DONEGAL SCHOOL DISTRICT
Energy Efficiency Upgrades to the Donegal Primary School

VOLUME 3
DIVISIONS 21 through 23
DIVISIONS 26 through 28
TECHNICAL SPECIFICATIONS

CRA PROJECT NO. 3021

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VOLUME 3

TECHNICAL SPECIFICATIONS

FOR

DONEGAL SCHOOL DISTRICT
Energy Efficiency Upgrades
to the
Donegal Primary School

FOR THE

DONEGAL SCHOOL DISTRICT
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Mount Joy, PA 17552

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ARCHITECT'S PROJECT NO. 3021

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SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Basic Mechanical Requirements specifically applicable to Division 23 Sections, in addition to Division 1 - General Requirements.

1.2 GENERAL REQUIREMENTS

A. Nothing contained in these specifications or shown on the drawings shall be so construed as to conflict with any local, municipal, or state or federal laws,] regulations, codes or ordinances governing the installation of HVAC or any other work specified and all such laws, regulations, codes or ordinances are hereby incorporated and made part of these specifications. All such requirements shall be satisfied by the contractor at no additional cost to the Owner.

B. The mechanical drawings are intended to be diagrammatic and are based generally on the manufacturer's equipment specified. Due to the layout and small scale of the drawings it is not possible to show every item in its exact location, the exact dimensions or all the details of the equipment. The Contractor shall verify the actual dimensions of the proposed equipment to insure that equipment will fit into the available space.

C. Installation shall be within the limitations imposed by the architectural, structural, food services,heating, ventilating and air conditioning, plumbing, electrical requirements, and existing conditions with adequate space for maintenance.

D. All equipment shall be installed in such a way that all components requiring access (drain pans, drains, fire dampers, smoke dampers, control dampers, control operators, motors, drives, isolation/balancing valves, filters, etc.) are so located and installed that they may be serviced, reset, replaced or recalibrated, etc., by service people with normal service tools and equipment. If any equipment or components are shown in such a position that this Contractor cannot comply with the above, the Contractor shall notify the General Contractor and attempt to resolve the problem of access. If this consultation is not successful, the Architect and Engineer shall be notified in writing and a decision requested.

E. Equipment, devices and materials of similar types, function or one system shall be of the same manufacturer.

F. All cutting and patching for mechanical work shall be completed by the HVAC/Mechanical contractor. All patching shall be completed to match surrounding finishes of walls/floors/ceilings. This includes final finishes, paint, etc..

1.3 PPL Electric Utility Requirements

A. Successful contactor is responsible to work with the PPL Electric Utilities Business Energy Efficiency Program to seek all rebate opportunities. Wherever possible,

program eligible equipment will be specified and Contractor will compile required information and perform all necessary steps to apply rebate money on behalf of the District. This requirement will be outlined in any and all contracts with the successful contractor.

1.4 OWNER-FURNISHED PRODUCTS

1. None.

1.5 WORK SEQUENCE

A. Install work in phases to accommodate Owner's occupancy requirements during the construction period coordinate mechanical schedule and operations with Owner and A/E . Refer to bidding documents for phasing requirements and scope of work.

1.6 ALLOWANCES

A. None.

1.7 UNIT PRICE

A. None.

1.8 SUBMITTALS

A. Shop Drawings, Product Data, Samples: Submit under provisions of division 0.

B. No HVAC or associated equipment shall be installed prior to acceptance of such equipment by the A/E.

C. Refer to individual specification Sections for additional submittal requirements.

D. Submit shop drawings and product data grouped to include complete submittals of related systems, products and accessories in a single submittal.

E. Acceptance by A/E does not relieve the Contractor from complying with all the requirements of the contract drawings and specifications.

F. Mark dimensions and values in units to match those specified.

G. A written statement must accompany submissions not in accordance with drawings and specifications on the effect of the proposed substitution. Absence of this statement will be taken to mean that the submittal complies fully with the drawings and specifications.

1.9 MATERIALS SUBSTITUTIONS

A. When the Contractor desires to furnish equipment of a manufacturer other than that specified or intended, he shall include a complete specification of the substituted item, along with each submission copy of shop drawings indicating the necessary modifications to the substituted product to satisfy the requirements of the contract specifications. Manufacturer's specification shall be written as close as possible over the contract specifications and each paragraph shall bear the same paragraph

number as the contract specifications so that close comparison can be made.

1.10 REGULATORY REQUIREMENTS

A. All HVAC and related work, equipment and materials furnished or installed under this contract shall conform to the requirements of the following:
   1. American Gas Association.
   2. American National Standards Institute.
   3. American Society for Testing Materials.
   4. Applicable municipal, county, and state mechanical, electrical, gas, plumbing, health, and sanitary codes, laws, and ordinances.
   5. Pennsylvania state wide building Code- IBC 2010 all sections.
   6. National Electrical Code.
   7. National Electrical Manufacturer's Association.
   8. National Fire Protection Association (NFPA).
   9. National Standard Plumbing Code.
   10. Occupational Safety and Health Administration (OSHA).
   11. Pennsylvania Department of Labor and Industry (L&I) requirements.
   12. Underwriters' Laboratories, Inc.
   13. and any other local authority having jurisdiction.

B. Where any of the above are at variance with the drawings and specification, the code requirements shall take precedence and any costs necessary to comply to these shall be included in the contract.

C. The Contractor shall secure and deliver to the Engineer/Architect all permits, certificates and legal evidence of compliance with the above-mentioned laws, codes, ordinances and regulations.

D. Obtain permit, and request inspections from authority having jurisdiction.

1.11 APPROVALS

A. The Wisconsin Department of Industry, Labor and Human Relations shall approve all materials, equipment and devices furnished and installed on this project in writing.

1.12 PROJECT/SITE CONDITIONS

A. Install work in locations shown on Drawings.

B. Prepare drawings showing proposed rearrangement of work to meet project conditions, including changes to work specified in other Sections. Obtain permission of Architect/Engineer before proceeding.

1.13 MINOR DEMOLITION

A. For requirements and limitations for cutting, patching and finishing incidental to remodeling, refer to Division 0 and Division 1.

1.14 PAINTING

A. Where painting is specified, the Contractor shall refer to Division 9.

1.15 DRAWINGS AND SPECIFICATIONS

A. Anything shown on the drawings and not mentioned in the specifications, or anything mentioned in the specifications and not shown on the drawings, shall be of like effect, as if shown or mentioned in both, and shall be furnished and installed by the Contractor.

B. Should any incidental work or materials be required but not set forth in the drawings and specifications, either directly or indirectly, but which is, nevertheless, necessary for the proper carrying out or completeness of the intent thereof, the Contractor is to understand same to be implied and required and he shall perform all such work and furnish all such materials as fully as if they were particularly described.

1.16 WARRANTY

A. Provide Owner with manufacturer's warranty for each system and each specification section, including all hardware, components, parts and labor for a period of one year from date of Substantial Completion and Acceptance by owner. Warranties may be required beyond the one-year period as described in individual specification sections.

B. Any manufacturer defects or damage arising during the warranty period shall be prepaid or corrected to the satisfaction of the Owner at no additional cost.

PART 2 PRODUCT

Not applicable

PART 3 EXECUTION

3.1 DEFINITIONS

A. Furnish: Supply and deliver to the project site ready for installation.

B. Install: All operations of the project site including: unloading, unpacking, assembly, erection, placing, anchoring, connecting, finishing, protecting, cleaning, testing and startup as required.

C. Provide: Includes both furnish and install, complete and ready for the intended use.

D. Capable: Provide equipment/materials that are able to perform the function(s) described.

END OF SECTION

SECTION 23 05 19

HVAC PIPING INSULATION

PART 1 GENERAL

1.1 WORK INCLUDED

A. Piping insulation.

B. Jackets and accessories.

C. Fitting insulation.

D. Adhesive, tapes.

1.2 RELATED WORK

A. Section 15140 - HVAC Supports and Anchors

B. Section 15190 - Mechanical Identification

C. Section 15510 - Hydronic Piping

1.3 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM):
   1. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate
   2. ASTM C612 - Mineral Fiber Block and Board Thermal Insulation
   3. ASTM E84 - Surface Burning Characteristics of Building Materials

B. Underwriters Laboratories Inc. (UL):
   1. UL 723 - Surface Burning Characteristics of Building Materials

C. National Fire Protection Association (NFPA):
   1. NFPA 255 - Surface Burning Characteristics of Building Materials
   2. NFPA 220 - Standard on Types of Building Materials

D. National Board of Fire Underwriters:
   1. National Building Code, Section 200

1.4 QUALITY ASSURANCE

A. Applicator Qualifications: Company specializing in piping insulation application, with three years minimum experience.

B. Materials: Flame spread/fuel contributed/smoke developed rating of 25/50/50 in accordance with ASTM E84, NFPA 255 and UL 723.

1.5 SUBMITTALS

A. Shop Drawings, Product Data, Samples: Submit under provisions of Section 01340.

1. Shop Drawings: Prior to delivery of materials to site, submit shop drawings including product description, list of materials and thickness for each service and locations prior to delivery.
2. Product Data: Submit manufacturer's installation instructions and recommended procedures.
3. Samples: Submit samples of proposed insulating materials.

1.6 JOB CONDITIONS

A. Deliver material to job site in original nonbroken factory packaging, labeled with manufacturer's density and thickness.

B. Perform work at ambient and equipment temperatures as recommended by the adhesive manufacturer.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable Manufacturers:
1. Certainteed Corp., Valley Forge, PA.
2. Knauf Fiber Glass GmbH, Shelbyville, IN.
3. Owens-Corning Fiberglas Corp., Toledo, OH.
4. Johns Manville, Corp., Denver, CO.

B. Substitutions: Items of equal function and performance will be considered in accordance with Division 0.

2.2 GENERAL

A. Fiberglass type insulation shall be used at all locations except as otherwise specified.

2.3 MATERIALS AND COMPONENTS

A. Hot and Cold Piping: Fine fibrous glass insulation, with factory applied reinforced aluminum foil vapor barrier, white all service jacket and self sealing lap (ASJ-SSL) molded to conform to piping, "K" value at 75° F maximum 0.24 btu/in./sq.ft./° F/hr.

B. Where insulated piping is concealed in walls or furred spaces, serving terminal heating or cooling equipment the Contractor has the option to use flexible elastomeric, thermal, slip over insulation, only if the insulation material value is equal to that specified.

Caution: This type of insulation is not permitted in the chases, ceiling plenums or other concealed spaces used for return, transfer or movement of heating, ventilation and air-conditioned air.

PART 3 EXECUTION

3.1 PREPARATION

A. Do not install covering before piping has been tested and approved.

B. Insure surface is clean and dry prior to installation. Insure insulation is dry before and during application. Finish with systems at operating conditions.

3.2 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.

B. Insure insulation and vapor barrier is continuous through inside walls. Pack around pipes with fireproof self-supporting insulation material, fully sealed.

C. Insulate all fittings and valves.

D. Insulate all chilled water unions, flanges, strainers, flexible connections and expansion joints; for hot water piping, terminate insulation neatly with plastic material trowelled on bevel for the above items that need access.

E. Finish insulation neatly at hangers, supports and other protrusions.

F. Locate insulation or cover seams in least visible locations.

G. Cover insulation exposed to outdoors with 30 lb. coated glass base sheet with aluminum jacket and aluminum bands on 8” centers. Lap joints 3” minimum and seal with compatible waterproof lap cement.

H. Hot and Cold Piping: Cover fittings and valves with equivalent thickness and density of insulation material.

I. Use PVC fittings, prefabricated fittings or cover with open mesh glass cloth sealed with vapor barrier sealant.

J. Seal lap joints with vapor barrier self-sealing Lap.

K. Seal butt joints with 4” wide strips of vapor barrier sealed with vapor barrier adhesive.

L. Seal joints with vapor barrier tape or sealer.

M. Any gap in the vapor barrier or sweating of any part of the system is unacceptable.

N. Repair separation of joints or cracking of insulation due to the thermal movement or poor workmanship. Oversize insulation as recommended by heat tape manufacturer.

O. Do not insulate within radiation enclosures.

INSULATION THICKNESS SCHEDULE

Piping System Types	Fluid Temperature Range	Run-outs 2" and less *	1" and less	1 1/4" to 2"	2 1/2" - 4"	5" and 6"	8" and larger
	°F	Inches	Inches	Inches	Inches	Inches	Inches

Low Temperature (LTHW Supply & Return)	201-250	1.0	1.5	1.5	2.0	2.0	2.0
Low Temperature (Cold Water Make-up)	40-200	1.5	1.5	1.5	1.5	1.5	1.5
Condensate Drain	40-65	1.0	1.0	1.5	1.5	1.5	1.5
Refrigerant	Below 40	1.0	1.0	1.5	1.5	1.5	1.5

* **Note:** Runouts to individual units not exceeding 12' in length.

3.3 WEATHERPROOFING OUTDOOR INSULATION

A. Piping: Protective metal jacket.

B. Flexible Unicellular Insulation: Finish with two coats of a weather resistant finish as per manufacturer's recommendations and apply pvc covering.

END OF SECTION

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Pipe, ductwork and equipment hangers and supports.

B. Equipment bases and supports.

1.2 REFERENCES

A. ASME B31.1 - Power Piping

B. ASME B31.2 - Fuel Gas Piping

C. ASME B31.5 - Refrigeration Piping

D. ASME B31.9 - Building Services Piping

E. ASTM F708 - Design and Installation of Rigid Pipe Hangers

F. MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer

G. MSS SP69 - Pipe Hangers and Supports - Selection and Application

H. MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices

I. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA):
   1. SMACNA - Duct Manuals

1.3 SUBMITTALS

A. Shop Drawings, Product Data, Samples: Submit under provisions of Division 1.

B. Shop Drawings: Indicate system layout with location and detail of trapeze hangers.

C. Product Data: Provide manufacturers catalog data including load capacity.

D. Design Data: Indicate load carrying capacity of trapeze, multiple pipe and riser support hangers.

E. Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

PART 2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Acceptable Products:
   1. Pipe Hangers: Michigan Hanger Co., Inc., No. as specified.
   2. Prefabricated equipment curbs, roof curbs and equipment bases - Thycurb, Thybar Corp., Addison, IL, Model TC-1.
   3. Prefabricated roof equipment mounting supports: Thycurb, Thybar Corp., Addison, IL, Model TEMS-1.
   4. Pipe seals: Thunderline Corp., Belleville, MI, Model Link-Seal.
   5. Pipe portals: Roof Products & Systems Corp., Bensenville, IL, Model RPS.

B. Substitution: Items of equal function and performance will be considered in accordance with Division 0.

C. Hydronic Piping:
   1. Noninsulated Noncopper Pipe: Sizes 2 $^1/_2$" and smaller, Michigan No. 100 carbon steel electrogalvanized swivel loop hanger; sizes 3" and above, Michigan No. 401, carbon steel, electrogalvanized clevis ring hanger.
   2. Insulated Pipe: Sizes 2 $^1/_2$" and smaller Michigan No. 103, insulation hanger, electrogalvanized swivel loop hanger with shield; sizes 3" and above, Michigan No. 403, carbon steel clevis hanger with zinc electroplated finish after welding with shield welded in place.
   3. Copper Pipe: Sizes 2 $^1/_2$" and smaller, Michigan No. 101, copper electroplated swivel loop hanger; sizes 3” and above, Michigan No. 402, carbon steel with copper electroplated finish.
   4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
   5. Multiple or Trapeze Hangers for Hot Pipe Sizes 6” (150 mm) and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
   6. Wall Support for Pipe Sizes to 3” (76 mm): Cast iron hook.
   7. Wall Support for Pipe Sizes 4” (100 mm) and Over: Welded steel bracket and wrought steel clamp.
   8. Wall Support for Hot Pipe Sizes 6” (150 mm) and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
   9. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
   10. Floor Support for Hot Pipe Sizes to 4” (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
   11. Floor Support for Hot Pipe Sizes 6” (150 mm) and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
   12. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.2 ACCESSORIES

A. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

2.3 INSERTS

A. 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.

2.4 FLASHING

A. Metal Flashing: 26 gauge (0.5mm thick) galvanized steel.

B. Metal Counterflashing: 22 gauge (0.8 mm thick) galvanized steel.

C. Beam Clamps: Fixed or adjustable type.

2.5 SLEEVES

A. Sleeves for Pipes Through Nonfire Rated Floors: 18 gauge (1.2 mm thick) galvanized steel.

B. Sleeves for Pipes Through Nonfire Rated Beams, Walls, Footings and Potentially Wet Floors: Steel pipe or 18 gauge (1.2 mm thick) galvanized steel.

C. Sleeves for Pipes Through Fire Rated and Fire Resistive Floors and Walls and Fire roofing: Prefabricated fire rated sleeves including seals, UL listed , refer to Division 7.

D. Sleeves for Round Ductwork: Galvanized steel.

E. Sleeves for Rectangular Ductwork: Galvanized steel.

F. Stuffing and Firestopping Insulation: Glass fiber type, noncombustible or high quality acrylic caulk sealant ; refer to Division 7 .

G. Sealant: Acrylic ; refer to Division 9 .

H. Plastic sleeves are not permitted.

2.6 DUCT HANGERS AND SUPPORTS

A. Hangers: Galvanized steel band iron or rolled angle and $^{3}/_{8}$" rods.

B. Wall Supports: Galvanized steel band iron or fabricated angle bracket.

C. Vertical Support at Floor: Rolled angle.

2.7 EQUIPMENT BASES AND SUPPORTS

A. Provide concrete equipment bases under the air handling units. Extend the existing concrete basis as required to support entire AHU after blender sections are added. Concrete pads are to match existing concrete pad in height, width. New length to extend 6" beyond air handling unit mixing box.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.2 PIPE HANGERS AND SUPPORTS

A. Support horizontal piping as scheduled.

B. Install hangers to provide minimum $^1/_2$" (13 mm) space between finished covering and adjacent work.

C. Place hangers within 12" (300 mm) of each horizontal elbow.

D. Use hangers with $1^1/_2$" (38 mm) minimum vertical adjustment.

E. Support horizontal cast iron pipe adjacent to each hub, with 5' (1.5 m) maximum spacing between hangers.

F. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

G. Support riser piping independently of connected horizontal piping.

H. Provide copper plated hangers and supports for copper piping .

I. Design hangers for pipe movement without disengagement of supported pipe.

3.3 EQUIPMENT BASES AND SUPPORTS

A. Provide housekeeping pads of concrete, minimum 4" (100 mm) thick and extending 6" (150 mm) beyond supported equipment]. Refer to Division 3.

B. Provide templates, anchor bolts and accessories for mounting and anchoring equipment.

C. Construct supports of steel members. Brace and fasten with flanges bolted to structure.

D. Provide rigid anchors for pipes after vibration isolation components are installed.

3.4 PIPE HANGER SCHEDULES

Pipe Size Inches (mm)	Maximum Hanger Spacing Feet (m)	Hanger Rod Diameter Inches (mm)
1/2 to 1 1/4 (12 to 32)	6.5 (2)	3/8 (9)
1 1/2 to 2 (38 to 50)	10 (3)	3/8 (9)
2 1/2 to 3 (62 to 75)	10 (3)	1/2 (13)
4 to 6 (100 to 150)	10 (3)	5/8 (15)
PVC (All Sizes)	6 (1.8)	3/8 (9)

3.5 DUCT HANGER SCHEDULES

Duct Size Inches (mm)	Maximum Hanger Spacing Feet (m)	Width and Gauge Inch, Ga (mm)
Up to 30 (762)	10 (3)	1 x 16 gauge (25.4)
31 (787) to 48 (1220)	10 (3)	1 1/2 x 16 gauge (38)
Over 48 (1220)	8 (2.4)	1 1/2 x 16 gauge (38)

END OF SECTION

SECTION 23 05 53

HVAC IDENTIFICATION

PART 1

1 - GENERAL

1.1 WORK INCLUDED

A. Nameplates, tape labels and tags.

1.2 REFERENCE STANDARDS

A. American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME):

1. ANSI/ASME A13.1 - Scheme for Identification of Piping Systems

1.3 SUBMITTALS

A. Shop Drawings, Product Data, and Samples: Submit under provisions of Division 1.

B. Shop Drawings: Submit list of wording, symbols, letter size, and color coding for Mechanical and HVAC identification.

C. Product Data: Submit manufacturer's installation instructions and recommended procedures.

D. Samples: Submit one sample of pipe identification, labeling materials and valve tags.

E. Valve Chart: Submit valve chart and schedule, including valve tag number, location, function and valve manufacturer's name and model number.

PART 2

2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturers:

1. Seton Name Plate Corp., New Haven, CT

2. W. H. Brady Co., Milwaukee, WI

3. Bunting Stamp Co., Inc., Pittsburgh, PA

4. Crafmark, Inc., Fort Worth, TX

2.2 MATERIALS

A. Plastic Nameplates: Engraved $^1/_{16}$" thick laminated plastic with $^1/_2$" high "WHITE" letters on "BLACK" background color, styles M4562-H through M4565-H, Setonply® as manufactured by Seton.

B. Metal Tags: Minimum 19 gauge polished brass, with appropriate stamped $^1/_4$" "BLACK" filled service letters and $^1/_2$" "BLACK" filled valve number, $1^1/_2$" diameter tag size, style M4501-H (style M4506-H for plumbing) as manufactured by Seton.

C. Plastic Pipe Markers: Flexible, snap around type, wording protected by plastic coating Setmark® style as manufactured by Seton. Direction of the flow arrows is to be included. Flexible, semirigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and fluid being conveyed.

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

E. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape of not less than 6" wide x 4 mils thick, manufactured for direct burial service.

F. Hand printed identifications with felt markers, embossed tape or painted stencils are not permitted.

G. Colors: Unless otherwise specified, conform to ANSI/ASME A13.1.

PART 3

3 - EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials. Prepare surfaces in accordance with Division 9.

3.2 INSTALLATION

A. Install nameplates and/or tape labels parallel to equipment lines. Secure nameplates to equipment fronts using screws, rivets or adhesive.

B. Metal tags shall be fastened with brass "S" hooks or brass jack chain in a manner to permit easy reading.

C. Plastic Pipe Markers: Install in accordance with manufacturer's printed instructions.

D. Plastic Tape Markers: Install complete in accordance with manufacturer's printed instructions.

E. Underground Plastic Pipe Markers: Install 6" to 8" below finished grade, directly

above buried pipe.

F. All nameplates, tags and labels shall be coordinated with those being installed by other Contractors.

3.3 VALVE IDENTIFICATION

A. Identify valves in all main and branch lines and on all valves shown on the drawings. Do not tag valves whose use is obvious, such as isolation valves adjacent to equipment or valves which are existing.

B. Valve tags shall indicate identifying number and system. Number valves with series number by floor.

3.4 PIPE IDENTIFICATION

A. Identify all piping, both concealed and exposed, with plastic pipe markers. Identify service, flow direction and pressure.

B. Install in clear view and align with axis of piping. Locate identification not to exceed 20 ft. o.c. spacing on straight runs, including risers and drops, adjacent to each valve and "T", at each side of penetration of structure or enclosure and at each obstruction.

C. For pipes smaller than $^{3}/_{4}$", engraved metal or plastic tags may be used.

3.5 EQUIPMENT IDENTIFICATION

A. Identify air handling units, rooftop units, pumps, heat transfer equipment, tanks and water treatment devices with plastic nameplates, except at curved or irregular surfaces where plastic tape markers shall be used.

B. All major pieces of mechanical equipment shall include, at a suitable and accessible observation point on the equipment, a manufacturer's stamped metal identification plate, with all pertinent capacity data stamped on the plate. Plate shall include all specific data, such as model number, serial number, motor data, horsepower, sizes, capacities, flows, working pressures, and similar factors as applicable. Pumps shall include head in feet and impeller sizes. The Contractor shall be responsible for furnishing and installing the identification plate if not provided by the equipment manufacturer.

C. Small devices shall be identified with metal or plastic tags.

D. Identify equipment with identifying names, letters and numbers as used on drawings. Where space is available, use full name of equipment.

3.6 CONTROL EQUIPMENT IDENTIFICATION

A. Controls: Identify each control panel and major control components on outside of panel or enclosure with plastic nameplates.

3.7 DUCTWORK IDENTIFICATION

A. Identify ductwork with plastic tape markers.

B. Identify as to air system number and area served.

C. Provide arrow indicating air flow direction.

D. Locate identification at air handling unit, rooftop unit(s) or exhaust system at each side of penetration of structure or enclosure and at each obstruction.

3.8 IDENTIFICATION LABELS

A. Where valves, devices, panels, equipment etc., are located above removable tile ceilings or above access panels, provide identification labels on the ceiling tile metal channels/runners or at center of access panel.

B. Labels: Shall be provided with the words "VALVES, "CONTROL PANEL", “VAV” for vav box, etc., as appropriate. Coordinate with owner on locations and labels for each piece of equipment.

C. Identification labels shall not exceed 2 $^{1}/_{2}$” in length nor $^{3}/_{4}$” height. Black letters shall be $^{1}/_{4}$” high on white background. Labels shall be installed with pressure sensitive backing. Labels shall be additionally secured with screws or rivets.

D. Flexible punched tapes are not acceptable.

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

1.1 REQUIREMENTS INCLUDED

A. The Contractor shall retain, employ and pay for the services of a qualified independent testing and balancing organization having no affiliation with the Contractor, Equipment Sales Representatives or Design Engineers, except as permitted below, to perform specified testing, adjusting and balancing services.

B. Employment of an independent testing and balancing organization shall in no way relieve the Contractor's obligation to perform the work in this contract.

C. Should the Contractor have qualified personnel in his regular employ who are certified as described in paragraph 1.4, they will be considered for approval solely at the Engineer discretion.

1.2 RELATED REQUIREMENTS

A. Supplementary Conditions: Retainage to be withheld against installing contractor until final completion of testing, adjusting and balancing for one heating season and one cooling season.

B. Section 01340 - Submittals

C. Section 01740 - Operating and Maintenance Data

D. Section 15952 - Controls and Instrumentation

E. Section 15960 - Starting of Mechanical Systems

F. Section 15975 - Direct Digital Control System

G. Section 16921 - Mechanical Equipment Wiring

1.3 DESCRIPTION

A. Perform testing of central air handling units, balancing of distribution systems and adjustment of terminal devices for heating, ventilation and air conditioning systems of project including:
   1. Air handling units
   2. Single Duct VAV Boxes
   3. Fan Powered VAV Boxes
   4. Air outlets and inlets
   5. Dampers
   6. Control system
   7. Air distribution systems
   8. Water distribution systems
   9. Alarms
   10. Kitchen hood exhaust system

11. Kitchen Energy Recovery Unit

B. Perform testing of Hydronic systems, adjust and record liquid low at each piece of equipment.

C. Measurement of final operating condition of HVAC systems.

D. Provide instruments required for testing, adjusting and balancing operations.
   1. Make instruments available to Engineer to facilitate spot checks during testing.
   2. Retain possession of instruments, remove from site at completion of services.

E. Make instruments available to Engineer to facilitate spot checks during testing.

F. Retain possession of instruments, remove from site at completion of services.

1.4 QUALITY ASSURANCE

A. The organization which performs the service shall be a current member in good standing, certified to perform services required for the Project, of either:
   1. Associated Air Balance Council (AABC).
   2. National Environmental Balancing Bureau (NEBB).

B. The organization shall be company specializing in the adjusting and balancing of systems specified in this Section with minimum five years of documented experience certified by AABC or NEBB. The Agency shall not be the sheet metal subcontractor or any subsidiary thereof. Personnel performing the work shall be full time employees of the balancing contractor and shall be thoroughly trained and experienced in the testing, balancing, and adjusting of commercial building HVAC systems.

C. The firm shall show proof of having tested and balanced at least five projects of similar size and scope.

D. All field work shall be under the direct supervision of a Professional Engineer, registered in the State in which the Project occurs, who is a full-time employee of the testing and balancing organization and an AABC certified test and balance engineer or NEBB certified testing, balancing, and adjusting supervisor.

E. Within 30 days after award of contract, transmit to Engineer the name of the organization proposed to perform the services.
   1. Should separate firms perform services for the air and the Hydronic portions, the firm which will have managerial responsibilities for coordination of the entire testing and balancing process shall be designated in writing.

F. Comply with applicable procedures and standards of the certification sponsoring association; either:
   1. "National Standards for Field Measurements and Instrumentation, Total Systems Balance, Air Distribution-Hydronics Systems", Latest Edition by AABC.
   2. "Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems", Latest Edition by NEBB.
   3. Perform services under direction of the supervisor who is designated and qualified under certification requirements of sponsoring association.

4. All instruments used by this organization shall be accurately calibrated and maintained in good working order. Calibration and maintenance of instruments shall be in accord with requirements of the standards and calibration histories for each instrument shall be available for examination. If requested, the tests shall be conducted in the presence of the mechanical engineer responsible for the project and/or his representative.
5. Accuracy of measurements shall comply with requirements of the standards.

G. The organization shall include an extended warranty of 90 days, after completion of test and balance work, during which time the engineer at his discretion may request a recheck, or resetting of any outlet, supply air fan, or exhaust fan as listed in test report. The agency shall provide technicians to assist the engineer in making any tests he may require during this period of time.

1.5 SUBMITTALS

A. Shop Drawings, Product Data, Samples: Submit under provisions of Section 01340.

B. Preliminary:
1. Submit three copies of documentation to confirm compliance with Quality Assurance provisions:
2. Submit name of independent adjusting and balancing agency for approval under provisions of Division1 within 30 days after award of contract.
3. Submit three copies of documentation to confirm compliance with Quality Assurance provisions:
   a. Organization supervisor and personnel training and qualifications.
   b. Specimen copy of each of the report forms proposed for use as a submittal under provisions of Division 1.
4. Organization supervisor and personnel training and qualifications.
5. Specimen copy of each of the report forms proposed for use.
6. Final Report: At least 15 days prior to Contractor's request for final inspection, submit 3 copies of final reports, on applicable reporting forms, for review.
7. Schedule testing and balancing of parts of the systems which is delayed due to seasonal, climatic, occupancy, or other conditions beyond control of the Contractor, as early as the proper conditions will allow, after consultation with Engineer.

C. Submit reports of delayed testing promptly after execution of those services.
1. Form of Final Reports:
2. Each individual final reporting form must bear the signature of the person who recorded data and that of the Testing, Adjusting and Balancing supervisor of the reporting organization.
3. When more than one certified organization performs Testing, Adjusting and Balancing services, the firm having managerial responsibility shall make the submittals.
4. A complete list of instruments proposed to be used, organized in appropriate categories, with data sheets for each.

D. Show:
1. Manufacturer and model number.
2. Description and use when needed to further identify the instrument.
3. Size or capacity range.

4. Latest calibration date.

E. At least fifteen days prior to starting field work, submit three copies of:
   1. A set of report forms filled out as to the design flow values and the installed equipment pressure drops and the required CFM for air terminals.

F. At least 30 days prior to starting field work, submit three copies of the following for engineer review:
   1. A set of report forms filled out as to the design flow values and operating pressure drops and temperature rises/drops for all Hydronic and air side equipment and the required cfm for air terminals.
   2. A written agenda detailing the procedures and proposed testing and balancing program to be followed in testing and balancing the systems.
   3. Copy of AABC National Project Performance or NEBB Performance Guarantee.
   4. A complete list of instruments proposed for use, organized in appropriate categories, with data sheets for each.

G. Final Report: At least fifteen days prior to Contractor's request for final inspection, submit three copies of final reports, on applicable reporting forms, for review under provisions of Division 1. Provide additional copies of approved report for inclusion in operating and maintenance manuals.
   1. Schedule testing and balancing of parts of the systems which is delayed due to seasonal, climatic, occupancy, or other conditions beyond control of the Contractor, as early as the proper conditions will allow, after consultation with Engineer.
   2. Submit reports of delayed testing promptly after execution of those services.
   3. When more than one certified organization performs Testing, Adjusting, and Balancing services, the firm having managerial responsibility shall make the submittals.
   4. A set of report forms filled out as to the design flow values and the installed equipment pressure drops, and the required cfm for air terminals.

H. Form of Final Reports:
   1. Provide reports in hard cover, letter size, three-ring binger manuals, complete with index page and indexing tabs, with cover identification at front side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
   2. Each individual final reporting form must bear the signature of the person who recorded data and that of the Testing, Adjusting and Balancing supervisor of the reporting organization.
   3. Report shall be on AABC National Standards for Total System Balance test or NEBB forms.
   4. Forms shall include the following information:
      a. Title Page:
         1) Company name
         2) Company address
         3) Company telephone number
         4) Project name
         5) Project location
         6) Project Architect
         7) Project Engineer
         8) Project Contractor

9) Project altitude

b. Instrument List:
   1) Instrument
   2) Manufacturer
   3) Model
   4) Serial number
   5) Capacity range
   6) Latest calibration date

c. Air Moving Equipment:
   1) Location
   2) Manufacturer
   3) Model
   4) Air flow, specified and actual
   5) Return air flow, specified and actual
   6) Total static pressure (total external), specified and actual
   7) Total static pressure (total external), specified and actual
   8) Inlet pressure
   9) Discharge pressure
   10) Fan RPM

d. Return Air/Outside Air Data:
   1) Identification/location
   2) Design air flow
   3) Actual air flow
   4) Design return air flow
   5) Actual return air flow
   6) Design outside air flow
   7) Actual outside air flow
   8) Return air temperature
   9) Outside air temperature
   10) Required mixed air temperature
   11) Actual mixed air temperature
   12) Design outside/return air ratio
   13) Actual outside/return air ratio

e. Exhaust Fan Data:
   1) Location
   2) Manufacturer
   3) Model
   4) Air flow, specified and actual
   5) Total static pressure (total external), specified and actual
   6) Inlet pressure
   7) Discharge pressure
   8) Fan RPM

f. Electric Motors:
   1) Manufacturer
   2) HP/BHP
   3) Phase, voltage, amperage; nameplate, actual, full load, no load
   4) RPM
   5) Service factor
   6) Starter size, rating, heater elements

g. V-Belt Drive:
   1) Identification/location
   2) Required driven RPM

3) Driven sheave, diameter and RPM
4) Belt, size and quantity
5) Motor sheave, diameter and RPM
6) Center to center distance, maximum, minimum, and actual

h. Duct Traverse:
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
9) Air temperature
10) Air connection factor

i. Air Distribution Test Sheets
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

j. Cooling Data:
1) Identification/number
2) Location
3) Service
4) Manufacturer
5) Air flow, design, and actual
6) Entering air DB temperature, design and actual
7) Entering air DB temperature, design and actual
8) Leaving air DB temperature, design and actual
9) Leaving air WB temperature, design and actual
10) Air pressure drop, design and actual

k. Heating Coil Data:
1) Identification/number
2) Location
3) Service
4) Manufacturer
5) Air flow, design, and actual
6) Entering air DB temperature, design and actual
7) Entering air DB temperature, design and actual
8) Leaving air DB temperature, design and actual
9) Water flow, design and actual
10) Water pressure drop, design and actual
11) Entering water temperature, design and actual
12) Leaving water temperature, design and actual
13) Air pressure drop, design and actual

I. Engineer will review submittals for compliance with Contract Documents, and will return one set marked to indicate:
   1. Discrepancies noted between data shown and Contract Documents.
   2. Additional, or more accurate, instruments required.

J. Requests for re-calibration of specific instruments.

1.6 JOB CONDITIONS

A. Prior to start of testing, adjusting and balancing, verify that required "Job Conditions" are met:
   1. Systems installation is complete and in full operation.
   2. Outside conditions are within a reasonable range relative to design conditions.
   3. Lights are turned "on" when lighting is included in the cooling load.
   4. Special equipment such as computers, laboratory equipment, shop equipment and electronic equipment are in full operation.

1.7 PROCEDURES, GENERAL

A. Comply fully with the procedural standards of the certifying association under whose standards service will be performed.

B. Execute each step of the prescribed Testing, Adjusting and Balancing procedures without omission.

C. Accurately record the required data.

1.8 AIR BALANCING

A. Balance air systems before hydronic system.

B. Make measurements in accord with recognized procedures and practices of the certifying association.

C. Measure the air volume discharged at each outlet and adjust air outlets to design air volumes within ten percent over or under.

D. Identify each outlet as to location, area and fan system.

E. Outlet, manufacturer, and type.

F. Outlet size, free area, core area or neck area.

G. Required fpm and test velocity found for each outlet.

H. Adjust and record fan speeds and motor drives within drive limitations for required air volume.

I. Set a speed to provide air volume at farthest distance without excess static pressure.

J. Record motor horsepower and fan rpm.

K. Measure and adjust air supply and exhaust fan units to deliver design conditions at 100% cooling. Measure and adjust exhaust air fan units to exhaust design air volumes.

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

M. Measure static air pressure conditions on air supply units, including filter and coil pressure drops and total pressure across the fan.

N. Evaluate building and room pressure conditions to determine adequate supply and return air conditions.

O. Evaluate space and zone temperature conditions to determine adequate performance of the systems to maintain temperature without draft.

P. Measure temperature conditions across outside air, return air and relief dampers to check leakage.

Q. Mark balancing dampers and cocks.

R. List name of equipment manufacturer, size, model number, horsepower, voltage, phase, full load AMPS.

S. Inspect function and operation of all automatic temperature control systems. Verify all thermostat, aquastat, airstat, sensor, etc., setpoints and operation; enlist the aid of the automatic temperature subcontractor to make all necessary adjustments where required.

T. Field test equipment for fan speed no load operating amperes, fan motor operating amperes, calculated BHP and static pressure.

U. Test system for total air including return air and outside air ducts, number and locations of velocity readings taken, duct average velocity, total cfm, outside air cfm and return air cfm.

1.9 HYDRONIC BALANCING

A. Make measurements in accord with recognized procedures and practices of the certifying association.

B. Measure and adjust water flow for design conditions, within 10% over or under.

C. Check conditions at primary source equipment for performance of design conditions.

D. A qualified representative of the boiler/burner manufacturer shall adjust the boiler gas burners for maximum combustion efficiency.

E. Balance rate of flow through all the AHU/VAV/Fan Powered VAV heating coils, throughout the water circulation system.

1.10 TESTING

A. Test all systems in its entirety or in sections. Tests shall be performed before insulating, backfilling or in any way concealing the duct system or piping system.

B. Hot water heating piping test - subject all piping to hydrostatic pressure test of 100 pounds per square inch with water for not less than 30 minutes, and inspect all joints for leaks. Correct all leaks and retest until no leaks are evident.

C. Air handling units, roof top units, condensing units and other equipment specified in various sections shall be tested as specified in each respective section.

1.11 COORDINATION

A. Coordinate services with the work of the various trades to ensure rapid completion of the services.

B. Promptly report to Engineer any deficiencies noted during performance of services to allow immediate corrective action.

a. PRODUCTS

Not Applicable

b. EXECUTION

Not Applicable

END OF SECTION

SECTION 23 07 13

DUCT INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Duct thermal insulation.

B. Duct acoustic insulation.

C. Adhesives, tapes.

1.2 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM):
   1. ASTM E84 - Surface Burning Characteristics of Building Materials
   2. ASTM C423 - Sound Absorption and Sound Absorption coefficients by the Reverberation Room Method
   3. ASTM C1071 - Thermal and Acoustical insulation (glass fiber, duct lining material)

B. Underwriters Laboratories Inc. (UL):
   1. UL 723 - Surface Burning Characteristics of Building Materials

C. National Fire Protection Association (NFPA)
   1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
   2. NFPA 220 - Standard on Types of Building Construction
   3. NFPA 255 - Surface Burning Characteristics of Building Materials

D. National Board of Fire Underwriters:
   1. National Building Code, Section 200

1.3 QUALITY ASSURANCE

A. Applicator Qualifications: Company specializing in insulation application with three years minimum experience.

1.4 SUBMITTALS

A. Shop Drawings, Product Data, Samples: Submit under provisions of Division 1.
   1. Shop Drawings: Indicate complete material data, a list of materials proposed for this project and indicate thickness of material for individual services.
   2. Samples: Submit samples of each proposed insulating material.

1.5 JOB CONDITIONS

A. Deliver material to job site in original nonbroken factory packaging, labeled with manufacturer's density and thickness.

B. Perform work at ambient and equivalent temperatures as recommended by the adhesive manufacturer.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable Insulation Manufacturers:
   1. Certainteed Corp., Malvern, PA.
   2. Owens-Corning Fiberglass Corp., Toledo, OH
   3. Johns Manville, Corp., Denver, CO.

B. High Temperature Insulation:
   1. Pabco, Division of Fibreboard Corp., Fruita, CO, "Super Firetemp"
   2. Insul-Custic, Corp.

C. Adhesive:
   1. Foster 85-20 Fire Resistant

D. Mechanical Fasteners:
   1. Graham Omark Duct Insulation Fasteners

E. Duct liner:
   1. Johns-Manville - “Standard Linacoustic”.
   2. Owen-Corning “Aeroflex” Type 150

F. Vapor Barrier:
   1. Childers CP-76, Chil-Byl

G. Mastic Weatherproof Coating:
   1. Childers CP-10, Vi-Cyrl

H. Acceptable Coatings and Mastics Manufacturers: Standards products as manufactured by Childers Products Company, Beachwood, OH or equal as approved by Engineer.

I. Substitutions: Items of equal function and performance will be considered in accordance with Division 1.

2.2 GENERAL

A. Adhesives and Insulation Materials: Composite fire and smoke hazard ratings maximum 25 for Flame Spread, 50 for Fuel Contributed, and 50 Smoke Developed. Adhesives to be waterproof.

2.3 MATERIALS AND COMPONENTS

A. Type "A" - External "Flexible" Insulation

   1. "Flexible type" glass fiber blanket having a thermal conductivity (k) of 0.26 btu/hr./sq. ft./degree F/hr. maximum at a mean temperature of 75° F. and a density of 1 pound per cubic foot, "All-Service Duct Wrap FRK 100", or

approved equal. Insulation facing shall consist of aluminum foil, reinforced with fiber glass yarn mesh and laminated to 40 pound chemically treated fire resistant kraft paper FSK. 25% maximum allowable compression.

2. Insulation shall be cut slightly longer than circumference of duct to insure full thickness at corners. All insulation shall be applied with edges tightly butted. Insulation shall be adhered to duct with fire resistant adhesive. Adhesive shall be applied, so that insulation conforms to duct surfaces uniformly and firmly.

3. In addition to the adhesive, insulation shall be additionally secured to the bottom of all ducts 18" or wider by means of welded pins and speed clips or cup-head pins on 12" centers. The protruding ends of the pins shall be cut off flush after the speed clips have been applied. The vapor-barrier facing shall be thoroughly sealed with a vapor barrier mastic or tape where the pins have pierced through.

4. All joints of shall be sealed with 2" wide vapor barrier tabs or strips using a fire resistive adhesive. All cuts or tears shall be sealed with strips of the vapor barrier jacket applied with vapor barrier adhesive or pressure sensitive tape.

5. Density:

   a. Concealed areas: .75 PCF (pounds per cubic foot)

   b. Exposed areas: 1.0 PCF (pounds per cubic foot)

B. Type "B" - External Rigid

1. Rigid fiberglass insulation, thermal conductivity, "K" value at 75° F maximum 0.23 btu/hr./sq. ft./degree F/hr, plain. Facing shall consist of Foil Scrim Kraft FSK; having a maximum vapor transmission rating of 0.02 perms. Secured in place using adhesive and mechanical fasteners spaced a minimum of 12" on center with a minimum of 2 rows per side of duct. Insulation shall be secured with speed washers and all joints, breaks, punctures or protuberances sealed with appropriate pressure sensitive tape or glass fabric and vapor barrier mastic.

2. Density:

   a. Concealed areas: 3.0 PCF (pounds per cubic foot)

   b. Exposed Areas: 6.0 PCF (pounds per cubic foot)

C. Type "C" - Internal Lining

1. Duct lining shall be fibrous glass blanket having a factory applied fire resistive and non-eroding surface exposed to the air stream. Lining shall be not less than $1^1/_2$ pound density, and shall exhibit no erosion or fiber entrainment up to 4,000 FPM velocity, and shall have noise reduction coefficients of 0.45 for $^1/_2$" thickness, and 0.65 for 1" thickness based on Type "A" mounting. Liner shall have an average thermal conductivity "K" Value not to exceed 0.25 at 75° F.

mean temperature.

2. Linings shall be applied with fire resistive adhesives, mechanical fasteners. Mechanical fasteners shall be copper or cadmium plated steel, welded to the sheet metal on approximately 12” centers, except that pins at transverse duct joints shall be on approximately 6” centers, and as close to ends of duct joints as possible. Adhesive shall be applied to the entire surface of the ductwork.

   After the adhesive is applied, the fibrous glass liner shall be impaled over the pins and further secured with copper or cadmium plated steel self-locking speed clips pressed snugly against the liner. The excess of pin shall be clipped off close to the speed clip. All transverse and longitudinal edges of the lining shall tightly about the adjoining piece. Top sheets of acoustical liner in rectangular ducts shall lap on side sheets. All exposed edges at joints and as caused by cutting of liner in field for collars, tap-ins, trim, etc. shall be coated with the sealer. Insulation blanket within any one section of ductwork shall not be "pieced".

3. On leading edges of lining provide, on the upstream side, sheet metal hold-down strips to prevent erosion of linings.

D. Exterior Duct Insulation

1. Vapor Barrier Coating: Permanently flexible, non-shrinking, resistant to ultra-violet, water soaking, and vibrational stress, similar to "Childers CP-76 Chil Byl".

2. Mastic Weatherproof Coating: Breathing type, tough, durable, fire-resistive, non-toxic, freeze-thaw stabilized, indoor/outdoor use, dual temperature service.

3. Reinforcing Glass Cloth Membrane: Open mesh, coated fabric made of continuous filament glass yarns for use with resin, tar, and asphaltic weather protective coatings. **Note:** Chicken wire, hardware cloth or metal reinforcements is not accepted.

E. Type “D” - High Temperature Insulation

1. High Temperature Exhaust Duct Insulation: Rigid noncombustible, inorganic mineral fiber board, minimum 18 lbs. per cu. ft. density, composed of hydrous calcium silicate made primarily from high purity lime, silica and reinforced fibers and needle-like xonolite crystal structure, with low water of hydration. Insulation shall be capable of withstanding temperatures in excess of 2000° F and for continuous service at 1700° F, have a "K" value at 200° F maximum 0.57 BTU in./hr Ft. 2° F and shall not contain asbestos.

F. Type F – High Temperature Insulation assembly

1. Fastwrap+1 ½ “ Commercial Kitchen Grease Duct as manufacturerd by Thermal Ceramics. Provide a totally foil encaspuslated, non compustible 2000F rated, low bipersistence, flexible fire proofing wrap specifically tested to provide a 2 hour fire rated enclosure for horizontal and vertical commercial kitchen grease and air ventilation ducts. The core blanket chemistry is alkaline-earth silicate wool free of binders and lubricants. Material shall be approaved by the Underwriters Laboratory (UL), NFPA 96, IMC. Provide through

penetration system for walls, ceilings, roofs and floors. All places the grease ducts penetrate shall be provided with the through penetration system as provided by the insulation manufacturer.

PART 3 EXECUTION

3.1 APPLICATION DEMONSTRATION

A. Prior to the application of insulation, arrange a job demonstration of the application methods and workmanship performed by the Mechanical Contractor of the insulation subcontractor under the supervision of the actual job foreman assigned to this project.

B. Approved insulation materials shall be applied to short section of piping, ductwork, fitting and equipment, as selected by the Engineer, and once approved shall not be disturbed during the construction period.

3.2 PREPARATION

A. Do not install covering before ductwork and equipment has been tested and approved.

B. Ensure surface is clean and dry prior to installation. Ensure insulation is dry before and during application. Finish with system at operating conditions.

C. Determine clearances required for installation of insulation and review such requirements with the trades responsible for installing the various piping and ductwork systems and equipment to be insulated. Where it is determined that working clearances between equipment and material to be insulated and adjacent work will restrict or prohibit the proper installation of the work, immediately report such conditions to all interested parties.

D. Arrange to have the affected material relocated or pre-insulated before erection, as approved.

E. Failure to so comply will not relieve the contractor of full responsibility for providing the specified insulation.

3.3 INSTALLATION - GENERAL

A. Ensure insulation is continuous through inside walls, floors, sleeves and hangers. Pack around ducts with fireproof self-supporting insulation material, properly sealed.

B. Insulation on all cold surfaces must be applied with continuous unbroken vapor seal. Hangers, supports, anchors, etc. that are secured directly to cold surfaces must be adequately insulated and vapor sealed to prevent condensation.

C. Finish insulation neatly at hangers, supports and other protrusions.

D. Locate insulation or cover seams in least visible locations.

E. Exposed and Concealed Round, Oval, and Rectangular Ducts: Adhere flexible insulation to ductwork exterior with adhesive applied in 6" wide strips on 16" centers. Provide support for insulation until adhesive sets. Butt all insulation joints firmly. Overlap vapor barrier minimum of 2" at all seams and joints. Secure and seal seams, joints and breaks with minimum 2" pressure sensitive tape or mastic using moving pressure. Insulate all ductwork as described in Article 3.3.

F. Apply outward clinched staples, three minimum for each section of insulation in addition to self-sealing lap or factory applied pressure sensitive laps.

G. Exhaust Ducts: Do not insulate except where noted on the drawings for acoustical purposes.

H. Repair separation of joints or cracking of insulation due to thermal movement or poor workmanship.

I. Acoustic Lining: Apply 1" thick insulation to the interior of ductwork where noted, indicated or as herein scheduled. Secure to ductwork with adhesive using 50% coverage and with 12 gauge impale anchor tabs 12" o.c. Cut off excess fastener length and cover with brush coat of mastic. Ductwork with acoustic lining does not require external thermal insulation.

J. Duct sizes shown on the drawings are, internal, "Clear" dimensions.

3.4 KITCHEN HOOD DUCTWORK

A. Supply Ducts: Insulate same as exposed and concealed supply air ducts.

B. Exhaust Ducts: Insulate with 3" thick high temperature insulation, secured in place as recommended by the manufacturer. Install final finish over insulation as described in Article 2.3.E or 2.3.F.

3.5 INSULATION THICKNESS SCHEDULE

	DUCTWORK	**TYPE**	**INSULATION THICKNESS**
A.	Supply Air Ducts, rectangular and round	External "A"	1 $^{1}/_{2}$"
B.	Return Air Ducts	No insulation except in Mechanical rooms and spaces	
C.	Outside Air Intake Ducts	External "B"	2"
D.	Exhaust Ducts, within 5 feet of exterior surface	External "A"	1"
E.	Transfer Air Ducts	Internal "B"	1"
F.	Male/Female toilet room exhaust 10 feet up	Internal "C"	1"

	stream of last connection		
G.	Mechanical Rooms and Mechanical Spaces, Supply Air, Return Air, Outside Air Intake	External “B”	2”
L.	Supply Air Ducts, rectangular, exposed	External “B”	1 $^{1}/_{2}$”
M.	Supply Air Ducts, round, exposed	All exposed supply ducts to be double wall with insulation between ducts. Refer to specification 23 31 00 for double wall ductwork	—

All ductwork insulation is scheduled for above ceiling or concealed installation except as described otherwise.

3.6 PAINTING

A. Refer to Specification Division 9.

END OF SECTION

SECTION 23 09 23

DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

1.1 RELATED DOCUMENTS

A. The specifications sections “General Conditions,” “Special Requirements,” and “General Requirements” form a part of this section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 SUMMARY

A. The Building Automation System (BAS) shall be a fully functional Web-based system with unlimited simultaneous user capability that utilizes native BACnet communication, fully programmable controllers at all communication levels with a single graphical language programming tool.

B. This system must comply with the following Specifications, BAS sequence of operation and system I/O point schedules. A non-BACnet/Web-based system, systems that utilize application specific controllers or controllers that are configurable and systems that utilize more than one programming tool will not be acceptable. The intent of the system is for all controllers to be fully programmable utilizing one universal graphical language programming tool.

C. Furnish all labor, materials, equipment, and services necessary for a complete and operating temperature control system, utilizing a high speed peer to peer network of interoperable Direct Digital Controls (DDC), Graphical User Interface (GUI) with color-graphic displays and electronic interfaces and actuation devices, as shown on the drawings and as described herein.

1. All sensors, wiring, actuators, etc, are to be replaced with new. This system shall be a complete new system when completed. No DDC components shall be reused. Reuse the power feeds from the existing DDC system as applicable. Provide new power feeds to DDC equipment as required. Provide new breakers, conduit, etc..

D. Mechanical equipment, including but not limited to terminal units, shall be DDC controlled with electric actuation, unless otherwise specified in the sequences of operation.

1.3 SCOPE OF WORK

A. Contractor's Responsibilities: Furnish and install all necessary software and hardware, wiring, and computing equipment in compliance with this specification. Any variances from this specification or related documentation shall be submitted in writing at the time of Bid.

B. All power wiring and conduit for the BAS system controllers and supporting equipment (i.e. - Motor operated dampers, controllers, control panels, and sensors) are to be

provided and installed here in this specification. Reuse the power feeds from the existing DDC system as applicable.

C. The communications network used by the BAS systems is to be separate and independent from the building communications systems.

D. System Requirements:

1. Standard Material/Products: All material and equipment used shall be standard components, regularly manufactured and available and not custom designed specifically for this Project.
2. Modular Design: The system architecture shall be fully modular permitting expansion of application software, system peripherals, and field hardware.
3. Native BACnet: The system must communicate via native BACnet.

E. Equipment:

1. System Hardware.
2. PC's, Laptops, PDA's, server(s), routers, modems and control modules as specified.
3. All sensing devices, relays, switches, indicating devices, and transducers required to perform the functions as listed in the control sequences.
4. All monitoring and control wiring.
5. System Software: The Controls Contractor shall provide all software identified in Part 2, BAS Server and Web Browser GUI, of this Specification, including the BAS Server, fully configured database, graphics, reports, alarm/events. The Graphical User Interface (GUI) shall be completely Web based as specified herein.

F. Input/Output Point Summary Schedule: The system as specified shall monitor, control, and calculate all of the points and perform all the functions as needed to accomplish Sequence of Operation.

G. Codes and Regulations:

1. Standards Authority: All electrical equipment and material, and its installation, shall conform to the current requirements of the following authorities:

   a. Occupational Safety and Health Act (OSHA).
   b. National Electric Code (NEC).
   c. National Fire Code.
   d. 2006 International Mechanical Code.
   e. 2006 International Building Code.
   f. 2006 National Plumbing Code.

2. Product Applicable Standards: All distributed, standalone and unitary controllers supplied shall be in compliance with the following listings and standards:

   a. UL916 for Open Energy Management (for U.S. and Canada).
   b. FCC Part 15, Sub-Part B, Class A.
   c. CE Electro Magnetic Compatibility.

3. Conflict of Codes: Where two or more codes conflict, the most restrictive shall apply. Nothing in this Specification or related documentation shall be construed to permit work not conforming to applicable codes.

1.4 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. BACnet: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

1.5 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 5 seconds.
3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

    a. Water Temperature: Plus or minus 1 deg F.
    b. Water Flow: Plus or minus 5 percent of full scale.
    c. Water Pressure: Plus or minus 2 percent of full scale.
    d. Space Temperature: Plus or minus 1 deg F.
    e. Ducted Air Temperature: Plus or minus 1 deg F.
    f. Outside Air Temperature: Plus or minus 2 deg F.
    g. Dew Point Temperature: Plus or minus 3 deg F.
    h. Temperature Differential: Plus or minus 0.25 deg F.
    i. Relative Humidity: Plus or minus 5 percent.

j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
l. Airflow (Terminal): Plus or minus 10 percent of full scale.
m. Air Pressure (Space): Plus or minus 0.01-inch wg.
n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
o. Carbon Monoxide: Plus or minus 5 percent of reading.
p. Carbon Dioxide: Plus or minus 50 ppm.
q. Electrical: Plus or minus 5 percent of reading.

1.6 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
4. The BAS contractor shall coordinate with the owner to ensure that all new system point descriptors, controller addresses and programming descriptors adhere to the standardized naming convention established by the owner.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.
8. DDC System Hardware:

a. Wiring diagrams for control units with termination numbers.
b. Schematic diagrams and floor plans for field sensors and control hardware.
c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Graphical Programming Documentation: The CONTRACTOR shall provide a printout all Graphical Programs, identifying the specific HVAC or mechanical/electrical subsystem being controlled.
10. Controlled Systems:

    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.

C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

D. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.
5. Software license required by and installed for DDC workstations and control systems.

E. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

F. Field quality-control test reports.

G. Documentation:

1. Operating and Maintenance (O&M) manuals for the system shall be made available electronically using Acrobat 4.X (PDF) format and include the following categories: Workstation User's Manual, Project Engineering Handbook, Software Documentation.
2. BAS User's Manual shall Contain as a Minimum:

    a. System overview.
    b. Networking concepts.
    c. Launching a web browser from a networked PC/PDA and login.
    d. Graphical User Interface (GUI) screen menus and their definitions.
    e. Creating, modifying or deleting schedules.
    f. Uploading and downloading software to the field hardware.
    g. Creating historical trends, collecting trend data and generating trend graphs.
    h. Enabling and assigning alarms and messages to reporting actions/groups.
    i. Report generation and ‘third party software.
    j. Backing up software and data files.

3. Project Engineering Manual shall Contain as a Minimum:

    a. System architecture overview.

b. Hardware cut-sheets and product descriptions.
c. The CONTRACTOR shall deliver four sets of as-built Drawings. All Drawings shall be reviewed after the final system checkout and updated to provide as-built Drawings. The system will not be considered complete until the as-built Drawings have received their final approval.
d. Installation, mounting and connection details for all field hardware and accessories.
e. Commissioning, setup and backup procedures for all control modules/accessories, BAS server software, and database.
f. Listing of basic terminology, alarms/messages, error messages and frequently used commands or shortcuts.

1.7 QUALITY ASSURANCE

A. General:

1. The Building Automation System herein specified shall be fully integrated and installed as a complete package by the Building Automation System Contractor. The System shall include all wiring, installation supervision, calibration, adjustments, commissioning, and checkout necessary for a complete and fully operational system.
2. The Building Automation System Contractor shall be regularly engaged in the engineering, programming, installation, and service of building automation systems of similar size and complexity.
3. The BAS Contractor shall have a local branch facility within a 75-mile radius of this job site. Emergency service shall be available on a 24 hour, 7 day a week basis.
4. The BAS Contractor shall be responsible for all work fitting into place in a satisfactory and neat workmanlike manner acceptable to the Building Owner.
5. The BAS Contractor will coordinate with other Trade Contractors regarding the location and size of pipes, equipment, fixtures, conduit, ducts, openings, switches, outlets, etc., in order to eliminate any delays in the progress of the job.
6. The BAS Contractor will conduct a system wide point to point checkout and verification of the BAS systems operation with an Owner designated Facilities Management employee to confirm and validate operation of all BAS systems.

B. Experience Record:

1. The BAS contractor shall have a minimum of 5 years experience with the complete, turn-key installation of building automation systems of similar size and technical complexity.
2. The BAS contractor shall employ specialists in the field of Building Automation Systems including: Programming, engineering, field supervision and installation. Specialists shall have a minimum of 5 years of experience with building automation systems.

C. Products:

1. The Building Automation System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Automation/Energy Management Control Systems and shall be the manufacturer's latest standard of

design. Controllers and DDC system components shall be current production products.

2. All other equipment shall be the products of the BAS manufacturers or approved manufacturer regularly engaged in production of specialized building automation system materials or equipment.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.9 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

SECTION 2 - PRODUCTS

2.1 BAS System Manufacturers:

Furnish and install a complete Building Automation System manufactured by Automated Logic Corporation (ALC).The system shall be a direct extension of the existing Automated Logic WebCTRL Building Automation System using ALC controllers for all equipment and installed by Automated Logic Control Services, 6345 Flank Drive, Harrisburg, PA. 17112 – Main office number, (717) 909-7000.

A. Contact Mark Crow (717) 773-7992.

B. No Substitutes.

2.2 BAS SYSTEM OVERVIEW

C. The BAS contractor shall provide system software based on a server/thin client architecture, designed around the open standards of web technology.

D. The BAS server shall communicate using ASHRAE's BACnet/IP protocol, and in addition, offer concurrent support over the same data-link of the following protocols: MODBUS and SNMP.

E. The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support Microsoft Internet Explorer browser (6.0 or later versions), and Windows as well as non-Window operating systems. No special software, (active-x components or fat java

clients) shall be required to be installed on the PC's/Laptop used to access the BAS via a web browser.

F. The server software must support the following server platforms (Windows, Sun Solaris, and Linux). The BAS server software shall be developed and tested by the manufacturer of the system standalone controllers and network controllers/routers. Third party manufactured and developed BAS software is not acceptable. The web browser GUI shall provide a completely interactive user interface and must offer the following features as a minimum:

1. Trending.
2. Scheduling.
3. Time Span Graphic Relay
4. Downloading Memory to field devices.
5. Real time 'live' Graphic Programs.
6. Tree Navigation.
7. Parameter change of properties.
8. Set point Adjustments.
9. Alarm/Event information.
10. Configuration of operators.
11. Execution of global commands.

G. Software Components: All software components of the BAS system software shall be installed and completed in accordance with the Specification. BAS system components shall include:

1. Server Software, Database, and Web Browser Graphical User Interface.
2. System Configuration Utilities for future modifications to the system.
3. Graphical Programming.
4. Direct digital control software.
5. Application Software.

H. BAS Server Database: The BAS server software shall utilize a Java Data Base Connectivity (JDBC) compatible database such as: MS Access, MS SQL 7.0, Oracle 8i or IBM DB2. BAS systems written to Proprietary databases are NOT acceptable.

I. Communication Protocol(s): The native protocol for the BAS server software shall be BACnet as defined by ASHRAE standard SPC135.

J. Cross Platform Capability: The BAS system software (client and server) shall be operating system and hardware agnostic, being able to run on Windows 98, Windows 2000, Windows NT, Sun Microsystems Solaris, and Red Hat Linux.

K. Thin Client – Web Browser Based:

1. Web Browser's for PC's: Only a browser (Internet Explorer 6.0 or higher) will be required as the GUI, and a valid connection to the server network. No installation of any custom software shall be required on the operator's GUI workstation/client. Connection shall be over an intranet or the Internet.
2. Secure Sockets Layer: Communication between the Web Browser GUI and BAS server shall offer encryption using 128-bit encryption technology within Secure Sockets Layer (SSL) as a minimum level of security. Communication protocol shall be Hyper-Text Transfer Protocol (HTTP).

2.3 WEB BROWSER GRAPHICAL USER INTERFACE

A. Central Server – the BAS contractor shall utilize the existing Automated Logic server software. A new server shall be provided to the owner. The owner shall provide a network connection and IP address to allow for connection to the existing master server.

1. The BAS contractor shall furnish one (1) server PC with the following minimum system requirements: (Verify existing capacity of existing server. Existing server to be replaced with new)

    a. Dell Dimension 8400 or current equivalent
    b. Intel Pentium 4 Processor, 3.2GHz, 2MB L2 Cache, 800MHz FSB
    c. Windows 7 Operating System
    d. 500GB SATA Hard Drive, 2GB DDR2 SDRAM
    e. 48x CD/DVD Burner Combo Drive
    f. Integrated Gigabit Ethernet Card
    g. 20” Flat Panel Monitor

2. Web Browser Navigation: The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to “feel” like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser.
3. Login: On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and password. Navigation in the system shall be dependent on the operator’s role privileges, and geographic area of responsibility (see below).
4. Color Graphics: The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to set points and comfort. Animated gif’s, active set point graphic controls and valid web content (like local weather forecast) shall be used to enhance usability:

    a. Display Size: The GUI workstation software shall graphically display in 1024 by 768 pixels 24 bit True Color.
    b. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.
    c. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective set points (see section below). The colors shall be updated dynamically as a zone's actual comfort condition changes. Locations of space sensors shall also be shown for each zone. The intent of the specification is to enable the operator to readily assess ‘problems’ at a glance.
    d. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.

e. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:

5. Each piece of equipment monitored or controlled including each terminal unit.
6. Each building.
7. Each floor and zone controlled.
8. Zone Set Point Adjustments: Color floor plans displayed via a web browser shall utilize a contiguous band of colors, each corresponding to actual zone temperatures relative to the desired heating and cooling set points. The ideal temperature shall be shown as a green color band. Temperatures slightly warmer than ideal shall be shown in yellow, and even warmer temperature band shall be shown in orange. Temperatures slightly cooler than ideal shall be light blue, and even cooler temperatures shall be shown as dark blue. All alarm colors shall be in red.
9. Hierarchical Schedules:

    a. BACnet Schedules: Schedules shall comply with the BACnet standard, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:

10. Types of schedule shall be Normal, Holiday, or Override.
11. A specific date.
12. A range of dates.
13. Any combination of Month of Year (1 to 12, any), Week of Month (1 to 5, last, any), Day of Week (M to Sun, Any).
14. Wildcard (example, allow combinations like second Tuesday of every month).
15. Events (and Alarms):

    a. Event Categories: The operator shall be able to create, edit or delete vent categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each Event category, enabling the operator o easily sort through multiple events displayed using a built-in filter.
    b. BACnet Event Templates: BACnet Event template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity f event, acknowledgement requirements, high/low limit and out of range information.
    c. Event Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.
    d. Event Configuration: Operators shall be able to define the type of events generated per BACnet object. A ‘network’ view of the BAS shall expose all BACnet objects and their respective event configuration. Configuration shall include assignment of event, alarm, type of acknowledgement and notification for return to normal or fault status.
    e. Event Reporting Actions: Event Reporting Actions specified shall be automatically launched (under certain conditions) after an event is received by the BAS server software. Operators shall be able to fully define these Reporting Actions using the web browser GUI. Reporting

16. Actions shall be as follows:

a. Print: Alarm/Event information shall be printed to the BAS server's PC or a networked printer.
b. Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts.
c. Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.
d. File Write: The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
e. Write Property: The write property reporting action updates a property value in a hardware module.
f. SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an event.
g. Run External Program: The Run External Program reporting action launches specified program in response to an event.

17. Event Simulator: The web browser GUI user shall provide an Event Simulator to test assigned Reporting Actions. The operator shall have the option of using current time or scheduling a specific time to generate the Event. Utilizing the Navigation Tree and drop-down menus in the Graphic Pane, the operator shall be able to select the Event Type, Status, Notification, Priority, Message, and whether acknowledgement is required.
18. Trends: Trends shall conform to the BACnet Trend Log Object specification. The system shall be able to trend and display graphically all analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the web browser GUI. Sample intervals shall be as small as second.
19. Security Access: Systems that require Security access from the web browser GUI to BAS server are to require a Login Name and Password. Access to different areas of the BAS system shall be defined in terms of Roles, Privileges, and geographic area of responsibility as specified:

    a. Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of 'easily understood English language' privileges. Roles shall be defined in terms of View, Edit, and Function Privileges. Systems that use cryptic Boolean numbers to define system access are not acceptable.
    b. Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.
    c. Time Span Graphic Replay: Operator shall be able to "replay" any graphic in the system to see how key values changed over an operator-selected period of time. Operator shall be able to select the starting date/time for this display and the end date/time or the display period. On completion of the project specified herein, the BAS contractor shall demonstrate that up to 24 hours of data within the last 30 days of operation cab be instantly replayed. System shall then display the graphic as it would have looked at the

beginning of that period, displaying key data, dynamic colors, etc. based upon values recorded at the start time. When the operator starts the replay the graphics and key values shall dynamically change to produce the effect of "fast forwarding" through the designated period of time. Once the system has been operational for at least 30 days, the contractor shall demonstrate that up to 24 hours of data from within the last 30 days can be replayed on any graphic page. Owner's representative shall choose the graphic pages for this demonstration at the time of the demonstration.

2.4 GRAPHICAL PROGRAMMING

A. The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in standalone control modules. Any system that does not use a drag and drop method of graphical icon programming as described herein is NOT acceptable.

B. GPL Capabilities: The following is a minimum definition of the capabilities of the Graphic Programming software:

1. Function Block (FB): Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.
2. Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.
3. BACnet Points: Shall be points that comply with the BACnet structure as defined in the BIBB's Addendum B1/B2, and the BACnet standard.
4. Microblocks: Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors bid.
5. Wires: Shall be Graphical elements used to form logical connections between microblocks and between logical I/O. Different wires types shall be used depending on whether the signal they conduct is analog or digital.
6. Labels: Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a Drawing are logically connected even though there is no wire between them.
7. Parameter: A parameter shall be a value that may be tied to the input of a microblock.
8. Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and noneditable fields and shall contain 'push buttons' for the purpose of selecting default parameter settings.
9. Icon: An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes it function.
10. Menu-Bar Icon: Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.
11. Live Graphical Programs: The Graphic Programming software must support a 'live' mode, where all input/output data, calculated data, and set points shall be displayed in a 'live' real-time mode.

12. For each piece of HVAC equipment, the entire graphic program shall be displayed through the Web Browser GUI. The operator must have the ability to scroll through the entire 'live' graphic program as necessary. Piecemeal graphic programs that only show one part of HVAC equipment program at any one time are NOT acceptable. For example, when viewing an AHU live graphic program, the operator shall see the entire AHU graphic program, not just the Heating Coil control.

2.5 NETWORK ROUTERS AND BRIDGES

A. The controller network shall use BACnet as its native communication protocol. Network bridges and routers must be of a modular design to ensure reliability and system performance.

B. BACnet Router: The central system shall use the building Local Area Network (LAN) for communication. The communication between the central server and the controllers shall be BACnet/IP. A router shall be provided, as required, to bridge BACnet/IP and the data link used between the controllers (BACnet ARCNET and BACnet MS/TP). Proprietary networks and proprietary protocols are not acceptable.

1. BACnet BIBBS: BACnet Routers must use BACnet as the native communication protocol.
2. Firmware Updates: The BACnet Router utilize FLASH memory to flow firmware updates to be performed remotely.

2.6 STANDALONE CONTROLLERS

A. General Purpose Multiple Application Controllers:

1. BACnet BIBBS: General Purpose Multiple Application controllers must use BACnet as the native communication protocol between controllers.
2. Communication Speed: Controllers shall communicate at a minimum of 156 Kbps using ARCNET implemented over EIA-485 using an unshielded twisted pair at the Data Link Layer.
3. General Specification: Each General Purpose Multiple Application controller must be capable of standalone direct digital operation utilizing its own 32 bit processor, nonvolatile flash memory, input/output, 12 bit A to D conversion, hardware clock/calendar and voltage transient and lightning protection devices. A separate coprocessor shall be used for communications to the controller network. All nonvolatile flash memory shall have a battery backup of at least 5 years. Firmware revisions to the module shall be made from the BAS server or remotely over the Intranet or Internet. Controllers that require component changes to implement firmware revisions are not acceptable.
4. Point Expansion: The General Purpose Multiple Application Controllers shall be expandable to the specified I/O point requirements. Each controller shall accommodate multiple I/O Expander Modules via a designated expansion I/O bus port. These expander modules shall expand the total point capacity of each controller up to 192 points where specified. The controller, in conjunction with the expansion modules, shall act as one standalone controller.

5. Point Programming: All point data, algorithms and application software within a controller shall be custom programmable from the operator workstation utilizing one universal graphical language programming tool.
6. Program Execution: Each General Purpose Multiple Application Controller shall execute application programs, calculations, and commands via a 32-bit microcomputer resident in the controller. All operating parameters for application programs residing in each controller shall be stored in read/writable nonvolatile flash memory within the controller and will be able to upload/download to/from the BAS Server.
7. Self-Test Diagnostics: Each controller shall include self-test diagnostics, enabling the controller to report malfunctions to the router and BAS Server.
8. PID Loops: Each General Purpose Multiple Application Controller shall contain both software and firmware to perform full DDC Proportional, Integral, Derivative (PID) control loops and programs.
9. Input-Output Processing: Digital Outputs shall be relays, 24 Volts ac or dc maximum, 3 amp maximum current. Each configured as normally open or normally closed using jumpers and either dry contact or bussed. Each output shall have a manual Hand-Off-Auto switch to allow for override and an LED to indicate the operating mode of the output. Triac outputs are unacceptable.

    a. Universal Inputs shall be Thermistor (BAPI Curve II) 10K Ohm at 77 degrees F (25 degrees C), 0 to 5V dc, 10K Ohm maximum source impedance, 0 to 20mA – 24V dc loop power, 250 Ohm input impedance, dry contact - 0.5mA maximum current.
    b. Analog Output shall be electronic, voltage mode 0 to 10V dc or current mode 4 to 20mA.

B. General Purpose Single Application Controllers:

1. BACnet BIBBS: The General Purpose Single Application Controllers must use BACnet as the native communication protocol between controllers.
2. Communication Speed: Controllers shall communicate at a minimum of 156 Kbps using ARCNET implemented over EIA-485 using an unshielded twisted pair at the Data Link Layer.
3. General Specification: General Purpose Single Application controllers must be capable of stand-alone DDC operation utilizing its own 32-bit processor, nonvolatile flash memory, input/output, 8 bit A to D conversion, hardware clock/calendar and voltage transient protection devices. A separate coprocessor shall be used for communications to the controller network. All RAM memory shall have a battery backup of at least 5 years. Firmware revisions to the module shall be made from the BAS server or remote locations over the Internet. Controllers that require component changes to implement Firmware revisions are not be acceptable.
4. Point Programming: All point data, algorithms and application software within a controller shall be custom programmable from the operator workstation utilizing one universal graphical language programming tool.
5. Program Execution: Each General Purpose Single Application Controller shall execute application programs, calculations, and commands via a 32-bit microcomputer resident in the controller. All operating parameters for the application program residing in each controller shall be stored in read/writable nonvolatile flash memory within the controller and will be able to upload/download to/from the Operator Workstation.

6. Self-Test Diagnostics: Each controller shall include self-test diagnostics, enabling the controller to report malfunctions to the router and BAS Server input.
7. PID Loops: Each General Purpose Single Application Controller shall contain both software and firmware to perform full DDC PID control loops.
8. Rooftop Mounting: The General Purpose Single Application Controllers shall be capable of being mounted directly in or on rooftop AHU equipment.
9. Operating Temperature: The General Purpose Single Application Controllers shall be capable of proper operation in an ambient temperature environment of minus 20 degrees F to plus 150 degrees F (-28.9 degrees to 65.6 degrees C).
10. Input-Output Processing:

    a. Digital outputs shall be relays, 24 Volts ac or dc maximum, 3 amp maximum current. Each output shall have a manual Hand-Off- Auto switch to allow for override and an LED to indicate the operating mode of the output. Triac outputs are unacceptable.
    b. Universal inputs shall be Thermistor (BAPI Curve II) 10K Ohm at 77 degrees F (25 degrees C), 0 to 5V dc - 10K Ohm maximum source impedance, 0 to 20mA - 24V dc loop power, 250 Ohm input impedance, Dry Contact - 0.5mA maximum current.
    c. Analog electronic outputs shall be voltage mode 0 to 10V dc or current mode 4 to 20mA.
    d. Enhanced zone sensor input shall provide one thermistor input, one local set point adjustment, one timed local override switch, and an occupancy LED indicator.

C. Unitary Controller Network

1. Unitary Controllers:

    a. BACnet BIBBS: The Unitary Controllers shall use BACnet as the native communications protocol between controllers on the unitary controller network.
    b. Communication Speed: The communication between unitary controllers shall be 138 Kbps minimum over EIA-485 using ARCnet architecture.
    c. Point Programming: All point data, algorithms and application software within a controller shall be custom programmable from the operator workstation utilizing one universal graphical language programming tool.
    d. Sensor Support: Each Unitary Controller shall be able to support various types of zone temperature sensors, such as; temperature sensor only, temperature sensor with built-in local override switch and temperature sensor with built-in set point adjustment switch.
    e. Airflow Transducer: In order to provide reliable Pressure Independent VAV operation, Unitary Controllers for pressure independent VAV applications shall have a precision built-in airflow transducer for accurate air flow measurement.
    f. Integral Actuator: Each Unitary Controller for VAV applications shall have an integral direct coupled electronic actuator with the following features:

2. The actuator shall provide on-off/floating point control with a minimum of 35 inch-pound of torque.
3. The assembly shall mount directly to the damper operating shaft with a universal V-Bolt clamp assembly.

4. The actuator shall not require any limit switches, and shall be electronically protected against overload.
5. The actuator shall automatically stop when reaching the damper or actuator end position.
6. The gears shall be capable of being manually disengaged with a button on the assembly cover.
7. A visual pointer for the position of the actuator.
8. The assembly shall have an anti-rotational strap supplied with the assembly that will prevent lateral movement.

    a. Visual Status: Each Unitary Controller and Unitary Controller Interface shall have LED indication for visual status of communication, power, and all outputs.
    b. Standalone Algorithm: In the event of a loss of communication, each Unitary Controller shall control from a standalone algorithm, which maintains the assigned space temperature until communication with the Unitary Control Module Interface is restored.
    c. Input/Output Processing:

9. Digital outputs shall be relays, 24 Volts ac or dc maximum, having a 3 Amp maximum current. Each relay shall be configured as normally open or normally closed, and either dry contact or bussed. Triac outputs are not acceptable.
10. Universal inputs shall be Thermistor Type II, dry contacts or 0 to 5V dc with 0 to 10K Ohm input impedance.
11. Enhanced Zone Sensor Input. The input shall provide one thermistor input, one local set point adjustment, one timed local override switch, and an occupancy LED indicator.
12. Analog output electronic, voltage mode 0 to 10V dc or current mode 4 to 20mA.
13. Unitary Controller Router: A router shall be provided to bridge between the unitary controller network and the main controller network, as required.

    a. BACnet BIBBS: The Unitary Controllers Routers shall use BACnet as the native communications protocol between controllers on the unitary controller network.

2.7 BAS SYSTEM SOFTARE SOFTWARE APPLICATIONS

A. The following applications software shall be provided for the purpose of optimizing energy consumption while maintaining occupant comfort:

1. Time of Day Scheduling (TOD) The system shall be capable of the following scheduling features:

    a. Schedule by Type: Scheduling by building, area, zone, groups of zones, individually controlled equipment and groups of individually controlled equipment. Each schedule shall provide beginning and ending dates and times (hours: minutes). A weekly repeating schedule, i.e. between 8:00 a.m. and 5:00 p.m., Monday through Friday shall constitute one schedule, not five.
    b. Schedule in Advance: Dated schedules shall be entered up to 9 years in advance.

c. Self-Deleting: Schedules shall be self-deleting when effective dates have passed.
d. Leap Year: Leap years shall be adjusted automatically without operator intervention.

2. Optimum Start/Stop (OSS)/Optimum Enable/Disable (OED): This application provides software to start and stop equipment on a sliding Schedule based on the individual zone temperature and the heating/cooling capacity in degrees F/hour of the equipment serving that zone. The heating/cooling capacity value shall be operator adjustable. Temperature compensated peak demand limiting shall remain in effect during morning startup to avoid setting a demand peak.
3. Source Temperature Optimization (STO): The system shall automatically perform source optimization for all air handling units, chillers and boilers in response to the needs of other downstream pieces of equipment, by increasing or decreasing supply temperature set points, i.e. chilled water, discharge air, etc.. In addition to optimization, the STO capability shall also provide for starting and stopping primary mechanical equipment based on zone occupancy and/or zone load conditions.

    a. Set point Reset: The STO program will allow set points for various equipment in the heating/cooling chain to be reset between an operator defined maximum and a minimum set point based on the actual requirements of the building zones. The actual set point shall be calculated based on the number of heating or cooling requests which are currently being received from the equipment or zones served. Once every update period, the STO program surveys the network to see if any piece of equipment requires any additional heating or cooling from its source. As an example, a VAV air handler is the source of cold air for a number of VAV boxes.

4. Demand Limiting (DL) - Temperature Compensated: The DL application shall be programmable for a minimum of six separate time of day KW demand billing rate periods. The system shall be capable of measuring electrical usage from multiple meters serving one building and each piece of equipment being controlled on the LAN shall be programmable to respond to the peak demand information from its respective meter.

    a. Sliding Window: The demand control function shall utilize a sliding window method with the operator being able to establish the kilowatt threshold for a minimum of three adjustable demand levels. The sliding window interval shall be operator selectable in increments of 1 minute, up to 60 minutes. Systems that incorporate rotating shed tables will not be acceptable.

5. Set points for Defined Demand Level: The operator shall have the capability to set the individual equipment temperature set points for each operator defined demand level. Equipment shall not be shed if these reset set points are not satisfied; rather the set point shall be revised for the different established demand levels. The system shall have failed meter protection, such that when a KW pulse is not received from the utility within an operator adjustable time period, an alarm will be generated. The system software will automatically default to a predetermined fail-safe shed level.

6. Information Archiving: The system shall have the ability to archive demand and usage information for use at a later time. The system shall permit the operator access to this information on a current day, month to date and a year to date basis.

B. Day/Night Setback (DNS): The system shall allow the space temperature to drift down (up) within a preset (adjustable) unoccupied temperature range. The heating (cooling) shall be activated upon reaching either end of the DNS range and shall remain activated until the space temperature returns to the DNS range.

1. Outside and Exhaust Air: The system shall be capable of closing all outside air and exhaust air dampers during the unoccupied period, except for 100 percent outside air units.
2. Unoccupied Space Temperature: Unoccupied space temperature shall be monitored by the DDC temperature sensors located in the individual zones being controlled or within a representative room.
3. Parameter Changes: Operator shall be able to define, modify or delete the following parameters.

   a. DNS set point temperature(s).
   b. Temperature band for night heating operation.
   c. Period when the DNS is to be activated.

C. Timed Local Override (TLO): The system shall have TLO input points that permit the occupants to request an override of equipment that has been scheduled OFF. The system shall turn the equipment ON upon receiving a request from the local input device. Local input devices shall be push button (momentary contact), wind-up timer, or ON/OFF switches as detailed in the I/O summary.

1. Equipment On Time: If a push button is used the system operator shall be able to define the duration of equipment ON time per input pulse and the total maximum ON time permitted. The input point will cancel override time already entered. If a wind-up timer is used the equipment will stay in override mode until the timer expires. Year to date, month to date and current day override history shall be maintained for each TLO input point. History data shall be accessible by the operator at any time and shall be capable of being automatically stored on hard disk and/or printed on a daily basis.

D. Space Temperature Control (STC): There shall be two space temperature set points, one for cooling and one for heating, separated by a dead band. Only one of the two set points shall be operative at any time. The cooling set point is operative if the actual space temperature has more recently been equal to or greater than the cooling set point. The heating set point is operative if the actual space temperature has more recently been equal to or less than the heating set point. There are two modes of operation for the set points, one for the occupied mode (example: heating = 72 degrees F or 22 degrees C, cooling = 76 degrees F or 24.4 degrees C) and one for the unoccupied mode (example: heating = 55 degrees F or 12.7 degrees C, cooling = 90 degrees F or 32 degrees C).

1. Schedule: The occupied/unoccupied modes may be scheduled by time, date, or day of week.
2. Color Code: One of seven colors shall be generated to represent the comfort conditions in the space, and shall be displayed graphically at the operator station.

a. If the actual space temperature is in the dead band between the heating set point and the cooling set point, the color displayed shall be green for the occupied mode, representing ideal comfort conditions. If in the unoccupied mode, the color displayed shall be gray representing 'after-hours' conditions.
b. If the space temperature rises above the cooling set point, the color shall change to yellow. Upon further rise beyond the cooling set point plus an offset, the color shall change to orange. Upon further rise beyond the cooling set point plus the yellow band offset, plus the orange band offset, the color shall change to red indicating unacceptable high temperature conditions. At this point an alarm shall be generated to notify the operator.
c. When space temperature falls below the heating set point, the color shall change to light blue. Upon further temperature decrease below the heating set point minus an offset, the color shall change to dark blue. Upon further space temperature decrease below the heating set point minus the light blue band offset minus the dark blue band offset the color shall change to red indicating unacceptable low temperature conditions. At this point an alarm shall be generated to notify the operator.

3. Operator Definable: All set points and offsets shall be operator definable. When in the occupied mode, start-up mode, or when heating or cooling during the night setback unoccupied mode, a request shall be sent over the network to other equipment in the HVAC chain, such as to an AHU fan that serves the space, to run for ventilation. The operator shall be able to disable this request function if desired.
4. Additional Cooling: When comfort conditions are warmer than ideal, indicated by the colors yellow, orange, and high temperature red, a request for additional cooling shall be sent over the network to other cooling equipment in the HVAC chain, such as a chiller. This information is to be used for optimization of equipment in the HVAC chain. The operator shall be able to disable this function if desired.
5. Additional Heating: When comfort conditions are cooler than ideal; indicated by the colors light blue, dark blue, and low temperature red; a request for additional heating shall be sent over the network to other heating equipment in the HVAC chain, such as a boiler. This information is to be used for optimization of equipment in the HVAC chain. The operator shall be able to disable this function if desired.
6. Cooling/Heating Set Points: The cooling (and heating) set points may be increased (decreased) under demand control conditions to reduce the cooling (heating) load on the building during the demand control period. Up to three levels of demand control strategy shall be provided. The operator may predefine the amount of set point increase (decrease) for each of the three levels. Each space temperature sensor in the building may be programmed independently.
7. Optimum Start: An optimum startup program transitions from the unoccupied set points to the occupied set points. The optimum startup algorithm considers the rate of space temperature rise for heating and the rate of space temperature fall for cooling under nominal outside temperature conditions; it also considers the outside temperature; and the heat loss and gain coefficients of the space envelope (AI: Space Temperature).
8. PID Loop: A PID control loop, comparing the actual space temperature to its set point, shall modulate the dampers (and heating coil valve or heating stages in sequence) to achieve the set point target.

E. Environmental Index: Environmental performance of the control system shall be displayed as a percentage index for each time period displayed. For example, if consumption data for each day of the month is shown, then the Environmental Index shall be annotated to the consumption graph for each day. An Environmental Index shall be calculated and stored in the BAS historical trends database for each separate zone controlled. The Environmental Index shall be trended at 15 minute intervals and be accessible through the Energy and Environmental Performance reporting tool by clicking an appropriate button on the chart toolbar.

1. Environmental Index shall be calculated as follows: System shall monitor all occupied zones and compile an index that provides a numerical indication of the environmental comfort within the zone. As a minimum, this indication shall be based upon the deviation of the zone temperature from the heating or cooling setpoint. If humidity is being measured within the zone then the environmental index shall be adjusted to reflect a lower comfort level for high or low humidity levels. Similarly, if carbon dioxide levels are being measured as an indication of ventilation effectiveness then the environmental index shall be adjusted to indicate degraded comfort at high carbon dioxide levels. Other adjustments may be made to the environmental index based upon additional measurements. The system shall maintain a trend of the environmental index for each zone in the trend log. The system shall also compute an average comfort index for every building included in this contract and maintain trend logs of these building environmental indices. Similarly, the system shall compute the percentage of occupied time that comfortable conditions were maintained within the zones. Through the UI the user shall be able to add a weighting factor to adjust the contribution of each zone to the average index based upon the floor area of the zone, importance of the zone, or other static criteria.

F. Energy Report Builder:

1. Provide an intuitive, easily configured reporting tool with the Building Automation workstation that allows the user to create as a minimum the energy reports detailed below. The energy reporting tools shall be accessible through any type of browser (Internet Explorer, Firefox, etc) and be very user intuitive for the end-user customer. The energy reporting tool shall be pre-configured by the BAS contractor to interrogate all metered data in the BAS historical trends database using BACnet/IP, Web-Services, SQL Query Language or other open mechanisms.
2. Metered data shall be stored at 5 minute intervals for consumption and demand for each metered energy source unless specified otherwise. Energy data shall be stored and available for a period not less than five years in an SQL or Oracle Database. Only SQL (MS SQL, MySQL, PostgressSQL and Oracle databases are acceptable for storage of energy data.
3. The BAS controls contractor shall be responsible for all configuration of the Energy and Environmental Performance reporting tool. No knowledge of Databases, SQL queries or any programming language shall be required by the end-user customer to generate energy reports.
4. Metered sources shall be shown for each building in a ‘tree‘ configuration and data ranges selected on the fly by using an easy-to-use calendar control. Additionally, there shall be a ‘compare to’ calendar, so that one time period can easily be

compared to another period, e.g. 2007 annual consumption to 2006 consumption annual.

5. Additionally, the end-user shall be able to schedule configured energy reports to run on a recurring basis: For example, a monthly consumption report shall be scheduled to automatically be generated on the first Monday of the following month, archived on the server in both Adobe PDF and Microsoft Excel, and automatically emailed to designated personnel in the end-user organization.
6. Energy Reports Types:

    a. Consumption
    b. Demand

7. Capability to meter the following energy sources:

    a. Electricity, Gas, Oil, Steam, Chilled Water, Potable Water.

8. Energy Report Graphs formats:

    a. Bar, Line, Totalized, Pie and Tabular Data.

9. Engineering Units and Normalized Data available in graphical formats:

    a. Kwh (MWH), KBtu/hr, Kwh/square foot, KBtu/hr/square foot/year, Kwh/square foot/occupied hour, llbs CO2, Llbs CO2/sq.ft.

10. Low/ Average / High data shall be optionally displayed on the graph by clicking an appropriate button on a chart toolbar.
11. Benchmarking shall be incorporated into the energy reporting tool, allowing the customer to enter utility data for any periods prior to the presence of meters connected to the BAS. If the benchmark data has been entered, it shall be optionally be shown on the same graph by clicking an appropriate button on the chart toolbar.
12. Cooling and Heating Degree Days data shall be optionally shown graphically on top of the consumption graphs, by clicking an appropriate button in a tool bar.
13. Occupied/Unoccupied energy consumption shall be displayed by use of color. For example, a monthly consumption reports shown by day shall display unoccupied usage in a different color to occupied usage.

2.8 INPUT DEVICES

A. General Requirements: Provide installation (where applicable), testing, and calibration of all sensors, transmitters, and other input devices to meet the system requirements.

1. Wet Differential Pressure Transmitter:

    a. Shall be enclosed in a NEMA 1 enclosure with a 5 valve bypass assembly.
    b. Transmitter shall have an over pressure rating of at least 200 psi on either port without permanent damage.
    c. Transmitter shall have externally accessible zero and span adjustments.
    d. Transmitter shall have a static error band of +/- .5% full scale including linearity, hysteresis and repeatability.
    e. Output of transmitter shall be 4 to 20 ma.

2. Differential Pressure Switches – Air Type:

    a. Switch shall be diaphragm actuated type with a single-pole, double-throw, snap-acting switch.
    b. Motion of the diaphragm shall be restrained by a calibrated spring that can be adjusted to set the exact pressure differential at which the electrical switch will be actuated.
    c. Motion of the diaphragm shall be transmitted to the switch button by means of a direct mechanical linkage.
    d. Electrical rating shall be 6.0 amps at 120 VAC.
    e. Pressure range and temperature limits shall be suitable for the application.
    f. Switch shall be utilized in conjunction with static pressure probes when utilized across filters, and a static pressure probe on the low side and a velocity probe on the high side when utilized across a fan.

3. Differential Pressure Switches – Water Type:

    a. Switch shall be diaphragm-actuated type with a single-pole, double-throw snap-acting switch.
    b. Motion of the diaphragm shall be restrained by a calibrated spring that can be adjusted to set the exact pressure differential at which the electrical switch will be actuated.
    c. Switch shall be utilized in conjunction with shut off valves on the low and high sides of the switch to allow for ease of service.

4. Duct Mounted Humidity Sensor:

    a. Sensor shall have replaceable digitally profiled thin-film capacitive sensor element.
    b. Electronics shall be sealed in probe assembly, impervious to water and contaminants.
    c. Humidity sensor shall be 2 percent accurate at 0 to 90 percent RH.
    d. Sensor RH element shall be replaceable and transmitter shall perform to specified accuracy without calibration.
    e. Sensor shall operate over a 0 to 100 percent RH range.
    f. Sensor shall operate over a 0 to 60 degrees C temperature range.
    g. Sensor shall operate over a 12 to 30V dc voltage range.
    h. Sensor housing dimensions shall be 4.6 inch by 2.85 inch by 2.18 inch with probe length of 8.45 inch and provisions for mounting directly to duct.
    i. Sensor element shall be replaceable without disturbing conduit or mounting enclosure.
    j. Sensor electronics shall be encapsulated in stainless steel sensor probe for protection from damage due to contamination, condensation, or installation.
    k. Sensor housing shall be NEMA 4 rated enclosure.
    l. Sensor shall be ASTME certified Veris Industries, ACI or Vaisala.

5. Wall Mounted Humidity Sensor:

    a. Sensor shall have replaceable digitally profiled thin-film capacitive sensor element.

b. Electronics shall be sealed in probe assembly, impervious to water and contaminants.
c. Humidity sensor shall be 3 percent accurate at 0 to 90 percent RH.
d. Sensor RH element shall be replaceable and transmitter shall perform to specified accuracy without calibration.
e. Sensor shall operate over a 0 to 100 percent RH range.
f. Sensor shall operate over a 0 to 60 degrees C temperature range.
g. Sensor shall operate over a 12 to 30V dc voltage range.
h. Sensor housing dimensions shall be 4.6 inch by 2.85 inch by 2.18 inch with probe length of 8.45 inch and provisions for mounting directly to duct.
i. Sensor element shall be replaceable without disturbing conduit or mounting enclosure.
j. Sensor electronics shall be encapsulated in stainless steel sensor probe for protection from damage due to contamination, condensation, or installation.
k. Sensor housing shall be NEMA 4 rated enclosure.
l. Sensor shall be ASTME certified Veris Industries, ACI or Vaisala.

6. Temperature Sensors:

a. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.
b. Duct sensors shall be rigid or averaging as shown. Averaging sensors shall be a minimum of 5 feet in length.
c. Immersion sensors shall be provided with a separable stainless steel, or copper well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed.
d. Space sensors shall be equipped with set point adjustment, override switch and communication port.

7. Current Sensing Switches:

a. The current sensor shall be induce powered from the monitored load.
b. The current sensor shall provide ON/OFF status indication of electrical loads from 0.5 to 200 A.
c. The current sensor shall have a auto adjusting operating range from 0.5 to 200 A.
d. The current sensor switch point shall be fixed at 0.5A.
e. The current sensor shall be capable of providing accurate status at Temperatures from -15 to 60 degrees C.
f. The current sensor shall be isolated to 600V ac rms.
g. The current sensor output shall be N.O., Solid State, 1.0A at 30V ac/dc.
h. The current sensor shall be a solid core type with a hole size of 0.71 inch in diameter.
i. The current sensor dimensions shall be (L by W by H) 2.77 inch by 1.80 inch by 1.02 inch.
j. The current sensor shall be a Hawkeye; Model H Series.
k. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.

8. Wall Mount Thermostat:

a. Each room thermostat shall provide temperature indication to the digital controller, provide the capability for a software-limited set point adjustment and operation override capability.
b. Each wall mounted thermostat shall be equipped with local set point adjustment capability and a manual override button.
c. Each wall mounted thermostat shall be equipped with a CO2 sensor. Sensors shall be combination temperature and CO2 sensor with the following requirements:
    1. CO2 sensing method - NDIR with ABC automatic background calibration algoritm
    2. CO2 sampling method - diffusion
    3. CO2 response time - 20 sec diffusion time
    4. CO2 sensitivity - 20ppm +/- 1% of measured value
    5. CO2 accuracy - 30ppm +/- 5% of measured value
    6. Temperature type - precision thermistor
    7. Temperature range - 32 to 122 degrees F

d. The thermostat shall include a port for connection of the portable operator's terminal described elsewhere in this Specification.
e. A tamper proof cover shall be provided and installed for each wall mounted thermostat located in a common area (i.e. – hallways, corridors, etc.).

9. Carbon Dioxide Sensors:

    a. Carbon dioxide sensor, transmitter having an accuracy of 2.0% at 20 C [68 F].
    b. Output: 0-20mA, 4-20 mA, or 0-10 V signal
    c. Range: 0-2000 ppm CO2 nominal; 0-5000 ppm CO2 with recalibration
    d. Long-term stability: <5%FS / 5 years
    e. Acceptable manufacturers: Vaisala, General Eastern, ACI or approved equal.

10. Airflow Measuring Stations

    a. EBTRON, Inc. Model GTx116-PC for installation in the air handling unit outside air intake.
    b. Power Requirement: 24 VAC.
    c. Calibrated Velocity Range: 0 to 5000 fpm.
    d. Sensing Point Accuracy: ±2% of reading (airflow), ±0.15° F (temperature).
    e. Sensor Probes: aluminum alloy tube with stainless steel mounting brackets.
    f. Output to Host Controls: RS-485 LAN output with BACnet interface.
    g. Acceptable manufacturers: Ebtron or approved equal.

        1. The following specific technologies are excluded: Vortex shedding devices, pitot tubes, Pitot arrays, Piezo rings and other differential pressure based devices are not acceptable. Thermal anemometers using any type of chip thermistor are not acceptable

2.9 OUTPUT DEVICES

A. Actuators:

1. General Requirements:

    a. All control dampers shall have 24V electric actuators.
    b. Dampers shall fail to the positions indicated on Drawings or as indicated below.

2. Outside air dampers shall fail closed.
3. All plenum zone supply and return air dampers shall fail as is.
4. VAV box dampers shall fail as is.
5. Belimo Electronic Damper Actuators:

    a. Electronic damper actuators shall be direct shaft mount.
    b. Provide modulating and two-position actuators as required by the sequence of operation. Size damper sections based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations.
    c. Modulating actuators shall accept 24V ac power supply and consume no more than 15VA and be UL listed. Control signal shall be 2 to 10V dc or 4 to 20 mA.
    d. Two-position or OPEN/CLOSED actuators shall accept 24V ac power supply and be UL listed. Isolation, smoke, exhaust fan and other dampers as specified in the sequence of operations shall be furnished with adjustable end switches to indicate OPEN/CLOSED position or be hard wired to Start/Stop associated fan.

6. Belimo Electronic Valve Actuators:

    a. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
    b. Provide modulating and two-position actuators as required by the sequence of operation. Actuators shall provided the minimum torque required for proper valve close-off against the system pressure for the required application. Size valve actuator based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves as required.
    c. Modulating actuators shall accept 24V ac power supply and consume no more than 15VA and be UL listed. Control signal shall be 2 to 10V dc or 4 to 20 mA. Coordinate power connections with existing control valve power connections. Existing actuators have quick connectors.
    d. Two-position or open/closed actuators shall accept 24V ac power supply and be UL listed. Butterfly isolation and other valves as specified in the sequence of operations shall be furnished with adjustable end switches to indicate OPEN/CLOSED position or be hard wired to start/stop associated pump or chiller.

B. Control Dampers:

1. The BAS Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BAS Contractor or as specifically indicated on the Drawings.
2. Fabrication:

    a. Model: Ruskin CD60 or equivalent.
    b. Frame: 5 inches by minimum 16-gauge (127 by minimum 1.6 mm) roll formed, galvanized steel hat-shaped channel, reinforced at corners. Structurally equivalent to 13-gauge (2.3 mm) U-channel.
    c. Blades with edge seals.

3. Style: Airfoil-shaped, single-piece.
4. Action: Parallel.
5. Orientation: Horizontal.
6. Material: Minimum 14-gauge (2.0 mm) equivalent thickness, galvanized steel.
7. Width: Nominal 6 inches (152 mm).

    a. Bearings: Self-lubricating stainless steel sleeve, turning in extruded hole in frame.
    b. Seals:

8. Blade: Extruded Ruskiprene type for ultra-low leakage from -76 to 350 degrees F (-60 to 177 degrees C). Mechanically attached to blade edge.
9. Jamb: Flexible metal compression type.
10. Orientation: Horizontal.

    a. Linkage: Concealed in frame.
    b. Axles: Minimum 1/2 inch (13 mm) diameter plated steel, hex shaped, mechanically attached to blade.
    c. Mounting: Vertical and/or Horizontal.
    d. Finish: Mill galvanized.

11. Performance Data:

    a. Temperature Rating: Withstand -76 to 350 degrees F (-60 to 177 degrees C).
    b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions.

12. Closed Position: Maximum pressure of 13 inches w.g. (3.2 kPa) at a 12-inch blade length.
13. Open Position: Maximum air velocity of 6,000 feet per minute (1,829 m/min).

    a. Leakage: Maximum 2.0 cubic feet per minute per square foot (0.6 m3/min/m2) at 1-inch w.g. (0.25 kPa) for all sizes 24 inches (610 mm) wide and above.
    b. Pressure Drop: Maximum 0.05-inch w.g. (0.01 kPa) at 1,500 feet per minute (457 m/min) across 24 inch by 24 inch (610 by 610 mm) damper.

C. Belimo Control Valves:

1. Valves ½ inch through 3 inches shall be class 125 forged brass body with nickel plating, NPT screw type. The operating temperature range shall be 0 degrees to 212 degrees F.
2. The valves shall have an ISO type 4 bolt flange for mounting actuator in any orientation parallel or perpendicular to the pipe. A nonmetallic thermal isolation adaptor shall separate flange from actuator with high temperature materials rated for continual use at greater than the application temperature. Valve assemblies without thermal isolation as described are not acceptable.
3. The isolation adaptor shall also provide stable direct coupled mechanical connection between the valve body and actuator and prevent lateral or rotational forces from affecting the stem and its packing O-rings.
4. All control ball valves shall be furnished with a stainless steel ball and stem and fiberglass reinforced Teflon® seats and seals. The valves shall have a blow out proof stem design. Each valve shall be tested by the valve manufacturer.
5. Flow type for modulating two-way valves shall be equal percentage. All control ball valves shall have a flow characterizing disc in the inlet of the valve to provide this equal percentage flow response. Three-way valves shall have equal percentage control port. They shall have a modified linear bypass port which will yield 70 percent of the flow of the A port. The total flow remains near constant. Three-way valves shall be applicable for both mixing and diverting.
6. Characterizing disc shall be held securely by a keyed ring.
7. The stem packing shall consist of two O-rings designed for on-off or modulating service and requiring no maintenance.
8. Manufacturer shall provide a 1 year unconditional warranty from date of installation.

D. Variable Frequency Drives

1. Reuse existing VFD's on pumps, air handling units.

SECTION 3 - EXECUTION

3.1 TESTING

A. The equipment shall be guaranteed to produce the functions and sequences listed, under the conditions specified, and tested to prove it meets the warranty. Results of such tests must be filed with the Professional and Owner. Equipment must be factory tested.

3.2 INSTALLATION

A. The BAS contractor shall furnish and install the complete facility management control system and electric system as herein described, including tubing, wiring and conduit.

B. The BAS contractor shall provide trained field personnel in its direct employ to trouble-shoot, calibrate and tune all equipment related to the BMS and electric system during the startup phase.

C. The system shall be installed complete by the BAS contractor with factory trained mechanics, with the exception of control valves and immersion wells (separable sockets) which shall be turned over to the Heating Contractor for installation. All sensing elements located in water lines or tanks shall be provided with stainless steel separable

sockets. The BAS contractor shall select the proper location for each separable well. Sensing elements installed in ducts shall be securely anchored, and when long or averaging sensing elements are used the elements shall be strung through the duct to ensure representative cross sectional sampling.

D. Power wiring to all equipment from panelboards or switchboards will be furnished and installed by the Electrical Contractor.

E. Automatically controlled dampers shall be provided complete by the Heating Contractor. The BAS contractor shall furnish and install operators for the dampers which shall be of ample power to meet their specific requirements.

F. All power and control wiring from the automatic temperature control panels to VAV boxes, control valves, etc., shall be furnished and installed by the BAS contractor.

G. All new construction thermostat drops shall be installed utilizing conduit with an electrical wall box installed within the wall construction. All wall thermostats and wall sensors located in classrooms, offices and lounges shall be mounted with centerline 4'-0" above the finished floor to comply with ADA mounting height requirements. All thermostats located in restrooms, corridors and other public areas shall be mounted with centerline 7'-0" above the finished floor.

H. All electrical control wiring and electrical control connections shall be installed by mechanics employed by the local field office. The control manufacturer shall include in his bid all controls, control wiring system and equipment and installation of the wiring systems and equipment as specified herein. All wiring shall be installed in conduit, and conduit shall be concealed in finished areas, except as hereinafter specified. Power or interlock wiring shall be run in separate conduit from sensor wiring.

I. All control wiring outside of control panels shall be run in rigid conduit or EMT, except as hereinafter specified, and installed in strict accordance with the requirements of The National Electrical Code. Wiring for the control system, except the low voltage conductors, shall be single conductor solid or stranded copper not less than No. 14 AWG, with 600 volt Type THHN insulation, except where the manufacturer requires special types and sizes. Flameproof insulation shall be used where required by the NEC. Wiring for DDC system inputs/outputs shall be No. 18 two conductor with shield installed in accordance with the requirements of The National Electrical Code. Wiring for DDC system communication trunk shall be 2 conductor, 24AWG, stranded shielded low capacitance cable. All wiring in panel construction may be No. 16 or No. 18 AWG copper as recommended by the manufacturer provided same is properly protected and/or is in accordance with the NEC. No temperature control wiring installed under this contract shall be installed in the building lighting and power circuit systems. Communication trunk wiring shall not be installed in raceway and/or enclosures containing Class 1 or other Class 2 wiring.

J. All low voltage conductors shall be types as herein indicated. Other types and sizes required by the temperature control manufacturer shall be submitted for approval. Low voltage two conductor wire shall be black twisted (six turns per foot) 16 AWG or 18 AWG wire, as indicated, 1/32, 80 degrees C., 600 volt PVC insulation. Low voltage three conductor wire shall be red, yellow, blue twisted (six turns per foot) 16 AWG or 18 AWG wire as indicated, 1/32, 80 degrees C., 600 volt PVC insulation. Cable shall

be as manufactured by Alpha Wire Company, Belden Wire Company, Standard Wire and Cable or approved equal.

K. All conduit, fittings, hangers and accessories for control wiring installed under the HVAC Contract shall conform to the levels of quality specified under Division 16.

L. All BMS panels and input/output interface panels shall be identified with black laminated plastic nameplates with white lettering. Panel identification shall be such that it can be easily cross referenced with as-built drawings. All items of equipment within input/output interface panels shall be labeled with an identification that corresponds with as-built drawings. All items mounted on the face of input/output interface panels shall be identified with black laminated plastic nameplates with white lettering. Identification shall include function and position information where applicable. All field devices shall be identified with black laminated plastic nameplates with white lettering secured with either double-backed tape or metallic strapping. Identification shall be same tag symbol as found on the as-built drawings.

M. Wiremold shall be used for temperature sensor and communication trunk rises/drops in occupied spaces when fishing of existing walls is not possible.

N. The use of plenum cable shall be permitted in concealed accessible areas.

O. The ATC Contractor shall furnish network management hardware and software and logically install BAS Control Devices. Network management shall include the following services: device installation, device configuration, device diagnostics, field programming, device maintenance, network variable binding, channel traffic analysis, message routing and repeating and protocol conversion.

3.3 START-UP AND WARRANTY

A. The local field office shall warranty all BMS computers and related I/O equipment and all new pneumatic and electric hardware for a period of twelve (12) months following Owner acceptance of the system.

B. All equipment found to have defects in material or workmanship during this warranty period shall be replaced at no charge to the Owner with equipment of equal type and quality by the BMS manufacturer. All labor required during the warranty period shall also be included, with the following clarification. Materials furnished but not installed by the BMS contractor shall be covered to the extent of the product only. Installation labor shall be the responsibility of the trade contractor performing the installation

C. Operator workstation software, project-specific software, graphic software (where specified), database software, and firmware updates which resolve known software deficiencies as identified by the BMS Contractor shall be provided to the Owner at no charge during the warranty period.

D. The Contractor shall respond to the job site within a 24 hour period for any warranty work relating to the control system.

3.4 START-UP AND CHECK-OUT PROCEDURES

A. The ATC Contractor shall be responsible for developing test plans and procedures to establish that the ATC system functions as described in the Sequence of Operations. The methodology shall address the observations, measurements, adjustments, calibrations and corrections necessary to accomplish the commissioning process. A detailed item-by-item procedure shall be followed for each item of HVAC equipment. Forms used by the ATC Contractor to record the results of the start-up and check-out procedures shall be available for review by the Professional and the owner.

B. The procedures followed shall, as a minimum, incorporate the intent of the following guidelines:

1. Where weather-dependent procedures are checked by simulation, the Contractor shall also verify the actual results in the appropriate weather condition and/or season.
2. Signals used to change the mode of unit operation shall originate from the actual control device intended for that purpose. Simulation may be used to cause the mode to change. All relay contacts, indicating lights and so on shall be checked for proper functioning with each operational mode change signal.
3. All sensing elements and transmitters shall have an accuracy check of their calibration performed by comparing the ATC panel level readout with the actual value of the variable measured at the sensing element/transmitter location. All test instruments shall be traceable to NBS standards. Multiple comparisons shall be required for averaging-type sensing elements.
4. Each HVAC system shall first be observed in the shutdown condition. The HVAC control panel shall be checked for power availability and dampers and valves shall be checked for normal position. Proper operation of all actuators and positioners shall also be checked while the HVAC system is in the shutdown condition. The control signal shall be varied from one extreme to the other and actuator travel from zero stroke to full stroke shall be verified. In addition, it shall be verified that the actuator moves the connected device in the proper direction from one extreme position to the other.
5. Unit operation shall then be verified in the warm-up/cool-down mode, the occupied mode and the unoccupied mode, as well as during transition between modes. Proper damper and valve position shall be verified during each mode and proper operation of the control loop(s) shall be demonstrated by slightly changing controller inputs, outputs and/or setpoints. Proper operation of sensors used for night setback/setup operation shall be verified by changing setpoints and observing proper unit operation as previously described.
6. Differential pressure switch, current switch, freezestat, firestat and smoke detector operation shall be verified via simulation while the associated unit is running. Simulation shall be accomplished without any false alarms to the Life Safety system. Proper contact output at the DDC panel location shall be verified for all hardware simulation. In addition, proper control device actions and interlock functions as described in the Sequences of Operation shall be verified. Proper system operation shall also be verified as the devices are reset.

C. Where Maintenance Time Reminders, Change-of-State Alarms, Analog Limit Alarms, etc. are to be provided, the ATC Contractor shall verify that each message is sent to the appropriate output device whenever the trigger condition occurs.

D. Where colorgraphics are being provided, the ATC Contractor shall verify that all links from dynamic point displays to the actual hardware and software points are correct.

This verification shall involve using each colorgraphic screen to make all setpoint changes, schedule overrides, control overrides etc. and verify that the appropriate changes to the control hardware and panel databases take place.

E. Where implemented trends at the panel level and/or the HMI computer level are to be provided, the ATC Contractor shall demonstrate successful implementation via actual printout of the data being gathered in the case of panel trends, and display, archiving and printout of trend data being gathered at the HMI level.

3.5 TRAINING AND DOCUMENTATION

A. Provide forty (40) hours of training for the building BAS operators. This training shall be "hands' on" type. A mutual agreement on the scheduling of this training class will be made between the Owner and the ATC Contractor.

B. The training class will use the actual Operator & Maintenance manual that will be submitted for this project.

C. As a minimum, this training will cover the following topics:

1. System Overview

    a. Architecture and Function

2. System Operation

    a. System Access
    b. Operation Monitoring
    c. Exception Reporting and Acknowledge
    d. Operation Override
    e. Scheduling
    f. Editing Programmed Variables

D. The training class will cover topics in a "hands-on" mode.

E. Proper and adequate documentation must be provided, this will include:

1. Accurate as-built drawings and sequences submitted in hard copy and floppy disk form (the floppy disk can be easily updated via a standard Computer Aided Drafted (CAD) program).
2. Technical specification sheets
3. Signed software license agreement (as required)
4. Operator & Maintenance (O & M) manuals
5. Warranty statement
6. In-warranty service proposal

F. In addition to classroom training, the BAS Contractor shall provide full Computer Based Training in the operation, maintenance, and programming of the system.

3.6 ACCEPTANCE TESTING

A. The Contractor shall notify the Owner's representative of systems which perform all specified sequences. The Professional shall verify all sequences of operation and place the system into warranty acceptance test.

4.1 Hot Water System

A. General

1. The hot water system shall consist of two (2) modulating boilers, two (2) primary hot water pumps and two (2) constant speed secondary hot water pumps.

B. Boiler System Run Conditions:

1. The boiler system shall be enabled to run whenever:

a. Outside air temperature is less than 65°F (adj.).

2. To prevent short cycling, the boiler system shall run for and be off for minimum adjustable times (both user definable), unless shutdown on safeties or outside air conditions.
3. The boiler shall run subject to its own internal safeties and controls.
4. The boiler system shall also run for freeze protection whenever the outside air temperature is less than 38°F (adj.).

C. Boiler Safeties

1. The following safeties shall be monitored:

a. Boiler alarm.

2. Alarms shall be provided as follows:

a. Boiler alarm.

D. Boiler Circulator Pumps BP-1/BP-2 Operation

1. The boiler circulator pumps shall operate whenever its associated boiler is enabled to operate.

E. Software alarms shall be provided as follows:

1. Primary Hot Water Pump BP-1

a. Failure: Commanded on, but the status is off.
b. Running in Hand: Commanded off, but the status is on.

2. Primary Hot Water Pump BP-2

a. Failure: Commanded on, but the status is off.
b. Running in Hand: Commanded off, but the status is on.

F. Secondary Hot Water Pump HWP-1/HWP-2 Lead/Lag Operation

1. The secondary hot water pumps shall operate in a lead/lag fashion.

    a. The lead pump shall run first.
    b. On failure of the lead pump, the lag pump shall run and the lead pump shall turn off.

2. The designated lead pump shall rotate upon one of the following conditions (user selectable):

    a. Manually selected through a software switch
    b. If pump runtime exceeds 1,000 hours (adj.)
    c. Weekly

G. Software alarms shall be provided as follows:

1. Secondary Hot Water Pump P-1

    a. Failure: Commanded on, but the status is off.
    b. Running in Hand: Commanded off, but the status is on.
    c. Runtime Exceeded: Status runtime exceeds 1,000 hours (adj.).

2. Secondary Hot Water Pump P-2

    a. Failure: Commanded on, but the status is off.
    b. Running in Hand: Commanded off, but the status is on.
    c. Runtime Exceeded: Status runtime exceeds 1,000 hours (adj.).

H. Boiler Lead/Standby Operation:

1. The boilers shall operate in a lead/standby fashion when called to run by the BAS and flow is proven.

    a. The lead boiler & its associated circulation pump shall run first.
    b. On failure of the lead boiler, the standby boiler & its associated circulation pump shall run and the lead boiler and its associated circulation pump shall turn off.

2. The designated lead boiler shall rotate upon one of the following conditions: (user selectable):

        a. manually selected through a software switch
        b. if pump runtime exceeds 1,000 hours (adj.)
        c. weekly

3. Software alarms shall be provided as follows:

    a. Boiler 1

        1. Failure: Boiler is commanded on but the status is off.
        2. Failure: Circulation pump is commanded on but the status is off.
        3. Running in Hand: Commanded off but the status is on.
        4. Runtime Exceeded: Status runtime exceeds 1,000 hours (adj.).

b. Boiler 2

1. Failure: Commanded on but the status is off.
2. Failure: Circulation pump is commanded on but the status is off.
3. Running in Hand: Commanded off but the status is on.
4. Runtime Exceeded: Status runtime exceeds 1,000 hours (adj.).

c. Lead Boiler Failure: The lead boiler is in failure and the standby boiler is on.

I. Hot Water Supply Temperature Setpoint Reset:

1. The hot water supply temperature setpoint shall reset using a trim and respond algorithm based on heating requirements.
2. As the facility's hot water valves open beyond a user definable threshold (90% open, typ.), the setpoint shall reset to a higher value (adj.). Once the hot water coils are satisfied (valves closing) then the setpoint shall gradually lower over time to reduce heating energy user.
3. The BAS shall send each boiler a modulating signal via a Modbus or BACnet connection to control the boiler supply water temperature based upon the required setpoint (adj). If the lead boiler is unable to maintain the supply water temperature setpoint, the BAS shall enable and stage the lag boilers and send a modulating signal to maintain the required supply water temperature (adj).

J. Primary Hot Water Temperature Monitoring:

1. The following temperatures shall be monitored:

a. Primary hot water supply.
b. Primary hot water return.

2. Software alarms shall be provided as follows:

a. High Primary Hot Water Supply Temp: If greater than 200°F (adj.).
b. Low Primary Hot Water Supply Temp: If less than 100°F (adj.).

K. Secondary Hot Water Temperature Monitoring:

1. The following temperatures shall be monitored:

a. Secondary hot water supply.
b. Secondary hot water return.

2. Software alarms shall be provided as follows:

a. High Secondary Hot Water Supply Temp: If greater than 200°F (adj.).
b. Low Secondary Hot Water Supply Temp: If less than 100°F (adj.).

L. Boiler 1 Hot Water Temperature Monitoring:

1. The following temperatures shall be monitored:

a. Boiler 1 hot water supply.

2. Alarms shall be provided as follows:

   a. High Hot Water Supply Temp: If greater than 200°F (adj.).
   b. Low Hot Water Supply Temp: If less than 100°F (adj.).

M. Boiler 2 Hot Water Temperature Monitoring:

1. The following temperatures shall be monitored:

   a. Boiler 2 hot water supply.

2. Alarms shall be provided as follows:

   a. High Hot Water Supply Temp: If greater than 200°F (adj.).
   b. Low Hot Water Supply Temp: If less than 100°F (adj.).

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show On Graphic
Boiler Control Interface (Modbus or BAC-net)	×							×	×	×
Outside Air Temperature	×							×	×	×
Outside Air Humidity	×							×	×	×
Outside Air CO2	×							×	×	×
Primary Hot Water Return Temp	×							×	×	×
Primary Hot Water Supply Temp	×							×	×	×
Secondary Hot Water Return Temp	×							×	×	×
Secondary Hot Water Supply Temp	×							×	×	×
Boiler 1 Hot Water Supply Temp	×							×	×	×
Boiler 2 Hot Water Supply Temp	×							×	×	×
Boiler 1 Hot Water Supply Temp Setpoint		×						×		×
Boiler 2 Hot Water Supply Temp Setpoint		×						×		×
Boiler 1 Status			×					×	×	×
Boiler 1 Alarm			×					×	×	×
Boiler 2 Status			×					×	×	×
Boiler 2 Alarm			×					×	×	×
Boiler Circulator Pump BP-1 Status			×					×	×	×
Boiler Circulator Pump BP-2 Status			×					×	×	×
Hot Water Pump P-1 Status			×					×	×	×
Hot Water Pump P-2 Status			×					×	×	×
Boiler Circulator Pump BP-1 Start/Stop				×				×		×
Boiler Circulator Pump BP-2 Start/Stop				×				×		×
Hot Water Pump P-1 Start/Stop				×				×		×
Hot Water Pump P-2 Start/Stop				×				×		×
Boiler 1 Enable				×				×		×
Boiler 2 Enable				×				×		×

4.2 VARIABLE VOLUME AIR HANDLING UNITS

A. General

1. The air handling unit is equipped with a variable speed supply fan, chilled water cooling coil, hot water heating section, outside air damper, return air damper and outside air measuring station.

B. Run Conditions - Requested:

1. The unit shall run whenever:

   a. The occupancy schedule calls for the unit to operate.
   b. OR 30% (adj.) of unoccupied zones are overridden by the thermostat manual override.
   c. OR a VAV box within the AHU zone requires night heating or night cooling.

C. High Static Shutdown:

1. The unit shall shut down and generate an alarm if the supply static pressure exceeds 3" w.c. (adj.) as sensed by a static pressure switch located downstream of the supply fan.
2. The static pressure switch shall have an adjustable range of 0"-5"w.c. and a manual reset button.

D. Supply Air Smoke Detection

1. The unit shall shut down and generate an alarm upon receiving a supply air smoke detector status.

E. Optimal Start:

1. The unit shall start prior to scheduled occupancy based on the time necessary for the zones to reach their occupied setpoints. The start time shall automatically adjust based on changes in outside air temperature and zone temperatures. During optimal start-up, the outside air damper shall remain closed and the return air damper shall remain open

F. Morning Warm-up/Morning Cool Down/Night Heating/Night Cooling:

1. Morning Warm-up and Morning Cool Down shall be initiated by the VAV box zones served by the associated AHU. When Morning Warm-up or Morning Cool Down is initiated, the following shall occur:

   a. The AHU shall be enabled to operate.
   b. The outside air damper shall remain closed and the return air damper shall remain open unless conditions are suitable for economizing.
   c. If the AHU reaches the scheduled occupancy time, the outside air damper shall open to the minimum ventilation position and the RTU shall continue to operate per the occupied mode sequence.

2. Night Heating and Night Cooling shall be initiated by the VAV box zones served by the associated AHU. When Night Heating or Night Cooling is initiated, the following will occur:

    a. The AHU shall be enabled to operate.
    b. The outside air damper shall remain closed and the return air damper shall remain open unless conditions are suitable for economizing.
    c. Once all zone night setback temperatures have been satisfied, the RTU shall return to the unoccupied mode.

G. Supply Fan:

1. The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties.
2. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime.
3. Software alarms shall be provided as follows:

    a. Supply Fan Failure: Commanded on, but the status is off.
    b. Supply Fan in Hand: Commanded off, but the status is on.
    c. Supply Fan Runtime Exceeded: Status runtime exceeds 480 hours (adj.).

H. Supply Air Duct Static Pressure Control:

1. The controller shall measure duct static pressure and shall modulate the supply fan VFD speed to maintain a duct static pressure setpoint of 1.5in H_2O (adj.). The supply fan VFD speed shall not drop below 50% (adj.). The BAS contractor shall coordinate with the equipment manufacturer and the project balancer to establish a minimum supply fan speed to ensure adequate DX cooling coil face velocity.
2. Software alarms shall be provided as follows:

    a. High Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) greater than setpoint.
    b. Low Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) less than set point.
    c. Supply Fan VFD Fault.

I. Supply Air Temperature Setpoint – Optimized

1. The controller shall monitor the supply air temperature and shall maintain a supply air temperature setpoint reset based on zone cooling and heating requirements
2. The supply air temperature setpoint shall be reset for cooling based on zone cooling requirements as follows:

    a. The initial supply air temperature setpoint shall be 55°F (adj.).
    b. As cooling demand increases, the setpoint shall incrementally reset down to a minimum of 53°F (adj.).
    c. As cooling demand decreases, the setpoint shall incrementally reset up to a maximum of 72°F (adj.)

3. If more zones need heating than cooling, then the supply air temperature setpoint shall be reset for heating as follows:

a. The initial supply air temperature setpoint shall be 82°F (adj.).
b. As heating demand increases, the setpoint shall incrementally reset up to a maximum of 85°F (adj.).
c. As heating demand decreases, the setpoint shall incrementally reset down to a minimum of 72°F (adj.).

J. Cooling Coil:

1. The BAS controller shall measure the supply air temperature and modulate the cooling control valve to maintain its cooling setpoint.
2. The cooling shall be enabled whenever:

a. Outside air temperature is greater than 60°F (adj.).
b. AND the economizer (if present) is disabled or fully open.
c. AND the supply fan status is on.
d. AND the heating (if present) is not active.

3. BAS alarms shall be provided as follows:

a. High Supply Air Temp: If the supply air temperature is 5°F (adj.) greater than setpoint.

K. Hot Water Heating Section

1. The BAS controller shall measure the supply air temperature and **modulate the heating coil control valve** to maintain its heating setpoint.
2. The hot water heating shall be enabled whenever:

a. Outside air temperature is less than 65°F (adj.).
b. AND the supply fan status is on.
c. AND the cooling is not active.

3. The hot water heating section shall energize whenever:

a. Supply air temperature drops from 40°F to 35°F (adj.).

4. Alarms shall be provided as follows:

a. Low Supply Air Temp: If the supply air temperature is 5°F (adj.) less than setpoint.

L. Economizer

1. The BAS controller shall measure the mixed air temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F (adj.) less than the supply air temperature setpoint.

2. The economizer shall be enabled whenever:

a. Outside air temperature is less than 55°F (adj.).
b. AND the outside air enthalpy is less than 22Btu/lb (adj.)
c. AND the outside air temperature is less than the return air temperature.
d. AND the outside air enthalpy is less than the return air enthalpy.

e. AND the supply fan status is on.

3. The economizer shall close whenever:

a. Mixed air temperature drops from 40°F to 35°F (adj.)
b. OR on loss of supply fan status.

4. The outside and exhaust air dampers shall close and the return air damper shall open when the unit is off. If Optimal Start Up is available the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully close.

M. Minimum Outside Air Ventilation – Space Air CO2 Control

1. When in the occupied mode, the controller shall measure the space air CO2 levels and modulate the outside air dampers open on rising CO2 concentrations, overriding normal damper operation to maintain a CO2 differential setpoint of 1200 ppm (adj.) as compared to the outdoor air. The controller shall poll all thermostats CO2 settings/inputs and adjust the outside air damper setting based on the average (adjustable) CO2 levels. Outside air damper max setting shall be as scheduled in the air handling units schedule. Minimum setpoint is 5% of supply air flow. The Graphic for the Air handling unit shall include a table display of the VAV/Fan Powered box, space name and associated CO2 level.

2. The return air CO2 shall be measured and displayed on the AHU graphic.

N. Prefilter Differential Pressure Monitor:

1. The BAS controller shall monitor the differential pressure across the prefilter.
2. The differential pressure monitor shall have a fixed range of 0”-2.5”w.c.
3. Software alarms shall be provided as follows:

a. Prefilter Change Required: Prefilter differential pressure exceeds 2”w.c. (adj.).

O. Mixed Air Temperature:

1. The BAS controller shall monitor the mixed air temperature and use as required for economizer control (if present) or preheating control (if present).
2. Software alarms shall be provided as follows:

a. High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).
b. Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

P. Return Air Temperature:

1. The BAS controller shall monitor the return air temperature and use as required for setpoint control or economizer control.
2. Software alarms shall be provided as follows:

a. High Return Air Temp: If the return air temperature is greater than 90°F (adj.).
b. Low Return Air Temp: If the return air temperature is less than 45°F (adj.).

Q. Supply Air Temperature

1. The BAS controller shall monitor the supply air temperature.
2. Software alarms shall be provided as follows:

a. High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
b. Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

R. Outside Air CFM

1. The BAS controller shall monitor the outside air CFM to ensure proper ventilation air is being introduced.
2. The existing airflow monitoring station shall be removed and replaced with the airflow station specified here in these specifications by the BAS contractor.

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show On Graphic
Supply Air Static Pressure	×							×	×	×
Filter Differential Pressure	×							×	×	
Return Air Temp	×							×	×	×
Return Air Humidity	×							×	×	×
Return Air CO2	x							x	x	x
Space Air CO2 w/VAV Tag/Room Tag	×							×	×	×
Mixed Air Temp	×							×	×	×
Supply Air Temp	×							×	×	×
Supply Fan VFD Speed		×						×		×
Outside air CFM	x							x	x	x
Hot water Coil Valve		×		x				×		×
Chilled Water Coil Valve		×		x				×		×
Hot Gas Reheat		×						×		×
Mixed Air Dampers		×						×		×
High Static Shutdown			×					×	×	×
Supply Air Smoke Detector			×					×	×	×
Return Air Smoke Detector			×					×	×	×
Supply Fan VFD Fault			×					×	×	×
Supply Fan Status			×					×	×	×
Supply Fan Start/Stop				×				×		×

4.3 CONSTANT VOLUME AIR HANDLING UNITS

A. General

1. The air handling unit shall be equipped with a constant speed supply fan, chilled water cooling coil, hot water heating coil, outside air damper, return air damper and outside air measuring station.

B. Run Conditions - Requested:

1. The unit shall run according to a user definable time schedule in the following modes:

a. Occupied Mode: The unit shall maintain

1. A 74°F (adj.) cooling setpoint
2. A 70°F (adj.) heating setpoint.

b. Unoccupied Mode (night setback): The unit shall maintain

1. A 85°F (adj.) cooling setpoint.
2. A 55°F (adj.) heating setpoint.

C. Demand Limiting - Zone Setpoint Optimization:

1. To lower power consumption, the zone setpoints shall automatically relax when the facility power consumption exceeds definable thresholds. The amount of relaxation shall be individually configurable for each zone. The zone setpoints shall automatically return to their previous settings when the facility power consumption drops below the thresholds.

D. Zone Setpoint Adjust:

1. The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

E. Zone Optimal Start:

1. The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

F. Zone Unoccupied Override:

1. A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for 60 minutes (adj.). At the expiration of this time, control of the unit shall automatically return to the schedule.

G. Supply Air Smoke Detection (If Applicable):

1. The unit shall shut down and generate an alarm upon receiving a supply air smoke detector status.

H. Supply Fan

1. The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties.
2. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime.
3. Software alarms shall be provided as follows:

    a. Supply Fan Failure: Commanded on, but the status is off.
    b. Supply Fan in Hand: Commanded off, but the status is on.
    c. Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

I. Supply Air Temperature Setpoint - Optimized:

1. The BAS controller shall monitor the supply air temperature and shall maintain a supply air temperature setpoint reset based on zone cooling and heating requirements
2. The supply air temperature setpoint shall be reset for cooling based on zone cooling requirements as follows:

    a. The initial supply air temperature setpoint shall be 55°F (adj.).
    b. As cooling demand increases, the setpoint shall incrementally reset down to a minimum of 53°F (adj.).
    c. As cooling demand decreases, the setpoint shall incrementally reset up to a maximum of 72°F (adj.)

3. If more zones need heating than cooling, then the supply air temperature setpoint shall be reset for heating as follows:

    a. The initial supply air temperature setpoint shall be 82°F (adj.).
    b. As heating demand increases, the setpoint shall incrementally reset up to a maximum of 85°F (adj.).
    c. As heating demand decreases, the setpoint shall incrementally reset down to a minimum of 72°F (adj.).

J. Cooling Coil

1. The BAS controller shall measure the supply air temperature and modulate the cooling to maintain its cooling setpoint.

2. The cooling shall be enabled whenever:

    a. Outside air temperature is greater than 60°F (adj.).
    b. AND the economizer (if present) is disabled or fully open.
    c. AND the supply fan status is on.
    d. AND the heating (if present) is not active.

3. Software alarms shall be provided as follows:

    a. High Supply Air Temp: If the supply air temperature is 5°F (adj.) greater than setpoint.

K. Hot Water Heating Section

1. The BAS controller shall measure the supply air temperature modulate the heating coil control valve to maintain its heating setpoint.
2. The heating shall be enabled whenever:

    a. Outside air temperature is less than 65°F (adj.).
    b. AND the supply fan status is on.
    c. AND the cooling is not active.

3. The gas heating section shall energize whenever:

    a. Supply air temperature drops from 40°F to 35°F (adj.).

4. Software alarms shall be provided as follows:

    a. Low Supply Air Temp: If the supply air temperature is 5°F (adj.) less than setpoint.

L. Economizer

1. The BAS controller shall measure the mixed air temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F (adj.) less than the supply air temperature setpoint.

2. The economizer shall be enabled whenever:

    a. Outside air temperature is less than 55°F (adj.).
    b. AND the outside air enthalpy is less than 22Btu/lb (adj.)
    c. AND the outside air temperature is less than the return air temperature.
    d. AND the outside air enthalpy is less than the return air enthalpy.
    e. AND the supply fan status is on.

3. The economizer shall close whenever:

    a. Mixed air temperature drops from 40°F to 35°F (adj.)

    b. OR on loss of supply fan status.

4. The outside and exhaust air dampers shall close and the return air damper shall open when the unit is off. If Optimal Start Up is available the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully closed.

M. Minimum Outside Air Ventilation – Space Air CO2 Control:

1. When in the occupied mode, the controller shall measure the space air CO2 levels and modulate the outside air dampers open on rising CO2 concentrations, overriding normal damper operation to maintain a CO2 differential setpoint of 1200 ppm (adj.) as compared to the outdoor air. The controller shall poll all thermostats CO2 settings/inputs and adjust the outside air damper setting based on the average (adjustable) CO2 levels. Outside air damper max setting shall be as scheduled in the air handling units schedule. Minimum setpoint is 5% of

supply air flow. The Graphic for the Air handling unit shall include a table display of the space name and associated CO2 level.

2. The return air CO2 levels shall be displayed on the AHU screen.

N. Prefilter Differential Pressure Monitor

1. The BAS controller shall monitor the differential pressure across the prefilter.
2. The differential pressure monitor shall have a fixed range of 0”-2.5”w.c.
3. Software alarms shall be provided as follows:

   a. Prefilter Change Required: Prefilter differential pressure exceeds 2”w.c. (adj.).

O. Mixed Air Temperature:

1. The BAS controller shall monitor the mixed air temperature and use as required for economizer control (if present) or preheating control (if present).
2. Software alarms shall be provided as follows:

   a. High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).
   b. Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

P. Return Air Temperature:

1. The BAS controller shall monitor the return air temperature and use as required for setpoint control or economizer control.
2. Software alarms shall be provided as follows:

   a. High Return Air Temp: If the return air temperature is greater than 90°F (adj.).
   b. Low Return Air Temp: If the return air temperature is less than 45°F (adj.).

Q. Supply Air Temperature

1. The BAS controller shall monitor the supply air temperature.
2. Alarms shall be provided as follows:

   a. High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
   b. Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

R. Environmental Index:

1. When the zone is occupied, the controller will monitor the deviation of the zone temperature from the heating or cooling setpoint. This data will be used to calculate a 0 - 100% *Environmental Index* which gives an indication of how well the zone is maintaining comfort. The controller will also calculate the percentage of time since occupancy began that the Environmental Index is 70% or higher. Optionally, a weighting factor can be configured to adjust the contribution of the zone to the rollup average index based upon the floor area of the zone, importance of the zone, or other static criteria.

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show On Graphic
Zone Temperature	×							×	×	×
Zone Setpoint Adjust	×							×	×	×
Filter Differential Pressure	×							×	×	
Return Air Temp	×							×	×	×
Return Air CO2	×							×	×	×
Space Air CO2	×							×	×	×
Mixed Air Temp	×							×	×	×
Supply Air Temp	×							×	×	×
Chilled Water Coil Valve		X						X	X	X
Hot Water Coil Valve		×						×	X	×
Mixed Air Dampers		×						×		×
Zone Override			×					×	×	×
Supply Air Smoke Detector			×					×	×	×
Return Air Smoke Detector			×					×	×	×
Supply Fan Status			×					×	×	×
Supply Fan Start/Stop				×				×		×

4.4 VARIABLE VOLUME BOXES- SINGLE DUCT

A. Run Conditions - Scheduled:

1. The unit shall run according to a user definable time schedule in the following modes:

   a. Occupied Mode: The unit shall maintain

      1. A 74°F (adj.) cooling setpoint
      2. A 70°F (adj.) heating setpoint.

   b. Unoccupied Mode (night setback): The unit shall maintain

      1. A 85°F (adj.) cooling setpoint.
      2. A 55°F (adj.) heating setpoint.

2. Alarms shall be provided as follows:

   a. High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
   b. Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

B. Demand Limiting - Zone Setpoint Optimization

1. To lower power consumption, the zone setpoints shall automatically relax when the facility power consumption exceeds definable thresholds. The amount of

relaxation shall be individually configurable for each zone. The zone setpoints shall automatically return to their previous settings when the facility power consumption drops below the thresholds.

C. Zone Setpoint Adjust

1. The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

D. Zone Optimal Start

1. The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

E. Morning Warm-up/Night Heating Mode

1. If morning warm-up or night heating is required, the following shall occur:

   a. The AHU serving the associated VAV box shall energize.
   b. The VAV box damper shall modulate to the minimum position and the hot water coil control valve shall modulate to maintain the space temperature setpoint (night setback or morning warm-up).

2. Once the night setback space temperature setpoint (night setback or morning warm-up) has been achieved, the unit shall return to the scheduled mode.

F. Morning Cool-down/Night Cooling Mode

1. If morning cool-down or night cooling is required, the following shall occur:

   a. The AHU serving the associated VAV box shall energize.
   b. The VAV box damper shall modulate to maintain the space temperature setpoint (night setback or morning cool-down).

2. Once the night setback space temperature setpoint (night setback or morning cool-down) has been achieved, the unit shall return to the scheduled mode.

G. Zone Unoccupied Override:

1. A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for 60 minutes (adj.). At the expiration of this time, control of the unit shall automatically return to the schedule.

H. Variable Volume Terminal Unit - Flow Control

1. The unit shall maintain occupied zone setpoints by controlling the airflow through one of the following:

   a. When zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum occupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.

b. When the zone temperature is between the cooling setpoint and the heating setpoint, the zone damper shall maintain the minimum required zone ventilation (adj.).
c. When zone temperature is less than its heating setpoint, the controller shall enable heating to maintain the zone temperature at its heating setpoint. Additionally, if warm air is available from the AHU, the zone damper shall modulate between the minimum occupied airflow (adj.) and the maximum heating airflow (adj.) until the zone is satisfied.

2. The unit shall maintain unoccupied zone setpoints by controlling the airflow through one of the following:

a. When the zone is unoccupied the zone damper shall control to its minimum unoccupied airflow (adj.).
b. When the zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum unoccupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.
c. When zone temperature is less than its unoccupied heating setpoint, the controller shall enable heating to maintain the zone temperature at the setpoint. Additionally, if warm air is available from the AHU, the zone damper shall modulate between the minimum unoccupied airflow (adj.) and the auxiliary heating airflow (adj.) until the zone is satisfied.

I. Reheating Coil Valve

1. The controller shall measure the zone temperature and modulate the reheating coil valve open on dropping temperature to maintain its heating setpoint.

J. Reheating - High Discharge Air Temperature Limit

1. The controller shall measure the discharge air temperature and limit reheating if the discharge air temperature is more than 15°F (adj.) above the zone temperature.

K. Discharge Air Temperature

1. The controller shall monitor the discharge air temperature.
2. Alarms shall be provided as follows:

a. High Discharge Air Temp: If the discharge air temperature is greater than 120°F (adj.).
b. Low Discharge Air Temp: If the discharge air temperature is less than 40°F (adj.).

L. Environmental Index

1. When the zone is occupied, the controller will monitor the deviation of the zone temperature from the heating or cooling setpoint and calculate a 0 - 100% *Environmental Index* which gives an indication of how well the zone is maintaining comfort. The controller will also calculate the percentage of time since occupancy began that the Environmental Index was 70% or higher. The environmental index information shall be shown graphically for each zone as well as the entire building.

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show On Graphic
Zone Temp	×							×	×	×
Zone Setpoint Adjust	×							×	×	×
Airflow	×							×	×	×
Discharge Air Temp	×							×	×	×
Reheat Valve		×						×		×
Zone Damper		×						×		×
Zone Override			×					×		×

4.5 FAN POWERED VARIABLE VOLUME BOXES

C. Run Conditions - Scheduled:

1. The unit shall run according to a user definable time schedule in the following modes:

   a. Occupied Mode: The unit shall maintain

      1. A 74°F (adj.) cooling setpoint
      2. A 70°F (adj.) heating setpoint.

   b. Unoccupied Mode (night setback): The unit shall maintain

      1. A 85°F (adj.) cooling setpoint.
      2. A 55°F (adj.) heating setpoint.

2. Alarms shall be provided as follows:

   a. High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
   b. Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

D. Demand Limiting - Zone Setpoint Optimization

1. To lower power consumption, the zone setpoints shall automatically relax when the facility power consumption exceeds definable thresholds. The amount of relaxation shall be individually configurable for each zone. The zone setpoints shall automatically return to their previous settings when the facility power consumption drops below the thresholds.

E. Zone Setpoint Adjust

1. The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

F. Zone Optimal Start

1. The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

G. Morning Warm-up/Night Heating Mode

1. If morning warm-up or night heating is required, the following shall occur:

   a. The AHU serving the associated VAV box shall energize.
   b. The VAV box damper shall modulate to the minimum position and the hot water coil control valve shall modulate to maintain the space temperature setpoint (night setback or morning warm-up).

2. Once the night setback space temperature setpoint (night setback or morning warm-up) has been achieved, the unit shall return to the scheduled mode.

H. Morning Cool-down/Night Cooling Mode

1. If morning cool-down or night cooling is required, the following shall occur:

   a. The AHU serving the associated VAV box shall energize.
   b. The VAV box damper shall modulate to maintain the space temperature setpoint (night setback or morning cool-down).

2. Once the night setback space temperature setpoint (night setback or morning cool-down) has been achieved, the unit shall return to the scheduled mode.

I. Zone Unoccupied Override:

1. A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for 60 minutes (adj.). At the expiration of this time, control of the unit shall automatically return to the schedule.

J. Variable Volume Terminal Unit - Flow Control

1. The unit shall maintain occupied zone setpoints by controlling the airflow through one of the following:

   a. The fan powered box fan shall operate continuously during the occupied period. During the unoccupied period the fan shall cycle based on space temperature setpoint.

   b. When zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum occupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.
   c. When the zone temperature is between the cooling setpoint and the heating setpoint, the zone damper shall maintain the minimum required zone ventilation (adj.).
   d. When zone temperature is less than its heating setpoint, the controller shall enable heating to maintain the zone temperature at its heating setpoint. Additionally, if warm air is available from the AHU, the zone damper shall

modulate between the minimum occupied airflow (adj.) and the maximum heating airflow (adj.) until the zone is satisfied.

2. The unit shall maintain unoccupied zone setpoints by controlling the airflow through one of the following:

    a. Cycling the fan powered box fan.

    b. When the zone is unoccupied the zone damper shall control to its minimum unoccupied airflow (adj.).
    c. When the zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum unoccupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.
    d. When zone temperature is less than its unoccupied heating setpoint, the controller shall enable heating to maintain the zone temperature at the setpoint. Additionally, if warm air is available from the AHU, the zone damper shall modulate between the minimum unoccupied airflow (adj.) and the auxiliary heating airflow (adj.) until the zone is satisfied.

K. Reheating Coil Valve

1. The controller shall measure the zone temperature and modulate the reheating coil valve open on dropping temperature to maintain its heating setpoint.

L. Reheating - High Discharge Air Temperature Limit

1. The controller shall measure the discharge air temperature and limit reheating if the discharge air temperature is more than 15°F (adj.) above the zone temperature.

M. Discharge Air Temperature

1. The controller shall monitor the discharge air temperature.
2. Alarms shall be provided as follows:

    a. High Discharge Air Temp: If the discharge air temperature is greater than 120°F (adj.).
    b. Low Discharge Air Temp: If the discharge air temperature is less than 40°F (adj.).

N. Environmental Index

1. When the zone is occupied, the controller will monitor the deviation of the zone temperature from the heating or cooling setpoint and calculate a 0 - 100% *Environmental Index* which gives an indication of how well the zone is maintaining comfort. The controller will also calculate the percentage of time since occupancy began that the Environmental Index was 70% or higher. The environmental index information shall be shown graphically for each zone as well as the entire building.

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show On Graphic

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show On Graphic
Zone Temp	×							×	×	×
Zone Setpoint Adjust	×							×	×	×
Box Supply Fan		x		x				x	x	x
Airflow	×							×	×	×
Discharge Air Temp	×							×	×	×
Reheat Valve		×						×		×
Zone Damper		×						×		×
Zone Override			×					×		×

4.5 KITCHEN VENTILATOR SYSTEM (HRU-1 and Kitchen Hood Exhaust fan)

A. General

1. The Kitchen Ventilator System shall be equipped with a make-up air unit (ERU-1) which contains a supply fan, Energy recovery device, hot water coil in supply duct, a two position outside air damper and a hood exhaust fan with an exhaust temperature sensor. The BAS contractor shall provide all controls for the Kitchen Ventilator System.

B. Run Conditions - Interlocked:

1. The ERU and exhaust hood fan shall be interlocked to run whenever the kitchen hood exhaust system manual switch is placed in the “On” position unless the unit is shutdown on safeties. Provide a separate switch for enabling on the heat.

2. In addition to the manual switch, a hood exhaust temperature sensor shall also be present. If a hood exhaust temperature of 100°F (adj.) is sensed, the BAS shall enable the hood exhaust fan as well as the MAU. This shall be hardwired into the hood exhaust fan starter.

C. Smoke Detection:

1. The unit shall shut down and generate an alarm upon receiving a smoke detector status.

D. Outside Air Damper:

1. The outside air damper shall open anytime the unit runs and shall close anytime the unit stops. The supply fan shall start only after the damper status has proven the damper is open. The outside air damper shall close 4sec (adj.) after the supply fan stops.
2. Alarms shall be provided as follows:
   - Outside Air Damper Failure: Commanded open, but the status is closed.
   - Outside Air Damper in Hand: Commanded closed, but the status is open.

E. Supply Fan:

1. The supply fan shall run anytime the unit is commanded to run. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime, unless shutdown on safeties.
2. Alarms shall be provided as follows:
   - Supply Fan Failure: Commanded on, but the status is off.
   - Supply Fan in Hand: Commanded off, but the status is on.
   - Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

F. Supply Air Temperature Setpoint - Fixed:

1. The controller shall monitor the supply air temperature and shall maintain a fixed supply air temperature setpoint of 55°F (adj.).

G. Hot water heating coil:

1. The controller shall measure the supply air temperature and modulate the heating hot water control valve to maintain its discharge heating setpoint.
2. The heating shall be enabled whenever:
   - Outside air temperature is less than 65°F (adj.).
   - AND the supply air temperature is below heating setpoint.
   - AND the fan status is on.

I. Prefilter Differential Pressure Monitor:

1. The BAS controller shall monitor the differential pressure across the prefilter.
2. The differential pressure monitor shall have a fixed range of 0”-1.0” w.c. (adj.).
3. Software alarms shall be provided as follows:
   - Prefilter Change Required: Prefilter differential pressure exceeds 1.0” w.c. (adj.).

J. Supply Air Temperature:

1. The controller shall monitor the supply air temperature.
2. Alarms shall be provided as follows:
   - High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
   - Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

K. Hood Exhaust Fan:

1. The exhaust fan shall run anytime the unit is commanded to run or whenever the exhaust temperature sensor detects high temperature. To prevent short cycling, the exhaust fan shall have a user definable (adj.) minimum runtime, unless shutdown on safeties.
2. Alarms shall be provided as follows:
   - Exhaust Fan Failure: Commanded on, but the status is off.
   - Exhaust Fan in Hand: Commanded off, but the status is on.
   - Exhaust Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

L. Dish washer Exhaust Fan:

1. The dishwasher exhaust fan shall run anytime the unit is commanded to run or whenever the wall switch is turned on.

	Hardware Points				Software Points					
Point Name	**AI**	**AO**	**BI**	**BO**	**AV**	**BV**	**Sched**	**Trend**	**Alarm**	**Show On Graphic**
Supply Air Temp	×							×		×
Hood Exhaust Temperature	×							×	×	×
Filter Differential Pressure	×							×	×	×
Hot water heating coil control valve		x						×		×
Smoke Detector			×					×	×	×
Supply Fan Status			×					×		×
Exhaust Fan Status			×					×		×
Outside Air Damper				×				×		×
Supply Fan Start/Stop				×				×		×
Exhaust Fan Start/Stop				×				×		×
ERU start/stop			x	x				x		x
ERU Heater Enable			x	x				x		x
Kitchen Dishwasher Exh Fan			x	x				x		x

4.6 EXHAUST FAN – OCCUPIED/UNOCCUPIED

A. Run Conditions - Scheduled:

1. The fan shall run according to a user definable schedule.
2. Fan

   a. The fan shall have a 5 minute (adj.) minimum runtime.

B. Fan Status:

1. The controller shall monitor the fan status.
2. Alarms shall be provided as follows:

   a. Fan Failure: Commanded on, but the status is off.
   b. Fan in Hand: Commanded off, but the status is on.
   c. Fan Runtime Exceeded: Fan status runtime exceeds a user definable limit (adj.).

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show On Graphic
Fan Status			×					×		×
Fan Start/Stop				×				×		×

4.7 EXHAUST FAN – SPACE TEMPERATURE CONTROL

A. Run Conditions – Continuous

1. The unit shall be continuously enabled to maintain a zone temperature cooling setpoint of 78°F (adj.).
2. Alarms shall be provided as follows:

    a. High Zone Temp: If the zone temperature is greater than the cooling setpoint by 5°F (adj.).

B. Fan

1. The fan shall run and the outdoor intake damper shall open (if applicable) anytime the zone temperature rises above cooling setpoint, unless shut down on safeties.

C. Fan Status

1. The controller shall monitor the fan status.
2. Alarms shall be provided as follows:

    a. Fan Failure: Commanded on, but the status is off.
    b. Fan in Hand: Commanded off, but the status is on.
    c. Fan Runtime Exceeded: Fan status runtime exceeds a user definable limit (adj.).

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show On Graphic
Zone Temp	×							×	×	×
Fan Status			×					×	×	×
Fan Start/Stop				×				×		×
OA intake Damper				×				×		×

4.8 MINI SPLIT SYSTEM UNITS

A. Run Conditions - Scheduled

1. The units shall be furnished with a programmable thermostat by the unit manufacturer. The BAS contractor shall be responsible for the following:

    a. Mount and wire each split system unit space thermostat.
    b. Wire condenser interlock wiring to outdoor unit.
    c. Provide a redundant BAS space sensor to monitor space temperature.

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show On Graphic

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show On Graphic
Zone Temp	×							×	×	×

4.9 CABINET/HORIZONTAL UNIT HEATERS

A. Run Conditions – Scheduled

1. The unit shall run according to a user definable time schedule in the following modes:

   a. Occupied Mode: The unit shall maintain

      1. A 70°F (adj.) heating setpoint.

   b. Unoccupied Mode (night setback): The unit shall maintain

      1. A 55°F (adj.) heating setpoint.

2. Alarms shall be provided as follows:

   a. Low Zone Temp: If the zone temperature is less than the heating setpoint by 2°F (adj.).

B. Fan

1. The fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime.

C. Fan Status

1. The controller shall monitor the fan status.

D. Heating Coil Valve

1. The controller shall measure the zone temperature and modulate the heating coil valve to maintain its heating setpoint.
2. The heating shall be enabled whenever:

   a. Outside air temperature is less than 65°F (adj.).
   b. AND the zone temperature is below heating setpoint.

E. Environmental Index

1. When the zone is occupied, the controller will monitor the deviation of the zone temperature from the heating or cooling setpoint and calculate a 0 - 100% *Environmental Index* which gives an indication of how well the zone is maintaining comfort. The controller will also calculate the percentage of time

since occupancy began that the Environmental Index was 70% or higher. The environmental index information shall be shown graphically for each zone as well as the entire building.

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show On Graphic
Zone Temp	×							×	×	×
Heating Valve		×						×		×
Supply Fan Status				×				×		×
Supply Fan				×				×		×

4.10 MISCELLANEOUS MONITORING AND METERING

A. The BAS system shall monitor the emergency generator transfer switch.

B. The BAS shall monitor the following generator points:
   1. Generator Run Status.
   2. Generator Alarm.

A. The BAS system shall monitor and alarm the freezer and refrigerator temperatures.

	Hardware Points				**Software Points**					
Point Name	**AI**	**AO**	**BI**	**BO**	**AV**	**BV**	**Sched**	**Trend**	**Alarm**	**Show On Graphic**
Freezer Temperature	×							×	×	×
Refrigerator Temperature	×							×	×	×
Emergency Generator Run Status			×					×	×	×
Emergency Generator Alarm			×					×	×	×
Emergency Generator Transfer Switch Contactor Monitoring			×					×	×	×

4.11 OCCUPIED/UNOCCUPIED OPTIMUM START STOP ZONES:

A. The direct digital control system shall provide occupied/unoccupied zone time schedules for the new equipment and existing equipment as indicated below. Zone temperature sensors shall function to provide representative space temperature information for each zone and displayed on the DDC system. Each zone shall be provided with its own discrete program and operator shall be able to edit and view the programs via the web or on any operator workstation. Zone scheduling shall be approved by the Project Engineer and Owner prior to implementation of any application programming by the BAS Contractor. The following zones shall be provided at a minimum plus any addition existing zones found shall also be included.

1. Primary School A Wing
2. Primary School B Wing
3. Primary School C Wing
4. Primary School Library/Media Center
5. Primary School Main Gym
6. Primary School Cafeteria
7. Kitchen
8. District Administration Wing

END OF SECTION 23 09 23

SECTION 23 36 05

AIR HANDLING UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Air Handling Unit Blender Section.

1.2 REFERENCES

A. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):
   1. ASHRAE 36 - Methods of Testing for Sound Rating Heating, Refrigerating and Air-Conditioning Equipment

B. Air Diffusion Council (ADC):
   1. ADC 1062R4 - Equipment Test Code

C. National Fire Protection Association (NFPA):
   1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems

D. Underwriters Laboratories Inc. (UL):
   1. UL 181 - Factory-Made Air Duct Materials and Duct Connections

1.3 SUBMITTALS

A. Shop Drawings, Product Data, and Samples: Submit under provisions of Division 1.

B. Shop Drawings: Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands and inlet pressures of 1” to 4” w.g.

C. Product Data: Submit manufacturer's installation instructions.

D. Submit manufacturer's descriptive literature, operating instructions and maintenance and repair data.

E. Include in operating instructions, directions for resetting constant volume regulators.

1.4 WARRANTY

A. Provide Owner with manufacturer's warranty for the complete unit, including all hardware and components for a period of one year from date of Substantial Completion.

B. Any manufacturer defects or damage arising during the warranty period shall be corrected to the satisfaction of the Owner at no additional cost.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

1. Manufacturer: diffusers shall be standard products as manufactured by Trane Company, Lacrosse, WI

B. Other Acceptable Manufacturers:
1. None.

2.2 AIR HANDLING UNIT AIR BLENDER SECTION

A. Air mixers (blenders) shall be provided and located as indicated on the schedule and drawings. Mixers shall incorporate fixed blades, with no moving parts. Mixer panels shall be sized and installed in the unit with adequate distances upstream and downstream, based on the manufacturer's cataloged performance, to ensure a minimum mixing effectiveness of 70% at 25% outside air, at one mixer diameter downstream of the mixer.

B. Construction:

1. Cabinets shall be constructed of same material as existing air handling unit. The blender section shall bolt to existing air handling unit seamlessly. There shall be full gasketing, etc., to be provided by the Trane Company.

PART 3 EXECUTION

3.1 INSTALLATION

A. Support units individually from the building floor. Install per unit manufacturers recommendations. Do not support from the ceiling system, conduit, piping or adjacent ductwork.

B. During construction and prior to installation, all units shall be protected from dust, dirt, grit and other foreign matter. Units shall be covered with plastic, craft paper, or other suitable and approved protection material.

C. The installation shall be approved by the Trane Company. Contractor shall receive a written letter that the final installation meets Trane Company requirements for a complete and operational air handling unit. The unit shall pass all air flow tests and leakage requirements of the Trane Company for these size units.

3.2 ADJUSTMENT

A. Reset volume with damper operator attached to assembly allowing flow range modulation from 100% of design flow to 0% full flow.

END OF SECTION