supply duct static pressure setpoint. When the static pressure as sensed is below the setpoint, the control system shall cause the variable frequency drive to increase the supply fan speed until the static pressure setpoint has been re-established. The reverse shall occur if the static pressure in the duct were to rise above the setpoint.
   2) Duct Static Pressure Reset Control
      (a) Reset duct static pressure setpoint from 0.25in wg (adj.) to 1.0in wg (adj.) to maintain the worse VAV damper position at 90%.
      (b) The BAS contractor shall provide on the AHU graphics a live graph of the reset and a live report the VAV boxes above 90% damper position.
      (c) The BAS contractor shall work with engineer during commissioning to determine if some V A V boxes are always above 90% damper position.
      (d) The BAS contractor shall work with engineer if some non-critical VAV boxes should be excluded from the reset calculation.
      (e) A dedicated air handler day/night schedule will limit the duct pressure to a fixed pressure setpoint from 0.5in wg (adj.) during night mode.

h. Return fan variable frequency drive shall modulate fan speed to maintain a return duct pressure that yields a -0.5” WC differential pressure between building interior and exterior. Differential pressure shall be controlled by maintaining a return airflow that is a fixed cfm offset below the measured supply fan airflow. Coordinate fixed cfm offset value with balancing contractor based upon operating status of exhaust fans serving system.

i. Supply duct static pressure sensor shall disable fan if adjustable maximum pressure setpoint is exceeded.

j. All air handling unit control sequences shall commence based upon operating status of fans via the “Fanwall Systems” BACnet interfaces and not start/stop command. This allows unit to function as specified if fans are manually enabled instead of enabled through the BMS.

2. Ventilation: Modulate return damper and outside air damper to maintain minimum ventilation rate as measured by outside air flow station (Ebtron Gold Series). Reset the minimum outside air flow from a minimum XXXX cfm maximum of XXXX cfm of outside air. This outdoor air quantity is based upon the maximum occupancy.
   a. An outside air airflow measuring station shall be mounted in the intake section of the air handler unit. The airflow monitoring device shall provide a 0-10 VDC or 4-20 mA signal proportional to the velocity across the duct section of the AHU. This signal shall correspond to the CFM for controlling and documenting the outside airflow.
   b. The air airflow measuring station transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over- current protected analog output signals and an isolated RS-485 BACnet MS/TP network connection.
   c. The BAS shall modulate the outside-air damper to minimum position as required for ventilation. The outdoor air damper can also be modulated open as required by the worse room carbon dioxide sensor measured in the building. When a room carbon dioxide sensor exceeds the carbon dioxide setpoint of 1000 ppm (adj.) above outdoor carbon dioxide levels, the outdoor air damper shall open by 5% (adj.) increments at a frequency of 10 minutes (adj.) until the damper is at full open or the critical zone setpoint is satisfied. Once the critical zone is satisfied for a period of 5 minutes (adj.), the outdoor air damper shall return to the minimum position as required for ventilation.

The minimum outdoor air damper control shall be limited to a maximum of 25% open range.

d. Provide low-leakage dampers on outside air, return air and exhaust air ducts.
e. Dampers shall modulate to operate in economizer mode based on outside air enthalpy.
f. If outside air enthalpy is higher than return air enthalpy, drive outside air damper to minimum position. If outside air enthalpy is lower than return air enthalpy, operate unit in economizer mode.
g. Relief damper shall modulate to maintain +0.25" WC differential pressure between the return fan discharge plenum and the exterior wall of the relief louver section.

3. Return Air Flow Control: Modulate return air damper on each floor to maintain each floor air flow setpoint as measured by a return air flow station (Ebtron Gold Series) on each floor. Calculate the return air flow setpoint as 90% (adj.) of the sum of total air flow of the VAVs serving that floor minus the calculated cfm from exhaust fans running on that floor. On the first floor provide a building differential pressure sensor with the high port pickup location in the lobby and the low port outside the main entrance door. Reset the return air flow setpoint offset from 80% (adj.) to 90% (adj.) of the sum of air flow for the VAVs on that floor.
   a. A return air airflow measuring station shall be mounted in the intake section of the return air duct on each floors. The airflow monitoring device shall provide a 0-10 VDC or 4-20 mA signal proportional to the velocity across the duct section. This signal shall correspond to the CFM for controlling and documenting the outside airflow.
   b. The air airflow measuring station transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over- current protected analog output signals and an isolated RS-485 BACnet MS/TP network connection.
   c. The BAS shall modulate the return air damper to maintain the return airflow at the calculated airflow setpoint.
   d. Provide low-leakage dampers on return air air ducts.
4. Hydronic Heating Coils: Modulate two-way hot water control valve to maintain the current supply air temperature setpoint.
5. Hydronic Cooling Coils: Open chilled water control valve fully and modulate the chilled water plant leaving temperature setpoint to maintain the current air handler supply air temperature at setpoint. Once the chilled water setpoint reaches 44F, modulate the chilled water pump to increase/decrease chilled water flow to maintain the discharge temperature at the current setpoint. The chilled water pump will not modulate below the minimum differential pressure required by the chillers. Once the pumps are at mimimum speed for maintaining the minimum chiller flow, the water setpoint can be reset to maintain the AHU discharge temperature to the current setpoint.
6. Discharge Temperature Control:
   a. Reset the discharge air temperature setpoint from 55 deg F (adj.) to 65 deg F (adj.) to maintain the worse VAV cooling demand at 90%.
   b. The BAS contractor shall provide on the AHU graphics a live graph of the reset and a live report the VAV boxes above 90% cooling demand.
   c. The Bas contractor shall work with engineer during commissioning to determine if some VAV boxes are always above 90% damper position.
   d. The BAS contractor shall work with engineer if some non-critical VAV boxes should be excluded from the reset calculation.
   e. A dedicated air handler day/night schedule will have a separate day or night outdoor air reset schedule. The outdoor air reset shall override the low temperature setpoint on the cooling demand reset.
7. Filters: Differential air pressure sensor shall notify BMS of pressure drop across filters.
8. Coordination of Air-Handling Unit Sequences: Ensure that mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.
9. Display: Refer to the Input/Output Schedule at the end of the section.

B. Variable Air Volume Terminal Units.

1. General: Occupancy zones shall enable VAV terminal unit to occupied room temperature setpoint during occupied mode and setback to unoccupied room temperature setpoint when unoccupied.
   a. Work with engineer and owner to determine zones and schedules.
2. Airflow: Refer to Variable Air Volume Terminal Unit Schedule.
3. Room Temperature Sensor: VAV damper shall modulate to maintain adjustable room temperature setpoint. Provide thermostat with adjustable setpoint but provide BMS limits initially set at 68 deg F for heating and 74 deg F for cooling. Enable hot water reheat coil if the boiler plant is enabled and if the VAV cannot maintain room heating setpoint.
4. Timed Override: Provide timed override request push button for activation during unoccupied mode.
   a. Occupied Mode: 72 deg F.
   b. Unoccupied Heating Mode: 65 deg F.
   c. Unoccupied Cooling Mode: 78 deg F.
5. Display: Refer to the Input/Output Schedule at the end of the section.

C. Exhaust Fans.
1. General Exhaust or other exhaust (unless otherwise indicated): Exhaust fan shall operate based on the AHU day/night schedule.
2. Display: Refer to the Input/Output Schedule at the end of the section.

D. Cabinet Unit Heaters
1. General: Connect the existing cabinet unit heaters to the facilities BAS.
2. Room Temperature Sensor: Provide a room temperature sensor adjustable through the BAS. On a call for heating, the unit's fan shall start and the motorized control valve shall open.
3. Display: Refer to the Input/Output Schedule at the end of the section.

3.02 INPUT/OUTPUT POINTS: (REUSE EXISTING BMS POINTS WERE APPLICABLE)

Point	DI	DO	AI	AO	ADJ	Alarm	Remarks
VAV Air Handling System							
Air Handling Unit Enable		X			X		BACnet
Supply Fan VFD				X	X	X	BACnet
Supply Fan Airflow			X				BACnet
Supply Fan Discharge Static Pressure			X				2/3 down duct
Return Fan VFD				X	X	X	BACnet
Return Fan Airflow			X				BACnet
Return Fan Discharge Static Pressure			X				BACnet
Return Fan Suction Static Pressure			X				
Supply Discharge Air Temperature			X				
Return Air Temperature			X				
Return Air CO2			X				
Return Air Humidity			X				
Return Air Enthalpy			X				
Mixed Air Temperature			X		X		
Outside Airflow			X				
Outside Air Temperature			X				
Outside Air Humidity			X				
Outside Air Enthalpy			X				Calculated

Point	DI	DO	AI	AO	ADJ	Alarm	Remarks
Outside Air Damper				X	X		
Return Air Damper				X	X		
Relief Air Damper				X	X		
Building Pressure			X				Lobby
Individual Floor Return Air Damper				X			
Individual Floor Return Air Flow			X				
Hydronic Heating Coil Valve				X			
Hydronic Cooling Coil				X			
Filter Differential Pressure			X				
Final Filter Differential Pressure			X				
Fanwall Alarm	X					X	
VAV Terminal Unit							
BMS Occupancy Schedule	X						By Zones
Occupied Temperature Setpoint	X						
Unoccupied Temperature Setpoint	X						
Room Temperature (Provide wired or wireless as shown on plans)			X				See Plans for Loc.
VAV Damper Minimum Position				X	X		
VAV Damper Position			X				
Reheat Coil		X					
Discharge Air Temperature			X				
Timed Override Setpoint		X			X		
Timed Override Status	X						
Large rooms CO2 sensor (Provide combo wall temp/CO2 sensor)			X			X	See Plans for Loc.
Exhaust Fan							
Exhaust Fan Enable		X			X		
Exhaust Fan Status	X					X	

Point	DI	DO	AI	AO	ADJ	Alarm	Remarks
Cabinet Unit Heater							
Occupied Temperature Setpoint	X						
Unoccupied Temperature Setpoint	X						
Room Temperature			X				
Supply Fan		X					
Control Valve				X			

ADJ = OWNER ADJUSTABLE

END OF SECTION 23 0993

SECTION 23 2113

HYDRONIC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Heating water piping, above grade.

B. Pipe hangers and supports.

C. Unions, flanges, mechanical couplings, and dielectric connections.

D. Valves:
   1. Ball valves.
   2. Butterfly valves.
   3. Check valves.

1.02 RELATED REQUIREMENTS

A. Section 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT.

B. Section 23 0719 - HVAC Piping Insulation.

C. Section 23 2114 - Hydronic Specialties.

D. Section 23 2500 - HVAC Water Treatment: Pipe cleaning.

1.03 REFERENCE STANDARDS

A. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Welding, Brazing, and Fusing Qualifications; The American Society of Mechanical Engineers; 2013.

B. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; The American Society of Mechanical Engineers; 2011.

C. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2012 (ANSI B16.18).

D. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2013.

E. ASTM A106/A106M - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service; 2014.

F. ASTM B32 - Standard Specification for Solder Metal; 2008.

G. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2014.

H. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers; 1992 (Reapproved 2008).

I. ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications; 2007 (Reapproved 2013).

J. MSS SP-58 - Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 2009.

1.04 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data:
   1. Include data on pipe materials, pipe fittings, valves, and accessories.

C. Project Record Documents: Record actual locations of valves.

D. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.05 QUALITY ASSURANCE

A. Provide all grooved joint couplings, fittings, valves, specialties, and grooving tools from a single manufacturer.

B. Welder Qualifications: Certify in accordance with ASME BPVC-IX.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

B. Provide temporary protective coating on cast iron and steel valves.

C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.01 HYDRONIC SYSTEM REQUIREMENTS

A. Comply with ASME B31.9 and applicable federal, state, and local regulations.

B. Piping: Provide piping, fittings, hangers and supports as required, as indicated, and as follows:
   1. Where more than one piping system material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.
   2. Use non-conducting dielectric connections (Clear-Flow nipples or dielectric flanges) whenever jointing dissimilar metals.
   3. Make hydronic piping branch taps off of the top of the system mains.
   4. Grooved mechanical joints fittings may be used in any location.
      a. Grooved mechanical connections and joints comply with AWWA C606.
         1) Steel: Comply with ASTM A106/A106M, Grade B or ASTM A53/A53M.
      b. Use rigid joints unless otherwise indicated.
   5. Engineered copper and bronze press fittings (ProPress or equal) may be used in any location.
      a. Press fillting shal comply with ASTM 16.18 or ASTM 16.22.
   6. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.

C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use flanges, unions, grooved couplings, or press fittings to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.

D. Valves: Provide valves where indicated:
   1. Isolate equipment using butterfly valves with lug end flanges or grooved mechanical couplings.
   2. For throttling, bypass, or manual flow control services, use globe, ball, or butterfly valves.
   3. For shut-off and to isolate parts of systems or vertical risers, use ball or butterfly valves.

E. Welding Materials and Procedures: Conform to ASME BPVC-IX.

2.02 HEATING WATER PIPING, ABOVE GRADE

A. Steel Pipe: ASTM A53/A53M, Schedule 40, black, using one of the following joint types:
   1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D1.1/D1.1M welded.
   2. Threaded Joints (only allowed up to 2" size): ASME B16.3, malleable iron fittings.
   3. Grooved Joints: AWWA C606 grooved pipe, fittings of same material, and mechanical couplings.

B. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), drawn, using one of the following joint types:
   1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings.
      a. Solder: ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
      b. Braze: AWS A5.8/A5.8M BCuP copper/silver alloy. Braze all piping joints 2" and larger.

2. Grooved Joints: AWWA C606 grooved tube, fittings of same material, and copper-tube-dimension mechanical couplings.
3. Press Fitttings (Propress or equal): ASTM 16.18 or ASTM 18.22 with EPDM seals.

2.03 PIPE HANGERS AND SUPPORTS

A. Provide hangers and supports that comply with MSS SP-58 and ASME B31.9.
1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, split ring.
3. Hangers for Hot Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
5. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
6. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
7. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.04 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

A. Unions for Pipe 2 Inches and Under:
1. Ferrous Piping: 150 psig malleable iron, threaded.
2. Copper Pipe: Bronze, soldered joints.

B. Flanges for Pipe Over 2 Inches:
1. Ferrous Piping: 150 psig forged steel, slip-on.
2. Copper Piping: Bronze.
3. Gaskets: 1/16 inch thick preformed neoprene.

C. Mechanical Couplings for Grooved and Shouldered Joints: Two or more curved housing segments with continuous key to engage pipe groove, circular C-profile gasket, and bolts to secure and compress gasket.
1. Dimensions and Testing: In accordance with AWWA C606.
2. Mechanical Couplings: Comply with ASTM F1476.
3. Housing Material: Ductile iron, galvanized complying with ASTM A536.
4. Bolts and Nuts: Hot dipped galvanized or zinc-electroplated steel.
5. When pipe is field grooved, provide coupling manufacturer's grooving tools.

D. Dielectric Connections:
1. Waterways:
a. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
b. Dry insulation barrier able to withstand 600 volt breakdown test.
c. Construct of galvanized steel with threaded end connections to match connecting piping.
d. Suitable for the required operating pressures and temperatures.
2. Flanges:
a. Dielectric flanges with same pressure ratings as standard flanges.
b. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
c. Dry insulation barrier able to withstand 600 volt breakdown test.
d. Construct of galvanized steel with threaded end connections to match connecting piping.
e. Suitable for the required operating pressures and temperatures.

2.05 BALL VALVES

A. Manufacturers:
1. Milwaukee Valve Company
2. Apollo Valve

B. Up To and Including 2 Inches:
   1. Bronze one piece body, chrome plated brass ball, teflon seats and stuffing box ring, lever handle with balancing stops, solder ends with union.

C. Over 2 Inches:
   1. Ductile iron body, chrome plated steel ball, teflon or Virgin TFE seat and stuffing box seals, lever handle, flanged ends, rated to 800 psi.

2.06 BUTTERFLY VALVES

A. Manufacturers:
   1. Crane Co.
   2. Milwaukee Valve Company

B. Body: Cast or ductile iron with resilient replaceable EPDM seat, wafer, lug, or grooved ends, extended neck.

C. Disc: Construct of aluminum bronze, chrome plated ductile iron, stainless steel, ductile iron with EPDM encapsulation, or Buna-N encapsulation.

D. Operator: 10 position lever handle.

2.07 SWING CHECK VALVES

A. Manufacturers:
   1. Milwaukee Valve Company

B. Up To and Including 2 Inches:
   1. Bronze body, bronze trim, bronze rotating swing disc, with composition disc, solder ends.

C. Over 2 Inches:
   1. Iron body, bronze trim, bronze or bronze faced rotating swing disc, renewable disc and seat, flanged or grooved ends.

2.08 SPRING LOADED CHECK VALVES

A. Manufacturers:
   1. Crane Co.
   2. Milwaukee Valve Company

B. Iron body, bronze trim, split plate, hinged with stainless steel spring, resilient seal bonded to body, wafer or threaded lug ends.

PART 3 EXECUTION

3.01 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.

C. Prepare pipe for mechanical press fittings as required by coupling manufacturer.

D. Remove scale and dirt on inside and outside before assembly.

E. Prepare piping connections to equipment using jointing system specified.

F. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

G. After completion, flush, clean, fill, and treat systems with specified fluid with corrosion inhibitors. Refer to Section 23 2500 for additional requirements.

H. Refer to Division 22 0000 for piping insulation and identification.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install heating water piping to ASME B31.9 requirements.

C. Route piping in orderly manner, parallel to building structure, and maintain gradient.

D. Install piping to conserve building space and to avoid interfere with use of space.

E. Group piping whenever practical at common elevations.

F. Sleeve pipe passing through partitions, walls and floors constructed of a minimum of 18 gauge sheetmetal. Provide schedule 40 pipe as sleeves with appropriate sealant at fire and/or smoke rated penetrations around pipe sleeve. Extend sleeves through floors a minimum of 2" above the floor. Wall sleeves shall be flush with the wall and chrome plated solid steel escutcheons shall be installed..

G. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified.

H. Slope piping and arrange to drain at low points.

I. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

J. Grooved Joints:
   1. Install in accordance with the manufacturer's latest published installation instructions.
   2. Gaskets to be suitable for the intended service, molded, and produced by the coupling manufacturer.

K. Pipe Hangers and Supports:
   1. Install in accordance with ASME B31.9, ASTM F708, or MSS SP-58.
   2. Support horizontal piping as scheduled.
   3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
   4. Place hangers within 12 inches of each horizontal elbow.
   5. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
   6. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
   7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
   8. Provide copper plated hangers and supports for copper piping.
   9. Prime coat exposed steel hangers and supports. Refer to Section 09 9123. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

L. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 22 0719.

M. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 08 3100.

N. Use eccentric reducers to maintain top of pipe level.

O. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

P. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting. Refer to Section 09 9123.

Q. Install valves with stems upright or horizontal, not inverted.

R. Hydrostatically test all hydronic piping systems with 125 psi of water pressure for 24 hours.

S. Testing of mechanical piping systems shall be witnessed by the Engineer. Provide a mimimum of 24 hours notice prior to the testing.

3.03 SCHEDULES

A. Hanger Spacing for Copper Tubing.
   1. 1/2 inch and 3/4 inch: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. 1 inch: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. 1-1/2 inch and 2 inch: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   4. 2-1/2 inch: Maximum span, 9 feet; minimum rod size, 3/8 inch.

B. Hanger Spacing for Steel Piping.
   1. 1/2 inch, 3/4 inch, and 1 inch: Maximum span, 7 feet; minimum rod size, 1/4 inch.
   2. 1-1/4 inches: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   3. 1-1/2 inches: Maximum span, 9 feet; minimum rod size, 3/8 inch.
   4. 2 inches: Maximum span, 10 feet; minimum rod size, 3/8 inch.
   5. 2-1/2 inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
   6. 3 inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.
   7. 4 inches: Maximum span, 14 feet; minimum rod size, 1/2 inch.

END OF SECTION 23 2113

SECTION 23 2500

HVAC WATER TREATMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Cleaning of piping systems.

B. Chemical treatment.

1.02 RELATED REQUIREMENTS

A. Section 23 2113 - Hydronic Piping.

1.03 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.

1.04 REGULATORY REQUIREMENTS

A. Conform to applicable code for addition of non-potable chemicals to building mechanical systems and to public sewage systems.

B. Products Requiring Electrical Connection: Listed and classified by UL as suitable for the purpose specified and indicated.

1.05 MAINTENANCE SERVICE

A. Furnish service and maintenance of treatment systems for one year from Date of Substantial Completion.

B. Include two hour training course for operating personnel, instructing them on installation, care, maintenance, testing, and operation of water treatment systems. Arrange course at start up of systems.

PART 2 PRODUCTS

2.01 MATERIALS

A. System Cleaner:
   1. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products; sodium tripoly phosphate and sodium molybdate.

B. Closed System Treatment (Water):
   1. Manufacturers:
      a. Fremont Industries #927 or approved equal.
   2. Product shall be registered by NSF for Nonfood Compounds as an acceptable water conditioner for the treatment of entire potable water systems at concentrations not to exceed 10 ppm calculated as phosphate ion in and around food processing areas.
   3. Sequestering agent to reduce deposits and adjust pH; polyphosphate.
   4. Corrosion inhibitors; boron-nitrite, sodium nitrite and borax, sodium totyltriazole, low molecular weight polymers, phosphonates, sodium molybdate, or sulphites.
   5. Conductivity enhancers; phosphates or phosphonates.

PART 3 EXECUTION

3.01 PREPARATION

A. Systems shall be operational, flushed, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.

B. Place terminal control valves in open position during cleaning.

C. Verify that electric power is available and of the correct characteristics.

3.02 CLEANING SEQUENCE

A. Concentration:

1. As recommended by manufacturer.

B. Hot Water Heating Systems:
   1. Apply heat while circulating, slowly raising temperature to 160 degrees F and maintain for 12 hours minimum.
   2. Remove heat and circulate to 100 degrees F or less; drain systems as quickly as possible and refill with clean water.
   3. Circulate for 6 hours at design temperatures, then drain.
   4. Refill with clean water and repeat until system cleaner is removed. Final system fill shall be with softened water.

C. Remove, clean, and replace strainer screens.

D. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.03 CLOSED SYSTEM TREATMENT

A. Introduce closed system treatment through bypass feeder when required or indicated by test.

END OF SECTION 23 2500

SECTION 23 3100
HVAC DUCTS AND CASINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Metal ductwork.

B. Nonmetal ductwork.

C. Casing and plenums.

1.02 RELATED REQUIREMENTS

A. Section 23 0593 - Testing, Adjusting, and Balancing for HVAC.

B. Section 23 0713 - Duct Insulation: External insulation and duct liner.

C. Section 23 3300 - Air Duct Accessories.

D. Section 23 3600 - Air Terminal Units.

E. Section 23 3700 - Air Outlets and Inlets.

1.03 REFERENCE STANDARDS

A. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2014.

B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2015.

C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2015a.

D. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; National Fire Protection Association; 2012.

E. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations; National Fire Protection Association; 2014.

F. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; Sheet Metal and Air Conditioning Contractors' National Association; 2005.

G. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

1.04 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience, and approved by manufacturer.

1.06 REGULATORY REQUIREMENTS

A. Construct ductwork to NFPA 90A and NFPA 96 standards.

PART 2 PRODUCTS

2.01 DUCT ASSEMBLIES

A. Regulatory Requirements: Construct ductwork to NFPA 90A standards.

B. All Ducts: 2 inch w.g. pressure class, galvanized steel, unless otherwise indicated.

2.02 MATERIALS

A. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G60/Z180 coating.

B. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
   1. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
   2. VOC Content: Not more than 250 g/L, excluding water.
   3. Surface Burning Characteristics: Flame spread index of zero and smoke developed index of zero, when tested in accordance with ASTM E84.
   4. For Use With Flexible Ducts: UL labeled.

C. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

2.03 DUCTWORK FABRICATION

A. Fabricate and support in accordance with SMACNA (DCS) and as indicated.

B. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.

C. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

D. Fabricate continuously welded round and oval duct fittings in accordance with SMACNA (DCS).

2.04 MANUFACTURED DUCTWORK AND FITTINGS

A. Flat Oval and Spiral Round Ducts: Machine made from round spiral lockseam duct.
   1. Manufacture in accordance with SMACNA (DCS).
   2. Fittings: Manufacture at least two gages heavier metal than duct.
   3. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.

B. Flexible Ducts: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound spring steel wire.
   1. Pressure Rating: 10 inches WG positive and 1.0 inches WG negative.
   2. Maximum Velocity: 4000 fpm.
   3. Temperature Range: Minus 20 degrees F to 210 degrees F.

2.05 CASINGS

A. Fabricate casings in accordance with SMACNA (DCS) and construct for operating pressures indicated.

B. Mount floor mounted casings on 4 inch high concrete curbs. At floor, rivet panels on 8 inch centers to angles. Where floors are acoustically insulated, provide liner of galvanized 18 gage, 0.0478 inch expanded metal mesh supported at 12 inch centers, turned up 12 inches at sides with sheet metal shields.

C. Reinforce door frames with steel angles tied to horizontal and vertical plenum supporting angles. Install hinged access doors where indicated or required for access to equipment for cleaning and inspection.

D. Fabricate acoustic casings with reinforcing turned inward. Provide 16 gage, 0.0598 inch sheet steel back facing and 22 gage, 0.0299 inch perforated sheet steel front facing with 3/32 inch diameter holes on 5/32 inch centers. Construct panels 3 inches thick packed with 4.5 lb/cu ft minimum glass fiber insulation media, on inverted channels of 16 gage, 0.0598 inch sheet steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install, support, and seal ducts in accordance with SMACNA (DCS).

B. Install in accordance with manufacturer's instructions.

C. Provide all ductwork offsets and fittings as required for a quality installation.

D. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

E. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.

F. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

G. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

H. Connect flexible ducts to metal ducts with liquid adhesive plus tape.

I. Connect diffusers to low pressure ducts with 3 feet maximum length of flexible duct held in place with strap or clamp.

J. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.

K. Seal all supply duct connections to VAV boxes etc.

END OF SECTION 23 3100

SECTION 23 3300

AIR DUCT ACCESSORIES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Air turning devices.

B. Volume control dampers.

1.02 RELATED REQUIREMENTS

A. Section 23 3100 - HVAC Ducts and Casings.

B. Section 23 3600 - Air Terminal Units: Pressure regulating damper assemblies.

1.03 REFERENCE STANDARDS

A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; National Fire Protection Association; 2012.

B. SMACNA (DCS) - HVAC Duct Construction Standards; 2005.

1.04 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide for shop fabricated assemblies including volume control dampers and duct access doors. Include electrical characteristics and connection requirements.

PART 2 PRODUCTS

2.01 AIR TURNING DEVICES

A. Multi-blade device with radius blades attached to pivoting frame and bracket, steel construction, with push-pull operator strap.

2.02 VOLUME CONTROL DAMPERS

A. Manufacturers:
   1. Nailor Industries Inc.
   2. Ruskin Company.
   3. Greenheck.

B. Fabricate in accordance with SMACNA (DCS) and as indicated.

C. Single Blade Dampers: Fabricate for duct sizes up to 6 x 30 inch. Round single blade dampers shall have rolled stiffener blades with a firm, closed-cell neoprene seal at damper edges. Leakage shall not exceed 0.15 cfm per inch of blade circumference at a pressure difference of 4" w.g.

D. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

E. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.

F. Quadrants:
   1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
   2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). Refer to Section 23 3100 for duct construction and pressure class.

B. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.

C. Provide balancing dampers in air systems where indicated.

D. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

E. Install high efficiency takeoffs (HETO's) as shown on drawings on round supply duct connections to rectangular duct mains. Seal flange connections and all joints with duct sealant.

END OF SECTION 23 3300

SECTION 23 3417

FAN ARRAY HVAC FANS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Forward curved centrifugal fans.

B. Motors and drives.

C. Fan accessories.

1.02 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide data on centrifugal fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.

C. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Protect motors, shafts, and bearings from weather and construction dust.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fan Wall.

B. Greenheck Fan Corp.

2.02 FANWALL FAN ARRAY

A. The Contractor shall furnish and install “fanwall” or equal fan array system. The fanwall system shall consist of multiple, direct driven, arrangement 4 plenum fans with fan wheels that are rated and certified with tests and procedures in accordance with AMCA publication 211 and comply with the requirements of the AMCA certified ratings program and constructed per the AMCA requirements for the duty specified, (CLASS I, II, OR III). All fans shall be selected to deliver the specified airflow quantity at the specified operating total static pressure and specified fan/motor speed. The fanwall array shall be selected to operate at a system total static pressure that does not exceed 90% of the specified fan’s peak static pressure producing capability at the specified fan/motor speed. Each fan/motor “cube” shall include a 12 gauge, g 90u galvanized steel intake wall, 16 gauge spun steel fan inlet funnel, and a 1/4” steel motor support plate rail and structure. The fan intake wall, inlet funnel, and motor support structure shall be powder coated for superior corrosion resistance. All motors shall be standard foot mounted type, Tefc or Teao motors selected at the specified operating voltage, rpm, and efficiency as specified or as scheduled elsewhere. Motors shall meet the requirements of NEMA mg-1 part 30 and 31, section 4.4.2. Motors shall be as manufactured by Baldor, Seimens, or Toshiba as approved for use in multiple fan arrays that operate at varying synchronous speeds as driven by an approved VFD. Steel cased motors and/or odp motors are not acceptable. Six pole motors, unless specifically called for will not be accepted. All motors shall include permanently sealed bearings and shaft grounding to protect the motor bearings from electrical discharge machining due to stray shaft currents. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, category bv-5, to meet or exceed an equivalent grade g.55, indicating a maximum of .022” per second peak, filter in (.55mm per second peak, filter in) residual unbalance.
   1. The fan array shall consist of multiple fan and motor ”cubes”, spaced in the air way tunnel cross section to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein. Each fan cube shall be (wired to an individual VFD as specified elsewhere for each fan motor). Wire sizing shall be determined, and installed, in accordance with applicable NEC standards.
   2. Each fan/motor assembly shall be removable through a 30” wide, free area, access door located on the (discharge) (inlet) side of the fan wall array.

3. Each fan/motor “cube” will be provided with an individual back-draft damper. Huntair backdraft dampers are made with heavy duty 6063-t5 extruded aluminum on the frames and blades and engineered to produce little to no static pressure loss at the designed operating conditions. Seals shall be solid rubber. Bearings shall be rubber shielded radial ball bearings, permanently lubricated. The vertical blades of the damper open as airflow commences and close when the fan is idle. This is accomplished without the use of mechanical means or weights.
4. Each fan assembly shall be supplied with a complete flow measuring system, Huntair flow-cone, which indicates airflow in cubic feet per minute. The flow measuring system shall consist of a flow measuring station and two pressure taps with one high static pressure tap and one low total pressure tap located at the throat of the inlet cone. The flow measuring station shall not obstruct the inlet of the fan and shall have no effect on fan performance (flow or static) or sound power levels. A surface mounted indicator, located on the unit exterior, shall provide a (digital) (analog) cfm readout, and/or a (4-20 ma) (0-10 volt) output control signal for use in the bas as specified elsewhere.
5. Provide a complete electrical and control system required to run the fanwall system including all equipment, material, electrical enclosure, electrical components and electrical labor.
6. Fanwall designs shall be in accordance with specific system requirements. Please see system requirements before electrical design of fanwall system is to commence.
7. Fanwall electrical designs shall be in accordance with the NEC, ul 508a, and local codes. The disconnect for the electrical shall have a minimum 100,000 amp short circuit current rating.
8. There shall be a controller provided as an integral part of the fan system electrical panel that automatically reconfigures the number of active fans in the multiple fan array to achieve substantially peak operating efficiency for the fan array at any fan system operating point. System optimization shall be achieved by enabling and disabling fans in the active array while the controller varies the enabled fan operating speeds to achieve substantially peak efficiency at the concurrent system flow and pressure demands of the system. The fan array controller shall also be provided with an interface as indicated or specified that is compatible with the building automation system and which shall allow remote monitoring and/or control of the multiple fan array being interfaced with. The multiple fan array control panel(s) shall be provided with means to indicate fan and motor status, operating mode, system flow rate and fan total static pressure. Status shall be displayed at the unit control panel and/or at the remote location of the building automation system control panel and interface screens. When specified and/or indicated, the optional communication interface with the bas system shall be provided by the ahu manufacturer and shall require a single interface point at the multiple fan array system control panel by the project controls Contractor.
9. As required by system design, provide variable frequency drive to all motors in the fanwall array. The variable frequency drive shall be sized accordingly to start and hold all motors in the fan wall. Provide short circuit protection of motor circuits through means of using fuses with fused circuit breakers.
10. Provide three phase power distribution wiring and control wiring as required. All three phase power components shall have a rating listed for short circuit current rating. Provide control wiring and components required for complete operation of fan wall system. System controls, controls components and control wiring shall include but is not limited to auto mode or manual mode, cfm control mode, or BMS control mode. Controls and control wiring shall include auto start/stop, manual start stop, safety shutdown, smoke shutdown, system alarms and VFD alarms. All control wiring shall be included in VFD enclosure provided with system.
11. As required by system design, provide a programmable logic controller (plc) to control all functions of the fanwall array system. The programmable logic controller system will be designed and programmed to control auto and manual functions, provide cfm totalizing, cfm control, optimization control, and all functions required by the fan wall system. Provide

an operator interface unit for communication with PLC. Provide BMS communication via BACNET MSTP.

12. The programmable logic controller, variable frequency drives, and all other PLC related equipment shall be mounted in a dedicated enclosure for connection to single point power. The enclosure shall be provided with a main disconnecting means. Provide appropriate cooling of enclosure.
13. As required by system design, each fan assembly shall be supplied with a complete flow measuring system, Huntair flow-cone, which indicates airflow in cubic feet per minute. The flow measuring system shall consist of a flow measuring station and two pressure taps with one high static pressure tap and one low total pressure tap located at the throat of the inlet cone. The flow measuring station shall not obstruct the inlet of the fan and shall have no effect on fan performance (flow or static) or sound power levels. A surface mounted indicator, located on the unit exterior, shall provide a (digital) (analog) cfm readout, and/or a (4-20 ma) (0-10 volt) output control signal for use in the bas as specified elsewhere.
14. As required by electrical design, when using variable frequency drives provide input line reactors with five percent impedance mounted externally if not already internal to variable frequency drive.
15. As required by electrical design, when using variable frequency drives where distance and filtering is an issue, provide output line reactors as required. Size output filter accordingly to manufactures recommendations.
16. As required by system design, when using variable frequency drives provide a shaft grounding system for each ac motor to prevent electrical damage to motor bearings and to extend motor life by safely channeling harmful shaft currents to ground. Baldor motors come pre-installed with a brush system from the factory. This system utilizes a silver graphite brush that maintains a low contact point that maintains shaft voltages at safe, minimum levels near zero.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install fans with resilient mountings and flexible electrical leads.

END OF SECTION 23 3417

SECTION 23 3600
AIR TERMINAL UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Variable volume terminal units.

B. Integral heating coils.

1.02 RELATED REQUIREMENTS

A. Section 23 2113 - Hydronic Piping: Connections to heating coils.

B. Section 23 3100 - HVAC Ducts and Casings.

C. Section 23 3300 - Air Duct Accessories.

D. Section 23 3700 - Air Outlets and Inlets.

E. Section 23 0913 - Instrumentation and Control Devices for HVAC: Thermostats and Actuators.

1.03 REFERENCE STANDARDS

A. ASTM A492 - Standard Specification for Stainless Steel Rope Wire; 1995 (Reapproved 2013).

B. ASTM A603 - Standard Specification for Zinc-Coated Steel Structural Wire Rope; 1998 (Reapproved 2014).

C. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; National Fire Protection Association; 2012.

D. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems; Sheet Metal and Air Conditioning Contractors' National Association; 2008.

E. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

1.04 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements for submittal procedures.

B. Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings that indicate air flow, static pressure, and NC designation. Include electrical characteristics and connection requirements.

C. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant volume regulators.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Titus

B. Trane

C. Kreuger

2.02 MANUFACTURED UNITS

A. Ceiling mounted variable air volume supply air control terminals for connection to single duct, central air systems, with electronic variable volume controls,, hot water heating coils.

B. Identify each terminal unit with clearly marked identification label and air flow indicator. Include unit nominal air flow, maximum factory set airflow, minimum factory set air flow, and coil type.

2.03 SINGLE DUCT VARIABLE VOLUME UNITS

A. Basic Assembly:
   1. Casings: Minimum 22 gage galvanized steel.

2. Lining: Minimum 1/2 inch thick neoprene or vinyl coated fibrous glass insulation, 1.5 lb/cu ft density, meeting NFPA 90A requirements and UL 181 erosion requirements. Face lining with mylar film.
3. Plenum Air Inlets: Round stub connections for duct attachment.
4. Plenum Air Outlets: S slip and drive connections.

B. Basic Unit:
1. Configuration: Air volume damper assembly inside unit casing. Locate control components inside protective metal shroud.
2. Volume Damper: Construct of galvanized steel with peripheral gasket and self lubricating bearings; maximum damper leakage: 2 percent of design air flow at 1 inches rated inlet static pressure.

C. Hot Water Heating Coil:
1. Construction: 1/2 inch copper tube mechanically expanded into aluminum plate fins, leak tested under water to 200 psig pressure, factory installed.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide ceiling access doors or locate units above easily removable ceiling components.

C. Support units individually from structure with wire rope complying with ASTM A492 and ASTM A603 in accordance with SMACNA (SRM).

D. Do not support from ductwork.

E. Connect to ductwork in accordance with Section 23 3100.

F. Install heating coils in accordance with Section 23 8200.

END OF SECTION 23 3600

SECTION 23 3700

AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Diffusers.

B. Registers/grilles.

1.02 REFERENCE STANDARDS

1.03 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements for submittal procedures.

B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

PART 2 PRODUCTS

2.01 (SEE DRAWINGS FOR REGISTERS, GRILLES AND DIFFUSERS SCHEDULE)

2.02 MANUFACTURERS

A. Krueger.

B. Titus.

C. Tuttle & Bailey.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

C. Install diffusers to ductwork with air tight connection.

D. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.

E. Provide balancing dampers on supply and exhaust ductwork, even if not shown on drawings, if required to accurately balance systems. Opposed blade dampers shall be provided on supply diffusers and registers and on exhaust grilles to aid balancing and draft control.

END OF SECTION 23 3700

I, Daniel W. Schinstock am the Coordinating Professional on the Foundation for Educational Services Supply Fans Replacement Project.