PROPOSED
FIREHOUSE ADDITION & ALTERATION
HARRISON FIRE DISTRICT
206 HARRISON AVENUE
HARRISON, NY 10528

PREPARED FOR:

HARRISON FIRE DISTRICT
TOWN/VILLAGE OF HARRISON
206 HARRISON AVENUE
HARRISON, NY 10528

ARCHITECT:

SENDLEWSKI ARCHITECTS PC.
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MECHANICAL WORK
CONTRACT 20-04 M

ISSUED FOR BIDDING: April 1, 2021

HVAC

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. HVAC contractor to supply and install the following: all packaged rooftop units and all split systems, all hot water (hydronic) coils and three way valves, all boilers with all controls, pumps, all ductwork, duct insulation, duct supports, diffusers, grilles, dampers, louvers, domestic range hood, all PTACS, ERV, uvc light kits, baseboard radiation, cabinet heaters, unit heaters, control switches and timers, all exhaust fans, ventilation fans, filters, Install smoke detectors and relays in all return/supply ductwork to shut down units upon detection of smoke or loss of power in building. Integrate with building fire/smoke detection and sprinkler system and provide manual unit restart in accordance with Section 16721E. Building automation system with All controls, remote sensors, zone controllers, control wiring for controls and connection to equipment to be provided and installed by HVAC contractor. See Building Automation System (BAS) specification. HVAC contractor shall prepare, pay for and obtain all permits and approvals as required. All systems shall be installed complete and in working order.

*Alternate: One ducted cooling only split system for the apparatus bay.
*Alternate: The replacement of the existing cookline exhaust system and the addition of a makeup air unit.

C. Supply and install intake and venting, for boiler and domestic hot water heater and include condensate drains, neutralization kits and piping to plumbing system for boiler, domestic hot water heater and air handling units.

D. Contractors shall furnish all tools, machinery, equipment, scaffolding, appurtenances and appliances necessary for the satisfactory handling and execution of their work.

E. N/A

F. The work under these contracts shall include all labor, materials and incidentals necessary to execute a complete workmanlike job in accordance with the requirements of the Code and all local authorities having jurisdiction.

G. All work shall be done in such locations and at such times as directed.

H. The contractors shall place and store his materials as directed.

I. The contractor shall at all times keep the premises free from accumulations of waste material or rubbish caused by his machines, materials, employees, or work and shall pile in neat piles outside of each building as directed. He shall cooperate with all other trades appurtenant to his work. At the completion of the work, he shall remove all his tools, scaffolding and surplus materials.

J. Contractors shall be responsible for initiating, maintaining and supervising all safety precautions in accordance with O.S.H.A. requirements.

K. In the event that part of the building will be occupied during construction, the interior of the building will be separated and the Contractor will schedule his work accordingly.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section General Conditions - Temporary facilities and controls, including temporary heat, light, power and water. Cooperate in ensuring adequate protection.

B. Section General Conditions - General material, equipment and workmanship standards.

C. Section 03100 - Concrete.

D. Section 07620 - Flashing of mechanical work.

E. Section 09900 - Finish painting.

F. Section General Conditions - Protection of equipment.

G. Section General Conditions - Cutting and patching.

H. Section 15010S - General Provisions Sprinkler.

I. Section 15010P - General Provisions Plumbing.

J. Section 16010E - General Provisions Electrical.

1.02 DRAWINGS AND COORDINATION

A. It is not the intention of the drawings to show every item, piece of equipment and detail but rather to show systems to be installed. Provide systems with all appurtenant equipment to make a complete operating system.

B. Inspect the work area prior to commencing the job. Install work as closely as possible to layouts shown on drawings. Modify work as necessary to meet job conditions and to clear other equipment. Consult Architect before making changes which affect the function or appearance of systems.

C. Dimensions, elevations and locations are shown approximately. Verify measurements in field and coordinate with other trades.

D. Architect reserves the right to order changes in layout of such items as piping, ducts and equipment if such changes do not substantially affect costs and if affected items have not been fabricated or installed.

E. In some cases, drawings are based on products of one manufacturer, as listed in the specifications. Be responsible for modifications made necessary by substitution of products of other manufacturers.

F. Do not install part of a system until all critical components of the system and related systems have been approved. Coordinate parts of system.

G. Coordinate work with work specified in other sections. Relocate work if required for proper installation and functioning of other systems.

H. Install products in accordance with manufacturers' instructions. Notify Architect if contract documents conflict with manufacturers' instructions. Comply with Architect's interpretations.

I. Provide and install all brackets, supports, anchors and frames required for installation of work specified in this division. Provide all require pitch pockets for both mechanical and electrical needs of work herein.

J. Provide all cutting and patching, excavation and backfilling required for installation of work specified in this Division.

K. Provide and install a motor starter as required.

1.03 PROJECT RECORD DRAWINGS

A. Submit shop drawings in accordance with Section 15011H.

B. Note that the General Conditions specify that project record drawings be prepared.

1.04 EQUIPMENT CLEARANCES

A. Deliver equipment knocked down if necessary.

B. Install equipment with adequate clearances for maintenance and operation both of the equipment and of adjacent equipment.

1.05 PRELIMINARY OPERATION

A. Provide start-up lubrication in accordance with manufacturer's recommendations. Operate mechanical systems with required supervision for at least 2 full days prior to substantial completion. Make necessary adjustments and check proper operation.

1.06 TESTS PRIOR TO SUBSTANTIAL COMPLETION

A. Tests shall be attended by representatives of mechanical subcontractors, equipped with instruments required to demonstrate proper functioning of systems, as specified. Demonstrate the following:
   1. Equipment installed and operating in accordance with manufacturer's specifications

and instructions and with these specifications.
2. Safety and temperature controls operating as specified.
3. Systems properly flushed, cleaned and free of contaminants.
4. Systems properly balanced.
5. Motors equipped with proper overload protection and not operating under overload. Obtain ammeter readings.
6. Instruments recording properly.

1.07 WARRANTY

A. Submit written warranty or warranties covering work specified in this division. Period: 1 year from the date of substantial completion of the building or of the equipment being warranted, whichever is later. Owner is to receive full use of equipment for period of warranty.

1.08 MAINTENANCE AND OPERATING INSTRUCTIONS

A. Submit three (3) typed copies of maintenance and operating instructions for equipment having moving parts and parts which may reasonably be anticipated to require replacement.
1. List replacement parts and order procedure.
2. Include lubrication instructions and schedule, with types of lubricant to be used.
3. Include maintenance and service procedures.

B. Instruct Owner's personnel in use of equipment specified in this Division.

C. Submit three (3) typed copies of maintenance and operating manuals for equipment specified in this Division.

1.09 MECHANICAL SYSTEMS IDENTIFICATION

A. See Section 15190H - Mechanical Identification.

1.10 FIELD QUALITY CONTROL

A. Test piping systems hydrostatically at 150% of expected working pressure unless otherwise specified.

B. Reports shall list system tested, date, results, description of correction of faults, and witnesses.

C. Maintain tests 4 hours, unless otherwise specified.

D. Preform preliminary tests before witnessed tests.

E. Give Architect 48 hours notice of tests. Architect will observe tests.

1.11 CODES AND ORDINANCES

A. Conform to the requirements of codes and ordinances of authorities having jurisdiction, as specified in the General Conditions. In particular, conform to the requirements of the State of New York Building Code.

B. Conform to the State of New York Building Code energy conservation requirements, including certification, labelling and maintenance instructions for equipment.

C. If Contract Documents conflict with codes and ordinances, notify Architect. If requirements of Contract Documents exceed requirements of codes and ordinances, comply with requirements of Contract Documents.

1.12 REMOVAL AND DISPOSAL OF WASTE MATERIALS

A. Take down and remove existing mechanical equipment indicated to be removed. Turn over all equipment to owner or dispose of by direction of the owner's authorized representative.

B. Remove and dispose of all debris and waste materials from the site in a safe and legal manner.

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

1.02 APPLICABILITY

A. This section applies to the contract for HVAC and supplements the General Conditions. Should any discrepancy exist between this section and the General Conditions, precedence shall be given to this section.

B. Contractor is required to make all submissions indicated herein in the manner indicated.

C. No materials of any kind are to be installed until submissions have been approved in writing by the Architect.

1.03 PAYMENT WITHHELD

A. Contractor is notified that requisitions for payment for items installed prior to approved submissions may be denied in full until submission is made and approved.

1.04 TYPES OF SUBMITTALS

A. Certification:
   1. Certification shall be a written statement indicating full compliance of the material in questions with the contract documents.
   2. Certification shall include all applicable test reports or calculations indicating compliance.
   3. Certifications shall be furnished on the letterhead of the issuing organization and signed by a responsible officer of that organization.

B. Coordination Data:
   1. Coordination data shall be information required to be furnished to other prime contractors to allow coordination of the work.
   2. Coordination data shall indicate locations, dimensions and roughing requirements of equipment or materials indicated.
   3. Coordination data shall be transmitted directly to Contractors, with a copy to the Architect for his information.

C. Manufacturers Literature:

1. Manufacturers literature shall be standard catalogs or data sheets furnished by the manufacturer.
2. Literature must furnish sufficient data to indicate compliance with the contract documents.
3. Specific items to be furnished must be highlighted.

D. Samples:
1. A sample shall be an actual piece of the material in question, fabricated to the exact dimensions and finish specified.
2. Each sample shall be sized as appropriate to demonstrate compliance with the contract documents.

E. Shop Drawings:
1. Shop drawings shall consist of drawings to scale by a competent draftsman.
2. Shop drawings must be prepared specifically for this project.
3. Manufacturers standard drawings will not be accepted as shop drawing unless modified specifically for this project.
4. Shop drawings shall be sufficiently detailed to indicate compliance with the contract documents and shall contain the following:
   a. Plan views, elevations, sectional views, necessary details and methods of installation including details showing connections to other work.
   b. Description of items submitted i.e., materials, gauge, finish, etc.
   c. Locations at which the materials or equipment are to be incorporated into the work.
   d. Schedules as may be necessary or required.

F. Supplies:
1. Supplies shall consist of items required for the maintenance of the building.
2. Supplies shall be turned over directly to the Owner and a signed receipt furnished to the Architect.

G. Installation Instructions:
1. Manufacturers installation instructions shall be standard catalogs or installation sheets furnished by the manufacturer modified as necessary to meet specific job conditions.
2. Instructions shall be of sufficient detail to indicate proper procedures to be used to comply with contract drawings.
3. Installation instructions shall be transmitted to the Architect for his information.

H. Operation and Maintenance (O & M) Literature
1. Manufacturers O & M literature shall be standard catalogs or O & M sheets furnished by the manufacturer modified as necessary to meet specific job conditions.

2. O & M literature shall be of sufficient detail to indicate proper procedures to be used to comply with contract documents.
3. O & M literature shall be transmitted to the Architect for his information.

1.05 SUBMISSION PROCEDURE

A. Contractor shall submit five (5) copies of each required submission as indicated on the submission schedule to the Architect.

B. Each submission shall be accompanied by a completed copy of the transmittal form included herewith.

C. Architect will return to the contractor three (3) copies of each submission which has resulted in an "Approved" or "Approved as Noted" determination. One copy shall be maintained at the project site for referral by the Architect. Two (2) copies shall be for the use of the contractor.

D. Architect will return to the contractor for his use two (2) copies of each submission which has resulted in a "Disapproved" or "Approved As Noted - Resubmit" determination.

E. If the contractor requires additional copies of the submission, he shall submit a sepia or other reproducible copy for the Architect's review, which shall be returned to the contractor for his own reproduction.

F. If the contractor should alter any information on previous submittals besides the notation called for by the Architect, he must circle this new information to bring it to the Architect's attention and resubmit for approval.

G. Submit all associated items relating to a complete assembly at one and the same time so that each may be checked in relation to the entire proposed assembly.

1.06 ARCHITECT'S REVIEW

A. Architect will review the contractors submissions as expeditiously as possible. Contractor should allow sufficient time for each review and schedule his submissions accordingly.

B. Contractor shall notify the Architect of any review he feels has been delayed at least one week prior to the date approved is required to maintain the project schedule.

C. Architect will return the indicated copies of each submission to the contractor with one

of the following markings:

1. Approved - The contractor may proceed with installation of this material since the Architect's review indicates that his submission demonstrates an understanding of the contract documents and the intention to meet or exceed their requirements. Approval of the submission does not indicate final approval of the actual installation and materials. Approval of submittals does not relieve the contractor of the responsibility for accuracy of such submittals, coordination between subcontractors and with other prime contractors, nor the furnishing of materials or work required by the contract and not shown in the submittals. Approval of submittals shall not be construed as approval of departures from the contract.
2. Approved As Noted - The contractor may proceed with the installation of this material as long as the changes and comments noted by the Architect are complied with. Submissions so marked convey the same intent as those marked "Approved".
3. Approved As Noted, Resubmit - The contractor may, at his own risk, proceed with the installation of this material as long as the changes and comments noted by the Architect are complied with. However, the submission itself must be corrected and resubmitted to indicate that the contractor has fully understood the Architects comments and to complete the project documentation.
4. Disapproved - The contractor may not proceed with the installation of this material since the Architects review indicates non compliance with the contract documents. Contractor shall revise the submission in accordance with the Architects comments and resubmit for another review.

1.07 SUBMISSION SCHEDULE

A. Contractor shall furnish all submissions indicated herein. Detailed requirements for each submission are included in the referenced section.

B. Architect shall maintain a copy of this schedule during the course of the project, indicating the status of each submission. Copies of the updated schedule will be sent to the Contractor as required to notify him of deficiencies in his submissions.

C. Submissions indicated as PRIORITY are important for coordination with other trades and must be expedited.

D. Schedule of Submissions:

Section	Item	Submission	Submitted	Action/Date
15121H		EXPANSION COMPENSATION		
	1.	System Layout	Shop Drawing	

15140H	SUPPORTS AND ANCHORS		
	1.	Supports	Shop Drawing
	2.	Anchors	Shop Drawing
	3.	Support Framing	Shop Drawing
	4.	Attachment Methods	Shop Drawing
15190H	MECHANICAL IDENTIFICATION		
	1.	Nameplates	Product Data
	2.	Metal Tags	Product Data
	3.	Plastic Pipe Markers	Product Data
	4.	Valve Chart	Product Data
15242H	VIBRATION ISOLATION		
	1.	System Layout	Shop Drawing
	2.	Isolation	Product Data
	3.	Installation Inst.	Mfgs. Lit.
	4.	Design Loads	Certification
15260H	PIPING INSULATION		
	1.	Insulation	Product Data
	2.	Jackets	Product Data
	3.	Insulating Cement	Product Data
	4.	Adhesives	Product Data
	5.	Installation Inst.	Mfgs. Lit.
15290H	DUCTWORK INSULATION		
	1.	Insulation	Product Data
	2.	Jackets	Product Data
	3.	Adhesives	Product Data
	4.	Insulation Inst.	Mfgs. Lit.
15510H	HYDRONIC PIPING		
	1.	Heating Water Piping	Product Data
	2.	Condensate Piping	Product Data
	3.	Drain Piping	Product Data
	4.	Gate Valves	Product Data
	5.	Globe Valves	Product Data
	6.	Ball Valves	Product Data
	7.	Check Valves	Product Data
	8.	Relief Valves	Product Data

15515H	HYDRONIC SPECIALTIES		
	1.	System Layout	Shop Drawing
	2.	Expansion Tanks	Product Data
	3.	Air Vents	Product Data
	4.	Strainers	Product Data
	5.	Flow Indicators	Product Data
	6.	Radiator Valves	Product Data
	7.	Relief Valves	Product Data
	8.	Pressure Vessels	Certification
15540H	HVAC PUMPS		
	1.	Pumps	Product Data
	2.	Pump Curves	Certification
15556H	CAST IRON BOILERS		
	1.	System Layout	Shop Drawing
	2.	Boiler	Product Data
	3.	Boiler Trim	Product Data
	4.	Burner	Product Data
	5.	Operation & Maint.	Mfgs. Lit.
15577H	LINED PREFABRICATED CHIMNEYS & BREECHINGS		
	1.	System Layout	Shop Drawing
	2.	Vent Piping	Product Data
15671H	AIR COOLED CONDENSING UNITS		
	1.	Condensing Unit	Product Data
	2.	Refrigerant Piping	Product Data
	3.	Controls	Product Data
15781H	PACKAGED ROOFTOP COOLING UNITS		
	1.	HVAC Unit	Product Data
	2.	Installation Inst.	Mfgs. Lit.
	3.	Operation & Maint.	Mfgs. Lit.
	4.	Roof Openings & Support Locations	Shop Drawings
15835H	TERMINAL HEAT TRANSFER UNITS		
	1.	Finned Tube	Product Data
	2.	Convectors	Product Data
	3.	Unit Heaters	Product Data
	4.	Cabinet Heaters	Product Data

	5.	Installation Inst.	Mfgs. Lit.
15855H	AIR HANDLING UNITS WITH COILS		
	1.	Air Handlers	Product Data
	2.	Filters	Product Data
15870H	POWER VENTILATORS		
	1.	Roof Exhausts	Product Data
	2.	Cabinet Fans	Product Data
	3.	Grilles	Product Data
	4.	Installation Inst.	Mfgs. Lit.
	5.	Roof Openings & Support Locations	Shop Drawings
15887H	ENGINE EXHAUST SYSTEM		
	1.	Exhaust Fans	Product Data
	2.	System Layout	Shop Drawing
	3.	Roof Openings & Support Locations	Shop Drawings
15890H	DUCTWORK		
	1.	System Layout	Shop Drawing
	2.	Roof Openings & Support Locations	Shop Drawings
15910H	DUCTWORK ACCESSORIES		
	1.	Volume Dampers	Product Data
	2.	Fire Dampers	Product Data
	3.	Backdraft Dampers	Product Data
	4.	Access Doors	Product Data
15936H	AIR OUTLETS AND INLETS		
	1.	Diffusers	Product Data
	2.	Grilles	Product Data
	3.	Louvers	Product Data
	4.	Gravity Hoods	Product
15952H	CONTROLS AND INSTRUMENTATION		
	1.	System Layout	Shop Drawing
	2.	Thermostats	Product Data
	3.	Control Valves	Product Data
	4.	Operating Data	Mfgs. Lit.

15990H TESTING, ADJUSTING AND BALANCING

1. Balancing Report Certification

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Pipe loops, offsets, and swing joints.

1.02 RELATED WORK

A. Section 15140H - Supports and Anchors.

1.03 REFERENCES

A. Conform to Standards of Expansion Joint Manufacturer's Association.

1.04 DESIGN CRITERIA

A. Base expansion calculations on 50 degrees F installation temperature to 210 degrees F for hot water heating and 140 degrees F for domestic hot water, plus 30 percent safety factory.

1.05 SUBMITTALS

A. Submit shop drawings in accordance with Section 15010H.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Pathway Bellows.

PART 3 EXECUTION

3.01 INSPECTION

A. Examine piping layout and notify Architect/Engineer of additional anchors or expansion joints required to adequately protect system.

3.02 INSTALLATION

A. Accomplish structural work and provide equipment required to control expansion and contraction of piping, loops, pipe offsets, and swing joints, and provide corrugated bellows type expansion joints where required.

B. Rigidly anchor pipe to building structure where necessary. Provide pipe guides so that movement takes place along axis of pipe only.

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Pipe, duct, and equipment hangers, supports, and associated anchors.

C. Equipment bases and supports.

D. Sleeves and seals.

E. Flashing and sealing equipment and pipe stacks.

1.02 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

A. Furnish hanger and support inserts and sleeves to Section 3A for placement into formwork.

1.03 RELATED WORK

A. Section 03100: Concrete equipment bases.

B. Section 15242H - Vibration Isolation.

C. Section 15260H - Piping Insulation.

D. Section 15280H - Equipment Insulation.

E. Section 15671H - HVAC system.

1.04 REFERENCES

A. ANSI/ASME B31.1 - Power Piping.

1.05 SUBMITTALS

A. Submit shop drawings in accordance with Section 15011H.

B. Indicate hanger and support framing and attachment methods.

PART 2 PRODUCTS

2.01 PIPE HANGERS AND SUPPORTS

A. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Carbon steel, adjustable swivel, split ring.

B. Hangers for Pipe Sizes 2 to 4 Inches and Cold Pipe Sizes 6 Inches and Over: Carbon steel, adjustable, clevis.

C. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.

D. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.

E. Vertical Support: Steel riser clamp.

F. Floor Support for Pipe Sizes to 4 Inches and All Cold Pipe Sizes: Cast iron adjustable pipe saddle, lock nut nipple, floor flange, and concrete pier or steel support.

G. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

H. Shield for Insulated Piping 2 Inches and Smaller: 18 gage galvanized steel shield over insulation in 180 degree segments, minimum 12 inches long at pipe support.

I. Shield for Insulated Piping 2-1/2 Inches and Larger (Except Cold Water Piping): Pipe covering protective saddles.

J. Shields for Insulated Cold Water Piping 2-1/2 Inches and Larger: Hard block non-conducting saddles in 90 degree segments, 12 inch minimum length, block thickness same as insulation thickness.

K. Shields for Vertical Copper Pipe Risers: Sheet lead.

2.02 HANGER RODS

A. Steel Hanger Rods: Threaded both ends, threaded one end, or continuous threaded.

2.03 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.

2.04 FLASHING

A. Metal Flashing: 26 gage galvanized steel.

B. Lead Flashing: 5 lb./sq. ft. sheet lead for waterproofing; one lb./sq. ft. sheet lead for soundproofing.

C. Flexible Flashing: 47 mil. thick sheet butyl; compatible with roofing.

D. Caps: Steel, 22 gage minimum; 16 gage at fire resistant elements.

2.05 EQUIPMENT CURBS

A. By equipment manufacturer, when available or fabricate curbs of manufacturer approved material. All curbs shall be insulated.

2.06 SLEEVES

A. Sleeves for Pipes Through Non-fire Rated Floors: Form with 18 gage galvanized steel.

B. Sleeves for Pipes Through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Form with steel pipe or 18 gage steel. All pipe sleeves shall be 2 standard sizes larger than the pipe passing through.

C. Sleeves for Pipes Through Fire Rated and Fire Resistive Floors and Walls, and Fireproofing: Prefabricated fire rated sleeves including seals, UL listed.

D. Sleeves for Round Ductwork: Form with galvanized steel.

E. Sleeves for Rectangular Ductwork: Form with galvanized steel.

F. Stuffing Insulation: Glass fiber type, non- combustible.

G. Calk: Acrylic sealant.

2.07 FABRICATION

A. Size sleeves large enough to allow for movement due to expansion and contraction, two standard sizes larger than the pipe passing through. Provide for continuous insulation wrapping.

B. Design hangers without disengagement of supported pipe.

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

2.08 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 EXECUTION

3.01 INSERTS

A. Provide inserts to Section 03100 for placement in concrete formwork.

B. Where inserts are omitted, drill through concrete slab from below and provide thru-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.02 PIPE HANGERS AND SUPPORTS

A. Support horizontal piping as follows:

PIPE SIZE	MAX. HANGER SPACING	HANGER DIAMETER
1/2 to 1-1/4 inch	6'-0"	3/8"
1-1/2 to 2 inch	6'-0"	3/8"
2-1/2 to 3 inch	10'-0"	1/2"
Copper 2 inch and smaller	6'-0"	3/8"
Copper 2 inch and larger	10'-0"	3/8"

B. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

C. Place a hanger within 12 inches of each horizontal elbow.

D. Use hangers with 1-1/2 inch minimum vertical adjustment.

E. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.

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.

3.03 EQUIPMENT BASES AND SUPPORTS

A. Provide equipment bases of concrete type specified in Section 03100.

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

equipment.

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

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

3.04 FLASHING

A. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.

B. Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms, installed in accordance with manufacturer's instructions for sound control.

C. Provide manufacturers curbs for mechanical roof installations. Flexible sheet flash and counterflash with sheet metal; seal watertight.

3.05 SLEEVES

A. Set sleeves in position in formwork. Provide reinforcing around sleeves.

B. Extend sleeves through floors one inch above finished floor level. Calk sleeves full depth and provide floor plate.

C. Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with fire stopping insulation and calk seal. Provide close fitting metal collar or escutcheon covers at both sides of penetration.

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Identification of mechanical products installed under Division 15.

1.02 RELATED WORK

A. Section 09900 - Painting: Identification painting.

1.03 REFERENCES

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

1.04 SUBMITTALS

A. Submit product data in accordance with Section 15011H.

B. Submit list of wording, symbols, letter size, and color coding for mechanical identification.

C. Submit typed valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

D. Submit manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Seton.

B. Emed.

C. W. H. Brady - Signmark

2.02 MATERIALS

A. Color: Unless specified otherwise, conform with ANSI/ASME A13.1.

B. Plastic Nameplates: Laminated three-layer plastic with engraved black letters on light

contrasting background color. Seton Setonply Style 2060.

D. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges. Seton Style 250-BL.

E. Stencils: With clean cut symbols and letters of following size:

OUTSIDE DIAMETER OF INSULATION OR PIPE	LENGTH OF COLOR FIELD	SIZE OF LETTERS
3/4" - 1-1/4"	8"	1/2"
1-1/2" - 2"	8"	3/4"
2-1/2" - 6"	12"	1-1/4"
8" - 10"	24"	2-1/2"
Over 10"	32"	3-1/2"
Ductwork and Equipment	---	2-1/2"

F. Stencil Paint: In accordance with Section 09900, semi-gloss enamel. Seton Coverall Pipe Paint Style CPP.

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

H. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape of not less than 6 inch wide by 4 mil. thick, manufactured for direct burial service. Seton Underground Warning Tapes.

PART 3 EXECUTION

3.01 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

B. Prepare surfaces in accordance with Section 09900 for stencil painting.

3.02 INSTALLATION

A. Plastic Nameplates: Install with corrosive-resistant mechanical fasteners, or adhesive.

B. Metal Tags: Install with corrosive-resistant chain.

C. Stencil Painting: Apply in accordance with Section 09900.

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

E. Plastic Tape Pipe Markers: Install complete around pipe in accordance with manufacturer's instructions.

F. Underground Plastic Pipe Markers: Install 6 to 8 inches below finished grade, directly above buried pipe.

G. Equipment: Identify air handling units, pumps, and, tanks, plastic nameplates. Small devices, such as in-line pumps, may be identified with metal tags.

H. Controls: Identify control panels and major control components outside panels with plastic nameplates.

I. Valves: Identify valves in main and branch piping with tags.

J. Piping: Identify piping, concealed or exposed, with plastic pipe markers. Tags may be used on small diameter piping (under 1 1/2 inches). Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet 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.

K. Ductwork: Identify ductwork with stenciled painting. Identify as to air handling unit number, and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

3.03 VALVE CHART AND SCHEDULE

A. Provide typed valve chart and schedule in aluminum frame with clear plastic shield. Install at location as directed. Seton Valve Chart Frame #A11P.

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Inertia bases.

C. Vibration isolation.

1.02 RELATED WORK

A. Section 15010H - HVAC system.

1.03 REFERENCES

A. ASHRAE - Guide to Average Noise Criteria Curves.

1.04 QUALITY ASSURANCE

A. Maintain ASHRAE criteria for average noise criteria curves for all equipment at full load condition.

1.05 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 15011H.

B. Indicate inertia bases on shop drawings.

C. Indicate vibration isolator locations, with static and dynamic load on each, on shop drawings and described on product data.

D. Submit manufacturer's installation instructions under provisions of Section 15011H.

1.06 CERTIFICATES

A. Submit manufacturer's certificate under provisions of Section 15011H that isolators are properly installed and properly adjusted to meet or exceed specified requirements.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Mason Industries.

2.02 INERTIA BASES

A. Type A: Integral structural steel fan and motor base with motor slide rails.

2.03 VIBRATION ISOLATORS

A. Type 1: Elastomer mount with threaded insert and hold down holes.

B. Type 2: Closed spring mount with top and bottom housing separated with neoprene rubber stabilizers.

2.04 FABRICATION

A. Provide pairs of neoprene side snubbers or restraining springs where side torque or thrust may develop.

B. Color code spring mounts.

C. Select springs to operate at 2/3 maximum compression strain, with 1/4 inch ribbed neoprene pads.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install vibration isolators for motor driven equipment.

B. Set steel bases for one inch clearance between housekeeping pad and base. Set concrete inertia bases for 2 inch clearance. Adjust equipment level.

C. Provide spring isolators on piping connected to isolated equipment as follows: Up to 4 inch diameter, first three points of support; 5 to 8 inch diameter, first four points of support; 10 inch diameter and over, first six points of support. Static deflection of first point shall be twice deflection of isolated equipment.

3.02 SCHEDULE

ISOLATED EQUIPMENT	ISOLATOR Type	Thickness
Condensing Units	Type	1
Air Handlers	Type	2
Fans	Type	2

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Piping insulation.

C. Jackets and accessories.

1.02 RELATED WORK

A. Section 09900 - Painting: Painting insulation jacket.

B. Section 15190H - Mechanical Identification.

1.03 REFERENCES

A. ANSI/ASTM C195 - Mineral Fiber Thermal Insulation Cement.

C. ANSI/ASTM C547 - Mineral Fiber Preformed Pipe Insulation.

D. ANSI/ASTM C578 - Preformed, Block Type Cellular Polystyrene Thermal Insulation.

E. ASTM B209 - Aluminum and Aluminum-alloy Sheet and Plate.

F. ASTM C449 - Mineral Fiber Hydraulic-setting Thermal Insulating and Finishing Cement.

G. ASTM E84 - Surface Burning Characteristics of Building Materials.

H. NFPA 255 - Surface Burning Characteristics of Building Materials.

I. UL 723 - Surface Burning Characteristics of Building Materials.

1.04 QUALITY ASSURANCE

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

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

1.05 SUBMITTALS

A. Submit product data in accordance with Section 15011H.

B. Include product description, list of materials and thickness for each service, and locations.

C. Submit manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manville.

B. Dow Corning.

C. Certainteed.

2.02 INSULATION

A. Type A: Glass fiber insulation; ANSI/ASTM C547; 'k' value of 0.24 at 75 degrees F; noncombustible. Manville Micro-Loc.

B. Type B: Closed cell insulation; ASTM C0534; 'k' valve of 0.255 at 75 degrees F; noncombustible. Halstead Insul-Tube.

C. Type C: Calcium silicate; ASTM C533; 'k' valve of 0.44 at 300 degrees F. Manville Thermo-12.

2.03 JACKETS

A. Interior Applications:
   1. Vapor Barrier Jackets: Kraft reinforced foil vapor barrier with self-sealing adhesive joints.
   2. Canvas Jackets: UL listed treated cotton fabric, 6 oz/sq. yd.

2.04 ACCESSORIES

A. Insulation Bands: 3/4 inch wide; 0.015 inch thick galvanized steel.

B. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum. 0.010 inch thick stainless steel.

C. Insulating Cement: ANSI/ASTM C195; hydraulic setting mineral wool.

D. Finishing Cement: ASTM C449.

E. Fibrous Glass Cloth: Untreated; 9 oz/sq. yd. weight.

F. Adhesives: Compatible with insulation.

PART 3 EXECUTION

3.01 PREPARATION

A. Install materials after piping has been tested and approved.

3.02 INSTALLATION

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

B. Continue insulation with vapor barrier through penetrations.

C. In exposed piping, locate insulation and cover seams in least visible locations.

D. On insulated piping with vapor barrier, insulate fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.

E. On insulated piping without vapor barrier and piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation at such locations.

F. Provide an insert, not less than 6 inches long, of same thickness and contour as adjoining insulation, between support shield and piping, but under the finish jacket, on piping 2 inches diameter or larger, to prevent insulation from sagging at support points. Inserts shall be cork or other heavy density insulating material suitable for the planned temperature range. Factory fabricated inserts may be used.

G. Neatly finish insulation at supports, protrusions, and interruptions.

H. Jackets:

1. Indoor, Concealed Applications: Insulated pipes conveying fluids above ambient temperature shall have standard jackets, with vapor barrier, factory-applied. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass cloth and adhesive.
2. Indoor, Concealed Applications: Insulated dual-temperature pipes or pipes

conveying fluids below ambient temperature shall have vapor barrier jackets, factory-applied. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe, and finish with glass cloth and vapor barrier adhesive.

3. Indoor, Exposed Applications: For pipe exposed in mechanical equipment rooms or in finished spaces, insulate as for concealed applications. Finish with PVC jacket; size for finish painting.

3.03 SCHEDULE

PIPING	TYPE	INSULATION PIPE SIZE Inch	INSULATION THICKNESS Inch
Domestic Cold Water	A	All	1-1/2
Heating Water Supply and Return	A	All	1-1/2
Refrigerant Suction	B	All	1/2
Refrigerant Hot Gas	B	All	1/2
Cooling Coil Condensate	A	All	1-1/2

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Ductwork insulation.

C. Insulation jackets.

1.02 RELATED WORK

A. Section 09900 - Painting: Painting insulation jackets.

B. Section 15190H - Mechanical Identification.

1.03 REFERENCES

A. ANSI/ASTM C553 - Mineral Fiber Blanket and Felt Insulation.

B. ANSI/ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.

C. ASTM E84 - Surface Burning Characteristics of Building Materials.

D. NFPA 255 - Surface Burning Characteristics of Building Materials.

E. UL 723 - Surface Burning Characteristics of Building Materials.

1.04 QUALITY ASSURANCE

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

B. Materials: UL listed; flame spread/fuel contributed/smoke developed rating of 25/-/50 in accordance with NFPA 255, UL 723.

1.05 SUBMITTALS

A. Submit product data in accordance with Section 15011H.

B. Include product description, list of materials and thickness for each service, and locations.
C. Submit manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS - INSULATION

A. Knauf.

B. Johns Manville.

C. Certainteed.

2.02 MATERIALS

A. Type A: Flexible glass fiber; ANSI/ASTM C612; commercial grade; 'k' value of 0.29 at 75 degrees F; foil scrim facing for air conditioning ducts. Knauf Duct Wrap with Commercial Foil Skrim (FCK) .75 PCF.

B. Type B: Rigid glass fiber; ANSI/ASTM C612, Class 1; 'k' value of 0.24 at 75 degrees F; 0.002 inch foil scrim facing for air conditioning ducts. Knauf Air Duct.

C. Type C: Flexible glass fiber; ANSI/ASTM C553; 'k' value of 0.24 at 75 degrees F; 1.5 lb./cu. ft.; coated air side for maximum 4,000 ft./min. air velocity Knauf Duct Liner.

D. Adhesives: Waterproof fire-retardant type.

E. Indoor Jacket: 6 oz./sq. yd. canvas. Presized glass cloth, minimum 7.8 oz./sq. yd.

F. Outdoor Jacket: Coated glass fiber sheet, 30 lb./sq. yd.

G. Lagging Adhesive: Fire resistive to NFPA 255, UL 723.

H. Impale Anchors: Galvanized steel, 12 gage, self- adhesive pad.

I. Joint Tape: Glass fiber cloth, open mesh.

J. Tie Wire: Annealed steel, 16 gage.

PART 3 EXECUTION

3.01 PREPARATION

A. Install materials after ductwork has been tested and approved.

B. Clean surfaces for adhesives.

3.02 INSTALLATION

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

B. Provide insulation with vapor barrier when air conveyed may be below ambient temperature.

C. Exterior Insulation (Type A or Type B) Application:
   1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
   2. Secure insulation without vapor barrier with staples, tape, or wires.
   3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

D. Liner (Type C) Application:
   1. Adhere insulation with adhesive for 100 percent coverage. Secure insulation with mechanical fasteners on 15-inch centers maximum on top and side of ductwork with dimension exceeding 20 inches. Seal and smooth joints. Do not use nail-type fasteners. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
   2. Ductwork dimensions indicated are net inside dimensions required for air flow. Increase ductwork to allow for insulation thickness.

E. Walk-in Plenum Application:
   1. Adhere insulation on interior surface of plenum with adhesive for 100 percent coverage. Secure insulation with mechanical fasteners. Seal and smooth joints. Do not use nail- type fasteners.

F. Continue insulation with vapor barrier through penetrations.

3.03 SCHEDULE

A. Insulation shall be as per below schedule unless specifically stated otherwise in the contract drawings.

DUCTWORK	INSULATION TYPE	THICKNESS Inch	FINISH
Exhaust Ducts Within 10 ft. of Exterior Openings and Exhaust Ducts Exposed to Outdoor Air	A	1"	Foil
Outside Air Intake Ducts	A	1-1/2"	Foil
Plenums	B	1"	Foil
Plenums (Cooling System)	B	1"	Foil
Supply Ducts	A	1-1/2"	Foil
Return Ducts	A	1-1/2"	Foil
Internal Acoustic Lining	C	1"	Mat
Internal Lining in Supply Ducts	C	1"	Mat
Relief Ducts in Mechanical Rooms	A	1"	Foil

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Pipe and pipe fittings.

C. Valves.

D. Heating water piping system.

1.02 RELATED WORK

A. Section 08305 - Access Doors.

B. Section 09900 - Painting.

C. Section 15121H - Expansion Compensation.

D. Section 15140H - Supports and Anchors.

E. Section 15190H - Mechanical Identification.

F. Section 15260H - Piping Insulation.

1.03 REFERENCES

A. ANSI/ASME - Boiler and Pressure Vessel Code.

B. ANSI/ASME Sec 9 - Welding and Brazing Qualifications.

C. ANSI/ASME B16.3 - Malleable Iron Threaded Fittings Class 150 and 300.

D. ANSI/ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV.

E. ANSI/ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV.

F. ANSI/ASME B31.9 - Building Services Piping.

G. ANSI/AWS A5.8 - Brazing Filler Metal.

H. ANSI/AWS D1.1 - Structural Welding Code.

I. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.

J. ASTM A1 20 - Pipe, Steel, Black and Hot-Dipped Zinc Coated (Galvanized), Welded and Seamless, for Ordinary Uses.

K. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.

L. ASTM B32 - Solder Metal.

M. ASTM B88 - Seamless Copper Water Tube.

1.04 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME B31.9.

1.05 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

B. Welding Materials and Procedures: Conform to ANSI/ASME SEC 9 and applicable state labor regulations.

C. Welders Certification: In accordance with ANSI/ASME SEC 9.

1.06 SUBMITTALS

A. Submit product data in accordance with Section 15011H.

B. Include data on pipe materials, pipe fittings, valves, and accessories.

C. Include welders certification of compliance with ANSI/ASME SEC 9.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site.

B. Store and protect products.

C. Deliver and store valves in shipping containers with labelling in place.

PART 2 PRODUCTS

2.01 HEATING WATER ABOVE GROUND

A. Copper Tubing: ASTM B88, Type L, hard drawn.
   1. Fittings: ANSI/ASME B16.23 cast brass of ANSI/ASME B16.29 solder wrought copper.

   2. Joints: ASTM B32, solder, Grade 95TA.

2.02 CONDENSATE WATER PIPING, ABOVE GROUND

A. Copper Tubing: ASTM B88, Type L, hard drawn.
   1. Fittings: ANSI/ASME B16.23 cast brass, or ANSI/ASME B16.29 solder wrought copper.
   2. Joints: ASTM B32, solder, Grade 95TA.

2.03 EQUIPMENT DRAINS AND OVERFLOWS

A. Copper Tubing: ASTM B88, Type L, hard drawn.
   1. Fittings: ANSI/ASME B16.23 cast brass, or ANSI/ASME B16.29 solder wrought copper.
   2. Joints: ASTM B32, solder, Grade 95TA.

2.04 FLANGES, UNIONS, AND COUPLINGS

A. Pipe Size 2 Inches and Under: 150 psig malleable iron unions for threaded ferrous piping; bronze unions for copper pipe, soldered joints.

B. Pipe Size Over 2 Inches: 150 psig forged steel slip-on flanges for ferrous piping; bronze flanges for copper piping.

C. Grooved and Shouldered Pipe End Couplings: Malleable iron housing clamps to engage and lock, designed to permit some angular deflection, contraction, and expansion; C-shape elastomer composition sealing gasket for operating temperature range from -30 degrees F to 230 degrees F; steel bolts, nuts, and washers; galvanized couplings for galvanized pipe.

2.05 ACCEPTABLE MANUFACTURERS - GATE VALVES

A. Nibco Model T-113.
B. American Model 325.
C. Watts Model GV, GVS.

2.06 GATE VALVES

A. Up to 2 Inches: Bronze body, bronze trim, rising stem, handwheel, inside screw, double wedge or disc, solder or threaded ends.

B. Over 2 Inches: Iron body, bronze trim, rising stem, handwheel, OS&Y, single or double wedge, flanged ends.

2.07 ACCEPTABLE MANUFACTURERS - GLOBE VALVES

A. Watts Model GLV.

B. American Fig. 13.

C. Nibco Model T-21.

2.08 GLOBE VALVES

A. Up to 2 Inches: Bronze body, bronze trim, rising stem and handwheel, inside screw, renewable composition disc, solder or screwed ends, with backseating capacity.

B. Over 2 Inches: Iron body, bronze trim, rising stem, handwheel, OS&Y, plug-type disc, flanged ends, renewable seat and disc.

2.09 ACCEPTABLE MANUFACTURERS - BALL VALVES

A. Appolo - Conbraco Model 70-100.

B. Nibco Mode 585.

C. Watts Model G-6400.

2.10 BALL VALVES

A. Up to 2 Inches: Bronze Chromium plated ball, teflon seats and stuffing box ring, lever handle, solder or threaded ends.

B. Over 2 Inches: Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle, flanged.

2.11 ACCEPTABLE MANUFACTURERS - SWING CHECK VALVES

A. Watts Model CV.

B. Nibco Model T-480.

C. Jenkins.

2.12 SWING CHECK VALVES

A. Up to 2 Inches: Bronze 22 degree swing disc, solder or screwed ends.

B. Over 2 Inches: Iron body, bronze trim, 22 degree swing disc, renewable disc and seat, flanged ends.

2.13 ACCEPTABLE MANUFACTURERS - SPRING LOADED CHECK VALVES

A. Watts Model CV.

B. Nibco Model T-480.

2.14 SPRING LOADED CHECK VALVES

A. Iron body, bronze trim, stainless steel spring, renewable composition disc, screwed, wafer or flanged ends.

2.15 ACCEPTABLE MANUFACTURERS - RELIEF VALVES

A. Watts.

B. B & G.

2.16 RELIEF VALVES

A. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

PART 3 EXECUTION

3.01 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment with flanges or unions.

D. After completion, fill, clean, and treat systems.

3.02 INSTALLATION

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

B. Install piping to conserve building space, and not interfere with use of space and other work. Run all piping concealed.

C. Group piping whenever practical at common elevations.

D. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 15121.

E. Provide clearance for installation of insulation, and access to valves and fittings.

F. Provide access where valves and fittings are not exposed.

G. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.

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

I. Prepare pipe, fittings, supports, and accessories for finish painting. Refer to Section 09900.

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

3.03 APPLICATION

A. Use grooved mechanical couplings and fasteners only in accessible locations.

B. Install unions downstream of valves and at equipment or apparatus connections.

C. Install brass male adapters each side of valves in copper piped system. Sweat solder adapters to pipe.

D. Install gate valves for shut-off and to isolate equipment, part of systems, or vertical risers.

E. Install ball valves for throttling, bypass, or manual flow control services.

F. Provide spring loaded check valves on discharge of condenser water pumps.

G. Use plug cocks for throttling service. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.

H. Use only butterfly valves in chilled and condenser water systems for throttling and isolation service.

I. Use lug end butterfly valves to isolate equipment.

J. Provide 3/4 inch gate drain valves at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest drain.

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Expansion tanks.

C. Air vents.

D. Strainers.

E. Pump suction fittings.

F. Combination fittings.

G. Flow indicators, controls, meters.

H. Radiator valves.

I. Relief valves.

1.02 RELATED WORK

A. Section 15510H - Hydronic Piping.

1.03 REFERENCES

A. ANSI/ASME - Boilers and Pressure Vessels Code.

1.04 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME Boilers and Pressure Vessels Code Section 8D for manufacture of tanks.

1.05 QUALITY ASSURANCE

A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1.06 SUBMITTALS

A. Submit shop drawings and product data in accordance with Section 15011H.

B. Submit shop drawings and product data for manufactured products and assemblies required for this project.

C. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.

D. Submit inspection certificates for pressure vessels from authority having jurisdiction.

1.07 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include installation instruction, assembly views, lubrication instructions, and replacement parts list.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site.

B. Store and protect products.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS - EXPANSION TANKS

A. B & G.

B. Taco.

2.02 EXPANSION TANKS

A. Construction: Closed, welded steel, tested and stamped in accordance with Section 8D of ANSI/ASME Code; 125 psi rating; cleaned, prime coated, and supplied with steel support saddles; with tappings for installation of accessories.

B. Quick Connect Air Inlet: Automotive tire valve type, manual air vent, tank drain, and pressure relief valve.

C. Automatic Cold Water Fill Assembly: Pressure reducing valve, reduced pressure double check back flow preventer, test cocks, strainer, vacuum breaker, and valved by-pass.

D. Hot Water Heating System: Set expansion tank pressure relief valve at 50 psi maximum and pressure reducing valve at 30 psi.

2.03 ACCEPTABLE MANUFACTURERS - AIR VENTS

A. B & G.

B. Sarco.

C. Watts.

2.04 AIR VENTS

A. Manual Type: Short vertical sections of 2-inch diameter pipe to form air chamber, with 1/8-inch brass needle valve at top of chamber.

B. Float Type: Brass or semi-steel body, copper float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.

2.05 ACCEPTABLE MANUFACTURERS - AIR SEPARATORS

A. B & G.

B. Watts.

2.06 AIR SEPARATORS

A. Dip Tube Fitting: For 125 psig operating pressure; to prevent free air collected in boiler from rising into system.

B. In-line Air Separators: Cast iron for sizes 1-1/2 inch and smaller, or steel for sizes 2 inch and larger; tested and stamped in accordance with Section 8D of ANSI/ASME Code; for 125 psig operating pressure.

C. Air Elimination Valve: Bronze, float operated, for 125 psig operating pressure.

D. Combination Air Separators/Strainers: Steel, tested and stamped in accordance with Section 8D of ANSI/ASME Code, for 125 psig operating pressure, with galvanized steel integral strainer with 3/16-inch perforations, tangential inlet and outlet connections, and internal stainless steel air collector tube.

2.07 ACCEPTABLE MANUFACTURERS - STRAINERS

A. Armstrong.

B. Sarco.

2.08 STRAINERS

A. Size 2 inch and Under: Screwed brass or iron body for 175 psig working pressure, Y pattern with 1/32 inch stainless steel perforated screen.

B. Size 2-1/2 inch to 4 inch: Flanged iron body for 175 psig working pressure, Y pattern with 3/64 inch stainless steel perforated screen.

2.09 ACCEPTABLE MANUFACTURERS - FLOW CONTROLS

A. McDonnald Miller.

B. Bell & Gossett.

C. Taco.

2.10 FLOW CONTROLS

A. Construction: Brass or bronze body with union on inlet, and outlet, temperature and pressure test plug on inlet.

B. Calibration: Control flow within 5 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control.

C. Control Mechanism: Stainless steel or nickel plated brass piston or regulator cup, operating against stainless steel helical or wave formed spring.

D. Accessories: In-line strainer on inlet and ball valve on outlet.

2.11 ACCEPTABLE MANUFACTURERS - RADIATOR VALVES

A. Danfoss.

B. Bell & Gossett.

2.12 RADIATOR VALVES

A. Angle or straight pattern, saturated vapor charged bellows and a setting dial.

2.13 ACCEPTABLE MANUFACTURERS - RELIEF VALVES

A. B & G.

B. Watts.

2.14 RELIEF VALVES

A. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

PART 3 EXECUTION

3.01 INSTALLATION AND APPLICATION

A. Install specialties in accordance with manufacturer's instructions to permit intended performance.

B. Support tanks inside building from building structure, in accordance with manufacturer's instructions.

C. Where large air quantities can accumulate, provide enlarged air collection standpipes.

D. Provide manual air vents at system high points and as indicated.

E. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.

F. Provide air separator on suction side of system circulation pump and connect to expansion tank.

G. Provide valved drain and hose connection on strainer blow down connection.

K. Provide radiator valves on water inlet to terminal heating units such as radiation, unit heaters, and fan coil unit.

I. Provide radiator balancing valves on water outlet from terminal heating units.

J. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.

K. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.

L. Pipe relief valve outlet to nearest floor drain.

M. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

END OF SECTION

PART ONE GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Piping.

C. Refrigerant.

D. Moisture and liquid indicators.

E. Valves.

F. Strainers.

G. Check valves.

H. Pressure relief valves.

I. Filter-driers.

J. Solenoid valves.

K. Expansion valves.

L. Flexible connections.

1.02 RELATED SECTIONS

A. Section 09900 - Painting.

B. Section 15260H - Piping Insulation.

C. Section 15671H - Air Cooled Condensing Units.

D. Section 15952H - Controls and Instrumentation.

E. Section 16180E - Equipment Wiring Systems.

1.03 REFERENCES

A. ANSI/ARI 495 - Refrigerant Liquid Receivers.

B. ANSI/ARI 710 - Liquid Line Dryers.

C. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.

D. ANSI/ASHRAE 34 - Number Designation of Refrigerants.

E. ANSI/ASME SEC 8D - Boilers and Pressure Vessels Code, Rules for Construction of Pressure Vessels.

F. ANSI/ASME SEC 9 - Boilers and Pressure Vessels Code, Welding and Brazing Qualifications.

G. ANSI/ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

H. ANSI/ASME B16.26 - Cast Copper Alloy Fittings For Flared Copper Tubes.

I. ANSI/ASME B31.5 - Refrigeration Piping.

J. ANSI/ASME B31.9 - Building Services Piping.

K. ANSI/ASTM B32 - Solder Metal.

L. ANSI/ASTM B88 - Seamless Copper Water Tube.

M. ANSI/AWS A5.8 - Brazing Filler Metal.

N. ANSI/AWS D1.1 - Structural Welding Code, Steel.

O. ANSI/UL 429 - Electrically Operated Valves.

P. ARI 750 - Thermostatic Refrigerant Expansion Valves.

Q. ARI 760 - Solenoid Valves for Use With Volatile Refrigerants.

R. ASTM B280 - Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

1.04 SUBMITTALS

A. Submit test reports and product data in accordance with Section 15011H.

B. Include data on pipe materials, pipe fittings, valves and accessories.

C. Submit welders certification of compliance with ANSI/ASME Sec 9.

D. Submit Test reports indicating results of leak test, acid test.

1.05 PROJECT RECORD DOCUMENTS

A. Submit documents under provisions of Section 15011H.

B. Accurately record exact locations of equipment and refrigeration accessories on record drawings.

1.06 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME B31.9.

B. Welding Materials and Procedures: Conform to ANSI/ASME SEC 9 and applicable state labor regulations.

C. Welders Certification: In accordance with ANSI/ASME SEC 9.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site.

B. Deliver and store piping and specialties in shipping containers with labelling in place.

C. Store and protect products.

D. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.

PART TWO PRODUCTS

2.01 PIPING

A. Copper Tubing: ASTM B280, Type ACR hard drawn.
   1. Fittings: ANSI/ASME B16.22 wrought copper.
   2. Joints: ANSI/ASTM B32, solder Grade 95TA.

B. Copper Tubing to 7/8 inch OD: ANSI/ASTM B88, Type K, annealed.
   1. Fittings: ANSI/ASME B16.26 cast copper.
   2. Joints: Flared.

2.02 REFRIGERANT

A. Refrigerant: ANSI/ASHRAE 34; R-410A.

2.03 MANUFACTURERS

A. Mitsubishi.

B. Lennox.

2.04 MOISTURE AND LIQUID INDICATORS

A. Indicators: Double port type, UL listed, with copper or brass body, flared or solder ends, sight glass, color coded paper moisture indicator with removable element cartridge and plastic cap; for maximum working pressure of 500 psi, and maximum temperature of 200 degrees F.

2.05 VALVES

A. Diaphragm Packless Valves: UL listed, globe or angle pattern, forged brass body and bonnet, phosphor bronze and stainless steel diaphragms, rising stem and handwheel, stainless steel spring, nylon seat disc, solder or flared ends, with positive backseating; for maximum working pressure of 500 psi and maximum temperature of 275 degrees F.

B. Packed Angle Valves: Forged brass, forged brass seal caps with copper gasket, rising stem and seat with backseating, molded stem packing, solder or flared ends; for maximum working pressure of 500 psi and maximum temperature of 275 degrees F.

C. Packed Ball Valves: Two piece forged brass Body with teflon ball seals and copper tube extensions, brass seal cap, chrome plated ball, stem with neoprene ring stem seals; for maximum working pressure of 500 psi and maximum temperature of 300 degrees F.

2.06 STRAINERS

A. Straight Line or Angle Line Type: Brass or steel shell, steel cap and flange, and

replaceable cartridge, with screen of stainless steel wire or monel reinforced with brass; for maximum working pressure of 430 psi.

B. Straight Line, Non-Cleanable Type: Steel shell, copper plated fittings, stainless steel wire screen, for maximum working pressure of 430 psi.

2.07 CHECK VALVES

A. Globe Type: Cast bronze or forged brass body, forged brass cap with neoprene seal, brass guide and disc holder, phosphor- bronze or stainless steel spring, teflon seat disc; for maximum working pressure of 500 psi and maximum temperature of 300 degrees F.

B. Straight Thru Type: Brass body and disc, phosphor-bronze or stainless steel spring, neoprene seat; for maximum working pressure of 500 psi and maximum temperature of 250 degrees F.

2.08 PRESSURE RELIEF VALVES

A. Straight Thru or Angle Type: Brass body and disc, neoprene seat, factory sealed and stamped with ASME UV and National Board Certification NB; for standard 400 psi setting; selected to ANSI/ASHRAE 15.

2.09 FILTER-DRIERS

A. Replaceable Cartridge Angle Type: ANSI/ARI 710, UL listed, brass shell and bronze cap, perforated brass shell and molded desiccant filter core; for maximum working pressure of 350 psi.

B. Permanent Straight Thru Type: ANSI/ARI 710, UL listed, steel shell with molded desiccant filter core, for maximum working pressure of 350 psi.

2.10 SOLENOID VALVES

A. Valve: ARI 760, pilot operated, copper or brass body and internal parts, synthetic seat, stainless steel stem and plunger assembly, with flared, solder, or threaded ends; for maximum working pressure of 450 psi. Stem shall permit manual operation in case of coil failure.

B. Coil Assembly: UL listed, replaceable with molded electromagnetic coil, moisture and fungus proof, with surge protector and color coded lead wires, integral junction box.

2.11 EXPANSION VALVES

A. Angle or Straight Thru Type: ARI 750; design suitable for refrigerant, brass body, internal or external equalizer, bleed hole, adjustable superheat setting, replaceable inlet strainer, with replaceable capillary tube and remote sensing bulb and remote bulb well.

B. Selection: Evaluate refrigerant pressure drop through system to determine available pressure drop across valve. Select valve for maximum load at design operating pressure and minimum 10 degrees F superheat. Select to avoid being undersized at full load and excessively oversized at part load.

2.12 FLEXIBLE CONNECTORS

A. Corrugated stainless steel hose with single layer of stainless steel exterior braiding, minimum 9 inches long with copper tube ends; for maximum working pressure 400 psi.

PART THREE EXECUTION

3.01 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

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

C. Prepare piping connections to equipment with flanges or unions.

3.02 INSTALLATION

A. Install refrigeration specialties in accordance with manufacturer's instructions.

B. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.

C. Install piping to conserve building space and not interfere with use of space.

D. Group piping whenever practical at common elevations and locations. Slope piping one percent in direction of oil return.

E. Provide non-conducting dielectric connections when joining dissimilar metals.

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

G. Provide clearance for installation of insulation and access to valves and fittings.

H. Provide access to concealed valves and fittings. Coordinate size and location of access doors with Architect.

I. Where pipe support members are welded to structural building frame, brush clean, and apply one coat of zinc rich primer to welding.

J. Prepare pipe, fittings, supports, and accessories not prefinished, ready for finish painting. Refer to Section 09900.

K. Insulate piping; refer to Section 15260.

L. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.

M. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.

N. Install flexible connectors at right angles to axial movement of compressor.

O. Fully charge completed system with refrigerant after testing.

P. Provide electrical connection to solenoid valves.

3.03 APPLICATION

A. Provide line size liquid indicators in main liquid line leaving condenser, or if receiver is provided, in liquid line leaving receiver.

B. Provide line size strainer upstream of each automatic valve. Where multiple expansion valves with integral strainers are used install single main liquid line strainer.

C. On steel piping systems, provide strainer in suction line.

D. Provide shut-off valve on each side of strainer.

E. Provide replaceable cartridge filter-driers vertically in liquid line adjacent to receivers with three valve bypass assembly to permit isolation of driers for servicing.

F. Provide replaceable cartridge filter-driers, with three-valve bypass assembly. Provide filter-driers for each solenoid valve.

G. Provide solenoid valves in liquid line of systems operating with single pump-out or pump-down compressor control, in liquid line of single or multiple evaporator systems, and in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into the suction line when system shuts down.

H. Provide refrigerant charging valve connections in liquid line between receiver shut-off valve and expansion valve.

I. Utilize flexible connectors at or near compressors where within piping configuration does not absorb vibration.

3.04 FIELD QUALITY CONTROL

A. Test refrigeration system in accordance with ANSI/ASME B31.5

B. Pressure test system with dry nitrogen to 200 psig. Perform final tests at 27 inches vacuum and 200 psig using electronic leak detector. Test to no leakage.

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. This Section includes all pumps except where integral with a manufactured piece of equipment.

C. Pump controls where self-contained or auxiliary. Provide and install all motor starters as required.

1.02 RELATED WORK

A. Section 15260H - Piping and Equipment Insulation.

B. Section 15556H - Boilers.

1.03 SUBMITTALS

A. Submit shop drawings in accordance with Section 15011H.

B. Submit certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Bell & Gossett.

B. TACO.

2.02 GENERAL

A. Statically and dynamically balance rotating parts.

B. Construction to permit complete servicing without breaking piping or motor connections.

C. Pumps to operate at 1750 rpm unless specified otherwise.

D. Pump connections to be flanged.

E. Heating pumps to be suitable for handling water at 230 degrees F.

2.03 IN-LINE CIRCULATOR

A. Casing: Bronze Cast iron rated for 125 psi working pressure.

B. Impeller: Bronze.

C. Shaft: Alloy steel with integral thrust collar and two oil lubricated bronze sleeve bearings.

D. Seal: Carbon rotating against a stationary ceramic seat.

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide line sized gate valve and strainer on suction and line sized soft seated check valve and globe valve on discharge.

B. Decrease from line size, with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings.

C. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

D. Provide die-electric connectors at all dissimilar materials.

END OF SECTION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Condensing unit package.

C. Charge of refrigerant and oil.

D. Controls and control connections.

E. Refrigerant piping connections.

F. Electrical power connections.

1.02 RELATED SECTIONS

A. Section 03100 - Cast-in-Place Concrete: Equipment bases.

B. Section 15260H - Piping Insulation.

C. Section 15280H - Equipment Insulation.

D. Section 15855H - Air Handling Units with Coils.

E. Section 15952H - Controls and Instrumentation.

1.03 REFERENCES

A. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.

B. ANSI/ASHRAE 90A - Energy Conservation in new Building Design.

C. ANSI/NEMA MG 1 - Motors and Generators.

D. ANSI/UL 207 - Refrigerant-Containing Components and Accessories, Non-Electrical.

E. ANSI/UL 465 - Central Cooling Air Conditioners.

F. ASHRAE 14 - Methods of Testing for Rating Positive Displacement Condensing Units.

G. ARI 270 - Sound Rating of Outdoor Unitary Equipment.

1.04 SUBMITTALS

A. Submit shop drawings in accordance with Section 15011H.

B. Submit shop drawings indicating components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Include schematic layouts showing condensing units, cooling coils, refrigerant piping, and accessories required for complete system.

C. Submit product data in accordance with Section 15011H.

D. Submit product data indicating rated capacities, weights specialties and accessories, electrical nameplate data, and wiring diagrams.

E. Submit design data.

F. Submit design data indicating pipe and equipment sizing.

G. Submit manufacturer's installation instructions.

1.05 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data in accordance with Section 15011H.

B. Include start-up instructions, maintenance instructions, parts lists, controls, and accessories.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site.

B. Store and protect products.

C. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

D. Protect units on site from physical damage. Protect coils.

1.07 WARRANTY

A. Provide five-year warranty.

B. Warranty: Include coverage for refrigerant compressors.

1.08 EXTRA MATERIALS

A. Provide one complete change of lubricating oil.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Mitsubishi.

B. Lennox.

2.02 MANUFACTURED UNITS

A. Units: Self-contained, packaged, factory assembled and pre- wired units suitable for outdoor use consisting of cabinet, compressors, condensing coil and fans, integral sub-cooling coil, controls, liquid receiver, screens, roof curbs and dunnage.

B. Construction and Ratings: In accordance with ARI 210/240, Testing shall be in accordance with ASHRAE 14.

C. Performance Ratings: Energy Efficiency Rating (EER) not less than prescribed by ANSI/ASHRAE 90A.

D. Provide air cooled condensing units, having a heat rejection capacity as specified on contract drawings.

2.03 CASING

A. House components in galvanized steel panels with weather resistant, baked enamel finish.

B. Mount starters, disconnects, and controls in weatherproof panel provided with full opening access doors. Provide mechanical interlock to disconnect power when door is opened.

C. Provide removable access doors or panels with quick fasteners.

2.04 CONDENSER COILS

A. Coils: Aluminum fins mechanically bonded to seamless copper tubing. Provide sub-cooling circuits.

B. Coil Guard: Expanded metal.

2.05 FANS AND MOTORS

A. Vertical/Horizontal discharge direct driven propeller type condenser fans with fan guard on discharge.

B. Weatherproof motors suitable for outdoor use, single phase permanent split capacitor or 3 phase, with permanent lubricated ball bearings and built in current and thermal overload protection.

2.06 COMPRESSORS

A. Construction: hermetic reciprocating type with heat treated forged steel or cast iron shafts, aluminum alloy connecting rods, automotive type pistons, rings to prevent gas leakage, suction and discharge valves, and sealing surface immersed in oil.

B. Mounting: Statically and dynamically balance rotating parts and mount on rubber-in-shear vibration isolators.

C. Lubrication System: Reversible, positive displacement oil pump with oil charging valve, oil level sight glass, oil filter, and magnetic plug or strainer.

2.07 REFRIGERANT CIRCUIT

A. Provide each unit with one refrigerant circuit, factory supplied and piped.

B. Provide the following for each refrigerant circuit:
1. Filter dryer.
2. Liquid line sight glass and moisture indicator.
3. Thermal expansion valve for maximum operating pressure.
4. Insulated suction line.
5. Suction and liquid line service valves.
6. Liquid line solenoid valve.
7. Charging valve.

8. Discharge line check valve.
9. Compressor discharge service valve.
10. Condenser pressure relief valve.

2.08 CONTROLS

A. On unit, mount weatherproof steel control panel, NEMA 250, containing power and control wiring, molded case disconnect switch, factory wired with single point power connection.

B. Provide the following operating controls:
1. Thermostat located in room.
2. Five minute off timer prevents compressor from short cycling.
3. Low ambient thermostat to lock out compressor at low ambient temperatures.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide for connection to electrical service.

C. Install units on dunnage with vibration isolation.

D. Install units on concrete base as indicated. Concrete bases supplied by HVAC Contractor.

E. Provide connection to refrigeration piping system and evaporators.

3.02 MANUFACTURER'S FIELD SERVICES

A. Prepare lubricate and start systems.

B. Provide initial and cooling season start-up, and winter season shut down during first year of operation, including routine servicing and check out.

C. Supply initial charge of refrigerant and oil for each refrigerant circuit. Replace losses of refrigerant and oil.

D. Inspect and test for refrigerant leaks every 3 months during first year of operation.

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Packaged rooftop cooling unit.

C. Controls and control wiring.

D. Remote panel.

E. Roof mounting frame.

F. Cutting, Patching & Repair of work area to original condition.

G. Removal of all debris from the site.

1.02 RELATED WORK

A. Section 15952H - Controls and Instrumentation.

1.03 REFERENCES

A. ARI 210 - Standard for Unitary Air-Conditioning Equipment.

1.04 QUALITY ASSURANCE

A. Meet the requirements of UL and applicable codes.

B. Test and rate cooling systems to Air-Conditioning and Refrigeration Institute Standard 210.

1.05 SUBMITTALS

A. Submit shop drawings and product data.

B. Submit manufacturer's installation instructions under provisions of Section 01340.

1.06 OPERATION AND MAINTENANCE DATA

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

1.07 WARRANTY

A. Provide five-year unconditional parts warranty on heat exchangers.

B. Provide five-year unconditional parts warranty on compressor units.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Lennox.

2.02 TYPE

A. Provide roof-mounted cooling units as indicated on the contract drawings.

B. Units shall be self-contained, packaged, factory assembled and prewired, consisting of cabinet and frame, supply fan, controls, air filter, economizer, barometric relief, refrigerant cooling coil, compressor, condenser coil and fan, 7-day night setback thermostat, insulated roof curbs by manufacturer.

2.03 PERFORMANCE

A. See contract drawings.

2.04 OPERATING CONTROLS

A. Provide low voltage, adjustable thermostat to control compressor and condenser fan, and supply fan to maintain temperature setting.

1. Include system selector switch (cool-heat-off) and fan control switch (on-auto).
2. Locate thermostat in as shown.

B. Provide remote mounted fan control switch (on-auto).

C. Provide in supply air low limit thermostat to close outside air damper and stop supply fan.

D. Provide night control energized by controller to maintain night thermostat setting, for night and unoccupied operation.

PART 3 EXECUTION

3.01 INSTALLATION

A. Mount units on factory built insulated roof mounting frame providing watertight enclosure to protect ductwork and utility services.

3.02 PACKAGED ROOF TOP COOLING UNITS SCHEDULE

A. See contract drawings.

END OF SECTION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Finned tube radiation.

C. Convectors.

D. Unit heaters.

E. Cabinet unit heaters.

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Section 15952H - Controls and Instrumentation: Installation of room thermostats.

B. Section 16180E - Equipment Wiring Systems: Installation of room thermostats.

1.03 RELATED SECTIONS

A. Section 15510H - Hydronic Piping.

B. Section 15515H - Hydronic Specialties.

C. Section 15952H - Controls and Instrumentation.

D. Section 16180E - Equipment Wiring Systems: Electrical supply to units.

1.04 REFERENCES

A. ANSI/NFPA 70 - National Electrical Code.

1.05 SUBMITTALS

A. Submit shop drawings in accordance with Section 15011H.

B. Submit shop drawings indicating cross section of cabinets, grille, bracing and reinforcing, and typical elevation.

C. Submit product data in accordance with Section 15011H.

D. Submit product data indicating typical catalog of information including arrangements.

E. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
F. Indicate mechanical and electrical service locations and requirements, specifically indicating deviations from indicated products.

G. Submit certification of unit performance.

H. Submit manufacturer's installation instructions.

1.06 PROJECT RECORD DOCUMENTS

A. Submit record documents.

B. Accurately record actual locations of access doors in radiation cabinets required for access or valving.

1.07 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturers descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.

1.08 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years experience.

1.09 REGULATORY REQUIREMENTS

A. Conform to local and ANSI/NFPA 70 code for internal wiring of factory wired equipment.

1.10 DELIVERY, STORAGE AND HANDLING

A. Deliver products to site.

B. Store and protect products.

C. Protect units from physical damage by storing in protected areas and leaving factory covers in place.

1.12 SEQUENCING AND SCHEDULING

A. Sequence and schedule work.

B. Install radiation, convectors, and cabinet heaters (equipment exposed to finished areas) after walls and ceiling are finished and painted. Avoid damage.

1.13 WARRANTY

A. Provide five-year manufacturer's warranty.

B. Warranty: Include coverage of unit heater and cabinet heater motors.

PART 2 PRODUCTS

2.01 MANUFACTURERS – PANEL RADIATION, CONVECTORS, UNIT HEATERS, AND CABINET UNIT HEATERS

A. Runtal.

2.03 RADIATION

A. General: Provide steel panel radiator elements of lengths and in locations as indicated, and of capacities, style and having accessories as scheduled. The wall hung heating panel radiation shall be of one-piece all-welded steel construction, consisting of flattened water tubes welded to headers at each end. The radiator shall include an integral heavy gauge (0.09” minimum) all-welded perforated top grille (for curved radiators the grille is omitted). RF models to have steel corrugated fins welded to the rear side of the water tubes to increase the convective output of the unit. There shall be no less than 32 fins per foot. Fins shall start within 1” of the headers, and shall be spot welded three times per tube. The radiator’s headers shall include all necessary inlet, outlet and vent connections as required. Standard connection sizes are ½” NPT tapered thread for supply and return piping, and 1/8” for the vent connection. Internal baffling is provided where required for proper water flow. Optional ¾” connections shall be available at an additional cost. The radiant heating panels shall be available in lengths from 2’-0” to 29’-6” in two inch even increments without the need for splicing. The panel radiation shall be capable of being mounted to typical stud wall construction without additional blocking or strapping. Appropriate wall mounting brackets or shall be provided with the radiation. Panel radiation expansion shall not exceed 1/64” per foot of radiation at 215ºF. The installer shall provide adequate expansion compensation for each radiator. The panel radiation shall be manufactured in the USA.

B. Pressure Ratings: Pressure ratings for the radiation shall be as follows: STANDARD:

Working pressure-56 PSI maximum, Test Pressure-74 PSI maximum Test Pressure 184 PSI maximum

C. Finishes: The panel radiation shall be cleaned and phosphatized in preparation for the powder coat finish. The radiation is then finish painted with a gloss powder coat finish, for a total paint thickness of 2-3 mils (0.002" - 0.003"). The color shall be selected from Runtal's ten Standard Colors; or Runtal Optional Colors shall be available at and additional cost.

D. Warranty: All Runtal radiators are covered by a 5-Year Limited Warranty.

E. Manufacturer: Subject to compliance with requirements, provide flat tube panel radiation as manufactured by Runtal North America, Inc.

F. provide: 1. Ribbed pipe cover trims, finished to match the radiators shall be provided with the radiation.

G. 2. The radiation manufacturer shall provide combination shutoff valve/union fitting of less than two inches in width for the supply and return to each panel radiator, to be field installed by others.

H. 3. Runtal-Flex connectors shall be used where appropriate to provide expansion compensation for the radiators.

2.04 CONVECTORS

A. Heating Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and cast iron headers, steel side plates and supports, factory air pressure tested at 100 psi under water, with means of adjusting pitch of element.

B. Cabinet: 16 gage steel front and top, 18 gage steel back and ends; exposed corners rounded; easily secured removable front panels, adequately braced and reinforced for stiffness.

C. Finish: Factory applied baked primer coat and enamel of color as selected by architect on visible surfaces of enclosure or cabinet.

D. Access Doors: For otherwise inaccessible valves, provide factory-made permanently hinged access doors, 6 x 7 inch minimum size, integral with cabinet.

2.05 UNIT HEATERS

A. Coils: Seamless copper tubing, 0.025 inch minimum wall thickness, silver brazed to steel headers, and with evenly spaced aluminum fins mechanically bonded to tubing.

B. Casing: 18 gage steel with threaded pipe connections for hanger rods.

C. Finish: Factory apply baked primer coat and enamel of color as selected by architect on visible surfaces of enclosure or cabinet.

D. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.

E. Air Outlet: Adjustable pattern diffuser on projection models and four way louvers on horizontal throw models.

F. Motor: Horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.

G. Control: Local disconnect switch. See contract drawings.

2.06 CABINET UNIT HEATERS

A. Coils: Evenly spaced aluminum fins mechanically bonded to copper tubes, designed for 100 psi and 220 degrees F.

B. Cabinet: 16 gage steel with exposed corners and edges rounded, easily removed panels, insulation integral air outlet, and inlet grilles.

C. Finish: Factory applied baked primer coat and enamel of color as selected by architect on visible surfaces of enclosure or cabinet.

D. Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven.

E. Motor: Sleeve bearings, resiliently mounted.

F. Control: Multiple speed switch, factory wired, located in cabinet.

G. Filter: Easily removed one inch thick glass fiber throw-away type, located to filter air before coil.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that surfaces are ready to receive work and opening dimensions are as instructed by the manufacturer.

B. Verify that required utilities are available, in proper location, and ready for use.

C. Beginning of installation means installer accepts existing surfaces.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Locate radiation on outside walls and run cover wall-to-wall unless otherwise indicated. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window. Install wall angles where units butt against walls. Install with bottom of cover 4 1/4" above finished floor.

C. Install convectors as indicated. Coordinate to assure correct recess size for recessed convectors.

D. Hang unit heaters from building structure, with pipe hangers anchored to building, not from piping. Mount as high as possible to maintain greatest headroom unless otherwise indicated.

E. Install cabinet unit heaters as indicated. Coordinate to assure correct recess size for recessed units.

F. Protect units with protective covers during balance of construction.

G. Provide hydronic units with valving and specialties as shown on contract drawings. If not easily accessible, extend vent to exterior surface of cabinet for easy servicing. For cabinet unit heaters, fan coil units, and unit heaters, provide float operated automatic air vents with stop valve. Provide manual air vents at all high point in system.

3.03 CLEANING

A. Clean work.

B. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

C. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

D. Install new filters.

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Packaged air handling units.

1.02 RELATED WORK

A. Temporary Heating, Cooling, and Ventilating.

B. Section 15890H - Ductwork.

C. Section 15910H - Ductwork Accessories: Flexible duct connections.

1.03 REFERENCES

A. AMCA 99 - Standards Handbook.

B. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

C. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

D. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.

E. AMCA 500 - Test Methods for Louver, Dampers, and Shutters.

F. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

G. ANSI/AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

H. ANSI/UL 900 - Test Performance of Air Filter Units.

I. ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.

J. ARI 430 - Standard for Central-Station Air-Handling Units.

K. ARI 435 - Standard for Application of Central-Station Air- Handling Units.

L. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

M. SMACNA - Low Pressure Duct Construction Standards.

1.04 QUALITY ASSURANCE

A. Fan Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301; tested to AMCA 300 and bear AMCA Certified Sound Rating Seal.

C. Fabrication: Conform to AMCA 99.

D. Filter Media: ANSI/UL 900 listed, Class I or Class II, approved by local authorities.

E. Air Coils: Certify capacities, pressure drops, and selection procedures in accordance with ARI 410.

F. Air Handling Units: Product of manufacturer regularly engaged in production of components who issues complete catalog data on total product.

1.05 SUBMITTALS

A. Submit shop drawings and product data in accordance with Section 15011H.

B. Shop drawings shall indicate assembly, unit dimensions, weight loading, required clearances, construction details, and field connection details.

C. Product data shall indicate dimensions, weights, capacities, ratings, fan performance, motor electrical characteristics, and gages and finishes of materials.

D. Provide fan curves with specified operating point clearly plotted.

E. Submit sound power levels for both fan outlet and casing radiation at rated capacity.

F. Submit product data of filter media, filter performance data, filter assembly, and filter frames.

G. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

H. Submit two samples of replacement filter media with frame.

I. Submit manufacturer's installation instructions.

1.06 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data in accordance with Section 15011H.

B. Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs.

B. Store and protect products.

C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.08 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.09 EXTRA STOCK

A. Provide one set of disposable panel filters.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Lennox.

B. Carrier.

C. Trane

2.02 GENERAL

A. Fabricate draw-thru type air handling units suitable for low pressure operation.

B. Fabricate units with fan or fan and coil section plus accessories, including cooling coil section.

C. Factory fabricate and test air handling units of sizes, capacities, and configuration as indicated and specified.

D. Base performance on sea level conditions.

2.03 COILS

A. Provide coil section with heating and cooling coils as indicated on contract drawings and access to both sides of coils. Enclose coils with headers and return bends exposed outside casing. Slide coils into casing through removable end panel.

B. Provide drain pans and down spouts for cooling coil banks more than one coil high. Provide eliminators of Type 304 stainless steel, mounted over drain pan.

2.04 FILTERS

A. Provide filter box of galvanized steel with filter guides, access doors from both sides, for side loading.

B. Provide flat arrangement with 1 inch deep disposable panel filters disposable.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Assemble high pressure units by bolting sections together.

C. Install unit on vibration isolators.

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Roof exhausters.

C. Cabinet exhaust fans.

1.02 RELATED WORK

A. Section 15890H - Ductwork.

B. Section 15910H - Duct Accessories: Backdraft dampers.

1.03 REFERENCES

A. AMCA 99 - Standards Handbook.

B. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

C. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

D. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.

E. SMACNA - Low Pressure Duct Construction Standard.

1.04 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal.

C. Fabrication: Conform to AMCA 99.

1.05 SUBMITTALS

A. Submit shop drawings and product data in accordance with Section 15011H.

B. Provide product data on wall and roof exhausters, and ceiling and cabinet fans.

C. Provide fan curves with specified operating point clearly plotted.

D. Submit sound power levels for both fan inlet and outlet at rated capacity.

E. Submit manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Penn.

B. Greenheck.

C. Carnes.

2.02 ROOF EXHAUSTERS

A. Centrifugal or Axial Fan Unit: V-belt and or direct driven, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 16 gage aluminum birdscreen; square base to suit roof curb with continuous curb gaskets; secured with stainless steel bolts and screws.

B. Roof Curb: 12 inch high self-flashing aluminum, 16 gauge, with continuously welded seams, built-in cant strip, one inch insulation and curb bottom, and factory installed door nailer strip. Suitable for pitched roof.

C. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor.

D. Backdraft Damper: Gravity activated, aluminum multiple blade construction, felt edged with nylon bearings.

E. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid- position; fan shaft with self-aligning pre-lubricated ball bearings.

2.03 CABINET AND CEILING EXHAUST FANS

A. Centrifugal Fan Unit: V-belt or direct driven, with galvanized steel housing lined with 1/2 inch acoustic insulation, resilient mounted motor, gravity backdraft damper in discharge.

B. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload

protected motor.

C. Grille: Molded plastic or aluminum with baked white enamel finish.

D. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid- position; fan shaft with self-aligning pre-lubricated ball bearings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Anchor roof curb securely to roof and secure roof exhausters with lag screws to roof curb.

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Low pressure ducts.

C. Dryer ducts and kitchen exhaust hood ductwork.

D. Duct cleaning.

1.02 RELATED WORK

A. Section 09900 - Painting: Weld priming, weather resistant, paint or coating.

B. Section 15140H - Supports and Anchors: Sleeves.

C. Section 15290H - Duct Insulation.

D. Section 15910H - Ductwork Accessories.

E. Section 15990H - Testing, Adjusting and Balancing.

1.03 REFERENCES

A. ASHRAE - Handbook 1981 Fundamentals; Chapter 33 - Duct Design.

B. ASHRAE - Handbook 1983 Equipment; Chapter 1 - Duct Construction.

C. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles.

D. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.

E. ASTM A 525 - General Requirements for Steel Sheet, Zinc- Coated (Galvanized) by the Hot-Dip Process.

F. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.

G. ASTM B209 - Aluminum and Aluminum Alloy Sheet and Plate.

H. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

I. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.

J. SMACNA - Low Pressure Duct Construction Standards.

K. UL 181 - Factory-Made Air Ducts and Connectors.

1.04 DEFINITIONS

A. Duct Sizes: Inside clear dimensions. For lined ducts, maintain sizes inside lining.

B. Low Pressure: Three pressure classifications: 1/2 inch WG positive or negative static pressure and velocities less than 2,000 fpm; 1 inch WG positive or negative static pressure and velocities less than 2,500 fpm and 2 inch WG positive or negative static pressure and velocities less than 2,500 fpm.

1.05 REGULATORY REQUIREMENTS

A. Construct ductwork to NFPA 90A and NFPA 90B and NFPA 96 standards as applicable.

1.06 SUBMITTALS

A. Submit shop drawings and product data in accordance with Section 15011H.

B. Indicate duct fittings, particulars such as gages, sizes, welds, and configuration prior to start of work.

C. Submit samples.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site.

B. Store and protect products.

PART 2 PRODUCTS

2.01 MATERIALS

A. General: Non-combustible or conforming to requirements for Class 1 air duct materials, or UL 181.

B. Steel Ducts: ASTM A525 or ASTM A527 galvanized steel sheet, lock-forming quality, having zinc coating of 1.25 oz. per sq. ft. for each side in conformance with ASTM

A90.

C. Fasteners: Rivets, bolts, or sheet metal screws.

D. Sealant: Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic.

E. Hanger Rod: Steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

2.02 LOW PRESSURE DUCTWORK

A. Fabricate and support in accordance with SMACNA Low Pressure Duct Construction Standards and ASHRAE handbooks, except as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.

B. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts. No variation of duct configuration or sizes permitted except by written permission of architect/engineer.

C. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide air foil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.

D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees.

E. Provide easements where low pressure ductwork conflicts with piping and structure. Where easements exceed 10 percent duct area, split into two ducts maintaining original duct area.

F. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with crimp in direction of air flow.

G. Use double nuts and lock washers on threaded rod supports.

H. Provide and install flanges, sleeves, transitions as required for the installation of coils in ductwork, conform to SMACNA for construction.

PART 3 EXECUTION

3.01 INSTALLATION

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

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

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

D. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for cleanout. Use stainless steel for ductwork exposed to view and stainless steel or galvanized steel for ducts where concealed.

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

3.02 DUCTWORK APPLICATION SCHEDULE

AIR SYSTEM	MATERIAL
Low Pressure Supply (Heating Systems)	Steel
Low Pressure Supply (System with Cooling Coils)	Steel
Return and Relief	Steel
General Exhaust	Steel
Outside Air Intake	Steel
Combustion Air	Steel

3.03 ADJUSTING AND CLEANING

A. Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.

B. Clean duct systems with high power vacuum machines. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate

access into ductwork for cleaning purposes.

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Volume control dampers.

C. Fire dampers.

D. Backdraft dampers.

E. Air turning devices.

F. Flexible duct connections.

G. Duct access doors.

H. Duct test holes.

1.02 RELATED WORK

A. Section 15890H - Ductwork.

1.03 REFERENCES

A. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

B. SMACNA - Low Pressure Duct Construction Standards.

C. UL 33 - Heat Responsive lINKS for Fire-Protection Service.

D. UL 555 - Fire Dampers and Ceiling Dampers.

1.04 SUBMITTALS

A. Submit shop drawings and product data in accordance with Section 15011H.

B. Provide shop drawings for shop fabricated assemblies indicated, including volume control dampers duct access doors, duct test holes.

C. Submit manufacturer's installation instructions for fire dampers.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS - Volume Control Damper

A. Air Balance.

B. Arlan Model OBD

2.02 VOLUME CONTROL DAMPERS.

A. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards, and as indicated.

B. Fabricate splitter dampers of material same gage as duct to 24 inches size in either direction, and two gages heavier for sizes over 24 inches.

C. Fabricate splitter dampers of double thickness sheet metal to streamline shape. Secure blade with continuous hinge or rod. Operate with minimum 1/4 inch diameter rod in self aligning, universal joint action flanged bushing with set screw.

D. Fabricate single blade dampers for duct sizes to 9-1/2 x 30 inch.

E. Fabricate multi-blade damper of opposed blade pattern with maximum blade sizes 12 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

F. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.

G. Provide locking, indicating quadrant regulators on single and multi-blade dampers.

H. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

2.03 ACCEPTABLE MANUFACTURERS - FIRE DAMPERS

A. Air Balance.

B. Arlan Model UL10.

2.04 FIRE DAMPERS

A. Fabricate in accordance with NFPA 90A and UL 555, and as indicated.

B. Fabricate ceiling firestop flaps of galvanized steel, 22 gage frame and 16 gage flap, two layers 0.125 inch ceramic fiber on top side, with locking clip.

C. Fabricate ceiling dampers of galvanized steel, 22 gage frame, stainless steel closure spring, and light weight, heat retardant non-asbestos fabric blanket closure.

D. Fabricate curtain type dampers of galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream except for low pressure ducts up to 12 inches in height.

E. Fabricate multiple blade fire dampers with 16 gage galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 1/8 x 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock.

F. Fusible links, UL 33, shall separate at 160 degrees F. Provide adjustable link straps for combination fire/balancing dampers.

2.05 BACKDRAFT DAMPERS - Arlan Model BDD or equal.

A. Gravity backdraft dampers, size 18 x 18 inches or smaller, furnished with air moving equipment, may be air moving equipment manufacturers standard construction.

B. Fabricate multi-blade, parallel action gravity balanced backdraft dampers of 16 gage galvanized steel, with center pivoted blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

2.06 AIR TURNING DEVICES

A. Multi-blade device with blades aligned in short dimension; steel or aluminum construction; with individually adjustable blades, mounting straps.

2.07 FLEXIBLE DUCT CONNECTIONS

A. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards, and as indicated.

B. UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 36 oz. per sq. yd., approximately 2 inches, crimped into metal edging strip.

2.08 DUCT ACCESS DOORS - Arlan Fire Limit Model 50A insulated or equal.

A. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards and as indicated.

B. Review locations prior to fabrication.

C. Fabricate rigid and close-fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover.

D. Access doors smaller than 12 inches square may be secured with sash locks.

E. Provide two hinges and two sash locks for sizes up to 18 inches square, three hinges and two compression latches with outside and inside handles for sizes up to 24 x 48 inches. Provide an additional hinge for larger sizes.

F. Access doors with sheet metal screw fasteners are not acceptable.

2.09 DUCT TEST HOLES

A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

B. Permanent test holes shall be factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

PART 3 EXECUTION

3.01 INSTALLATION

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

B. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Use splitter dampers only where indicated.

C. Provide balancing dampers on medium and high pressure systems where indicated.

D. Provide fire dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.

E. Demonstrate re-setting of fire dampers to authorities having jurisdiction and Owner's representative.

F. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

G. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment.

H. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, and elsewhere as indicated. Provide minimum 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, and as indicated.

I. Provide duct test holes where indicated and required for testing and balancing purposes.

END OF SECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Diffusers.

C. Grilles.

D. Louvers.

1.02 RELATED WORK

A. Section 09900 - Painting: Painting of ductwork visible behind outlets and inlets.

1.03 REFERENCES

A. ADC 1062 - Certification, Rating and Test Manual.

B. AMCA 500 - Test Method for Louvers, Dampers and Shutters.

C. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

D. ARI 650 - Air Outlets and Inlets.

E. ASHRAE 70 - Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.

F. SMACNA - Low Pressure Duct Construction Standard.

1.04 QUALITY ASSURANCE

A. Test and rate performance of air outlets and inlets in accordance with ADC Equipment Test Code 1062 and ASHRAE 70.

B. Test and rate performance of louvers in accordance with AMCA 500.

1.05 REGULATORY REQUIREMENTS

A. Conform to ANSI/NFPA 90A.

1.06 SUBMITTALS

A. Submit product data in accordance with Section 15011H.

B. Provide product data for items required for this project.

C. Submit schedule of outlets and inlets indicating type, size, location, application, and noise level.

D. Review requirements of outlets and inlets as to size, finish, and type of mounting prior to submitting product data and schedules of outlets and inlets.

E. Submit manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS - CEILING DIFFUSERS

A. Titus.

B. Tuttle & Bailey.

C. Carnes.

2.02 SQUARE CEILING DIFFUSERS

A. Square, adjustable pattern, stamped, multicore type diffuser to discharge air in 360 degree pattern with sectorizing baffles where indicated.

B. Provide snap-in inverted T-bar type frame as required by ceiling construction.

C. Fabricate of steel with baked enamel finish. Color by Architect.

2.03 ACCEPTABLE MANUFACTURERS - GRILLES

A. Titus.

B. Tuttle & Bailey.

C. Carnes.

2.04 CEILING SUPPLY REGISTERS/GRILLES

A. Streamlined and individually adjustable curved blades to discharge air along face of grille. Paint finish to be baked enamel. Color by Architect.

2.05 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

A. Streamlined blades, depth of which exceeds 3/4 inch spacing, with spring or other device to set blades. Finish to be baked enamel. Color by Architect.

2.06 ACCEPTABLE MANUFACTURERS - LOUVERS

A. Titus.

B. Carnes.

C. Grillmaster.

2.07 LOUVERS

A. Provide 6-inch-deep louvers with blades on 45-degree slope with center baffle and return bend, heavy channel frame, birdscreen with 1/2-inch square mesh for exhaust and 3/4 inch for intake.

B. Fabricate of 12 gage extruded aluminum, welded assembly, with factory prime coat Kaynar 500 fluoro-polymer finish. Color by Architect.

C. Furnish with interior angle flange jambs and exterior flat flange for installation.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install items in accordance with manufacturers' instructions.

B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement. Refer to Section 09900.

C. Install diffusers to ductwork with air tight connection.

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

E. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 9A.

PART 1 GENERAL

1.01 WORK INCLUDED

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Complete system of automatic controls.

C. Electric control system.

D. Electronic control system.

E. Control devices, components, wiring and material.

F. Instructions for Owners.

G. Comply with requirements of electrical specifications.

1.02 RELATED WORK

A. Section 15910H - Ductwork Accessories.

B. Section 16010E - General Provisions Electrical.

1.03 REFERENCES

A. Not used.

1.04 SUBMITTALS

A. Submit shop drawings and product data in accordance with Section 15011H.

B. Provide damper shop drawings which show data such as arrangement, velocities, and static pressure drops for each system.

C. Provide complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences, and description and engineering data on each control system component. Include sizing as requested.

D. At completion of work, submit report of check-out of automatic control system.

E. Provide control diagrams for each system, framed under glass for wall mounting.

F. Submit manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Honeywell.

B. Johnson.

C. Lennox.

2.02 SYSTEM REQUIREMENTS

A. Provide control systems consisting of thermostats, control valves, dampers, operators, indicating devices, interface equipment, and other apparatus required to operate mechanical systems and to perform functions specified.

B. Provide necessary materials and fieldwork necessary to connect control components factory supplied as part of equipment controlled, unless specified otherwise. Generally, self- contained valves, filter gauges, liquid level controllers and similar instruments are not to be installed under this Section.

C. Unless specified otherwise, provide fully proportional components.

2.03 THERMOSTATS

A. Provide electronic solid-state microcomputer based zone thermostat, located as indicated on drawings. Provide remote sensors for heating cooling thermostats as indicated on drawings.

B. Room thermostat shall incorporate:
1. Automatic switching from staged heating to staged cooling on all split system units.
2. Preferential rate control to minimize overshoot and deviation from set point.
3. Instant override of setpoint for continuous or timed period from one hour to 31 days.
4. Short cycle protection.
5. Programming based on weekdays, Saturday and Sunday, night setback.
6. Switch selection features including temperature display, 12 or 24 hour clock, keyboard disable, fan on-auto.
7. Carbon monoxide control with demand ventilation.
8. fresh air/return air damper control.

C. Room thermostat display shall include:
1. Time of Day.
2. Actual room temperature.

3. Programmed temperature.
4. Programmed time.
5. Duration of timed override.
6. Day of week.
7. System mode indication: Heating, cooling, auto, off, fan auto, fan on.
8. Staged (heating or cooling) operation.

2.04 CONTROL VALVES

A. Provide valves in accordance with general valve specification. Provide position indicators on valves and pilot positions on sequenced valves.

B. Select valves to fail safe in normally open or closed position as dictated by freeze, humidity, fire, or temperature protection.

C. Select two-way valves for liquids to have equal percentage characteristics. Select three-way valves to have linear characteristics. Size valve operators to close valves against pump shut off head. Size for maximum 3 psi drop.

2.05 SYSTEM OPERATION

A. Unit Heaters:
   1. Sequences of Operation:
      a. Unit heaters to be controlled on-off by wall mounted thermostat. Thermostat to control three-way valve at unit heater. Unit heater fan to be controlled on-off by unit mounted aquastat.

B. Boiler
   1. Sequence of Operation:
      a. The boiler shall be controlled on-off by an operating aquastat which will vary to a maximum of 190 degrees F. The boiler operating setpoint shall be reset with respect to outdoor air temperature.
      b. The boiler shall fully modulate based upon heating demand.

C. Pumps
   1. Sequence of Operation: Pumps
      a. Each pump shall have a hand-off-auto switch. The H-O-A switches shall be set to the auto position. The pumps shall run continuously at outdoor temperatures below 65 degrees F. in this position. In the hand position the pumps shall operate continuously and vary the output based upon pressure differential. In the off position the pumps shall not operate.

D. Baseboard Radiation
   1. Sequence of Operation:
      a. Radiation shall be controlled on-off by radiation mounted thermostatic valve.

E. Cabinet Heaters
   1. Sequence of Operation:
      a. Heaters shall be controlled by factory equipped thermostat mounted in unit. Thermostat to control three-way valve at heater.

F. Air Conditioning Units
   1. Control:
      a. Unit shall be controlled by 7-day programmable thermostat with user adjustable keypad and remote sensor. Locate thermostats as indicated on plans.

   2. Sequence of Operation:
      a. Occupied/Unoccupied mode:
         Heating: A hot water coil control valve shall modulate to maintain a constant discharge air setpoint.
         Cooling: first stage of cooling shall run compressors on low speed. Second stage of cooling shall run compressors on high speed. On any call for cooling the hot water valve shall be fully closed.
         Unit shall automatically switch between cooling and heating modes as required to maintain space temperature. The supply fan shall operate continuously and vary speed based upon demand.

G. Outdoor air dampers:
   1. Sequences of Operation:
      a. Unoccupied mode:
         Outdoor air damper shall fully close and return air damper shall fully open.
      b. Occupied mode:
         Outdoor air damper shall open to minimum position and return air damper shall be at its fully open position.

H. Demand ventilation:
   1. Sequence of Operation:
      a. N/A.

J. Bathroom Fans
   1. Sequence of Operation:
      a. Units shall be controlled on-off by occupancy sensor.

K. App bay Fans
   1. Sequence of Operation:
      a. N/A.

L. Kitchen Exhaust Fan
   1. Sequence of Operation:

a. Unit shall be controlled by an on-off switch and be interlocked with heated makeup air unit and equipment under hood

PART 3 EXECUTION

3.01 INSTALLATION

A. Check and verify location of thermostats and other exposed control sensors with plans and room details before installation. Locate thermostats 60 inches above floor.

B. Interlock alarms with starter switching to bypass alarm when equipment is manually disconnected. Provide all starters and on-off switches.

C. At completion of installation provide minimum of 27 days instruction period for operating personnel.

D. Provide for complete service of controls system, including call-backs, for one year running concurrent with connection period.

END OF SECTION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

B. Flow meters.

C. Pressure gages and pressure gage taps.

D. Thermometers and thermometer wells.

E. Static pressure and filter gages.

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Section 15510H - Hydronic Piping: Installation of thermometer wells, pressure gage tappings.

1.03 RELATED SECTIONS

A. Section 15952H - Controls and Instrumentation.

B. Section 15985H - Sequence of Operation.

C. Section 15990H - Testing, Adjusting and Balancing.

1.04 REFERENCES

A. ASME B40.1 - Gages - Pressure Indicating Dial Type - Elastic Element.

B. ASME MFC-3M - Measurement of Fluid Flow in Pipes Using Orifice, Nozzle and Venturi.

C. ASTM D2458 - Method of Flow Measurement by The Venturi Motor Tube.

D. ASTM E1 - Specification for ASTM Thermometers.

E. ASTM E77 - Verification and Calibration of Liquid-in-Glass Thermometers.

F. AWWA C706 - Direct Reading Remote Registration Systems for Cold Water Meters.

G. AWWA M6 - Water Meters - Selection, Installation, Testing, and Maintenance.

H. FS-GG-G-76 - Gages, Pressure and Vacuum, Dial Indicating (for Air, Steam, Oil, Water, Ammonia, Chloro- Flourhydrocarbon Gases, and Compressed Gases).

I. ISA RP 3.2 - Flange Mounted Sharp Edged Orifice Plates for Flow Measurement

J. UL 393 - Indicating Pressure Gages for Fire and Protection Services.

K. UL 404 - Gages, Indicating Pressure, for Compressed Gas Service.

1.05 SUBMITTALS

A. Submit under provisions of Section 15011H.

B. Product Data: Include list which indicates use, operating range, total range and location for manufactured components.

C. Submit manufacturer's installation instructions under provisions of Section 15011H.

1.06 PROJECT RECORD DOCUMENTS

A. Submit "as-built" record documents.

B. Accurately record actual locations of instrumentation.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Marshalltown.

2.02 PRESSURE GAGES

A. ASME B40.1, UL 393, UL 404 2-1/2 inch diameter drawn steel case, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background, one percent mid-scale accuracy, scale

calibrated in psi, Fig. 83K manufactured by Marshalltown.

2.03 PRESSURE GAGE TAPS

A. Gage Cock: Lever handle, brass for maximum 150 psig, Fig. 125 manufactured by Marshalltown.

B. Needle Valve: Steel for maximum 150 psig, Fig. 200 manufactured by Marshalltown.

C. Pulsation Damper: Pressure snubber, brass with 1/4 inch connections, Fig. 129 manufactured by Marshalltown.

D. Syphon: Steel, Schedule 40, 1/4 inch angle or straight pattern, Model 126 or 127 manufactured by Marshalltown.

2.06 STEM TYPE THERMOMETERS

A. ASTM E1, 9 inch scale, red appearing mercury, lens front tube, cast aluminum case with enamel finish and clear glass or polycarbonate window, brass stem, 2 percent of scale accuracy to ASTM E77 scale calibrated in degrees F, 91000 Series manufactured by Marshalltown.

2.07 DIAL THERMOMETERS

A. ASTM E1, 3-1/2 inch diameter dial in steel case, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed lens, stainless steel stem, one percent of full scale accuracy, calibrated in degrees F, Model SJ Series manufactured by Marshalltown.

2.08 THERMOMETER SUPPORTS

A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.

B. Flange: 3 inch outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.09 TEST PLUGS

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

degrees F.

B. Test Kit: Carrying case, internally padded and fitted containing one 2-1/2 inch diameter pressure gages, one gage adapter with 1/8 inch probes, two one inch dial thermometers.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide one pressure gage per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gage.

C. Install pressure gages with pulsation dampers. Provide gage cock to isolate each gage.

D. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch for installation of thermometer sockets.

E. Install thermometers in air duct systems on flanges.

F. Install thermometer sockets adjacent to controls system thermostat, transmitter, or sensor sockets. Refer to Section 15975. Where thermometers are provided on local panels, duct or pipe mounted thermometers are not required.

G. Locate duct mounted thermometers minimum 10 feet downstream of mixing dampers, coils, or other devices causing air turbulence.

I. Coil and conceal excess capillary on remote element instruments.

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

K. Install gages and thermometers in locations where they are easily read from normal operating level.

L. Locate test plugs adjacent to thermometers and thermometer sockets, adjacent to pressure gages and pressure gage taps, adjacent to control device sockets.

END OF SECTION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this Section.

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

C. Testing, adjustment, and balancing of hydronic systems.

D. Measurement of final operating condition of HVAC systems.

1.02 RELATED SECTIONS

A. Section 15556H - Cast Iron Boilers.

B. Section 15671H - Air Cooled Condensing Units.

C. Section 15855H - Air Handling Units with Coils.

D. Section 15870H - Power Ventilators.

E. Section 15890H - Ductwork.

F. Section 15910H - Ductwork Accessories.

G. Section 15952H - Controls and Instrumentation: Controls, compressors, and sequence of operation.

1.03 REFERENCES

A. AABC - National Standards for Field Measurement and Instrumentation, Total System Balance.

B. ASHRAE - 1984 Systems Handbook: Chapter 37, Testing, Adjusting and Balancing.

C. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

1.04 SUBMITTALS

A. Submit name of adjusting and balancing agency for approval within 30 days after award

of Contract.

B. Submit test reports as a submittal in accordance with Section 15011H.

C. Prior to commencing work, submit draft reports indicating adjusting, balancing, and equipment data required.

D. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect/Engineer and for inclusion in operating and maintenance manuals.

E. Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

F. Include detailed procedures, agenda, sample report forms, prior to commencing system balance.

1.06 REPORT FORMS

A. Submit reports on AABC National Standards for Total System Balance.

B. Forms shall include the following information:
   1. Title Page:
      a. Company name
      b. Company address
      c. Company telephone number
      d. Project name
      e. Project location
      f. Project Architect
      g. Project Engineer
      h. Project Contractor
      i. Project altitude
   2. Instrument List:
      a. Instrument
      b. Manufacturer
      c. Model
      d. Serial number
      e. Range
      f. Calibration date
   3. Air Moving Equipment:
      a. Location

b. Manufacturer
c. Model
d. Air flow, specified and actual
e. Return air flow, specified and actual
f. Outside air flow, specified and actual
g. Total static pressure (total external), specified and actual
h. Inlet pressure
i. Discharge pressure
j. Fan RPM

4. Exhaust Fan Data:
   a. Location
   b. Manufacturer
   c. Model
   d. Air flow, specified and actual
   e. Total static pressure (total external), specified and actual
   f. Inlet pressure
   g. Discharge pressure
   h. Fan RPM
5. Return Air/Outside Air Data:
   a. Identification/location
   b. Design air flow
   c. Actual air flow
   d. Design return air flow
   e. Actual return air flow
   f. Design outside air flow
   g. Actual outside air flow
   h. Return air temperature
   i. Outside air temperature
   j. Required mixed air temperature
   k. Actual mixed air temperature
   l. Design outside/return air ratio
   m. Actual outside/return air ratio
6. Electric Motors:
   a. Manufacturer
   b. HP/BHP
   c. Phase, voltage, amperage; nameplate, actual, no load.
   d. RPM
   e. Service factor
   f. Starter size, rating, heater elements
7. V-Belt Drive:
   a. Identification/location
   b. Required driven RPM
   c. Driven sheave, diameter and RPM

d. Belt, size and quantity
e. Motor sheave, diameter and RPM
f. Center to center distance, maximum, minimum, and actual

8. Duct Traverse:
   a. System zone/branch
   b. Duct size
   c. Area
   d. Design velocity
   e. Design air flow
   f. Test velocity
   g. Test air flow
   h. Duct static pressure
   i. Air temperature
   j. Air correction factor
9. Air Monitoring Station Data:
   a. Identification/location
   b. System
   c. Size
   d. Area
   e. Design velocity
   f. Design air flow
   g. Test velocity
   h. Test air flow
10. Pump Data:
   a. Identification/number
   b. Manufacturer
   c. Size/model
   d. Impeller
   e. Service
   f. Design flow rate, pressure drop, BHP
   g. Actual flow rate, pressure drop, BHP
   h. Discharge pressure
   i. Suction pressure
   j. Total operating head pressure
   k. Shut off, discharge and suction pressures
   l. Shut off, total head pressure
11. Cooling Coil Data:
   a. Identification/number
   b. Location
   c. Service
   d. Manufacturer
   e. Air flow, design and actual
   f. Entering air DB temperature, design and actual

g. Entering air WB temperature, design and actual
h. Leaving air DB temperature, design and actual
i. Leaving air WB temperature, design and actual
j. Water flow, design and actual
k. Water pressure drop, design and actual
l. Entering water temperature, design and actual
m. Leaving water temperature, design and actual
n. Air pressure drop, design and actual

12. Flow Measuring Station:
    a. Identification/station
    b. Location
    c. Size
    d. Manufacturer
    e. Model
    f. Design flow rate
    g. Design pressure drop
    h. Actual/final pressure drop
    i. Actual/final flow rate
    j. Station calibrated setting
13. Duct Leak Test:
    a. Description of ductwork under test
    b. Duct design operating pressure
    c. Duct design test static pressure
    d. Duct capacity, air flow
    e. Maximum allowable leakage duct capacity times leak factor
    f. Test apparatus
        1) Blower
        2) Orifice, tube size
        3) Orifice size
        4) Calibrated
    g. Test static pressure
    h. Test orifice differential pressure
    i. Leakage
14. Combustion Test:
    a. Boiler manufacturer
    b. Model
    c. Firing rate
    d. Overfire draft
    e. Gas meter timing dial size
    f. Gas meter time per revolution
    g. Gas pressure at meter outlet
    h. Gas flow rate
    i. Heat input

j. Burner manifold gas pressure
k. Percent carbon monoxide (CO)
l. Percent carbon dioxide (CO2)
m. Percent oxygen (O2)
n. Percent excess air
o. Flue gas temperature at outlet
p. Ambient temperature
q. Net stack temperature
r. Percent stack loss
s. Percent combustion efficiency
t. Heat output

1.07 PROJECT RECORD DOCUMENTS

A. Submit record documents.

B. Accurately record actual locations of flow measuring stations, balancing valves and rough setting.

1.08 QUALITY ASSURANCE

A. Agency shall be company specializing in the adjusting and balancing of systems specified in this Section with minimum three years experience. Perform Work under supervision of Balancing and Adjusting Supervisor.

B. Total system balance shall be performed in accordance with AABC National Standards for Field Measurement and Instrumentation, Total System Balance. ASHRAE - 1984 Systems Handbook.

1.09 SEQUENCING AND SCHEDULING

A. Sequence work.

B. Schedule work.

C. Sequence work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

D. Schedule and provide assistance in final adjustment and test of life safety system with Fire Authority.

PART 2 PRODUCTS Not Used

PART 3 EXECUTION

3.01 EXAMINATION

A. Before commencing work, verify that systems are complete and operable. Ensure the following:
   1. Equipment is operable and in a safe and normal condition.
   2. Temperature control systems are installed complete and operable.
   3. Proper thermal overload protection is in place for electrical equipment.
   4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
   5. Duct systems are clean of debris.
   6. Correct fan rotation.
   7. Fire and volume dampers are in place and open.
   8. Coil fins have been cleaned and combed.
   9. Access doors are closed and duct end caps are in place.
   10. Air outlets are installed and connected.
   11. Duct system leakage has been minimized.
   12. Hydronic systems have been flushed, filled, and vented.
   13. Correct pump rotation.
   14. Proper strainer baskets are clean and in place.
   15. Service and balance valves are open.

B. Report any defects or deficiencies noted during performance of services to Architect/Engineer.

C. Promptly report abnormal conditions in mechanical systems or conditions which prevent system balance.

D. If, for design reasons, system cannot be properly balanced, report as soon as observed.

E. Beginning of work means acceptance of existing conditions.

3.02 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect/Engineer to facilitate spot checks during testing.

B. Provide additional balancing devices as required.

3.03 INSTALLATION TOLERANCES

A. Adjust air handling systems to plus or minus 5 percent for supply systems and plus or minus 10 percent for return and exhaust systems from figures indicated.

B. Adjust hydronic systems to plus or minus 10 percent of design conditions indicated.

3.04 ADJUSTING

A. Adjust work.

B. Recorded data shall represent actually measured, or observed condition.

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

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

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

F. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

G. Check and adjust systems approximately six months after final acceptance and submit report.

3.05 AIR SYSTEM PROCEDURE

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

B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

C. Measure air quantities at air inlets and outlets.

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

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

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

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

H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

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

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

K. Where modulating dampers are provided, take measurements and balance at extreme conditions.

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

3.06 WATER SYSTEM PROCEDURE

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

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

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

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

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

F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

END OF SECTION

SECTION 23 09 00 BAS Instrumentation and Control

PART 1 - GENERAL

1.1 Related Sections

.1 SECTION 23 09 13, BAS Instrumentation and Control Devices

.2 SECTION 23 09 13.13, BAS Actuators and Operators

.3 SECTION 23 09 13.23, BAS Sensors and Transmitters

.4 SECTION 23 09 13.33, BAS Control Valves

.5 SECTION 23 09 13.43, BAS Control Dampers

.6 SECTION 23 09 33, Variable Frequency Drives

.7 SECTION 23 09 23, BAS Direct Digital Control System

.8 SECTION 23 09 93, BAS Sequences of Operations

1.2 References

.1 American National Standards Institute (ANSI)

.1 ANSI/ISA 5.5-1985 Graphic Symbols for Process Displays.

.2 ANSI/IEEE 260.1 2004, Standard Letter Symbols for SI and Certain Other Units of Measurements (SI Units, Customary Inch Pound Units and Certain Other Units).

.3 ANSI/ASHRAE 135-2016, BACnet® - A Data Communication Protocol for Building Automation and Control Networks.

1.3 Acronyms, Abbreviations and Definitions

.1 Acronyms used in BAS.

.1 BAS – Building Automation System

.2 EMCS – Energy Management and Control System

.3 GUI – Graphical User Interface

.4 HVAC - Heating, Ventilation, Air Conditioning

.5 I/O - Input/output

.6 ISA - Industry Standard Architecture

.7 O&M - Operation and Maintenance

.8 Niagara4 – Software framework for building device-to-enterprise applications and Internet-enabled products.

1.4 Permits and Fees

.1 In accordance with General Conditions of Contract.

.2 Submit certificate of acceptance from authority having jurisdiction to Owner.

1.5 General Description

.1 Refer to control schematics for general system architecture.

.2 Work covered by sections referred to above consists of fully operational BAS, including, but not limited to, following:

.1 Control devices as listed in I/O Summaries.

.2 Peripheral devices.

.3 Complete operating and maintenance manuals and field training of operators, programmers and maintenance personnel.

.4 Acceptance tests, technical support during commissioning, full documentation.

.5 Wiring interface co-ordination of equipment supplied by others.

.6 Miscellaneous work as specified in these sections and as indicated.

1.6 US Customary Measurement References

.1 Conform to NIST Handbook 44 - 2014 Edition Appendix C “General Tables of Units of Measurement”

.2 Provide required adapters between US Customary and Metric components.

1.7 Standards Compliance

.1 All equipment and material to be from manufacturer's regular production, UL and/or ULC or CSA certified, manufactured to standard quoted plus additional specified requirements.

.2 Where UL and/or ULC or CSA certified equipment is not available submit such equipment to inspection authorities for special inspection and approval before delivery to site.

.3 Submit proof of compliance to specified standards with shop drawings and product data. Label or listing of specified organization is acceptable evidence.

.4 In lieu of such evidence, submit certificate from testing organization, approved by Owner, certifying that item was tested in accordance with their test methods and that item conforms to their standard/code.

.5 For materials whose compliance with organizational standards/codes/specifications is not regulated by an organization using its own listing or label as proof of compliance, furnish certificate stating that material complies with applicable referenced standard or specification.

.6 Additional applicable codes and standards:

.1 National Electrical Code -- NFPA 70.

.2 Local Electrical Codes

.3 Federal Communications Commission -- Part J.

1.8 Work Included

.1 Provide a new building system to control and monitor all the building's mechanical and electrical systems.

.2 Provide control valves, control damper actuators / end switches (gravity, fire and smoke control dampers by others), flow switches, thermal wells for temperature control, air flow stations, and other control devices as necessary.

.3 Provide submittal data sheets, control drawings schematics (in Visio or AutoCAD), data entry, electrical installation, programming, start up, test and validation acceptance documentation, as-built documentation, maintenance manuals and system warranties.

.4 All labor, material, equipment and services not specifically referred to in this specification or on associated drawings that are required to fulfill the functional intent of this specification shall be provided at no additional cost to the Owner.

.5 The work covered by this specification and related sections consists of providing submittals, labor, materials, engineering, technical supervision, and transportation as required to furnish and install a fully operational BAS to monitor and control the facilities listed herein, and as required to provide the operation specified in strict accordance with these documents, and subject to the terms and conditions of the contract. The work in general consists of but is not limited to, the following:

.1 The preparation of submittals and provision of all related services.

.2 Furnish and install all to achieve system operation, any control devices, conduit and wiring, in the facility as required to provide the operation specified.

.3 Furnish complete operating and maintenance manuals and field training of operators, programmers, and maintenance personnel.

.4 Perform acceptance tests and commissioning as indicated.

.5 Provide full documentation for all applications and equipment.

.6 Miscellaneous work as indicated in these specifications.

1.9 Work By Others

.1 Setting in place of valves and dampers, access doors, flow meters, water pressure and differential taps, flow switches, thermal wells, air flow stations, and current transformers shall be by the mechanical contractor.

.2 Duct smoke detectors, smoke dampers, fire/smoke dampers, and associated actuators / end switches shall be provided under another Division of this specification. The Division 26 electrical contractor shall interlock these devices to the BAS for shutdown/monitoring unless otherwise outlined in the Sequences of Operations for this project. The BAS contractor shall coordinate where to land wires and programming as needed.

.3 Switches, and power wiring to motors, starters, thermal overload switches, and contactors, is specified under another Division of this specification.

1.10 BAS Open System Design and Qualifications

.1 Open System Design: It is the owners expressed goal to implement an open Building Automation System that will allow products from different manufacturers and/or suppliers to be integrated into a single unified system in order to provide flexibility for expansion, maintenance, and service of the system. The BAS manufacturer / contractor must provide proof of open system design as outlined below.

.2 Prior to award of the contract the BAS contractor is to provide proof of “Open System Design” with the following requirements:

.1 Provide proof of having a local office for at least 5 years, staffed by trained personnel capable of providing installation, engineering, programming, servicing, commissioning, instruction, routine maintenance, and emergency service on systems.

.2 The controls system shall utilize the Niagara4 software framework.

.1 The Contractor shall have a minimum of 2 years’ experience in the sales, installation, engineering, programming servicing and commissioning of Niagara4.

.2 Submit the Niagara Compatibility Statement (NiCS) via a letter from the manufacturer. The NiCS shall have no connectivity restrictions and all aspects of the Niagara Framework will be provided to maintain an Open System Design. The System as provided shall confirm with the following NiCS properties (Station Compatibility In, Station Compatibility Out, Tool Compatibility In, AND Tool Compatibility Out shall each have a value of “All”).

.3 The controls system shall conform to the following guidelines for communication protocols.

.1 BACnet shall be used for all BAS provided controllers.

.1 The manufacturer of the hardware and software components as well as its subsidiaries must be a member in good standing of the BACnet International and all controllers used shall be BACnet Listed with documentation on the BACnet website (https://www.bacnetinternational.net/btl/search.php)

.2 The use of BACnet Communications protocol alone shall NOT warrant an “Open System Design.” Manufacturers must adhere to all aspects of “BAS Open System Design and Qualifications” and “Acceptable System Manufacturers” sections to comply.

.2 Modbus shall only be acceptable for third party devices.

.3 Fox protocol shall NOT be acceptable.

.4 Proprietary communications protocols shall NOT be acceptable.

.4 A software programming tool shall be provided for this project and adhere to the following guidelines:

.1 All software tools needed for full functional use, including programming of controllers, Niagara4 Framework network management and expansion, and graphical user interface use and development, of the BAS described within these specifications shall be provided to the owner or his designated agent.

.2 The software programming tool shall be free of charge and openly available for download from the internet.

.3 For any manufacturer that does not have a free programming tool the manufacturer must provide the tool with this project for a minimum of 5 years with proof of availability via letter from the manufacturer.

.4 Any licensing required by the manufacturer now and to the completion of the warranty period, including changes to the licensee of the software tools and the addition of hardware corresponding to the licenses, to allow for a complete and operational system for both normal day to day operation and servicing shall be provided.

.5 Provide record of successful installations of similar size, performed by Contractor submitting the tender, showing successful experience with similar computer based systems.

.6 Provide proof of having access to local supplies of essential parts and provide 7 year guarantee of availability of compatible spare parts after manufacturer’s declaration of obsolescence.

.7 Provide proof of having in-house staff with expertise in pneumatic controls where applicable.

.8 Provide Profiles for each employee who will be involved in this project.

1.11 System Design Responsibility

.1 Design and provide all conduit and wiring linking all elements of system, including future capability.

.2 Design and provide all material for interfaces to existing pneumatic controls where applicable.

.3 Location of controllers to be approved by Owner prior to installation.

.4 Provide utility power or emergency power where directed and/or indicated on drawings, to controllers.

PART 2 - PRODUCTS

2.1 Acceptable System Manufacturers and Contractors

.1 Provide a building automation system supplied by a company regularly engaged in the manufacturing and distribution of building automation systems for a minimum of 5 years.

.2 The manufacturer of the hardware and software components shall have a technical support group accessible via a toll free number that is staffed with qualified personnel, capable of providing instruction and technical support service for networked control systems.

.3 Acceptable Manufacturers

.1 Distech Controls (Basis of Design)

.4 All other manufacturers/contactors besides the “Basis of Design” manufacturer (including those listed above) must submit a compliance matrix outlining “C – Comply”, “D – Does Not Comply”, and “E – Exclude” for the entirety of the 230900 and 230993 sections prior to bid award.

.1 Being listed as an approved manufacturer/contractor does not preclude the bidder from meeting all aspects and requirements of this specification.

.2 Those bidders not prequalified prior to review of bids will not be considered responsive. To be prequalified a bidder must be accepted to bid the project by the engineer either by a bid addendum or documented RFI response from the engineer. No other prequalifications shall be acceptable.

2.2 Quality Assurance

.1 All new building automation system products on this project shall be provided by a firm that is a registered ISO 9001:2008 manufacturer, for a minimum duration of 5 years, at time of bid.

.2 The Building Automation System shall be furnished, engineered, installed, tested and calibrated by factory certified technicians qualified for this work. The contractor shall be Factory Authorized in good standing with the Manufacturer. Factory trained technicians shall provide instruction, routine maintenance, and emergency service within 24 hours upon receipt of request.

.1 Upon request, installer shall present records of successful completion of factory training courses including course outlines.

.2 Upon request, the installer shall provide a letter from the manufacturer that they are a Factory Authorized installer in good standing with the Manufacturer.

2.3 Computer Hardware

.1 Provide the following computer hardware for this project:

.1 (1) Onsite Server(s)

.2 (1) Workstation Computer(s)

.3 (0) Notebook / Laptop Computer(s)

.4 (1) Local Touchscreen Display(s)

.5 (1) Printer(s)

.6 (1) Uniterruptable Power Supplies

.2 Server Hardware Requirements

.1 The Server shall be a PC with minimum Intel Core i5 Quad core 3.4 GHz processor with 8 GB RAM and a 1TB SATA hard drive with 6 GB/s transfer rate. It shall include a minimum 32X CD-ROM drive and 4-USB 3.0 ports. A minimum 21", HDMI, DVI-D video interfaces, minimum 1024 x 768 resolution, 4x3 Widescreen, LED color monitor with a minimum 60 Hz refresh rate shall also be included.

.2 Latest Windows operating system and Microsoft Office programs.

.3 Latest version of Symantec Antivirus Software that includes a 3 year subscription service to the Symantec software.

.4 Connection to the BAS LAN network shall be via an Ethernet network interface card, 100 Mbps.

.5 The server shall support all network/building controllers, OWSs, and 3rd party mechanical / electrical systems connected to the Facility Management Control / Building Automation System Local Area Network.

.6 Acceptable Manufacturers are:

.1 Dell

.2 Lenovo

.3 HP (Hewlett Packard)

.3 Workstation Hardware Requirements

.1 The workstation shall be a PC with minimum Intel Core i5 Quad core 3.4 GHz processor with 8 GB RAM and a 1TB SATA hard drive with 6 GB/s transfer rate. It shall include a minimum 32X CD-ROM drive and 4-USB ports. A minimum 21", HDMI, DVI-D video interfaces, minimum 1024 x 768 resolution, 4x3 Widescreen, LED color monitor with a minimum 60 Hz refresh rate shall also be included.

.2 Latest Windows operating system and Microsoft Office programs.

.3 Connection to the BAS LAN network shall be via an Ethernet network interface card, 100 Mbps.

.4 Workstation(s) should be loaded with Programming Tools

.5 Acceptable Manufacturers are:

.1 Dell

.2 Lenovo

.3 HP (Hewlett Packard)

.6 Latest Windows operating system and Microsoft Office programs.

.7 Acceptable Manufacturers are:

.1 Dell

.2 Lenovo

.3 HP (Hewlett Packard)

.4 Local Touchscreen Display Requirements

.1 Pre-loaded visual interface for simplified commissioning,operations and troubleshooting; including real time notification of alarms, trend viewing, schedule / calendar adjustment, point data view and override, and graphical displays.

.2 The local touchscreen display shall be associated with a single BACnet/IP controller such as a mechanical room display for a chilled water controller. The display(s) shall be associated with the following systems / equipment: XXXX.

.3 Acceptable Manufacturers are:

.1 Distech Horizon-C or Horizon-R

.2 Microsoft Surface Pro

.4 The report/graphics printer shall be a colour inkjet printer, 1440 x1440 dpi photo quality colour resolution, internal 1MB buffer memory, minimum 8 pages per minute in black and 4 pages per minute in colour, 100 sheet 8.5"x11" cassette feed, 100 sheet output cassette, with separate dedicated colour and black and white cartridges. Supply one spare set of ink cartridges and 5000 sheets of paper.

.5 Uninterruptable Power Supplies

.1 Provide the OWS, Server, and eachnetwork/building controller with individual UPS to provide clean, reliable, noise-filtered power at all times and to protect and maintain systems operation throughout short term power interruptions of up to 15 minutes duration.

.2 Acceptable Manufacturer is APC.

2.4 Operator Software

.1 Real-Time Displays

.1 Provide a visual graphical representation of buildings, floor layouts, each piece of mechanical equipment and/or mechanical system that duplicates the represented system, presented as a web page via any industry standard web browser, where applicable.

.2 Graphics shall include at a minimum the value of each input, each output, each setpoint, alarms and graphical representation of trend logs.

.2 On-Line Help.

.1 Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system.

.3 Security.

.1 Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data.

.2 System security shall be selectable for each operator.

.3 The system administrator shall have the ability to set passwords and security levels for all other operators.

.4 Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object.

.5 Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected.

.6 This auto log-off time shall be set per operator password.

.7 All system security data shall be stored in an encrypted format.

.4 System Diagnostics.

.1 The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers.

.2 The failure of any device shall be annunciate to the operator.

.5 Third-Party Windows-Based Programs

.1 The system shall be capable of utilizing third-party Windows-based programs for such things as spreadsheet analysis, graphing, charting, custom report generation, and graphics design packages.

.2 Graphics generation shall be done using standard Windows packages.

.3 No proprietary graphics generation software shall be needed.

.6 Overrides

.1 It shall be possible for the operator to override automatic analog and digital output commands.

.2 Where the BAS software normally originates these outputs, the provision shall exist for the operator to terminate automatic BAS control of any particular output and to originate a manual analog or digital output command.

.3 The provision shall exist for the operator to return analog or digital output command functions to automatic BAS software control.

.7 Password Protection

.1 Provide security system that prevents unauthorized use unless operator is logged on.

.8 Trend Data

.1 System shall periodically gather historically recorded selected samples of object data stored in the field equipment (global controllers, field controllers) and archive the information on the operator's workstation (server) hard disk.

.1 Archived files shall be appended with new sample data, allowing samples to be accumulated over **3** years.

.2 Systems that write over archived data shall not be allowed, unless limited file size is specified.

.3 Samples may be viewed at the operator's terminal in a trend log.

.4 Logged data shall be stored in spreadsheet format.

.5 Operator shall be able to scroll through all trend log data.

.2 Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x,y) graphs that display up to six object types at the same time in different colours and these Graphs shall show object type value relative to time.

.3 Operator shall be able to change trend log setup information such as time intervals and objects logged

.9 Graphics

.1 The operator's workstation shall display all data associated with the project.

.1 Operator's workstation shall display all data using 3-D graphic representations of all mechanical equipment.

.2 System shall be capable of displaying graphic file, text, and dynamic object data together on each display.

.1 Information shall be labelled with descriptors and shall be shown with the appropriate engineering units.

.2 All information on any display shall be dynamically updated without any action by the user.

.3 Terminal shall allow user to change all field-resident BAS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc. from any screen no matter if that screen shows all text or a complete graphic display.

.3 Animated graphic objects shall be displayed as a sequence of multiple bitmaps to simulate motion.

.4 Analog objects may also be assigned to an area of a system graphic, where the colour of the defined area would change based on the analog objects value.

.1 For example, an area of a floor-plan graphic served by a single control zone would change colour with respect to the temperature of the zone or its deviation from setpoint.

.5 Separate Displays shall be supplied, specific to the project, to form the following overall presentation style.

.6 All Displays will be linked in a logical fashion using hyperlink style (single left mouse click on text/display object/dynamic to load linked display if programmed)

.7 Entire system shall operate without dependency on the operator's terminal. Provide graphic generation software at each workstation.

.10 Alarms

.1 Operator’s terminal shall provide audible, visual, electronic and printed means of alarm indication.

.2 Any alarm may be handled based on its individual or assigned class actions.

.1 Displayed on the Alarm console.

.1 The system shall be provided with a dedicated alarm window or console.

.2 This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm.

.2 Alarm reports shall be viewable via the BAS system and available for delivery by electronic mail (e-mail) or printing.

.3 System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the system operator’s terminal.

.1 Each entry shall include a description of the event-initiating object generating the alarm, time and date of alarm occurrence, time and date of object state return to normal, and time and date of alarm acknowledgement.

.11 Scheduling

.1 Operator’s terminal display of weekly schedules shall show all information in easy-to-read 7-day (weekly) format for each schedule.

.2 Exception schedules (non-normal schedules, such as holidays or special events) shall display all dates that are an exception to the weekly schedules.

.3 At the operator's terminal, the system user shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.

.12 Archiving

.1 Store back-up copies of all controller databases in at least one OWS and the server.

.2 Provide continuous supervision of integrity of all controller databases.

.3 Data base back up and downloading to occur over LAN without operator intervention.

.4 Operator to be able to manually download entire controller database or parts thereof.

.13 Reports

.1 Provide a report facility to generate and format for display, printing, or permanent storage, as selected by the operator, the reports as specified in this section.

.2 Provide the software to automatically generate any report specified; the user will be able to specify the type of report, start time and date, interval between reports (hourly, daily, weekly, monthly) and output device.

.3 As a minimum, the following reports shall be configured on the system:

.1 Dynamic Reports: To allow operator to request a display of the dynamic value for the user specified points which shall indicate the status at the time the request was entered and updated at an operator modifiable scan frequency.

.2 Summary Report: To permit the display or printing of the dynamic values for the user specified points.

.3 Trend Reports: To permit the trending of points selected by the operator, including as a minimum digital input and output, analog input and output, set points, and calculated values.

.4 Historical Data Collection: Provision shall be made to ensure historical data is not lost.

.5 Alarm Summary: Provide a summary of all points in alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceeded, and time and date of occurrence.

.6 Disable Point Summary: Provide a summary of all points in the disabled state and include as a minimum point acronym and point description.

.7 Run Time Summary: Provide a summary of the accumulated running time of selected pieces of equipment with point acronym and description, run time to date, alarm limit setting. The run time shall continue to accumulate until reset individually by means of suitable operator selection.

.8 Schedule Summary: Provide a summary of all schedules and indicate as a minimum, which days are holidays and, for each section, the day of the week, the schedule times and associated values; for digital schedules value will be on or off; for analog schedules value will be an analog value.

.9 User Record Summary: Provide a summary of all user records to include as a minimum; user name, password, initials, command access level and point groups assigned.

2.5 BAS Controllers

.1 All controllers on the job shall have the following minimum requirements:

.1 IP Communication (BACnet/IP)

.1 BACnet/IP communication protocol shall be used for all BAS manufacturer provided controllers (including terminal devices such as VAVs, FCUs, etc.)

.2 Support for IPv4 addressing

.3 DHCP support and Auto DNS

.4 Baud rate of not less than 100 Mbps

.5 2 - RJ45 ports each capable of supporting 10/100 Base-T.

.1 Supporting controller daisy chaining on the Ethernet network via integral switch functionality.

.2 Integrated fail-safe should allow for communication when the controller is powered down.

.6 All controllers shall be able to communicate peer-to-peer without the need for a Network Control Unit (such as JACE, NAE, etc.) and shall be capable of assuming all responsibilities typically assumed by a Network Control Unit.

.1 Any controller on the Ethernet Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Slave controllers are not acceptable.

.2 The resulting network will be a ‘Flat’ topology with all devices (controllers, workstations, …) connecting at the same physical network level

.2 Memory and Processing

.1 512KB of RAM and 4GB of non-volatile flash memory.

.2 32-bit microprocessor operating at a minimum of 600 MHz

.3 Real time clock with rechargeable battery and 20 days power backup.

.3 Each individual controller shall have an embedded web-based HTML5 visual interface with the following functionality without reliance on any other controller for access:

.1 Typical and custom control processes

.2 Scheduling

.3 Energy management applications

.4 Alarm management applications

.5 Historical/trend data for points specified

.6 Maintenance support applications

.7 Graphical interface

.4 Shall be capable of monitoring/controlling the following types of inputs/outputs:

.1 Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

.2 Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.

.3 Digital outputs including Form C relay outputs and Triac outputs

.4 Analog outputs of 4-20 mA and 0-10 Vdc.

.5 A minimum of 10% spare capacity for each point type for future point connection.

.5 Any software required for programming shall be unlicensed and openly available

.6 Power and Environmental Requirements:

.1 24 VAC with local transformer power

.2 The controllers shall also function normally under ambient conditions of -40 ˚F to 158 ˚F and 0% to 90% RH (non-condensing).

.3 Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

.7 Code Compliance:

.1 “FIPS 140-2 Level 1 Compliant” cryptographic module

.2 BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.

.3 UL916 Energy management equipment

.4 FCC rules part 15, subpart B, class B

.5 UL94-V0 flammability rating

.6 State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

2.6 Control Panels

.1 Indoor control cabinets located in offices or dry/dust free environments shall be fully enclosed NEMA 1 Type construction with hinged door, and removable sub-panels or electrical sub-assemblies.

.2 All outdoor control cabinets and control cabinets located in mechanical/electrical rooms shall be NEMA 4.

.3 Control panels containing more than 4 controllers shall be provided with a terminal strip for field wiring. All control wiring inside the panel shall be between a terminal strip and controller inputs/outputs. All field control wiring shall be terminated at the terminal strip. Field control wiring inputs/outputs shall never be run directly to inputs/outputs of controller.

2.7 Automatic Control Dampers

.1 Provision of dampers shall be provided by another section of this specification (the BAS contractor shall only be responsible for providing actuators/end switches for control dampers).

.2 The BAS contractor shall be responsible for providing automatic control dampers in addition to the damper actuators / end switches for this project. Refer to Section 23 09 13.43 Automatic Control Dampers for further details on the dampers.

2.8 Variable Frequency Drives (VFDs)

.1 Provision of variable frequency drives shall be provided by another section of this specification (the BAS contractor shall only be responsible for providing associated low voltage wiring and controls programming for the VFDs).

2.9 Auxiliary Control Devices, Sensors, and Transmittors

PART 3 - EXECUTION

3.1 Communication Backbone

.1 To allow for future expandability, cyber security measures, optimal bandwidth, and enhanced data trending this project shall adhere to the below communication backbone requirements.

.2 Fiber Optic Network

.3 IP (CAT 5 / RJ45) Network

.1 BACnet/IP communication protocol shall be used for all BAS manufacturer provided controllers (including terminal devices such as UHs, FCUs, etc.)

.2 For all buildings NOT exceeding 5 levels (including rooftops/cellars), 100m between ethernet connections, 250 controllers, or more than 1 type of operational technology residing on the same network (CCTV, lighting, access, etc.):

.1 Ethernet Switches shall be provided as needed to support a fully functional BAS – fiber network shall not be required.

.2 BACnet/IP communication for all BAS manufacturer provided controllers

.3 Modbus TCP shall only be used for third party systems / equipment that do not support BACnet/IP

.4 Modbus RTU and BACnet MS/TP only to be used for third party systems / equipment that do not support BACnet/IP provisions (VFDs, boilers, etc.)

.4 Modbus RTU and BACnet MS/TP (RS-485) Network

.1 Only to be used for systems / equipment that do not have IP provisions (VFDs, boilers, etc.)

3.2 Installation of Sensors

.1 Install sensors according to manufacturer's recommendations.

.2 Mount sensors rigidly and adequately for operating environment.

.3 Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 1 ft. of sensing element for each 1 ft^2 of coil area.

.4 Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

.5 Install outdoor air temperature sensors on north wall at designated location with sun shield.

.6 Install building pressure pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.

.7 High and low limit thermostats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

3.3 Co-ordination

.1 All work shall be performed at times acceptable to the Engineer/Construction Manager. Provide work schedule at the start of the job for the approval of the Engineer / Construction Manager. Schedule shall show when all staff and sub-contractors shall be on-site.

.2 Organize all your sub-contractors and ensure that they maintain the schedule.

.3 Full cooperation shall be shown with other sub-contractors to facilitate installations and to avoid delays in carrying out the work.

.4 Notify Engineer/Construction Manager of any changes to the schedule. Send any schedule changes and weekly progress reports via e-mail to Engineer/Construction Manager.

.5 Where, in the judgment of the Engineer/Construction Manager, the work could disrupt the normal operations in or around the building, contractor shall schedule work to eliminate or minimize interference.

.6 When connecting to the existing systems, advise the Engineer/Construction Manager and obtain permission to so. Perform work at a time acceptable to the Engineer/Construction Manager and Owner.

3.4 Supervision of Personnel

.1 Maintain qualified personnel and supporting staff at this project with proven experience in erecting, supervising, testing, and adjusting projects of comparable nature and complexity.

.2 Supervisory personnel and their qualifications are subject to the approval of the Owner.

.3 All personnel working on-site shall sign in as required by the Owner and shall wear company identification.

.4 When requested and for whatever reason, remove personnel and/or support staff from project. Take immediate action.

3.5 System Design and Responsibility

.1 The drawings do not show conduit size or wire type to link the various elements of the system.

.2 The BAS contractor is responsible for designing these links in view of the present and future capabilities.

.3 The Contractor is responsible for supplying sufficient Controllers of all types to meet the intent of the specification.

.4 The quantity and point content of the Controllers must be approved by the Engineer prior to point installation.

3.6 Products

.1 Materials and equipment shall be essentially the catalogued products of manufacturers regularly engaged in production of such materials or equipment and shall be manufacturer's latest standard design that complies with the specification requirements.

.2 Where two units of the same class of equipment are required, these units shall be products of a single manufacturer, and the component parts of the system shall be the products of a single manufacturer.

.3 Each major component of equipment shall have the manufacturer's name and address and the model and serial number on a nameplate securely attached in a conspicuous place.

3.7 Electrical Work, Wiring and Safety

.1 Electrical work shall be in accordance ANSI/NFPA 70 and the local Electrical Code.

.2 Based on project location, Regional Regulation Compliance Certifications (CSA C22.1) will be required.

.3 Electrical wiring, terminal blocks and other high voltage contacts shall be fully enclosed or properly guarded and marked to prevent accidental injury to personnel.

.4 All wiring shall conform to the most stringent requirements of the local electrical authority having jurisdiction. Refer to Division 26 00 00 for electrical requirements, codes and regulations.

.5 Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26 00 00, and manufacturer's recommendations. Where the requirements of this Section differ from other Divisions, this Section shall take precedence.

.1 Power wiring to mechanical equipment, variable air volume boxes, and motor controllers shall be provided by the Electrical contractor (Division 26).

.2 EMT conduit shall be used in mechanical/electrical rooms and exposed spaces.

.3 Rigid Galvanized Steel conduit shall be used outdoors.

.4 Plenum rated cable shall be used in concealed spaces/hung ceilings.

.6 All wiring associated with and required by the BAS shall be the responsibility of this contractor.

.1 The term "wiring" shall be construed to include furnishing of wire, conduit, and miscellaneous material and labor as required to install a total working system.

.2 If departures from the contract documents are deemed necessary by the contractor, details of such departures, including changes in related portions of the project and the reasons therefore, shall be submitted with the drawings to the Engineer for approval.

.7 Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.

.8 Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

.9 Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

.10 Each run of communication wiring shall be a continuous length without splices when that length is commercially available.

.11 Label communication wiring to indicate origination and destination.

.12 Fiber optic cable shall comply with the following requirements:

.1 Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125 µm.

.2 Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

3.8 Manufacturer's Recommendations

.1 Installation to be to manufacturer's recommendations. Provide printed copies of recommendations with shop drawings or product data.

3.9 Nameplates

.1 Nameplates shall be provided for all control items listed or shown in the submittal and approved control diagrams.

.2 Each inscription shall identify its function, such as "mixed air controller", "cold deck sensor" in official languages etc. and when applicable, its position.

.1 Size of nameplates shall be 1 inch by 3 inches minimum.

.2 Lettering shall be minimum ¼ inch high normal black lettering.

.3 Submit duplicate samples of identification tags and lists of wording proposed for approval.

3.10 Preliminary Design Review

.1 The BAS contractor shall submit a preliminary design document for review. This document shall contain the following information:

.1 Provide a description of the proposed system along with a system architecture diagram with the intention of showing the contractors solution to meet this specification.

.2 Provide product data sheets and a technical description of all direct digital controller hardware required to meet specifications listed herein.

.3 Provide an overview of the BAS contractor's local/branch organization, local staff, recent related project experience with references, and local service capabilities.

.4 Provide information on the BAS contractor's project team including project organization, project manager, project engineer, programmers, project team resumes, and location of staff.

.5 Project Schedule of work indicating:

.1 Intended sequence of work items

.2 Start date of each work item

.3 Duration of each work item

.4 Planned delivery dates for ordered material and equipment and expected lead times

.5 Milestones indicating possible restraints on work by other trades or situations

3.11 Submittals

.1 Within 45 days of award of contract and before start of construction, submit 3 hard copies and 1 soft copy of manufacturer's information and shop drawings.

.1 Drawings to be in AutoCAD or VISIO and Sequence of Operations and Points List (Input/output Summary) shall be in Word and Excel format (latest versions) structured using menu format for easy loading and retrieval on the OWS.

.2 Provide in completely coordinated and indexed package to assure full compliance with the contract requirements.

.1 Piecemeal submittal of data is not acceptable and such submittals will be returned without review.

.2 Information shall be submitted for all material and equipment the contractor proposes to furnish under terms of this contract work.

.3 Arrange the submittals in the same sequence as these specifications and reference at the upper right-hand corner the particular specification provision for which each submittal is intended.

.4 Submittals for each manufactured item shall be manufacturer's descriptive literature (equipment specification), equipment drawings, diagrams, performance and characteristic curves, and catalog cuts, and shall include the manufacturer's name, trade name, catalog model or number, nameplate data, size layout dimension, capacity, specification reference, applicable specification references, and all other information necessary to establish contract compliance.

.3 Control System Shop Drawings

.1 Schematic diagram of each controlled system. Label control points with point names.

.2 Bill of Material for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.

.3 Specification sheets for each item including manufacturers descriptive literature, drawings, diagrams, performance and characteristic curves, manufacturer and model number, size, layout, dimensions, capacity, etc.

.4 Control schematics with narrative description and control descriptive logic fully showing and describing operation and/or manual procedures available to operating personnel to achieve proper operation of the building, including under complete failure of the BAS.

.5 Shop drawings for each input/output point showing all information associated with each particular point including sensing element type and location; details of associated field wiring schematics and schedules; point address; software and programming details associated with each point; and manufacturer's recommended installation instructions and procedures for each type of sensor and/or transmitter.

.6 Riser diagrams showing control network layout, communication protocol, and wire types.

.7 Network diagram of control, communication, and power wiring for BAS Server and OWS installation.

3.12 As-built Documentation (Operating and Maintenance (O&M) Manuals)

.1 As-built documentation shall consist of 4 hard copies and one soft copy for all information described below

.2 The final documentation package shall include:

.1 As-built Submittals: Final as built control submittals and technical data sheets.

.2 Programming, Sequences, and Graphics: All programming, sequences, and graphics saved to an external hard drive.

.3 Operation and Maintenance Manuals: Factory operating and maintenance manuals with any customization required.

.4 Test Procedures and Reports: The test implementation shall be recorded with a description of the test exercise script of events and documented as test procedures.

.5 Hard and soft copies of all control drawings.

.6 Manufacturer’s technical data sheets for all hardware and software.

.7 Factory operating and maintenance manuals with any customization required.

.8 Soft copies of programming and front-end software and each controller’s database. Hard copy output of programming is not necessary.

.9 Provide clear, concise, printed and soft copy descriptions of all control sequences in the working language.

.10 Soft copy text files shall be in Microsoft Word format.

.11 Copy of all graphics files.

.3 Each instruction and reference manual shall be bound in hardback, 3 ring, binders or an approved equivalent shall be provided to the Engineer.

.1 Binders to be no more than 2/3 full.

.2 Each binder to contain index to full volume.

.3 One complete set of manuals shall be furnished prior to the time that the system or equipment tests are performed, and the remaining manuals shall be furnished at acceptance.

.4 The identification of each manual's contents shall be inscribed on the cover and spine.

.5 The manuals shall include the names, addresses and telephone numbers of each subcontractor installing equipment systems and of the local representatives for each item of equipment and each system.

.6 The manuals shall have a table of contents and be assembled to conform to the table of contents with the tab sheets placed before instructions covering the subject.

.7 Additionally, each manual shall contain a comprehensive index of all manuals submitted in accordance with this paragraph.

.8 Manuals and specifications shall be furnished which provide full and complete coverage of the following subjects:

.1 Operational Requirements: This document shall describe in concise terms, all the functional and operational requirements for the system and its functions that have been implemented. It shall be written using common terminology for building operation staff and shall not presume knowledge of digital computers, electronics or in-depth control theory.

.2 System Operation: Complete step by step procedures for operation of the system, including required actions at each operator station; operation of computer peripherals; input and output formats; and emergency, alarm and failure recovery. Step-by-step instructions for system startup, back-up equipment operation, and execution of all system functions and operating modes shall be provided.

.3 Maintenance: Documentation of all maintenance procedures for all system components including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective module. This shall include calibration, maintenance, and repair or replacement of all system hardware.

.4 Test Procedures and Reports: The test implementation shall be recorded with a description of the test exercise script of events and documented as test procedures. A provision for the measurement or observation of results, based on the published test specification, forms the test reports. The procedures record and the results of these exercises shall be conveniently bound and documented together.

.5 Configuration Control: Documentation of the basic system design and configuration with provisions and procedures for planning, implementing, and recording any hardware or software modifications required during the installation, test, and operating lifetime of the system. This shall include all information required to ensure necessary coordination of hardware and software changes, data link or message format/content changes, and sensor or control changes in the event system modification are required, and to fully document such new system configurations.

3.13 Warranty

.1 The BAS system labor and materials shall be warranted free from defects for a period of 2 year(s) after final commissioning and owner acceptance.

3.14 Training

.1 BAS Contractor shall provide a minimum of 8 hours of training with course outline and materials for personnel designated by the owner.

.2 If desired manufacturer provided training on the use and operation of all products provided within these specifications shall be available for purchase and attendance by the Owner or his designated agent. A list of training courses with detailed course outline and duration with the associated cost shall be provided as part of the BAS submittals.

3.15 Balancing and Commissioning

.1 BAS Contractor shall provide a minimum of 12 hours of commissioning assistance with a commissioning agent and 8 hours of balancing assistance with a balancing agent. Balancing and commissioning agents shall NOT be provided by BAS contractor – BAS contractor is responsible for assistance only.

.2 For projects without balancing and commissioning agents the BAS contractor shall self commission the system utilizing the allotted hours stated above.

.3 Provide commissioning data sheets prior to acceptance testing.

3.16 Alternates

.1 Service Agreement (Analytics Reporting) and Estimated Energy Incentives

.1 Remote Access shall be given to service provider for offsite access of BAS. Service provider shall securely access data via VPN through the customer firewall. Cloud based analytics and 15-minute interval data shall be collected by the service provider through the building automation system.

.2 The service provider shall provide data collection, analytics and professional analysis for general facility performance, airside systems , variable air systems including, but not limited to, analytics, charts and graphs which indicate both current building performance and opportunities for building and HVAC system performance improvement.

.1 Identify building system performance trends and deviations from normal operation

.2 Prepare actionable recommendations to optimize HVAC system performance

.3 Prepare recommendations for operational adjustments

.4 Prepare risk analysis of emergency maintenance or failure

.5 Develop Energy Conservation Measures (ECMs)

.3 Utility data analytics shall identify possible causes for energy waste. Building ownership shall agree to provide the service provider with utility data and sign letter to proceed for energy analysis.

.4 The service provider shall actively seek, present, and assist in setting up applicable NYSERDA cost-shared support and incentives for building ownership. Incentives are provided for analysis of energy usage data and integrating real time energy management systems (such as building automation systems and other building metering data).

.1 NYSERDA offers incentives to building owners up to $300,000 dependent upon project type, data collection, and actionable insights.

.2 Ongoing building automation system analytics and continuous commissioning is provided by the service provider as part of these incentive programs.

.5 The service provider shall actively seek, present, and assist in evaluating applicable Con Edison incentives for building ownership.

.1 Con Edison offers incentives for controls, demand reduction, any energy reduction improvement (including upgrades to more energy efficient equipment). Participation in the most current Con Edison programs shall also be evaluated for this alternate.

.2 Building ownership shall agree to provide the service provider with utility information, existing equipment information relevant to the scope, and any other documentation required by Con Edison to verify eligibility.

.3 If applicable the service provider shall provide necessary support for measurement and verification activities such as providing data logs.

.6 The service provider shall present estimated energy incentives and associated services costs with this alternate.

.1 The service provider shall actively participate in these programs and shall provide proof of participation in NYSERDA / Con Edison incentive programs to be used prior to bid award.

.2 If multiple incentive programs are to be utilized for the same project all incentives shall be evaluated such that they do not conflict with other program incentive guidelines.

.2 Maintenance Contract:

.1 The BAS Contractor shall present a two year maintenance contract for the Owner's acceptance within sixty days after installation of the system begins. Show the price for each year with all payment terms and conditions.

.2 The Maintenance Contract shall include the following provisions: on-line diagnostic and troubleshooting service, quarterly software maintenance/consultation/database backup, repair and replacement as needed (T&M proposals), and emergency service (per predetermined agreement).

.3 Maintenance Routines include, but are not be limited to the following: checking performance of equipment and components (with diagnostic testing, examination, adjustment, and calibration) and 2 training sessions per year.

.4 The Maintenance Contract shall be renewable at the Owner’s option and include provision for increased charges due to expansion of the system, changes in service coverage, and/or inflation.

3.17

3.18 Manufacturer Training

.1 Manufacturer provided training on the use and operation of all products provided within these specifications shall be available for purchase and attendance by the Owner or his designated agent.

.1 Such training shall be of the same curriculum as the training courses provided by the manufacturer to the Contractor.

.2 A manufacturer certified instructors shall give all training classes.

.3 A list of training courses with detailed course outline and duration with the associated cost shall be provided as part of the BAS submittals.

3.19 Maintenance Contract

.1 The BAS Contractor shall present a two year maintenance contract for the Owner's acceptance within sixty days after installation of the system begins. Show the price for each year with all payment terms and conditions.

.2 The Maintenance Contract shall include the following provisions:

.1 On-line Service - Provide diagnostic and trouble-shooting services via remote communications capabilities. Response time to Owner requests for this type of corrective maintenance is within two (2) hours.

.2 Software Maintenance and Consultation - The BAS Contractor reviews the need for software modifications to the existing database quarterly, and implement modification.

.3 Backup of the database will be made quarterly and retained by the BAS Contractor.

.4 Software Maintenance - Provide software revisions as they become available.

.5 Repair and Replacement - The BAS Contractor provides materials and labor for repair or replacement of failed equipment and components with new or reconditioned equipment or components.

.6 The BAS Contractor must furnish new equipment and components.

.7 Emergency Service - The BAS Contractor provides emergency service, between scheduled preventive maintenance calls, including overtime, necessary to keep equipment and components in proper operation.

.8 The BAS Contractor guarantees future availability of continuous, twenty-four hour, seven days a seek service for the systems through available maintenance contracts.

.9 Emergency Response Time - When a site visit is required to complete troubleshooting procedures, the System Contractor will be on-site within 4 hours.

.10 Factory trained and employed service representatives of the BAS Manufacturer contractor will perform service.

.11 Perform preventive Maintenance in accordance within a program of standardized maintenance routines supplied to the Owner's equipment.

.12 Each schedule lists the equipment name, location, and appropriate preventive maintenance functions to be performed during that inspection.

.3 Maintenance Routines include, but are not be limited to the following:

.1 Checking performance of equipment and components.

.2 Diagnostic test, examination, cleaning, lubrication, adjustment and calibration of equipment and their components. Such components include but are not limited to: Central Processing Unit, disk memory, color graphic CRT, black and white CRT, printer, Remote Units, printed circuit boards, and associated sensors and controllers.

.3 Training of Building Personnel - The system contractor provides 2 training sessions per year to the Owner's personnel in the operation, capabilities, data point entry, customer programming and utilization of the Owner's Building Automation System.

.4 The Maintenance Contract shall be renewable at the Owner’s option and include provision for increased charges due to expansion of the system, changes in service coverage, and/or inflation.

End of Section

SECTION 23 09 13 BAS Instrumentation and Control Devices

PART 1 - GENERAL

1.1 Related Sections

.1 SECTION 23 09 00, BAS Instrumentation and Control

.2 SECTION 23 09 13.13, BAS Actuators and Operators

.3 SECTION 23 09 13.23, BAS Sensors and Transmitters

.4 SECTION 23 09 13.33, BAS Control Valves

.5 SECTION 23 09 13.43, BAS Control Dampers

.6 SECTION 23 09 23, BAS Direct Digital Control System

1.2 References

.1 Refer to Section 23 09 00 - References

1.3 Acronyms, Abbreviations and Definitions

.1 Refer to Section 23 09 00 - Acronyms, Abbreviations and Definitions

PART 2 - PRODUCT

2.1 Computer Hardware

.1 General Description:

.1 The computer shall consist of commercially available general-purpose equipment manufactured by a recognized manufacturer with factory authorized service centers within 75 miles of the job site.

.2 The server shall be provided for centralized system control, information management, alarm management and data base management functions.

.3 All real time control functions shall be resident in the standalone Network Control Unit (NCU) and local controllers (LCUs and TCUs).

.2 Provide a Server as detailed herein complete with software, as described in Section 23 09 13.

.3 Provide Operator workstations as detailed herein complete with software, as described in Section 23 09 13

.4 The system shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 32 simultaneous users. The BAS shall be provided with a minimum of 32 user licenses.

.5 Provide three copies of all Programming Software required for programming LCUs and TCUs as described herein.

.6 Any computer with access to the BAS LAN shall be capable of displaying the systems in a graphical and dynamic format utilizing a standard web browser. Screen refresh shall be automatic. Manual refresh is not acceptable

2.2 Server Hardware Requirements

.1 The Server shall be a PC with minimum Intel Core i5 Quad core 3.4 GHz processor with 8 GB RAM and a 1TB SATA hard drive with 6 GB/s transfer rate. It shall include a minimum 32X CD-ROM drive and 4-USB 3.0 ports. A minimum 21", HDMI, DVI-D video interfaces, minimum 1024 x 768 resolution, 4x3 Widescreen, LED color monitor with a minimum 60 Hz refresh rate shall also be included.

.2 Latest Windows operating system and Microsoft Office programs.

.3 The server operating system

.1 shall be one of:

.1 Windows 7 Professional 64bit

.2 Windows 8.1 64bit

.3 Windows Server 2012 64bit

.4 Windows 10 Pro 64bit

.5 Windows 10 Enterprise 64bit

.2 With VM support

.3 With the most recent service packs and system updates.

.4 Selected based on availability and project requirements.

.4 Latest version of Symantec Antivirus Software that includes a 3 year subscription service to the Symantec software.

.5 Acceptable Manufacturers are:

.1 Dell

.2 Lenovo

.3 HP (Hewlett Packard)

.6 Connection to the BAS LAN network shall be via an Ethernet network interface card, 100 Mbps.

.7 The server will be located in the IT room

.8 The server shall support all network/building controllers, OWSs, and 3rd party mechanical / electrical systems connected to the Facility Management Control / Building Automation System Local Area Network.

2.3 Workstation Hardware Requirements

.1 The workstation shall be a PC with minimum Intel Core i5 Quad core 3.4 GHz processor with 8 GB RAM and a 1TB SATA hard drive with 6 GB/s transfer rate. It shall include a minimum 32X CD-ROM drive and 4-USB ports. A minimum 21", HDMI, DVI-D video interfaces, minimum 1024 x 768 resolution, 4x3 Widescreen, LED color monitor with a minimum 60 Hz refresh rate shall also be included.

.2 Latest Windows operating system and Microsoft Office programs.

.3 The operating system

.1 shall be one of:

.1 Windows 7 Professional 64bit

.2 Windows 7 Ultimate 64bit

.3 Windows 8.1 64bit

.4 Windows 10 Pro 64bit

.5 Windows 10 Enterprise 64bit

.2 With the most recent service packs and system updates.

.3 Selected based on availability and project requirements.

.4 Acceptable Manufacturers are:

.1 Dell

.2 Lenovo

.3 HP (Hewlett Packard)

.5 Connection to the BAS LAN network shall be via an Ethernet network interface card, 100 Mbps.

.6 Provide ___ Workstations.

.7 The Workstation(s) will be located in the IT room.

.8 Add additional locations as required.

.9 Workstation(s) should be loaded with Programming Tools

.10 Latest Windows operating system and Microsoft Office programs.

2.4 Printers

.1 Provide a report printer connected to each Operator Workstation and one alarm printer connected to the Operator Workstation in the Engineer's office.

.2 The alarm printer(s) shall be a 24 pin head dot matrix printer, parallel interface, capable of 360x360 dpi, 132 characters per line, 192 cps in draft mode, NLQ mode, with spare ribbon, fan fold paper and 5000 sheets of paper.

.3 The report/graphics printer shall be a colour inkjet printer, 1440 x1440 dpi photo quality colour resolution, internal 1MB buffer memory, minimum 8 pages per minute in black and 4 pages per minute in colour, 100 sheet 8.5"x11" cassette feed, 100 sheet output cassette, with separate dedicated colour and black and white cartridges. Supply one spare set of ink cartridges and 5000 sheets of paper.

2.5 Uninterruptable Power Supplies

.1 Provide the OWS, Server, and eachnetwork/building controller with individual UPS to provide clean, reliable, noise-filtered power at all times and to protect and maintain systems operation throughout short term power interruptions of up to 15 minutes duration.

.2 Acceptable Manufacturer is APC.

2.6 Operator Software

.1 Operating System: See Sections 2.2 and 2.3 for specific OSs.

.2 The software shall employ browser-like functionality for ease of navigation.

.1 It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database.

.2 In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills.

.1 These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

.2 Tagging.

.3 An alternate Identification mechanism for advanced or simple query of the EMCS system.

.4 Real-Time Displays

.1 Provide a visual graphical representation of buildings, floor layouts, each piece of mechanical equipment and/or mechanical system that duplicates the represented system, presented as a web page via any industry standard web browser, where applicable.

.1 Graphics shall include at a minimum the value of each input, each output, each setpoint, alarms and graphical representation of trend logs.

.2 The graphic shall provide for the ability to command each point, including both timed and permanent overrides.

.3 Provide for all information represented in the graphics in an associated graphical table with links to the equipment graphics and command-able points.

.4 Sample graphics shall be provided as part of the submittals for approval by owner.

.5 The Operator software, shall at a minimum, support the following graphical features and functions:

.1 Graphic screens shall be developed using GIF, PNG, JPG or ICO file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.

.2 Graphic screens shall have the capability to contain objects for text, real-time values, animation, colour spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.

.3 Graphics shall support layering and each graphic object shall be configurable for assignment to one a layer. A minimum of six layers shall be supported.

.6 Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.

.1 Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.

.2 Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.

.7 Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.

.8 Right-clicking the selected object and using a graphical slider to adjust the value shall make adjustments to analog objects, such as set points. No entry of text shall be required.

.9 System Configuration.

.1 At a minimum, the Operator software shall permit the operator to perform the following tasks, with proper password access:

.1 Create, delete or modify control strategies.

.2 Add/delete objects to the system.

.3 Tune control loops through the adjustment of control loop parameters.

.4 Enable or disable control strategies.

.5 Generate hard copy records or control strategies on a printer.

.6 Select points to be alarm-able and define the alarm state.

.7 Select points to be trended over a period of time and initiate the recording of values automatically.

.10 On-Line Help.

.1 Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system.

.1 On-line help shall be available for all applications and shall provide the relevant data for that particular screen.

.2 Additional help information shall be available through the use of hypertext.

.3 All system documentation and help files shall be in HTML format.

.11 Security.

.1 Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data.

.2 System security shall be selectable for each operator.

.3 The system administrator shall have the ability to set passwords and security levels for all other operators.

.4 Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object.

.5 Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected.

.6 This auto log-off time shall be set per operator password.

.7 All system security data shall be stored in an encrypted format.

.12 System Diagnostics.

.1 The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers.

.2 The failure of any device shall be annunciate to the operator.

.13 Alarm Console.

.1 The system shall be provided with a dedicated alarm window or console.

.1 This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm.

.2 The use of the Alarm Console can be enabled or disabled by the system administrator.

.1 When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator.

.3 This window will notify the operator of new alarms and un-acknowledged alarms.

.4 Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

.14 Operator’s software shall contain an easy-to-operate system; allowing configuration of system-wide controllers, including management and display of the controller programming.

.1 This system shall provide the capability to configure controller binary and analog inputs/outputs.

.15 Third-Party Windows-Based Programs

.1 The system shall be capable of utilizing third-party Windows-based programs for such things as spreadsheet analysis, graphing, charting, custom report generation, and graphics design packages.

.2 Graphics generation shall be done using standard Windows packages.

.3 No proprietary graphics generation software shall be needed.

.16 Provide software, which enables the non-programmer operator to easily perform, tasks which are likely to be part of his daily routine.

.17 The operator's console shall provide facilities for manual entries and visual displays enabling an operator to enter information into the system and obtain displays and logs of system information.

.1 All requests for status, analog, graphic displays, logs, and control shall be selected from the operator's console.

.2 The operator interface shall minimize the use of typewriter style keyboard by implementing a mouse or similar pointing device and "point and click" approach to command selection.

.3 The facility shall be provided to permit the operator to perform the following tasks:

.1 Automatic logging of digital alarms and change of status message.

.2 Automatic logging of all analog alarms.

.3 System changes (alarm limits, set-points, alarm lock-outs, etc.).

.4 Display specific points as requested by the operator.

.5 Provide reports as requested by the operator and on Scheduled basis where so required.

.6 Display graphics as requested by the operator.

.7 Display of help information.

.8 Provide trend logs as required by the operator.

.9 Provide manual control of digital and analog outputs as required by the operator.

.10 Direct the hard copy output of information to the device selected by the operator.

.11 Data displayed on monitor to cyclic update as appropriate.

.18 Online changes:

.1 Alarm limits.

.2 Setpoints.

.3 Dead-bands

.4 Changes/deletions/additions of points.

.5 Control and change of state changes.

.6 Time of day, day, month, year.

.7 Control loop control description changes for NCU based CDM's.

.8 Control loop tuning changes

.9 Schedule changes

.10 Changes/additions/deletions to system graphics

.11 Changes/additions/deletions to total systems

.19 Overrides

.1 It shall be possible for the operator to override automatic analog and digital output commands.

.2 Where the BAS software normally originates these outputs, the provision shall exist for the operator to terminate automatic BAS control of any particular output and to originate a manual analog or digital output command.

.3 The provision shall exist for the operator to return analog or digital output command functions to automatic BAS software control.

.4 It shall be possible for the operator to place any computed system setpoint to a computed basis as and when required.

.5 All above functions shall operate under the password protection system.

.20 A vocabulary of at least 25 different descriptions using at least six alphanumeric characters to identify engineering units for analog input and output points. Typical description is as follows: %, ˚C, KPA, KW, KWH, L/S, CFM, ˚F, and PSI.

.1 The descriptions shall be alterable from the OWS console with the system on-line.

.21 Upon operator's request, the system shall present the condition of any single point, any system, and area or the whole system on printer or Monitor.

.1 The output device shall be by operator's choice.

.2 Analog values and status displayed on the Monitor shall be updated whenever new values are received.

.3 Points in alarm shall be flagged by blinking, inverse video different colour, bracketed, or by some other means to differentiate them from points not in alarm.

.22 Error Messages

.1 Inform operator of all errors in data, errors in entry instructions, failure of equipment to respond to requests or commands, or failure of communications between components of BAS.

.2 Error messages to be comprehensive and communicate clearly to operator precise nature of problem.

.23 Password Protection

.1 Provide security system that prevents unauthorized use unless operator is logged on.

.1 Access shall be limited to operator’s terminal functions unless user is logged on, including displays as outlined above.

.2 Each operator’s workstation shall provide security for 100 users minimum.

.1 Each user shall have an individual User ID, User Name and Password.

.2 Entries are alphanumeric characters only and are case sensitive (except for User ID).

.3 User ID shall be 8 characters,

.4 User Name shall be a maximum of 29 characters, and Password shall be a maximum of 8 characters long.

.5 Each system user shall be allowed individual assignment of only those control functions and menu items to which that user requires access.

.6 All passwords, user names, and access assignments shall be adjustable online at the operator’s terminal.

.7 Each user shall also have a set security level, which defines access to displays and individual objects the user may control.

.8 System shall include 10 separate and distinct security levels for assignment to users.

.24 Trend Data

.1 System shall periodically gather historically recorded selected samples of object data stored in the field equipment (global controllers, field controllers) and archive the information on the operator's workstation (server) hard disk.

.1 Archived files shall be appended with new sample data, allowing samples to be accumulated over **3** years.

.2 Systems that write over archived data shall not be allowed, unless limited file size is specified.

.3 Samples may be viewed at the operator's terminal in a trend log.

.4 Logged data shall be stored in spreadsheet format.

.5 Operator shall be able to scroll through all trend log data.

.6 System shall automatically open archive files as needed to display archived data when operator scrolls through the data vertically.

.7 All trend log information shall be displayed in standard engineering units.

.2 Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x,y) graphs that display up to six object types at the same time in different colours and these Graphs shall show object type value relative to time.

.3 Operator shall be able to change trend log setup information such as time intervals and objects logged

.1 This includes the information to be logged as well as the interval at which it is to be logged.

.1 Minimum interval of 1 minute.

.2 All input, output, and value object types in the system may be logged.

.3 All operations shall be password protected.

.4 Setup and viewing may be accessed directly from any and all graphics object is displayed on.

.4 System shall be capable of periodically gathering energy log data stored in the field equipment and archive the information on the operator workstation's hard disk.

.1 Archive files shall be appended with the new data, allowing data to be accumulated over several years.

.2 Systems that write over archived data shall not be allowed unless limited file size is specified.

.3 System shall automatically open archive files as needed to display archived data when operator scrolls through the data.

.4 Display all energy log information in standard engineering units.

.5 System software shall be provided that is capable of graphing the energy log data. Software shall be capable of creating two-axis (x,y) graph that show recorded data, relative to time.

.1 All data shall be stored in spreadsheet format for direct use by third-party spreadsheet or other database programs.

.2 Operation of system shall not be affected by this operation.

.6 Operator shall be able to change the energy log setup information.

.1 Including the meters to be logged, meter pulse value, and the type of energy units to be logged.

.2 All meters monitored by the system may be logged.

.3 All operations shall be password protected.

.25 Graphics

.1 The operator's workstation shall display all data associated with the project.

.1 The operator's terminal software shall accept, GIF, PNG, JPG and ICO format graphic files for display purposes.

.2 Graphic files shall be created using scanned, full colour photographs of system installation, AutoCAD or Visio drawing files of field installation drawings and wiring diagrams from as-built drawings.

.3 Operator's workstation shall display all data using 3-D graphic representations of all mechanical equipment.

.4 Displays can be used as templates to produce other displays

.2 System shall be capable of displaying graphic file, text, and dynamic object data together on each display.

.1 Information shall be labelled with descriptors and shall be shown with the appropriate engineering units.

.2 All information on any display shall be dynamically updated without any action by the user.

.3 Terminal shall allow user to change all field-resident BAS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc. from any screen no matter if that screen shows all text or a complete graphic display.

.4 This shall be done without any reference to object addresses or other numeric/mnemonic indications.

.3 All displays shall be generated and customized in such a manner by the local DDC system supplier that they fit the project as specified.

.1 Canned displays shall not be acceptable.

.2 Displays shall use Standard English for labelling and readout.

.3 Systems requiring factory programming for graphics are specifically prohibited.

.4 The installing contractor without factory dependency or assistance shall support all graphics and DDC programming locally.

.4 Binary objects shall be displayed as ON/OFF/NULL or with customized text.

.1 Text shall be justified left, right or centre as selected by the user.

.2 Allow binary objects to be displayed as individual change-of-state bitmap objects on the display screen such that they overlay the system graphic.

.3 Each binary object displayed in this manner shall be assigned up to three bitmap files for display when the point is ON, OFF or in alarm.

.4 For binary outputs, toggle the objects commanded status when the bitmap is selected with the system digitizer (mouse). Similarly, allow the terminal operator to toggle the object's status by selecting (with the mouse) a picture of a switch or light, for example, which then displays a different picture (such as an ON switch or lighted lamp).

.5 Additionally, allow binary objects to be displayed as an animated graphic.

.5 Animated graphic objects shall be displayed as a sequence of multiple bitmaps to simulate motion.

.1 For example: when a pump is in the OFF condition, display a stationary picture of the pump. When the operator selects the pump picture with the mouse, the represented objects status is toggled and the picture of the pumps impeller rotates in a time-based animation.

.2 The operator shall be able to click on an animated graphical object or switch it from the OFF position to ON, or ON to OFF.

.3 Allow operator to change bitmap file assignment and also create new and original bitmaps online.

.4 System shall be supplied with a library of standard bitmaps, which may be used unaltered or modified by the operator.

.5 Systems that do not allow customisation or creation of new bitmap objects by the operator (or with third-party software) shall not be allowed.

.6 Analog objects shall be displayed with operator modifiable units.

.1 Analog input objects may also be displayed as individual bitmap items on the display screen as an overlay to the system graphic.

.2 Each analog input object may be assigned to a minimum of five bitmap files, each with high/low limits for automatic selection and display of the bitmaps.

.3 As an example, a graphic representation of a thermometer would rise and fall in response to either the room temperature or its deviation from the controlling setpoint.

.4 Analog output objects, when selected with the mouse, shall be displayed as a prompted dialog (text only) box.

.5 Selection for display type shall be individual for each object.

.6 Analog object values may be changed by selecting either the increase or decrease arrow in the analog object spinner box without using the keypad.

.7 Analog objects may also be assigned to an area of a system graphic, where the colour of the defined area would change based on the analog objects value.

.1 For example, an area of a floor-plan graphic served by a single control zone would change colour with respect to the temperature of the zone or its deviation from setpoint.

.2 All editing and area assignment shall be created or modified online using simple icon tools.

.8 A customized menu label (push-button) shall be used for display selection.

.1 Menu items on a display shall allow penetration to lower level displays or additional menus.

.2 Dynamic point information and menu label push buttons may be mixed on the same display to allow sub-displays to exist for each item.

.3 Each display may be protected from viewing unless operator has appropriate security level.

.4 A separate security level may be assigned to each display and system object.

.9 A mouse, or other form of digitizer, shall be used to move the pointer arrow to the desired item for selection of new display or to allow the operator to make changes to object data.

.10 Separate Displays shall be supplied, specific to the project, to form the following overall presentation style.

.1 The presentation will contain displays for:

.1 Site Overview

.2 Specific Building(s)

.3 Floor plates within Building(s)

.4 Each controlled Zone

.5 Each controlled System or Sub-System

.6 Other specific displays as required by the project to be added here

.2 All Displays will be linked in a logical fashion using hyperlink style (single left mouse click on text/display object/dynamic to load linked display if programmed)

.1 Clicking on a building in the Site Overview displays the specific building display.

.2 Clicking on a floor, displays the floor plate display

.3 Clicking on a zone, displays the specific control system for that zone.

.4 Clicking on a specific system or sub-system coarse representation at the floor plate display level displays a detailed presentation of the system or sub-system.

.11 Displays are stored on the server and may be modified on site or via remote communications.

.12 Entire system shall operate without dependency on the operator's terminal. Provide graphic generation software at each workstation.

.26 Alarms

.1 Operator’s terminal shall provide audible, visual, electronic and printed means of alarm indication.

.2 Any alarm may be handled based on its individual or assigned class actions.

.1 Actions are, but not limited to

.1 Displayed on the Alarm console.

.1 The system shall be provided with a dedicated alarm window or console.

.2 This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm.

.3 The use of the Alarm Console can be enabled or disabled by the system administrator.

.4 When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator.

.5 This window will notify the operator of new alarms and un-acknowledged alarms.

.6 Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

.7 Printout of alarms shall be sent to the assigned terminal and port.

.2 Alarm reports shall be viewable via the BAS system and available for delivery by electronic mail (e-mail) or printing.

.1 Delivery by electronic mail (e-mail).

.1 Sent via e-mail to one or more recipients.

.2 Printed.

.1 Printed on local or network printer

.3 System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the system operator's terminal.

.1 Each entry shall include a description of the event-initiating object generating the alarm, time and date of alarm occurrence, time and date of object state return to normal, and time and date of alarm acknowledgement.

.4 Alarm messages shall be in user-definable text English or other specified language) and shall be entered either at the operator's terminal or via remote communication.

.27 Scheduling

.1 Operator's terminal display of weekly schedules shall show all information in easy-to-read 7-day (weekly) format for each schedule.

.1 This includes all ON/OFF times (to the minute) for each day's events.

.2 Exception schedules (non-normal schedules, such as holidays or special events) shall display all dates that are an exception to the weekly schedules.

.1 These speciality schedules shall be displayed at the operator's terminal in a format similar to the weekly schedules, again allowing easy data entry.

.2 Exception schedule data is entered by the following methods:

.1 date entries (one day entries)

.2 date-to-date (a range or span of days)

.3 by weekday (for example, a given day of a given week each month)

.3 User shall be able to scroll easily through the months for each year as a minimum.

.3 At the operator's terminal, the system user shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.

.28 Archiving

.1 Store back-up copies of all controller databases in at least one OWS and the server.

.2 Provide continuous supervision of integrity of all controller databases.

.1 Data base back up and downloading to occur over LAN without operator intervention.

.3 Operator to be able to manually download entire controller database or parts thereof.

.29 Reports

.1 Provide a report facility to generate and format for display, printing, or permanent storage, as selected by the operator, the reports as specified in this section.

.1 If display output (Monitor) is requested, it shall be scrollable; scroll bars will be used to allow easy and flexible movement within the report.

.2 Output to be sorted by area, system point.

.2 Periodic/Automatic Report:

.1 Provide the software to automatically generate any report specified; the user will be able to specify the type of report, start time and date, interval between reports (hourly, daily, weekly, monthly) and output device.

.2 The software will allow the operator to modify the periodic/automatic reporting profile at any time.

.3 As a minimum, the following reports shall be configured on the system:

.1 Dynamic Reports: To allow operator to request a display of the dynamic value for the user specified points which shall indicate the status at the time the request was entered and updated at an operator modifiable scan frequency.

.1 It shall be possible to select points on the following basis:

.1 All points in all areas

.2 Area (all points in area)

.3 Area system (all points in system)

.4 Area system point (individual point)

.5 System (all points by system and point type)

.6 System point (all points by system and point type)

.7 Area point (all points by area and point type).

.2 Summary Report: To permit the display or printing of the dynamic values for the user specified points.

.1 Reports to be available on same basis as dynamic reports.

.2 Output will be to the user selected output device.

.3 Trend Reports: To permit the trending of points selected by the operator, including as a minimum digital input and output, analog input and output, set points, and calculated values.

.4 Historical Data Collection: Provision shall be made to ensure historical data is not lost.

.1 The ability to off-load historical data to removable media, and to later load data previously backed-up, will be provided.

.2 Historical data values, for an operator specified time range and for operator specified points, may be output the same as for trend data.

.5 Critical Alarm Summary: Provide a summary of those points in the critical alarm state and include as a minimum; point acronym, point description, alarm type, limit exceed, current value, alarm type, time and date of occurrence.

.6 Maintenance Alarm Summary: Provide a summary of those points in maintenance alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceed, time and date of occurrence.

.7 Alarm Summary: Provide a summary of all points in alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceeded, and time and date of occurrence.

.8 Disable Point Summary: Provide a summary of all points in the disabled state and include as a minimum point acronym and point description.

.9 Run Time Summary: Provide a summary of the accumulated running time of selected pieces of equipment with point acronym and description, run time to date, alarm limit setting. The run time shall continue to accumulate until reset individually by means of suitable operator selection.

.10 Schedule Summary: Provide a summary of all schedules and indicate as a minimum, which days are holidays and, for each section, the day of the week, the schedule times and associated values; for digital schedules value will be on or off; for analog schedules value will be an analog value.

.11 User Record Summary: Provide a summary of all user records to include as a minimum; user name, password, initials, command access level and point groups assigned.

.30 LCU / TCU Programming Software

.1 The Programming software must be able to be seamlessly launched from within the Niagara Framework as a wizard.

.1 Connection methods (Tunneling or by building controller – not direct to controller).

.2 Provide programming software for the Local Control Unit (LCU) and the Terminal Control Unit (TCU) that allows for the development of the LCU/TCU control logic and point management and Graphical User Interface screens.

.1 A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens.

.2 Access to these functions shall be provided through Graphical User Interface software (GUI).

.3 Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool.

.4 Completed applications may be stored in the library for future use.

.5 Graphical User Interface screens shall be created in the same fashion.

.6 Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide “real-time” data updates.

.7 Any real-time data value or object property may be connected to display its current value on a user display.

.8 Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.

.9 Programming Methods:

.1 Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user’s application.

.2 Objects shall be linked by a graphical linking scheme by dragging a link from one object to another.

.3 Object links will support one-to-one, many-to-one, or one-to-many relationships.

.4 Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification.

.10 Object Configuration

.1 Each object will be done through the object’s property sheet using fill-in the blank fields, list boxes, and selection buttons.

.2 Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.

.11 The software shall provide the ability to view the logic with values being inputted to and outputted from the graphical blocks in real time. (debug mode)

.12 The system shall support object duplication within a client's database.

.1 An application, once configured, can be copied and pasted for easy re-use and duplication.

.2 All links, other than to the hardware, shall be maintained during duplication.

.13 Provides function to compare and calculate from multiple values from networked controllers (NCU, TCU and/or LCU).

.14 As a minimum, the function shall calculate and compared the values and return the average, sum, highest, lowest, 3 highest, 3 lowest values and multi-state value count.

.15 Auto-linking of objects to graphics

.16 Auto-Encapsulate functionality (the automatic ability to group multiple programming objects into a new singular programming object).

.17 Allow for uploading/downloading to/from multiple controllers

.31 Utility Software

.1 Supply and install software products to allow the owner to access and manipulate the control schematic diagrams, and to access product data sheets in an electronic format.

.2 Enter all soft copy submissions; including "Record" drawings as specified herein Shop Drawings, Product Data and Review Process in OWS.

2.7 Native Web Browser Interface

.1 The contractor shall provide web-browser delivered graphical visualization software as part of the operator workstation, server, NAC(s), and/or IP-CTRL devices, as indicated on construction documents. The contractor shall configure the graphical visualization software in accordance with project requirements.

.2 The graphical visualization software shall have two operating modes: Studio & Viewer, as described below. For both Studio & Viewer modes, the graphical user interface shall be delivered to the user by pointing a modern web browser to a project-specific URL and logging into the system. The software shall not require any software plugins to be installed in conjunction with the web browser.

.3 When delivered to a modern web browser, the software shall implement web development standards, including but not limited to Hypertext Markup Language (HTML) v5, Cascading Style Sheets (CSS) v3, and JavaScript (in compliance with ECMAScript specifications).

.4 Studio Mode:

.1 The graphical visualization software shall allow upload of user-generated content such as logos or floorplan background images.

.2 The graphical visualization software shall allow assembly and configuration of repeatable design elements, such as a table row for a points list, or an informative callout for equipment on a floor plan.

.3 The graphical visualization software shall allow for use of dynamic, zoomable, extensible mapping interfaces, such as Google Maps, provided internet connectivity.

.4 The graphical visualization software shall support creation and configuration of multiple chart types, including but not limited to line charts, bar charts, area charts, pie charts, including use of multiple foreground and background colors, legend positioning and color gradients.

.5 The graphic visualization software shall allow both view and manipulation (subject to user access level) of real-time data present on the host, as well as historical trend data. The scope of data shall depend only on whether the host device is an operator workstation, server, NAC, or IP-CTRL device and has been fully configured to meet project-required sequence of operation.

.6 The graphic visualization software shall allow binding of any data and/or data manipulation method to applicable graphical design elements, including but not limited to: text labels, buttons, charts, geographical mapping interfaces, applied against applicable properties including but not limited to: position/size, background image/color, foreground color, foreground font properties, visibility, opacity, animation timing and rotation.

.7 The graphic visualization software shall allow manipulation of position/scaling properties of any and all visual elements, with respect to user's screen size, parent and nested visual elements, and/or "User Agent Type" (designating Web Browser vendor and version), such that graphical screens created may be delivered and perform equally well on laptop screens, large displays, and/or mobile devices.

.5 Viewer Mode:

.1 In viewer mode, the graphical visualization software shall deliver content to the user's web browser in a fashion that matches configuration accomplished in Studio Mode.

.2 Scope and amount of content delivered in Viewer mode, and access to data manipulation methods shall be determined by which user has authenticated.

2.8 BAS Controllers

.1 Controllers –BACnet/IP Protocol

.1 Provide BACnet Controllers that are BACnet Testing Laboratory listed (v12 or later) as specified herein:

.1 BACnet Building Controller (B-BC)

.2 BACnet Advanced Application Controller (B-AAC)

.3 BACnet Application Specific Controller (B-ASC)

.2 All BACnet/IP Controllers shall use the following communication specifications and achieve performance as specified herein:

.1 All controllers shall be able to communicate peer-to-peer without the need for a Network Control Unit (such as JACE, NAE, etc.) and shall be capable of assuming all responsibilities typically assumed by a Network Control Unit. Any controller on the Ethernet Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Slave controllers are not acceptable.

.1 Performance

.1 Each BACnet controller shall have a minimum of 512KB of RAM and 4GB of non-volatile flash memory.

.2 Each controller shall have a 32-bit microprocessor operating at a minimum of 600 MHz and support a BACnet protocol stack in accordance with the ANSI/ASHRAE Standard 135-2012 and the BACnet Device Profile supported.

.3 Real time clock with rechargeable battery and 20 days power backup.

.2 BACnet Controllers shall be provided for Unit Ventilators, Fan Coils, Heat Pumps, Variable Air Volume (VAV) Terminals and other applications as shown on the drawings.

.4 The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals.

.3 Control Unit (LCU) and Terminal Control Unit (TCU)

.5 Shall be fully programmable and the programming software shall have a library of pre-built, tested, and user re-definable control sequences for a wide range of typical HVAC applications.

.6 All control sequences programmed into the LCU and TCU shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.

.7 LCU and TCU controllers that are not fully programmable and/or cannot retain programming as outlined in .2 are not acceptable.

.4 BACnet Controllers shall communicate with the Network Control Unit (NCU) via a BACnet/IP connection at a baud rate of not less than 100 Mbps

.5 BACnet TCU to have a communications port for connecting a matching room temperature and/or humidity sensor and does not utilize any of the I/O points of the Controller.

.8 The TCU and all other devices on the BACnet bus shall be accessible from this communications port.

.6 The Contractor supplying the BACnet Controllers shall provide documentation for each device, with the following information at a minimum:

.9 BACnet Device; MAC address, name, type and instance number.

.10 BACnet Objects; name, type and instance number

.7 It is the responsibility of the Contractor to ensure that the proper BACnet objects are provided in each BACnet controller, as required by the Point List located in the POINTS LIST section of this specification.

.2 Local Control Units (LCU) (Primary Systems such as AHU, MAU, Chiller, Boiler, Water System)

.1 The Local Control Units (LCU) shall be 32 bit microprocessor-based.

.1 They shall also be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules.

.2 Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

.3 The LCU will be supplied with a factory installed integral color operator interface (see 23 09 13 2.11.5.8 for details) that provides real-time access to monitored inputs, setpoints, modes, values, statuses, and outputs.

.1 Alternatively a field mounted display and interface, meeting the specified functionality, shall be supplied for each controller in lieu of this requirement.

.2 Each LCU shall have sufficient memory, to support its own operating system and databases, including:

.1 Control processes

.2 Energy management applications

.3 Alarm management applications

.4 Historical/trend data for points specified

.5 Maintenance support applications

.6 Custom processes

.7 Manual override monitoring

.3 Each LCU shall support:

.1 Monitoring of the following types of inputs, without the addition of equipment outside the DDC Controller cabinet:

.1 Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.

.2 Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

.3 Each LCU shall be capable of providing the following control outputs without the addition of equipment outside the DDC controller cabinet:

.4 Digital outputs (contact closure for motor starters up to size 4).

.5 Analog outputs of 4-20 mA and 0-10 Vdc.

.4 The LCU analog or universal input shall use a 16 bit A/D converter.

.1 Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.

.5 The LCU analog or universal output shall use a 10 bit D/A converter.

.6 Each LCU shall have a minimum of 10% spare capacity for each point type for future point connection.

.1 Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

.2 As a minimum, provide one of each type of point available on the controller.

.7 Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.

.8 The LCU's optional factory installed color operator interface will provide real-time access to monitored inputs, setpoints, modes, values, statuses, and outputs.

.1 The operator interface shall consist of :

.1 An icon-based, interactive backlit color display.

.2 A turn and select navigation jog dial to access, edit, and odify internal controller functions. The jog dial shall be used to navigate through menus, select options and icons, and change parameters. Scroll buttons (up, down, left and right) shall not be acceptable.

.3 Navigable menus to display, select, edit, and modify values and other controller information.

.4 List-based menus with a minimum of eight (8) lines of text.

.5 Icon-based menus.

.6 A display with the following minimum characteristics: a resolution of 400 W x 240 H pixels with an effective viewing area of 2.4" L x 1.4" H, and 2.8" diagonal viewing area.

.2 The operator interface shall use color-codes with icons and text lists to indicate values and controller statuses.

.3 The operator interface shall, at a minimum, have the following functions:

.1 Points. The operator interface shall provide points list menus to view the inputs, setpoints, and output values such as hardware inputs/outputs, analog values, binary values, multistate values, Intelligent Space Sensor (ISS) (see section 23 09 13 2.16 Intelligent Space Sensors (ISS)) inputs, and wireless inputs.

.1 The points list menus shall allow the operator to monitor, set, and override controller points and values.

.2 A color-code shall be used to indicate the conditions and statuses of points displayed in the points list menus.

.2 Alarms. The operator interface shall provide a controller's alarms menu to view details of an alarm, to acknowledge the alarm, and to view the alarm history.

.1 The alarm menu shall allow the operator to view the following type of alarms: active not acknowledged, active acknowledged, and inactive not acknowledged.

.2 The combination of an icon and its color state shall notify the operator of an alarm condition.

.3 The operator shall be able to select a single point in alarm to view further details such as the alarm to/from status, current status, event date and time, alarm event threshold, and alarm event value.

.3 Overrides. The operator interface shall provide an overrides menu to view a list of the controller's overridden points such as hardware input, hardware output, value, constant, or variable. The menu shall allow the operator to select an overridden point and to modify or release the override on the selected point.

.4 PID loops. The operator interface shall provide a PID Loops menu to view, configure, and adjust the PID parameters. The interface shall also provide visual PID tuning with live system response graphing (live-trend).

.5 The operator interface shall support Latin-based languages and allow the interface user to select from three (3) defined languages.

.6 The operator interface shall allow personalization of a contact information screen with a minimum of eight (8) lines of user configurable text as well as the option to add a color graphic such as a company logo. The tool shall support, but not be limited to; image file formats such as GIF, PNG, JPG, etc.

.7 Favorites. The operator interface shall allow access to a list of bookmarked points.

.8 Weather. The operator interface shall provide a weather menu to view the current weather conditions with a weather status icon. The units shall be configured to be displayed in either metric or US units.

.9 Password protected. The controller operator interface shall provide multi-level password protection, with user-defined, alphanumeric, name/password combinations. The operator interface shall return to lock mode after a user-defined log-off delay. A password icon shall indicate the lock mode state.

.10 Settings. The operator interface shall provide a settings menu to view and configure date and time parameters such as the current time, time zone, and daylight savings time.

.9 The LCU shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components.

.1 The controller shall provide both local and remote annunciation of any detected component failures or repeated failure to establish communication.

.10 Should the LCU memory be lost for any reason, the user shall have the capability of reloading the controller software via the BAS LAN OWS or Server.

.1 Controller requiring a local port to reload the controller software is not acceptable.

.11 Wireless port supporting a wireless transceiver for communication with wireless sensors/switches

.12 Acceptable Products:

.1 BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) or BACnet Advanced Application Controller (B-AAC)

.3 IP Plant Controller (IP-SYS-CTRL)

.1 The IP-SYS-CTRL shall be 32 bit microprocessor-based operating at a minimum of 1 GHz.

.1 They shall be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules.

.2 Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

.3 Each IP-SYS-CTRL shall have minimum of 512MB memory, with a minimum of 4GB non-volatile flash, to support its own operating system and databases.

.2 Each individual controller shall have an embedded web-based HTML5 visual interface with the following functionality without reliance on any other controller for access:

.1 Typical and custom control processes

.2 Scheduling

.3 Energy management applications

.4 Alarm management applications

.5 Historical/trend data for points specified

.6 Maintenance support applications

.7

.8 Web Based interface via integral Web Server.Support for up to a minimum of 256 I/O points which are added via Expansion I/O modules.

.9 Shall have a graphical interface with a common library of HVAC system image and animation such as AHU, MAU, Boiler Plant, Chiller Plant, and Rooftop Unit.

.3 The IP-SYS-CTRL shall have a Real Time clock.

.4 The IP-SYS-CTRL will support the following communications protocols:

.1 BACnet/IP

.1 Supporting IPv4 addressing.

.2 DHCP support and Auto DNS.

.3 2 - RJ45 ports each capable of supporting 10/100 Base-T.

.1 Supporting controller daisy chaining on the Ethernet network via integral switch functionality.

.2 Integrated fail-safe should allow for communication when the controller is powered down.

.4 If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality.

.2 BACnet MS/TP supporting up to minimum of 50 additional BACnet MS/TP controllers in addition to the Expansion I/O modules.

.1 Supporting 9600 to 115200 baud

.3 Modbus RTU

.1 Supporting 9600 to 115200 baud

.4 Modbus TCP

.5 2 x USB 2.0 Expansion ports for:

.1 802.11 Wi-Fi Adapter enabling wireless connectivity including:

.1 ‘Hot Spot’

.2 Client

.3 Access Point

.2 If the above functionality is not available then appropriate wireless router(s) and switches must be supplied to provide the functionality.

.5 Shall contain a “FIPS 140-2 Level 1 Compliant” cryptographic module

.6 Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICES

.7 Acceptable Products:

.1 BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.

.4 IP-SYS-CTRL Communication Modules

.1 Each IP-SYS-CTRL Communication module shall be capable of RS-485 communication with the following requirements, without the additional gateways/routers to enable RS-485 communication:

.2 Include two separate RS-485 communication ports.

.1 Allow for either Modbus RTU or BACnet MS/TP communication on either of the ports

.3 Allow for a minimum of 32 Modbus RTU communicating devices and/or a minimum of 50 BACnet MS/TP communicating devices to be connected on each RS-485 segment.

.4 Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICES

.5 IP-SYS-CTRL Expansion I/O modules:

.1 Each IP-SYS-CTRL Expansion I/O module shall be capable of monitoring of the following types of inputs, without the addition of equipment outside the DDC Controller cabinet:

.1 Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

.2 Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.

.1 The analog or universal input shall use a 16 bit A/D converter.

.1 Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.

.2 Each IP-SYS-CTRL Expansion I/O module shall be capable of providing the following control outputs without the addition of equipment outside the DDC controller cabinet:

.1 Digital outputs including Form C relay outputs and Triac outputs

.1

.2 Analog outputs of 4-20 mA and 0-10 Vdc.

.1 The analog or universal output shall use a 10 bit D/A converter.

.3 HOA (Hand, Off, Auto) support.

.3 Each completed configuration of IP-SYS-CTRL and Expansion I/O modules shall have a minimum of 10% spare capacity for each point type for future point connection.

.1 Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

.2 As a minimum, provide one of each type of point available on the controller.

.4 Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

.5 Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.

.6 Any software required for programming shall be unlicensed and openly available

.7 Power and Environmental Requirements:

.1 24 VAC with local transformer power

.2 The controllers shall also function normally under ambient conditions of -40 ˚F to 158 ˚F and 0% to 90% RH (non-condensing).

.3 Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

.8 Code Compliance:

.1 “FIPS 140-2 Level 1 Compliant” cryptographic module

.2 BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.

.3 UL916 Energy management equipment

.4 FCC rules part 15, subpart B, class B

.5 UL94-V0 flammability rating

.6 State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

.9

.6 IP nLight ECLYPSE™ System Controller (IP-NE-CTRL)

.1 The IP-NE-CTRL shall be 32 bit microprocessor-based operating at a minimum of 1 GHz.

.1 They shall be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, and power supplies.

.2 Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

.2 Each IP-NE-CTRL shall have minimum of 512MB memory, with a minimum of 4GB non-volatile flash, to support its own operating system and databases, including:

.3 Control processes

.4 Alarm management applications

.5 Maintenance support applications

.6 Custom processes

.7 Web Based interface via integral Web Server.

.8 Shall have a graphical interface with a common library of nLight system images.

.3 The IP-NE-CTRL shall have a Real Time clock.

.4 The IP-NE-CTRL will support the following communications protocols:

.1 BACnet/IP

.1 Supporting IPv4 addressing.

.2 DHCP support and Auto DNS.

.3 2 - RJ45 ports each capable of supporting 10/100 Base-T.

.1 Supporting controller daisy chaining on the Ethernet network via integral switch functionality.

.4 If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality.

.5 Network Lighting Control (NLC)

.6 Supporting up to 750 NLC devices.

.7 3 – RJ45 ports supporting NLC networks.

.8 Refer to 26 09 43 for NLC devices.

.9 If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality.

.2 BACnet MS/TP supporting up to minimum of 50 additional BACnet MS/TP controllers in addition to the Expansion I/O modules.

.1 Supporting 9600 to 115200 baud

.3 2 x USB 2.0 Expansion ports for:

.1 802.11 Wi-Fi Adapter enabling wireless connectivity including:

.1 'Hot Spot'

.2 Client

.3 Access Point.

.4 Spanning Tree Protocol

.2 If the above functionality is not available then appropriate wireless router(s) and switches must be supplied to provide the functionality.

.5 Shall contain a "FIPS 140-2 Level 1 Compliant" cryptographic module.

.6 Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICES.

.7 Acceptable Products:

.1 BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.

.7 IP Equipment Controller (IP-EQUIP-CTRL)

.1 The IP-EQUIP-CTRL shall be 32 bit microprocessor-based operating at a minimum of 600 MHz.

.1 They shall be multi-tasking, real-time digital control processor based supporting a fixed I/O point count.

.2 Each IP-EQUIP-CTRL shall have minimum of 512MB memory, with a minimum of 4 GB non-volatile flash, to support its own operating system and databases, including:

.1 Control processes

.2 Maintenance support applications

.3 Custom processes

.4 Energy management applications

.5 Alarm management applications

.6 Historical/trend data for points specified

.7 Embedded Web Server for local hosting of graphics

.3 The IP-EQUIP-CTRL shall have a Real Time clock with rechargeable battery.

.4 Power Requirements

.1 24 VAC with local transformer power

.5 The IP-EQUIP-CTRL will support the following communications protocols:

.1 BACnet/IP

.1 Supporting IPv4 addressing.

.2 DHCP support and Auto DNS.

.3 2 - RJ45 ports each capable of supporting 10/100 Base-T.

.1 Supporting controller daisy-chain topology on the wired IP network via integrated switch functionality.

.2 Integrated fail-safe should allow for communication when the controller is powered down.

.4 If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality.

.2 2 x USB 2.0 Expansion ports for:

.1 802.11 Wi-Fi Adapter enabling wireless connectivity including:

.1 'Hot Spot'

.2 Client

.3 Access Point

.2 If the above functionality is not available then appropriate wireless router(s) and switches must be supplied to provide the functionality.

.6 The IP-EQUIP-CTRL controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC (±15%), allowing for power source fluctuations and voltage drops.

.7 The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range.

.8 The controllers shall also function normally under ambient conditions of -40 ˚F to 158 ˚F and 0% to 90% RH (non-condensing).

.9 Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

.10 Provide a minimum of 8 software configurable Universal Inputs capable of supporting the following input signal types:

.1 Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

.2 Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.

.3 The analog or universal input shall use a 16 bit A/D converter.

.1 Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.

.11 Provide a minimum of 2 software configurable Universal Outputs capable of supporting the following output signal types:

.1 Digital outputs.

.2 Analog outputs of 4-20 mA and 0-10 Vdc.

.1 The analog or universal output shall use a 10 bit D/A converter.

.12 Provide a minimum of 4 digital/Triac outputs.

.13 Provide a minimum of 2 software configurable outputs that can either be utilized as additional digital/Triac outputs or as universal outputs.

.14 Provide a minimum of 3 Modbus connected devices.

.1 Provide on-board RS-485 communication for Modbus RTU communication to a minimum of 3 connected devices on the RS-485 segment.

.2 Provide Modbus TCP communication to a minimum of 3 connected devices.

.15 Provide connection to Intelligent Space Sensors (ISS) (see section 23 09 13 2.16 Intelligent Space Sensors (ISS)) via on-board RJ-45 subnetwork port.

.16 Shall contain a “FIPS 140-2 Level 1 Compliant” cryptographic module

.17 Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

.8 IP Terminal Unit Controller (IP-TU-CTRL) .

.1 The IP-TU-CTRL shall be 32 bit microprocessor-based operating at a minimum of 600 MHz. .

.1 They shall be multi-tasking, real-time digital control processor based supporting a fixed I/O point count.

.2 Each IP-TU-CTRL shall have minimum of 512MB memory, with a minimum of 4 GB non-volatile flash, to support its own operating system and databases, including: .

.1 Control processes

.2 Maintenance support applications

.3 Custom processes

.4 Energy management applications

.5 Alarm management applications

.6 Historical/trend data for points specified

.7 Embedded Web Server for local hosting of graphics.

.3 The IP-TU-CTRL shall have a Real Time clock with rechargeable battery.

.4 Power Requirements.

.1 24 VAC with local transformer power.

.5 The IP-TU-CTRL will support the following communications protocols: .

.1 BACnet/IP.

.1 Supporting IPv4 addressing.

.2 DHCP support and Auto DNS.

.3 2 - RJ45 ports each capable of supporting 10/100 Base-T.

.1 Supporting controller daisy-chain topology on the wired IP network via integrated switch functionality.

.2 Integrated fail-safe should allow for communication when the controller is powered down.

.3 If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality.

.2 2 x USB 2.0 Expansion ports for:

.1 802.11 Wi-Fi Adapter enabling wireless connectivity including: .

.1 'Hot Spot'.

.2 Client

.3 Access Point.

.2 If the above functionality is not available then appropriate wireless router(s) and switches must be supplied to provide the functionality..

.6 The IP-TU-CTRL controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC (±15%), allowing for power source fluctuations and voltage drops.

.7 The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range.

.8 The controllers shall also function normally under ambient conditions of -40 ˚F to 158 ˚F and 0% to 90% RH (non-condensing).

.9 Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

.10 Provide a minimum of 8 software configurable Universal Inputs capable of supporting the following input signal types:

.1 Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

.2 Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.

.1 The analog or universal input shall use a 16 bit A/D converter.

.2 Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.

.11 Provide a minimum of 2 software configurable Universal Outputs capable of supporting the following output signal types:

.1 Digital outputs.

.2 Analog outputs of 4-20 mA and 0-10 Vdc.

.1 The analog or universal output shall use a 10 bit D/A converter.

.12 Provide a minimum of 4 digital/Triac outputs.

.13 Provide a minimum of 2 software configurable outputs that can either be utilized as additional digital/Triac outputs or as universal outputs.

.14 Provide connection to Intelligent Space Sensors (ISS) (see section 23 09 13 2.16 Intelligent Space Sensors (ISS)) via on-board RJ-45 subnetwork port.

.15 Shall contain a “FIPS 140-2 Level 1 Compliant” cryptographic module

.16 Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

.9 IP VAV Controller (IP-VAV-CTRL)

.1 Refer to 23 09 13 2.11 Variable Air Volume (VAV) Terminal Control Units (TCU) for VAV related functionality requirements.

.1 In cases of conflict between this section (IP-VAV-CTRL) and the referenced section (VAV) this section (IP-VAV-CTRL) takes precedence.

.2 The IP-VAV-CTRL shall be 32 bit microprocessor-based operating at a minimum of 400 MHz.

.3 They shall be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules.

.4 Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

.5 Each IP-VAV-CTRL shall have minimum of 512MB memory, with a minimum of 1GB non-volatile flash, to support its own operating system and databases, including:

.1 Control processes

.2 Maintenance support applications

.3 Custom processes

.6 The IP-VAV-CTRL shall have a Real Time clock with rechargeable battery.

.7 Power Requirements

.1 24 VAC with local transformer power

.2 50 VAC utilizing Power Over Ethernet (POE)

.8 The IP-VAV-CTRL will support the following communications protocols:

.1 BACnet/IP

.1 Supporting IPv4 addressing.

.2 DHCP support and Auto DNS.

.3 2 - RJ45 ports each capable of supporting 10/100 Base-T.

.4 If the above functionality is not available then appropriate router(s) and switches must be supplied to provide the functionality.

.2 2 x USB 2.0 Expansion ports for:

.1 802.11 Wi-Fi Adapter enabling wireless connectivity including:

.1 ‘Hot Spot’

.2 Client

.3 Access Point

.2 If the above functionality is not available then appropriate wireless router(s) and switches must be supplied to provide the functionality.

.9 Shall contain a “FIPS 140-2 Level 1 Compliant” cryptographic module

.10 Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

.11 Acceptable Products:

.1 BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC)

.10 Blinds Control Module (B-C-M)

.1 Application

.1 To upgrade any ECLYPSE™ series TCU controllers to provide blinds control.

.2 Refer to 23 09 13 Terminal Control Units (TCU) for TCU related functionality requirements.

.1 In cases of conflict between this section (B-C-M) and the referenced section (TCU) this section (B-C-M) takes precedence.

.3 They shall consist of modular hardware with communication controllers, power supplies and input/output point modules.

.4 Blinds I/O to appear as extension to host HVAC controller.

.5 Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

.1 Support for up to 4 (24VDC or 100-220VAC) blinds actuators.

.2 Support for up to 4 Digital Inputs

.6 Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

.7 Acceptable Products:

.1 BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC)

.8 Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

.9 Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

.11 Integrated Lighting Control Unit (ILCU)

.1 Provide a standalone microprocessor based integrated lighting control panel that utilizes the BACnet protocol and contains line and or low voltage relays for control of the lighting circuits along with the appropriate schedules and local user interface.

.2 Integrated Lighting Control Unit that use proprietary protocols or require gateways to convert proprietary protocol into BACnet shall not be acceptable.

.1 BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) or BACnet Advanced Application Controller (B-AAC)

.12 Variable Air Volume (VAV) Terminal Control Units (TCU)

.1 The VAV TCU controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC (±15%), allowing for power source fluctuations and voltage drops.

.2 The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range.

.3 The controllers shall also function normally under ambient conditions of -40 ˚F to 158 ˚F and 0% to 90% RH (non-condensing).

.4 Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

.5 The VAV TCU shall include a built-in ‘flow thru’ differential pressure transducer.

.1 The controller shall convert this value to actual air flow.

.2 Single point differential pressure sensing device is not acceptable.

.3 Membrane based pressure differential transducer is not acceptable.

.4 The VAV TCU differential pressure transducer shall have a measurement range of 0 to 2 in. W.C. and measurement accuracy of ±4% at 0.05 to 2 in. W.C. and a minimum resolution of 0.0001 in. W.C., insuring primary air flow conditions shall be controlled and maintained to within ±5% of setpoint at the specified minimum and maximum air flow parameters.

.5 VAV TCU differential pressure transducer requiring periodic zero value air flow calibration is not acceptable.

.6 The BAS contractor shall verify the type of differential pressure sensors used in the existing boxes, and ensure compatibility with the VAV TCU controllers.

.7 The VAV TCU shall include provision for air flow balancing using a local air flow balancing interface.

.8 An Intelligent Space Sensor (ISS) (see section 23 09 13 2.16 Intelligent Space Sensors (ISS)) shall be used for balancing air flow.

.1 In lieu of an ISS, a portable air flow balancing interface capable of balancing air flow is acceptable.

.9 The portable air flow balancing interface shall connect to the VAV TCU or the matching room temperature sensor.

.10 The VAV TCU shall also provide an air flow balancing tool.

.11 This tool shall allow the air balancer to manually control the action of the actuator including the following function: open VAV damper, close VAV damper, open all VAV dampers, and close all VAV dampers.

.12 Systems not able to provide a web based air balance tool or a portable air flow balancing interface or an Intelligent Space Sensor (ISS) (see section 23 09 13 2.16 Intelligent Space Sensors (ISS)) capable of balancing air flow as part of the VAV TCU controller shall provide an individual full time technician during the air flow balancing process to assure full balance compliance.

.13 The VAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within ±1.5 ˚F of setpoint at the room sensor location.

.14 Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space requirements.

.1 This algorithm shall function to signal the respective controller to perform the required discharge temperature reset in order to maintain space temperature setpoint.

.15 It shall be possible to view and reset the space temperature, temperature setpoint, maximum airflow setting, minimum airflow setting, and actual airflow, through the BAS LAN.

.16 Auto Commissioning.

.1 Each ECLYPSE™ connected controller shall provide the following for auto commissioning:

.1 Edge testing and logging.

.2 Utilize RESTful™ communications

.3 EC-Net commissioning module

.4 Optional commissioning on schedule

.5 Optional reports by email

.6 Optional logging of supplying HVAC information such as:

.1 Supply air temperature

.2 Supply pressure

.3 Heating supply temperature

.4 Cooling supply temperature

.17 Shall comply with State of California Senate Bill No. 327, Chapter 886, TITLE 1.81.26. SECURITY OF CONNECTED DEVICE

.18 ECLYPSE™ Connected Thermostat

.1 Provides control for new or existing rooftop unit, heatpump unit, fancoil unit and other zone control applications. It features a touchscreen interface, multiple connectivity options (both wired IP and Wi-Fi) for system communication, and Bluetooth low energy (BLE) for mobile connectivity.

.2 Communications

.1 Wired Communications

.1 Ethernet Connection Speed 10/100 Mbpsl

.2 Addressing IPv4 or Hostname

.3 BACnet Profile BACnet Building Controller (B-BC), AMEV AS-A and AS-B

.4 Listing BTL, WSP B-BC (pending)

.5 BACnet Interconnectivity BBMD forwarding capabilities

.6 BACnet Transport Layer IP

.7 Web Server Protocol HTML5

.8 Web Server Application REST API

.2 Wireless Communications

.1 Bluetooth Version 4.2

.2 Bluetooth Frequency 2402 - 2480 MHz

.3 Wi-Fi Communication Protocol IEEE 802.11b/g/n

.4 Wi-Fi Connection Types Client and Hotspot

.3 Outputs

.1 Integral Temperature Sensor

.1 Range 32^0F to 104^0F

.2 Integral HumiditySensor

.1 Accuracy <±3% RH 0% to 70%

.3 4 UIs (Universal Input)

.4 5 or 3 DOs (Digital Output

.5 3 or 2 DUOs (Digital Universal Output)

.4 Display

.1 Type Full color, IPS, backlit,

.2 Capacitive LCD touchscreen

.3 Display Resolution High definition (320 × 480)

.4 Effective Viewing Area (W x H) 1.93 × 2.89”

.5 Languages English, French, Spanish,Italian, German, Danish, Dutch, Polish, and Portuguese

.5 Applications

.1 Summary View:

.1 equipment information on one screen, at a single glance

.2 Temperature:

.1 View ambient temperature and humidity level, and provide instantaneous temperature setpoint adjustment

.3 Fan speed:

.1 Instantaneous fan speed adjustment

.4 HVAC Mode:

.1 Quickly select the required HVAC mode of operation

.5 Lighting Control (if active):

.1 Instantaneous light level adjustment of individual or grouped lighting

.6 Sunblind Control (if active):

.1 Instantaneous sunblind level adjustment of individual or grouped sunblinds

.7 Custom Actions:

.1 Provide up to 8 custom buttons that can be programmed to activate personalized groups of environmental settings

.8 Scheduler:

.1 View and edit schedules and events. Scheduler supports a dual setpoint schedule as well as special events and can allow for local adjustments and overrides to networked schedules and events.

.9 Weather:

.1 View current and forecasted weather

.10 Mobile App Connectivity:

.1 Supports mobile control of environmental parameters from a mobile device via a localized, secure connection (Bluetooth).

.11 Custom applications:

.1 Develop custom solutions utilizing the built in RESTful™ API and the Cloud Connectivity of ECLYPSE™

.6 Standards and Regulations (pending)

.1 CE Emission EN61000-6-3: 2007+A1:2011

.2 CE Immunity EN61000-6-1: 2007

.3 CE Radio EN 300 328 V2.1.1 November 2016

.4 FCC Compliance with FCC rules part 15, subpart B, class B

.5 UL Listed (CDN & US) UL916 Energy management equipment

2.9 Local Display Unit (LDU)

.1 The LDU must provide for a color operator interface allowing for real-time access to monitored inputs, setpoints, modes, values, statuses, and outputs.

.1 The operator interface shall consist of :

.1 An icon-based, interactive backlit color display.

.2 A turn and select navigation jog dial to access, edit, and modify internal controller functions. The jog dial shall be used to navigate through menus, select options and icons, and change parameters. Scroll buttons (up, down, left and right) shall not be acceptable.

.3 Navigable menus to display, select, edit, and modify values and other controller information.

.4 List-based menus with a minimum of eight (8) lines of text.

.5 Icon-based menus.

.6 A display with the following minimum characteristics: a resolution of 400 W x 240 H pixels with an effective viewing area of 2.4” L x 1.4” H, and 2.8” diagonal viewing area.

.2 The operator interface shall use color-codes with icons and text lists to indicate values and controller statuses.

.3 The operator interface shall, at a minimum, have the following functions:

.1 Points. The operator interface shall provide points list menus to view the inputs, setpoints, and output values such as hardware inputs/outputs, analog values, binary values, multistate values, Intelligent Space Sensor (ISS) (see section 23 09 13 2.16 Intelligent Space Sensors (ISS)) inputs, and wireless inputs.

.1 The points list menus shall allow the operator to monitor, set, and override controller points and values.

.2 A color-code shall be used to indicate the conditions and statuses of points displayed in the points list menus.

.2 Alarms. The operator interface shall provide a controller's alarms menu to view details of an alarm, to acknowledge the alarm, and to view the alarm history.

.1 The alarm menu shall allow the operator to view the following type of alarms: active not acknowledged, active acknowledged, and inactive not acknowledged.

.2 The combination of an icon and its color state shall notify the operator of an alarm condition.

.3 The operator shall be able to select a single point in alarm to view further details such as the alarm to/from status, current status, event date and time, alarm event threshold, and alarm event value.

.3 Overrides. The operator interface shall provide an overrides menu to view a list of the controller's overridden points such as hardware input, hardware output, value, constant, or variable. The menu shall allow the operator to select an overridden point and to modify or release the override on the selected point.

.4 PID loops. The operator interface shall provide a PID Loops menu to view, configure, and adjust the PID parameters. The interface shall also provide visual PID tuning with live system response graphing (live-trend).

.5 The operator interface shall support Latin-based languages and allow the interface user to select from three (3) defined languages.

.6 The operator interface shall allow personalization of a contact information screen with a minimum of eight (8) lines of user configurable text as well as the option to add a color graphic such as a company logo. The tool shall support, but not be limited to; image file formats such as GIF, PNG, JPG, etc.

.7 Favorites. The operator interface shall allow access to a list of bookmarked points.

.8 Weather. The operator interface shall provide a weather menu to view the current weather conditions with a weather status icon. The units shall be configured to be displayed in either metric or US units.

.9 Password protected. The controller operator interface shall provide multi-level password protection, with user-defined, alphanumeric, name/password combinations. The operator interface shall return to lock mode after a user-defined log-off delay. A password icon shall indicate the lock mode state.

.10 Settings. The operator interface shall provide a settings menu to view and configure date and time parameters such as the current time, time zone, and daylight savings time.

.2 The LDU shall be provided as a din-rail mount or (panel) flush mount as shown on the mechanical drawings.

.3 The LDU shall utilize a single cable connection via on-board RJ-45 port, and can be connected to the subnetwork port of any LCU, IP-SYS-CTRL, or IP-EQUIP-CTRL, IP-VAV-CTRL and therefore can be utilized as a hand-held portable operator display.

.4 The LDU shall have a minimum rating of IP54 for dusty or splash-prone environment

2.10 IP Connected Local Display Unit (IP-LDU)

.1 The IP Connected Local Display Unit (IP-LDU) shall be provided as a surface mount or flush mount, as noted in construction documents.

.2 The IP-LDU shall consist of a touch screen display, with included power adapter port and one RJ45 Ethernet port.

.3 The IP-LDU Connected Local Display Unit shall support connectivity to any single supported field controller accessible on the same IP network.

.4 The IP-LDU shall support user authentication via credential entry. This authentication will determine the user's level of access to the connected field controller.

.5 The IP-LDU shall support the following functions, without any configuration required, other than IP address configuration and association with a connected field controller:

.1 PID Loop Tuning: The IP-LDU shall provide the ability to view PID Loop Performance on a connected field controller in a timestamped, multi-variable chart, and make adjustments to tuning parameters.

.2 Trend Viewing: The IP-LDU shall provide the ability to view charts for data points on a connected field controller, such as setpoints or hardware inputs and outputs.

.3 Schedule & Calendar Adjustment: The IP-LDU shall provide the ability to view and adjust weekly schedules residing on a connected field controller, as well as calendars (e.g. to make operational exceptions for holidays).

.4 Point Data View & Override: The IP-LDU shall provide the ability to view and override data points on a connected field controller, such as setpoints or hardware inputs and outputs.

.5 Alarm View & Acknowledgement: The IP-LDU shall provide the ability to view and acknowledge alarms present on the connected field controller.

2.11 Mobile Operator Application for Android[1] and iOS®[2] platforms

.1 The application can be installed on any smartphone running minimum Android OS 5+ (Lollypop) or Apple iOS 10+

1 An open source operating system by Google, based on the Linux kernel.

2 Is a mobile operating system developed by, and a registered mark of, Apple Inc.

.2 The application for mobile platforms shall provide real-time access to monitored inputs, setpoints, modes, values, statuses, and outputs.

.1 Connection of the application to the BEMS is via low energy Bluetooth utilizing Bluetooth access points at BEMS and BEIRI locations

.2 The operator interface consists of :

.1 An icon-based, interactive application for Android and iOS devices.

.2 Standard Android and iOS navigation methods shall be used to access, edit, and modify internal controller functions and shall be used to navigate through menus, select options and icons, and change parameters.

.3 Navigable menus to display, select, edit, and modify values and other controller information.

.4 List-based menus.

.5 Icon-based menus.

.3 The operator interface shall use color-codes with icons and text lists to indicate values and controller statuses.

.4 The operator interface shall, at a minimum, have the following functions:

.1 Points. The operator interface shall provide points list menus to view the inputs, setpoints, and output values such as hardware inputs/outputs, analog values, binary values, multistate values, Intelligent Space Sensor (ISS) (see section 23 09 13 Intelligent Space Sensors (ISS)) inputs, and wireless inputs.

.1 The points lists menus shall allow the operator to monitor, set, and override controller points and values.

.2 A color-code shall be used to indicate the conditions and statuses of points displayed in the points list menus.

.2 Alarms. The operator interface shall provide a controller’s alarms menu to view details of an alarm, to acknowledge the alarm, and to view the alarm history.

.1 The alarm menu shall allow the operator to view the following type of alarms: active not acknowledged, active acknowledged, and inactive not acknowledged.

.2 The combination of an icon and its color state shall notify the operator of an alarm condition.

.3 The operator shall be able to select a single point in alarm to view further details such as the alarm to/from status, current status, event date and time, alarm event threshold, and alarm event value.

.3 Overrides. The operator interface shall provide an overrides menu to view a list of the controller's overridden points such as hardware input, hardware output, value, constant, or variable. The menu shall allow the operator to select an overridden point and to modify or release the override on the selected point.

.4 PID loops. The operator interface shall provide a PID Loops menu to view, configure, and adjust the PID parameters. The interface shall also provide visual PID tuning with live system response graphing (live-trend).

.5 The operator interface shall support Latin-based languages and allow the interface user to select from three (3) defined languages.

.6 The operator interface shall allow personalization of a contact information screen with a minimum of eight (8) lines of user configurable text as well as the option to add a color graphic such as a company logo. The tool shall support, but not be limited to; image file formats such as GIF, PNG, JPG, etc.

.7 Favorites. The operator interface shall allow access to a list of bookmarked points.

.8 Weather. The operator interface shall provide a weather menu to view the current weather conditions with a weather status icon. The units shall be configured to be displayed in either metric or US units.

.9 Password protected. The controller operator interface shall provide multi-level password protection, with user-defined, alphanumeric, name/password combinations. The operator interface shall return to lock mode after a user-defined log-off delay. A password icon shall indicate the lock mode state.

.10 Settings. The operator interface shall provide a settings menu to view and configure date and time parameters such as the current time, time zone, and daylight savings time.

2.12 Mobile Occupant Application (myPERSONIFY) for Android[3] and iOS®[4] platforms

.1 The application can be installed on any smartphone running minimum Android OS 5+ (Lollypop) or Apple iOS 10+

.2 The application provides occupant access to manage temperature, fan, speed, lighting, and shades/sunblinds.

.1 Connection of the application to the BEMS is via low energy Bluetooth utilizing Bluetooth access points at BEMS and BEIRI locations

.2 The occupant interface consists of :

.1 An icon-based, interactive application for Android and iOS devices.

3 An open source operating system by Google, based on the Linux kernel.

4 Is a mobile operating system developed by, and a registered mark of, Apple Inc.

.2 Standard Android and iOS navigation methods shall be used to access, edit, change parameters and shall be used to navigate through menus, select options and icons.

.3 Navigable menus to display, select, edit, and modify values and other controller information.

.4 List-based menus.

.5 Icon-based menus.

.3 The occupant interface shall use color-codes with icons and text lists to indicate values and controller statuses.

.4 The occupant interface shall, at a minimum, have the following functions:

.1 Overrides. The occupant interface shall provide an override menu to view a limited list of the controller's overridden points such as value, constant, or variable. The menu shall allow the operator to select an overridden point/value and to modify or release the override on the selected point/value.

The Personal Comfort option allows a user to save, edit or remove a group of pre-set room preferences for quick and easy access at any time

.2 The occupant can define their personal preferences (units, theme, favorite devices, etc.) to customize their user interface and space comfort settings

.3 Favorite devices can also be defined in order to automatically connect to the most frequently used device

.4 All control screens have been designed with the occupant in mind, making this app easy to use, regardless of one's technical skillset

.5 The operator interface shall support Latin-based languages and allow the interface user to select from three (3) defined languages.

.6 Favorites. The operator interface shall allow access to a list of bookmarked points.

.7 Resolution: ±0.18 ˚F

2.13 BLE-Enabled Intelligent Room Interface - Allure UNITOUCH (BEIRI-UNITOUCH)

.1 The BLE-Enabled Intelligent Room Interface (BEIRI) shall communicate with any ECLYPSE Connected Controller and shall provide precise environmental zone control for temperature, fan speed, lighting, and blinds.

.1 The BEIRI-UNITOUCH shall support the following communications methods.

.2 Wired Communications

.1 Type – RS-485

.2 Rate – 38,400 bps

.3 Cable and Connections

.1 Type T568B Cat 5e network cable (4 twisted pairs)

.2 Maximum length: 328 ft.

.3 Connections (pass-through)

.1 IN – RJ-45

.2 OUT – RJ-45 for daisy chaining to other room devices)

.3 Wireless Communications

.1 Type: Bluetooth 4.2

.2 Frequency: 2402 – 2480 MHz

.2 Each BEIRI-UNITOUCH shall provide a full color Liquid Crystal Display (LCD), where indicated on the drawings, with the following minimum features:

.1 High definition (320 x 480)

.2 Minimum 1.93” x 2.89” effective viewing area

.3 Backlit

.3 The BEIRI-UNITOUCH shall be capable of displaying on its LCD the measured space temperature from 32 ˚F to 122 ˚F and/or humidity from 0 % RH to 100 % RH with one decimal and/or the CO2 measurement from 0 to 2000 ppm.

.4 The BEIRI-UNITOUCH shall also be capable of displaying the following elements:

.1 Space temperature

.2 Cooling space temperature set point

.3 Heating space temperature set point

.4 Current heating or cooling mode

.5 Current occupancy mode

.6 Fan speed

.7 Light status

.8 Blind position

.9 Alarm condition

.10 Current time

.11 Energy consumption indicator

.12 Home and menu images can be customized

.5 Each BEIRI-UNITOUCH shall provide a local touch screen for local user interface to perform navigation and adjustment of points configured as adjustable.

.6 Each BEIRI-UNITOUCH can be controlled, via Bluetooth low energy technology, using a mobile app on a smartphone.

.1 Allows for a mirrored user interface which provides remote control from anywhere within range.

.7 The BEIRI-UNITOUCH shall be configured for the intended application requirements.

.8 Provide an BEIRI-UNITOUCH where indicated on the drawings. Each BEIRI-UNITOUCH shall provide at a minimum the following on-board integral I/O without the consumption of any inputs and/or outputs at the host controller:

.1 Temperature Sensor

.1 Sensing Element: 10k Thermistor

.2 Accuracy: ±0.36 ˚F

.3 Resolution: ±0.18 ˚F

.4 Range: 32 ˚F to 122 ˚F

.2 Relative Humidity Sensor

.1 Accuracy: ±3 % RH : 0% to 70%

.2 Resolution: 1 % RH

.3 CO2 Sensor

.1 Accuracy: 400 to 1,250 ppm ± 30 ppm or 3% of reading,whichever is greater
1,250 - 2,000 ppm ± 5% of reading + 30 ppm

.2 Operating Elevation:16,000 ft

.3 Range: 0 to 2,000 ppm

.4 Calibration: Patented ABC Logic self-calibration algorithm.

.5 Stability: 2% of FS over life of sensor (15 years)

.6 Temperature dependence: 0.11% FS per ˚F

.7 Stability: <2% of FS over life of sensor (15 years)

.8 Pressure dependence:0.135% of reading per mm Hg

.9 Sensing method: Non-dispersive infrared (NDIR) absorption and Gold plated optics.

.9 The BEIRI-UNITOUCH shall provide password protected menus or any other mechanism to prevent a local user to access advanced configuration menus

.10 The BEIRI-UNITOUCH shall be capable of promoting good energy usage practices to the room occupant by displaying an Energy Consumption Indicator (ECI).

.1 The ECI shall be modified in real-time when the room occupant modifies a parameter such as the room temperature setpoint or the fan speed.

.2 The ECI shall indicate to the room occupant the energy impact of the parameter changes via a 5 level display icon where a full display (5th level) indicates excellent energy conservation and no display indicating no energy conservation.

.3 The ECI follows the algorithm for energy efficiency as outlined in ASHRAE 55-2004.

.4 If ECI is not available then:

.1 A stainless steel plate with 4 LEDs must be mounted adjacent to the thermostat.

.2 The plate is to be engraved, adjacent to each LED, with symbology which will encourage the occupant to conserve energy.

.3 ECI level (0 to 4) is to be indicated via digital outputs driving the LEDs.

.4 Algorithm to be used; as defined in ASHRAE 55-2004

.11 Standards and Regulations

.1 The BEIRI-UNITOUCH must meet or exceed the following:

.1 CE

.1 Emission EN 61000-6-3: 2007 + A1: ed.2011; Generic standards for residential, commercial and light-industrial environments

.2 Immunity EN 61000-6-1: 2007; Generic standards for residential, commercial and light-industrial environments

.3 Radio EN 300 328 V2.1.1 November 2016

.2 FCC

.1 Complies with FCC rules part 15, subpart B class B

.3 UL Listed (CDN & US)

.1 UL916 Energy management equipment

.4 RoHS

.1 All materials and manufacturing processes must comply with the RoHS directive.

2.14 BLE-Enabled Intelligent Room Interface - Allure UNI-WAVE (BEIRI-UNIWAVE)

.1 The BLE-Enabled Intelligent Room Interface (BEIRI-UNIWAVE) shall communicate with any ECLYPSE Connected Controller and shall provide users to manage all the comfort settings for a room. It utilizes wireless communications which makes it suitable for renovation or retrofit projects.

.1 The BEIRI-UNIWAVE shall support the following communication method.

.2 Wireless Communications

.1 Type: Bluetooth 5.0

.2 Frequency: 2402 – 2480 MHz

.3 Carrier Power +4 dBm.

.2 Each BEIRI-UNIWAVE shall provide a Liquid Crystal Display (LCD), where indicated on the drawings, with the following minimum features:

.1 Minimum 0.93” x 1.91” viewing area

.2 Display type: E-paper

.3 The BEIRI-UNIWAVE shall be capable of displaying on its LCD the measured space temperature from 32 ˚F to 122 ˚F and/or humidity from 0 % RH to 100 % RH with one decimal.

.4 The BEIRI-UNIWAVE shall also be capable of displaying the following elements:

.1 Space temperature

.2 Cooling space temperature set point

.3 Heating space temperature set point

.4 Current heating or cooling mode

.5 Current occupancy mode

.6 Fan speed

.7 Light status

.8 Blind position

.9 Current time

.10 Home can be customized

.5 Each BEIRI-UNIWAVE shall provide a local 6 button interface for local user interface to perform navigation and adjustment of points configured as adjustable.

.6 The BEIRI-UNIWAVE shall be configured for the intended application requirements.

.7 Provide an BEIRI-UNIWAVE where indicated on the drawings. Each BEIRI-UNIWAVE shall provide at a minimum the following on-board integral I/O without the consumption of any inputs and/or outputs at the host controller:

.1 Temperature Sensor

.1 Sensing Element: 10k Thermistor

.2 Accuracy: ±0.36 ˚F

.3 Resolution: ±0.18 ˚F

.4 Range: 32 ˚F to 122 ˚F

.2 Relative Humidity Sensor

.1 Accuracy: ±2% RH : 10% to 80%

.2 Resolution: 1 % RH

.8 Standards and Regulations

.1 The BEIRI-UNIWAVE must meet or exceed the following:

.1 CE

.1 Emission EN 61000-6-3: 2007 + A1: ed.2011; Generic standards for residential, commercial and light-industrial environments

.2 Immunity EN 61000-6-1: 2007; Generic standards for residential, commercial and light-industrial environments

.3 Radio EN 300 328 V2.1.1 November 2016

.2 FCC

.1 Complies with FCC rules part 15, subpart B class B

.3 RoHS

.1 All materials and manufacturing processes must comply with the RoHS directive.

2.15 BLE-Enabled Multi-Sensor (BEMS)

.1 The BLE-Enabled Multi-Sensor (BEMS) shall communicate with any controller and shall provide precise environmental zone values for luminosity, motion sensing, and temperature as well as Bluetooth low energy connectivity

.2 The BEMS shall support the following communications methods:

.1 Wired communications

.1 Type – RS-485

.2 Rate – 38,400 bps

.3 Cable and Connections

.1 Type T568B Cat 5e network cable (4 twisted pairs)

.2 Maximum length: 328 ft.

.3 Connections

.1 IN – RJ-45

.2 Wireless Communications

.1 Type: Bluetooth 4.2

.2 Frequency: 2402 – 2480 MHz

.3

.3 Each BEMS can be accessed, via Bluetooth low energy technology, using a mobile app on a smartphone.

.1 Allows for a mirrored user interface which provides remote control from anywhere within range.

.4 The BEMS shall have an integrated LED indicator to:

.1 Facilitate the localization and commissioning of the sensor.

.2 Provide a pairing indicator when mobile application Is used.

.5 The BEMS shall be configured for the intended application requirements.

.6 Provide a BEMS where indicated on the drawings. Each BEMS shall provide at a minimum the following on-board integral I/O without the consumption of any inputs and/or outputs at the host controller:

.1 Temperature Sensor

.1 Sensing Element: 10kΩ NTC Thermistor

.2 Range: 41 ˚F to 104 ˚F

.2 Luminosity Sensor

.1 Type: Photodiode

.2 Response Type: Human eye

.3 Range: 0-4000 lux

.3 Motion Sensor

.1 Optic: 16 face Fresnel lens

.2 Type: Ouad type passive infrared element

.3 Rated detection distance: 16ft

.4 Minimum temperature difference between target and surroundings 7.2˚F

.5 Detection Range

.1 Length: 94°

.2 Width: 82°

.3 Detection zones: 64

.7 Standards and Regulations

.1 The BEMS must meet or exceed the following:

.1 CE

.1 Emission EN 61000-6-3: 2007 + A1: ed.2011; Generic standards for residential, commercial and light-industrial environments

.2 Immunity EN 61000-6-1: 2007; Generic standards for residential, commercial and light-industrial environments

.2 FCC

.1 FCC rules part 15, subpart B class B

.3 UL Listed (CDN & US)

.1 UL916 Energy management equipment

.4 WEEE

.1 All products are marked according to the Waste Electrical and Electronic Equipment (WEEE) directive.

.5 RoHS

.1 All enclosure materials and manufacturing processes must comply with the RoHS directive.

.6 Plenum rated to UL Standard 2043

PART 3 - EXECUTION

3.1 Manufacturer's Recommendations

.1 Installation to be to manufacturer's recommendations. Provide printed copies of recommendations with shop drawings or product data.

3.2 General Workmanship

.1 Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

.2 Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

.3 Install equipment in readily accessible locations as defined by National Electrical Code (NEC) Chapter 1 Article 100 Part A.

.4 Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

.5 Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

3.3 Field Quality Control

.1 Work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances.

.2 Continually monitor field installation for code compliance and workmanship quality.

.3 Contractor shall arrange for work inspection by authorities having jurisdiction over the work.

3.4 Wiring

.1 Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26 00 00, and manufacturer's recommendations. Where the requirements of this Section differ from other Divisions, this Section shall take precedence.

.2 NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway as specified by NEC

.3 Low-voltage wiring shall meet NEC Class 2 requirements. Sub fuse low-voltage power circuits as required to meet Class 2 current limit.

.4 NEC Class 2 (current-limited) wires not in raceway but in concealed and accessible locations such as return air plenums shall be UL listed for the intended application.

.5 Install wiring in raceway where subject to mechanical damage and at levels below 3 m (10ft) in mechanical, electrical, or service rooms.

.6 Install Class 1 and Class 2 wiring in separate raceways. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two through relays and transformers.

.7 Do not install wiring in raceway containing tubing.

.8 Run exposed Class 2 wiring parallel to a surface or perpendicular to it and tie neatly at 10 ft. intervals

.9 Use structural members to support or anchor plenum cables without raceway. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.

.10 Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes shall not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.

.11 Size raceway and select wire size and type in accordance with manufacturer's recommendations and NEC requirements.

.1 Include one pull string in each raceway 1 in. or larger.

.12 Use color-coded conductors throughout.

.13 Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.

.14 Conceal raceways except within mechanical, electrical, or service rooms. Maintain minimum clearance of 6 in. between raceway and high-temperature equipment such as steam pipes or flues.

.15 Adhere to requirements in Division 16 where raceway crosses building expansion joints.

.16 Install insulated bushings on raceway ends and enclosure openings. Seal top ends of vertical raceways.

.17 Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.

.18 Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 3 ft in length and shall be supported at each end. Do not use flexible metal raceway less than ½ in. electrical trade size. Use liquid-tight flexible metal raceways in areas exposed to moisture including chiller and boiler rooms.

.19 Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join raceway sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes with bushings.

3.5 Communications Wiring

.1 Communication wiring shall be low-voltage Class 2 wiring and shall comply with Article 3.7 (Wiring).

.2 Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

.3 During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

.4 Verify entire network's integrity following cable installation using appropriate tests for each cable.

.5 Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

.6 Each run of communication wiring shall be a continuous length without splices when that length is commercially available.

.1 Runs that are longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

.7 Label communication wiring to indicate origination and destination.

.8 Ground coaxial cable according to NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.6 Fiber Optic Cable

.1 Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125 µm.

.2 Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

.3 During installation do not exceed maximum pulling tensions specified by cable manufacturer. Post-installation residual cable tension shall be within cable manufacturer's specifications.

.4 Install cabling and associated components according to manufacturers' instructions. Do not exceed minimum cable and unjacketed fiber bend radii specified by cable manufacturer.

End of Section

SECTION 23 09 13.13 BAS Actuators and Operators

PART 1 - GENERAL

1.1 Related Sections

.1 SECTION 23 09 00, BAS Instrumentation and Control

.2 SECTION 23 09 13, BAS Instrumentation and Control Devices

.3 SECTION 23 09 13.23, BAS Sensors and Transmitters

.4 SECTION 23 09 13.33, BAS Control Valves

.5 SECTION 23 09 13.43, BAS Control Dampers

.6 SECTION 23 09 23, BAS Direct Digital Control System

1.2 References

.1 Refer to Section 23 09 00 - References

1.3 Acronyms, Abbreviations and Definitions

.1 Refer to Section 23 09 00 - Acronyms, Abbreviations and Definitions

PART 2 - PRODUCT

2.1 Actuators

.1 For dampers, the actuators used shall be provided from a single manufacturer

.2 For valves, the actuators used shall be provided from a single manufacturer

.3 Actuators shall be provided from a manufacturer registered under ISO9001:2000.

.4 Electronic Damper Actuators.

.1 Size for torque required for damper seal at load conditions.

.2 Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle.

.3 Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.

.4 Overload Protection: Electronic overload or digital rotation-sensing circuitry without the use of end switches to prevent any damage to the actuator during a stall condition.

.5 Fail-Safe Operation: Mechanical, spring-return mechanism. Internal chemical storage systems, capacitors, or other internal non-mechanical forms of fail-safe operation are not acceptable.

.6 Power Requirements (Two-Position Spring Return): 24 or 120 VAC as required.

.7 Power Requirements (Proportional): Maximum 10 VA at 24 VAC or 8 W at 24 VDC.

.8 Temperature Rating: -22 to +122°F (-30 to +50°C)

.9 Housing: Minimum requirement NEMA type 2 / IP54 mounted in any orientation.

.10 Agency Listing: ISO 9001, UL, UL(C) and CSA C22.2 No. 24-93.

.5 Electronic Valve Actuators.

.1 Size for torque required for valve close off at 150% of total system (head) pressure for 2-way valves; and 100% of pressure differential across the valve or 100% of total system (pump) head differential pressure for 3-way valves.

.2 Coupling: Directly couple end mount to stem, shaft, or ISO-style direct-coupled mounting pad.

.3 Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.

.4 Overload Protection: Electronic overload or digital rotation-sensing circuitry without the use of end switches to deactivate the actuator at the end of rotation.

.5 Fail-Safe Operation: Mechanical, spring-return mechanism. Internal chemical storage systems, capacitors, or other internal non-mechanical forms of fail-safe operation are not acceptable.

.6 Power Requirements: Maximum 10 VA at 24 VAC or 8 W at 24 VDC.

.7 Maximum 1 VA at 24 VAC or 1 W at 24 VDC.

.8 Temperature Rating: -22 to +122°F (-30 to +50°C)

.9 Housing: Minimum requirement NEMA type 2 / IP54 mounted in any orientation.

.10 Agency Listing: ISO 9001, UL, UL(C) and CSA C22.2 No. 24-93.

.6 Terminal Unit Actuators

.1 Close-off (Differential) Pressure Rating: 200 psi.

.2 Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle or an ISO-style direct-coupled mounting pad.

.3 Power Requirements: Maximum 1 VA at 24 VAC or 1 W at 24 VDC.

.4 Temperature Rating: -22 to +122°F (-30 to +50°C). Housing Rating: Minimum UL94-5V(B) flammability.

.5 Agency Listing: CE, UL 60730-1A/-2-14, CAN/CSA E60730-1, CSA C22.2 No. 24-93, CE according to 89/336/EEC.

PART 3 - EXECUTION

3.1 Actuators

.1 General: Mount actuators and adapters according to manufacturer's recommendations.

.2 Electric and Electronic Damper Actuators.

.1 Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation.

.2 Link actuators according to manufacturer's recommendations.

.3 For low-leakage dampers with seals, mount actuator with a minimum 5° travel available for damper seal tightening.

.4 To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately the 5° open position, manually close the damper, and then tighten linkage.

.5 Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

.6 Provide necessary mounting hardware and linkages for actuator installation.

.3 Valve Actuators.

.1 Connect actuators to valves with adapters approved by actuator manufacturer.

End of Section

SECTION 23 09 13.23 BAS Sensors and Transmitters

PART 1 - GENERAL

1.1 Related Sections

.1 SECTION 23 09 00, BAS Instrumentation and Control

.2 SECTION 23 09 13, BAS Instrumentation and Control Devices

.3 SECTION 23 09 13.13, BAS Sensors and Transmitters BAS Actuators and Operators

.4 SECTION 23 09 13.33, BAS Control Valves

.5 SECTION 23 09 13.43, BAS Control Dampers

.6 SECTION 23 09 23, BAS Direct Digital Control System

1.2 References

.1 Refer to Section 23 09 00 - References

1.3 Acronyms, Abbreviations and Definitions

.1 Refer to Section 23 09 00 - Acronyms, Abbreviations and Definitions

PART 2 - PRODUCT

2.1 Sensors and Devices

.1 Input/output sensors and devices shall be closely matched to the requirements of the BAS controller for accurate, responsive, noise-free signal input/output. Control input response shall be high sensitivity and matched to the loop gain requirements for precise and responsive control.

.2 Sensors and transmitters shall be manually calibrated on site so that the wiring length does not detract from the sensor accuracy specified.

.3 Provide guards (plastic or wire) for sensors, thermostats, and transmitters that are installed in public areas such as gymnasiums, classrooms, corridors, and vestibules.

.4 Temperature sensors shall have the following characteristics:

.1 Sensors shall have +/- 1.0 ˚F accuracy between 32 ˚F and 212 ˚F.

.2 Space temperature sensors

.1 Shall consist of an element within a ventilated cover.

.2 Space sensors located in mechanical rooms and public shall contain a network jack, but shall have no ability to adjust temperature setpoint (Set Point Adjustment).

.3 Space sensors shall be provided in accordance with the drawings and specifications with the following options:

.1 Sensor complete with Network Jack

.2 Sensor complete with Network Jack, and Set Point Adjustment

.3 Sensor complete with Network Jack, and illuminated Override switch

.4 Sensor complete with Network Jack, Set Point Adjustment, and illuminated Override switch

.5 Sensor complete with Network Jack, Set Point Adjustment, illuminated Override switch and Fan Speed Selection.

.5 RTD Transmitter

.1 Where reference is made on the drawings for a RTD transmitter, it shall be interpreted as follows:

.2 Transmitters shall meet at minimum the following requirements.

.1 Provide an RTD transmitter in configurations below meeting the following requirements:

.1 100 ohm or 1000 ohm PT RTD

.2 24V ac/dc power supply.

.3 4-20 mA, 0-10Vdc or 0-5Vdc outputs compatible with BMS.

.4 Electronics accuracy of +/-0.1% of span.

.5 Operating temperature range of 32˚F to 158˚F. OSA only - operating temperature range of -40˚F to 185˚F.

.6 Optional LCD display

.6 Temperature Sensor – Outside Air

.1 Provide outside air temperature sensors as indicated within the field termination schedules and/or controls diagrams.

.2 Temperature sensors shall meet, at minimum, the following requirements:

.1 Aluminum LB with PVC sun and windscreen.

.2 Wall mount weatherproof enclosure with conduit entrance.

.3 Thermistor or RTD compatible with BMS

.7 Temperature Sensor – Duct Mounted – Single Point

.1 Provide duct mounted, single point, temperature sensor as indicated within the field termination schedules and/or controls diagrams as follows:

.1 In ducts less than 10 ft² in cross-sectional area.

.2 In ducts greater than 10 ft² in cross-sectional area if there is no heating coil and no cooling coil and no mixing of air flows of different temperature upstream.

.2 Temperature sensors shall meet, at minimum, the following requirements:

.1 0.25” stainless steel probe of length between one-third and two-thirds of the duct width.

.2 Thermistor or RTD compatible with BMS, sealed in probe with 3 part moisture protection system.

.3 Duct mounted ABS plenum rated housing with conduit entrance. (Optional metal, weather proof or no enclosure available)

.8 Temperature Sensor – Duct Mounted – Averaging

.1 Provide duct mounted, averaging, temperature sensor as indicated within the field termination schedules and/or controls diagrams as follows;

.1 In ducts greater than 10ft² in cross-sectional area.

.2 Temperature sensors shall meet, at minimum, the following requirements:

.1 Probe length of 12 feet minimum or 1ft per ft² of duct cross-sectional area, whichever is greater.

.2 Copper sheathed or plenum rated flexible construction.

.3 Thermistor or RTD compatible with BMS.

.4 BMS shall report the monitored temperature with an accuracy of 2.0°F

.5 Duct mounted ABS plenum rated housing with conduit entrance. (Optional metal or weather proof available)

.6 Suitable supports at all bends and at intermediate points to prevent movement in the air systems.

.9 Temperature Sensor – Wall Mounted – Lobby, Hallways Or Security Spaces

.1 Provide wall mounted stainless plate temperature sensors for lobbies and lobby vestibule spaces as indicated within the field termination schedules and/or control diagrams as follows.

.2 Temperature sensors shall meet, at minimum, the following requirements:

.1 Stainless plate sensors to fit 4” X 2” junction box, available with or without tamperproof screws.

.2 Thermistor or RTD compatible with BMS.

.10 Temperature Sensor – Immersion - Thermowell Mounted

.1 Provide thermowell mounted temperature sensors as indicated within the Field termination schedules and/or control diagrams as follows.

.2 Temperature sensors shall meet, at minimum, the following requirements:

.1 Rigid 0.25” stainless steel probe of length, which is, at minimum, 20% of the pipe width.

.2 Thermistor or RTD Compatible with BMS sealed in probe with three-part moisture protection system.

.3 BMS shall report the monitored temperature with an accuracy of 1.0°F

.4 ABS housing with conduit entrance. (Optional metal or weather proof available)

.5 Provide Brass or Stainless steel thermowell (316 or 304).

.6 Provide with thermal grease to aid temperature sensing.

.11 Temperature Sensor – Strap-On

.1 Provide strap-on mounted temperature sensors as indicated within the Field termination schedules and/or control diagrams or where thermo well mounted sensors cannot be mounted. Temperature sensors shall meet, at minimum, the following requirements:

.1 0.25” Stainless steel probe, 2”

.2 Thermistor or RTD compatible with BMS, sealed in probe with a three part moisture protection system

.3 ABS housing with conduit entrance. (Optional metal or weather proof available)

.12 Temperature Sensor – Strap-On - Plate

.1 Provide strap-on mounted temperature sensors as indicated within the Field termination schedules and/or control diagrams or where thermo well mounted sensors cannot be mounted. Temperature sensors shall meet, at minimum, the following requirements:

.1 Thermistor or RTD compatible with BMS, sealed in probe with a three part moisture protection system

.2 A single point strap-on temperature sensor to be precision bonded to a 1.5”x1.5” aluminum plate and adhered to a 1.5” x 1“compressible foam. A 10” S/S Pipe clamp to be provided to secure the assembly to various sizes of pipe.

.3 ABS housing with conduit entrance. (Optional metal or weather proof available)

.13 Relative Humidity Sensor – Wall Mounted

.1 Provide wall mounted relative humidity sensors as indicated within the Field termination schedules and/or control diagrams. Humidity sensors shall meet, at minimum, the following requirements:

.1 White protective enclosure

.2 Sensor to be laser trimmed thermoset polymer based capacitive type.

.3 24 Vac/dc power supply

.4 4-20 mA two wire, 0-10 Vdc and 0-5 Vdc output proportional to relative humidity range of 0% to 100% and compatible with BMS.

.5 2% accurate (5-95% RH). (3 & 5 % accurate units available)

.6 Operating temperature range of 32˚F to 158˚F.

.7 Reverse voltage protected and output limited.

.8 Optional LCD display-SP and RH100A series

.9 Optional set point adjustment-SP series

.10 Optional push button override-RH100A series

.14 Relative Humidity Sensor – Duct Mounted

.1 Provide duct mounted relative humidity sensors as indicated within the Field termination schedules and/or control diagrams. Duct mounted relative humidity sensors shall meet, at minimum, the following requirements:

.1 ABS housing with conduit entrance.

.2 Sensor to be laser trimmed thermoset polymer based capacitive type.

.3 24 Vac/dc power supply.

.4 4-20 mA two wires, 0-10 Vdc and/or 0-5 Vdc output proportional to relative humidity range of 0% to 100% and compatible with BMS.

.5 2% accurate (5-95% RH). (3 & 5 % accurate units available)

.6 9” probe length.

.7 Operating temperature range of 32˚F to 158˚F.

.8 Reverse voltage protected and output limited.

.9 60 micron HDPE filter

.15 Relative Humidity Sensor – Outside Air

.1 Provide OSA relative humidity sensors as indicated within the Field termination schedules and/or control diagrams. Humidity sensors shall meet, at minimum, the following requirements:

.1 ABS hinged weatherproof housing with conduit entrance.

.2 Sensor to be laser trimmed thermoset polymer based capacitive type.

.3 24 Vac/dc power supply

.4 4-20 mA two wire, 0-10 Vdc and 0-5 Vdc output proportional to relative humidity range of 0% to 100% and compatible with BMS.

.5 2% accurate (5-95% RH).

.6 Operating temperature range of 32˚F to 185˚F.

.7 Reverse voltage protected and output limited.

.16 Combination Relative Humidity And Temperature Sensors

.1 Where there is a requirement for the monitoring of both relative humidity and temperature at the same location, the BMS Contractor shall provide a combination relative humidity sensor and temperature sensor. The individual sensors must each meet the specifications details above.

.17 Static Pressure Sensor – Duct Mounted

.1 Provide duct mounted static pressure sensors as indicated within the Field termination schedules and/or control diagrams. Static pressure sensors shall meet, at minimum, the following requirements:

.1 Input range shall be appropriate for the application. Select range such that it covers from zero duct static pressure relative to the exterior of the duct up to a static pressure of between 20% and 50% in excess of the maximum static pressure that could be encountered in the duct relative to the duct exterior. Typically, for low pressure commercial duct consider using a range of 0 to 2” wc., for medium pressure duct use a range of 0 to 6” wc. and for high-pressure duct use a range of 0 to 10” wc.

.2 4-20mA, 0-5 or 0-10Vdc output proportional to pressure input range compatible with BMS system.

.3 1% Full scale output accuracy

.4 Operating temperature range of 32˚F to 140˚F.

.5 Easily accessible, integral non-interacting zero adjustment.

.6 Minimum over pressure input protection of two times rated input or 20 psi whichever is greater.

.18 Room Pressure Sensor

.1 Provide space static pressure sensors as indicated within the Field termination schedules and/or control diagrams. Static pressure sensors shall meet, at minimum, the following requirements:

.1 Input range of -0.2” to + 0.2” wc.

.2 4-20mA, 0-5 or 0-10Vdc output proportional to pressure input range compatible with BMS system.

.3 1% accuracy of range

.4 Operating temperature range of 32˚F to 140˚F.

.5 Easily accessible, integral non-interacting zero adjustment.

.6 Minimum over pressure input protection of two times rated input or 20 psi whichever is greater.

.19 Differential Pressure Sensor – Air (Filter/Coil Monitoring)

.1 Provide air differential pressure sensors as indicated in field termination schedules and/or control diagrams. Air differential pressure sensor shall meet, at minimum, the following requirements:

.2 Sensors used for filter or coil differential pressures shall also have a display of the monitored differential pressure.

.3 Output shall be 4-20mA, 0-10Vdc or 0-5Vdc output proportional to pressure input range compatible with BMS.

.4 Select range as required, taking into consideration pressure drop across filter or coil. Typically 0-2” wc range for low-pressure commercial duct.

.5 Operating temperature range of 32˚F to 140˚F.

.20 Differential Pressure Switch – Air

.1 Provide air differential pressure switches as indicated in field termination schedules and/or control diagrams. Air differential pressure switches shall meet, at minimum, the following requirements:

.1 An IP54 (NEMA 13) polycarbonate housing.

.2 SPDT switch rated at 250 Vac at 1 amp.

.3 Field adjustable range from 0.02” wc to max range of device. Select range as required, taking into consideration pressure drop across filter or coil. Typically 0.2-2” wc range for low-pressure commercial duct.

.4 Temperature range of -4˚F to 140˚F.

.5 Set point adjustment knob with indication.

.6 Automatic reset.

.21 Air Flow Sensor

.1 Provide airflow rate sensors and transducers as indicated in the Field termination schedules and/or control diagrams. Air flow rate sensors and transducer shall meet, at minimum, the following requirements:

.1 Hot wire anemometer type.

.2 Self-compensation for changes in air temperature.

.3 Probe and transducer housing shall be constructed of durable PVC.

.4 Probe shall be adjustable from 2" - 7.3".

.5 Power supply shall be 24 Vac/dc.

.6 Output signal of 4-20 mA or 0-10Vdc proportional to air flow speed equal to 3150 ft/min or 1575 ft/min jumper selectable.

.7 Air temperature range of 14˚F to 140˚ F.

.8 5% accuracy of measured value.

.22 Water Pressure Sensor

.1 Provide water pressure sensors as indicated within the Field termination schedules and/or control diagrams. Pressure sensors shall meet the following requirements:

.1 Operating range shall be suitable for the application. Select range such that it covers from zero pressure to twice the amount of pressure desired for control purposes or that could be encountered.

.2 4-20 mA output proportional to water pressure.

.3 0.25% accuracy of range.

.4 Temperature range of -40˚F to 260˚F.

.5 Over pressure input protection of a minimum two times rated input.

.6 An optional ABS wiring housing is available for an interior application and weatherproof wiring housing is available for an exterior application.

.7 17-4PH stainless steel wetted parts.

.8 Burst pressure of a minimum five times rated input.

.23 Water Differential/Gage Pressure Sensor

.1 Provide water differential or gage pressure sensors as indicated in the Field termination schedules and /or control diagrams. Water differential pressure sensors shall meet, at minimum, the following requirements:

.1 Output of 4-20 mA, 0-10 or 0-5 Vdc proportional to the pressure sensed.

.2 Momentary over pressure protection of five times the rated input.

.3 Operating range shall be suitable for the application. Select range such that it covers from zero differential pressure up to a differential static pressure of 20% to 50% in excess of the maximum static pressure that could be encountered. Remember that if the sensor is used for the control of a chilled water bypass and is located across, for example, a chilled water AHU coil, the pressure drop of both the coil and the associated valve at full design flow have to be taken into account.

.4 Accuracy of better than 1% of full-scale reading.

.5 Valve tapping shall be furnished and installed by the Mechanical contractor. Coordinate with the Mechanical contractor.

.24 Current Relay/Switch

.1 Provide current sensing relays as indicated in the Field termination schedules and/or control diagrams. Current sensing relays shall meet, at minimum, the following specifications:

.1 Rated for the applicable load.

.2 The output relay shall have an accessible trip adjustment over its complete operating range. Provide LED indication of relay status.

.3 Current relay shall have input and output isolation via current transformer.

.4 Current relay shall be self-powered with no insertion loss.

.5 Relay shall be in a dustproof housing.

.6 Accuracy to be <2% of full-scale max.

.7 Temperature rating of 5˚F to 140˚F.

.8 Whenever the status of a single speed motor is monitored it shall be done via a current sensing relay.

.9 The BMS contractor shall provide current sensing relays at the MCC starters.

.10 The BMS contractor shall provide the current sensing relays for motors with local starters and no MCC starter.

.25 Current Sensor

.1 Provide monitoring of the current as identified in Field termination sheets and/or control drawings. Current monitoring shall meet, at minimum, the following requirements:

.1 4-20 mA, 0-10 or 0-5 Vdc output proportional to current draw.

.2 Reverse polarity protected and output limited.

.3 50/60 Hz operation.

.4 Accuracy of better than 1%.

.5 Operating temperature range of -20˚F to 120˚F.

.26 Electronic To Pneumatic Transducers

.1 Provide electronic to pneumatic transducers as identified in the field termination sheets and/or controls drawings. Transducers shall include, at minimum, the following:

.1 Accept a control signal of 4-20mA or 0-10Vdc compatible with BMS.

.2 Output rating of 3-15psig consuming 515 scfm maximum @ 20 psig supply.

.3 Snap track mounted for panel applications or with an optional ABS enclosure.

.4 Operating temperature range of 32˚F to 140F.

.5 Male barb fittings for flexible tubing.

.27 Leak Detection Monitoring – Water

.1 Provide water leak monitoring as identified within the Field termination schedules and/or control diagrams. Water leak detection monitors shall meet, at minimum, the following requirements:

.1 Corrosion and abrasion resistant.

.2 Adjustable height-single point model

.3 Configured for normally open or normally closed as required by the application.

.4 Form C output relay rated at 5 am/s @ 120 Vac / 30 Vdc.

.5 Operating temperature range of -40˚F to 185˚F.

.6 Optional remote mount probe and water sensing cable available in different lengths.

.2 Continuous operating temperature of standard versions shall be 221°F [105°C].

.3 Enclosure shall be NEMA-6P [IP 68]v

2.2 Wireless Sensors

.1 Provide for wireless sensing of the designated sensors and or switches as shown on the Point List Chart.

.2 Wireless sensors shall be able to operate at a designated frequency of 315 MHz or 868 MHz, to be determined local regulation.

.3 Controllers shall be field upgradable to receive wireless communications from switches and sensors (become wireless-enabled) by connecting a plug-in wireless transceiver.

.4 Sensor data shall be made available on the network to control HVAC and non-HVAC applications such as lighting.

.5 Wireless sensing is comprised of the following components; wireless sensor or switch (transmitter), wireless receiver, wireless configuration application and wireless transmission test equipment. All components shall comply with these requirements.

.1 Wireless temperature sensor/switch – the wireless sensing technology provided shall transmit a RF message indicating the value or position of the sensor. The transmission range shall be a minimum of 305 ft. unobstructed line of sight and 100 ft. in buildings.

.2 Each sensor or switch shall be provided with energy harvesting technology such that no battery will be required to maintain normal operations. If using a Solar Cell for energy harvesting, normal operation parameters shall be defined as a minimum of 4 hours of 200lx of light to produce an operation of the sensor for a period of no less than 20 hours in total darkness. In sufficient light levels are not available, provide a battery backup.

.3 For temperature sensors all measurement of value shall be read by the sensor no less than once every 100 seconds and transmit a signal to the receiver within this time period should a variations occur from set point of more than ±1.0 ˚F for a space sensor or an outside air or duct or water sensor.

.4 Sensor or switch shall be provided with a unique identifying code to correspond its location to the receiver. The identifying code shall be displayed in bar code permanently attached to the sensor or switch. In addition the sensor or switch shall be provided with a manual push button to transmit its identifying code to the receiver for installation.

.5 All sensor locations shall be verified to be in compliance with manufacturer's installation requirements and be tested for acceptable signal strength.

.6 Wireless sensors and switches shall be provided for the following as required:

.1 Space Sensors – Space sensors shall be provided as required with temperature measurement, set point adjustment, override and humidity sensing. Accuracy of the sensors shall be 1.0 ˚F (0.5 ˚C). Sensor shall be submitted for pre-approval for performance and visual appearance.

.2 Mechanical Room Sensors – Duct temperature sensor, outside air sensor, Surface temperature contact temperature sensor and Well emersion sensor.

.3 Light Switches – Light switches shall be provided as required, either in a 2 channels or 4 channels configurations.

.7 For Local Control Unit (LCU), provide for a minimum of 14 wireless sensor or switches inputs.

.8 For Terminal Control Unit (TCU) provide for the management a minimum of 5 wireless sensors or switches inputs.

.9 Wireless Configuration: The configuration of the wireless sensors shall be an integral part of the LCU or TCU programming or configuration tool.

.10 Wireless Transmission Test Equipment.

.1 Provide for test equipment that will measure the strength of the transmission between the required location of the sensor or switch and the receiver located at the Controller.

.2 All Sensors or switches shall be verified to have acceptable signal strength prior to installation.

PART 3 - EXECUTION

3.1 Installation of Sensors

.1 Install sensors according to manufacturer's recommendations.

.2 Mount sensors rigidly and adequately for operating environment.

.3 Install room temperature sensors on concealed junction boxes properly supported by wall framing.

.4 Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

.5 Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.

.6 Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 1 ft. of sensing element for each 1 ft^2 of coil area.

.7 Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

.8 Install outdoor air temperature sensors on north wall at designated location with sun shield.

.9 Differential Air Static Pressure.

.1 Supply Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.

.2 Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.

.3 Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.

.4 Piping to pressure transducer pressure ports shall contain a capped test port adjacent to transducer.

.5 Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.

.6 Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

.10 Smoke detectors, high and low limit thermostats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

.11 Flow Switch Installation

.1 Use correct paddle for pipe diameter.

.2 Adjust flow switch according to manufacturer's instructions.

.12 Flow Sensors

.1 Insert-style Impeller Flow Sensor, Liquid

.1 Follow manufacturer’s recommendation for installation and conform to the guidelines provided by the Installation & Operation Manual.

.2 Straight pipe requirement for mounting shall be 10 diameters up stream and 5 downstream.

.3 Sensor shall be located with the least possible circumferential displacement from top-center of pipe; any circumferential location in vertical pipes is acceptable.

.4 Sensor mounted in 2¨ NPT tap in either pipe saddle or weld on fitting.

.5 An insertion depth of 1 1/2" for pipe sizes 2.5" and larger is required for accurate flow monitoring.

.6 Sensor orientation shall be such that flow arrow on sensor is aligned with flow direction.

.2 Electromagnetic Flow Meter, Liquid

.1 Follow manufacturer’s recommendation for installation. Installation will conform to the guidelines provided by the Installation & Operation Manual.

.2 Straight pipe requirement shall be an equivalent of three diameters on the inlet (upstream) side, and two diameters on the outlet (downstream) side.

.3 For best performance, place meter vertically, with liquid flowing upward and meter electrodes in a closed, full pipe.

.3 Impeller Flow Sensor and Energy Meter, Liquid

.1 Follow manufacturer’s recommendation for installation.

.2 Straight pipe requirement shall be 10 diameters upstream and 5 diameters downstream. Pipe bends, valves, other fittings, pipe enlargements and reductions should not be present in this length of pipe.

.3 Apply pipe compound over the first 3 or 4 threads of the mating pipe.

.4 Thread the pipe into the sensor tee until hand tight, and then tighten the pipe an additional 1-1/2 turns, using a wrench.

.5 System requires isolated 12-24 V AC/DC power supply. To avoid ground fault conditions, power should not be shared with other devices.

.6 The RS-485 requires three connections: RS-485+, RS-485- and REF. RS-485 is a high-speed connection and should be wired to meet TIA-EIA-485-A standards.

.7 The pulse output is a simple solid state switch. The switch is not polarity sensitive, however, the maximum voltage and current ratings should not be exceeded.

.4 Impeller Flow Sensor, Liquid

.1 Follow manufacturer's recommendation for installation and conform to the guidelines provided by the Installation & Operation Manual.

.2 Straight pipe requirement for mounting shall be 10 diameters up stream and 5 downstream.

.3 Tee sensor shall be vertically upright in horizontal locations; any circumferential orientation in vertical installations is acceptable.

.4 Sensor orientation shall be such that flow arrow on sensor is aligned with flow direction.

END OF SECTION

SECTION 23 09 23 BAS Direct Digital Control System

PART 1 - GENERAL

1.1 Related Sections

.1 SECTION 23 09 00 BAS Instrumentation and Control

.2 SECTION 23 09 13, BAS Instrumentation and Control Devices

.3 SECTION 23 09 13.13, BAS Actuators and Operators

.4 SECTION 23 09 13.23, BAS Sensors and Transmitters

.5 SECTION 23 09 13.33, BAS Control Valves

.6 SECTION 23 09 13.43, BAS Control Dampers

1.2 References

.1 Supplementing 23 09 00 1.2 References requirements.

.1 ANSI/ASHRAE 135-2016, BACnet® - A Data Communication Protocol for Building Automation and Control Networks.

1.3 Acronyms, Abbreviations and Definitions

.1 Supplementing 23 09 00 1.3 Acronyms, Abbreviations and Definitions requirements

.1 .Acronyms used in BAS.

.1 AI - Analog Input

.2 AO - Analog Output

.3 BACnet® - Building Automation and Control Network

.4 BAS - Building Automation System

.5 CAD - Computer Aided Design

.6 CDL - Control Description Logic

.7 COSV - Change of State or Value

.8 CPU - Central Processing Unit

.9 DI - Digital Input

.10 DO - Digital Output

.11 ECU - Equipment Control Unit

.12 IDE - Interface Device Equipment

.13 LAN - Local Area Network

.14 LCU - Local Control Unit

.15 NCU - Network Control Unit

.16 Niagara4 – Software framework for building device-to-enterprise applications and Internet-enabled products.

.17 OS - Operating System

.18 OWS - Operator Work Station

.19 PC - Personal Computer

.20 PCI - Peripheral Control Interface

.21 PCMCIA - Personal Computer Micro Card Interface Adapter

.22 RAM - Random Access Memory

.23 ROM - Read Only Memory

.24 TCU - Terminal Control Unit

.25 USB - Universal Serial Bus

.26 UPS - Uninterruptible Power Supply

.2 Definitions:

.1 Point: a point may be logical or physical. Logical points are values calculated by system such as totals, counts, derived corrections i.e. as result of and/or statements in CDL's. Physical points are inputs or outputs, which have hardware, wired to controllers which are measuring or providing status conditions of contacts or relays providing interaction with related equipment (stop, start) or valve or damper actuators.

.3 Symbols and Engineering unit abbreviations utilized in displays: to ANSI/ISAS 5.5.

.1 Printouts: to ANSI/IEEE 260.

1.4 BAS Contractor Qualifications

.1 Supplementing 23 09 00 1.12 BAS Contractor Qualifications.

.1 The contractor must be regularly engaged in the service and installation of BACnet and Niagara4 as specified herein,

.2 The Contractor shall have a minimum of 5 years' experience in the sales, installation, engineering, programming servicing and commissioning of Niagara4.

.3 The Contractor must be an authorized factory direct representative in good standing of the manufacturer of the proposed hardware and software components. Provide a letter dated within the last 12 months, from the manufacturer certifying that the Contractor is an authorized factory direct representative.

.4 The Contractor shall a minimum of three (3) technicians who have successfully completed the factory authorized training of the proposed manufactures hardware and software components and have successfully completed Niagara4 certification course(s).

.1 Contractor must provide proof of required training.

.2 The Contractor's capabilities shall include engineering and design of control systems, programming, electrical installation of control systems, troubling shooting and service.

.5 The contractor shall submit a list of no less than three (3) similar (in function, application and design) projects, which have similar Building Automation Systems as specified herein installed by the Contractor.

.1 These projects must be on-line and functional such that the Owner's/User's representative can observe the system in full operation.

1.5 General Description

.1 Supplementing 23 09 00 1.5 General Description requirements.

.1 System to be "Open Protocol".

.1 BACnet® communications protocol will be used for communications.

.2 Work covered by sections referred to above consists of fully operational BAS, including, but not limited to, following:

.1 Building Controllers NCU, LCU, TCU.

.2 OWSs.

.3 Data communications equipment necessary to achieve an BAS data transmission system including LAN hardware and software for a BACnet® system

.4 Software complete with full documentation for software and equipment.

1.6 Work Included

.1 Supplementing 23 09 00 1.10 Work Included requirements.

.2 Provide a new building automation system to control and monitor the building's mechanical and electrical systems.

.1 The system installed shall seamlessly connect devices other than HVAC throughout the building regardless of subsystem type, i.e. HVAC, lighting, and security devices should easily coexists on the same network channel without the need for gateways.

.2 Components not supplied by the primary manufacturer shall be integrated to share common software for network communications, time scheduling, alarm handling, and history logging.

.3 The Installer furnishing the BAS network shall meet with the Installer(s) furnishing each of the following products to coordinate details of the interface between these products and the DDC network.

.1 The variable frequency drive (VFD) vendor shall furnish VFDs with an interface to the control and monitoring points specified utilizing:

.1 Hardwired connections such as relay(s), 0-10VDC, or 4-20mA.

.2 BACnet/IP network connection.

.2 Energy and utility metering shall interface to the BAS system and provide the monitoring points specified herein utilizing:

.1 Hardwired connections such as relay(s), 0-10VDC, or 4-20mA.

.2 BACnet/IP network connection.

.3 The lighting control vendor shall furnish lighting controls with an interface to the control and monitoring points specified utilizing:

.1 Hardwired connections such as relay(s), 0-10VDC, or 4-20mA.

.2 BACnet/IP network connection.

.4 The Owner or his designated representative shall be present at this meeting.

.5 Each Installer shall provide the Owner and all other Installers with details of the proposed interface, hardware and software identifiers for the interface points, network identifiers, wiring requirements, communication speeds, and required network accessories.

.6 The purpose of this meeting shall be to insure there are no unresolved issues regarding the integration of these products into the BAS network.

.7 Submittals for these products shall not be approved prior to the completion of this meeting.

.4 Provide new controllers of the latest revisions with input and output points as specified herein.

.5 Operator workstations located as listed in the specifications.

.6 Furnish and install all controllers to achieve system operation, any control devices, conduit and wiring, in the facility as required to provide the operation specified.

.7 Furnish and load all software required to implement a complete and operational BAS.

1.7 System Design Responsibility

.1 Supplementing 23 09 00 1.13 System Design Responsibility requirements.

.1 Supply sufficient programmable controllers of all types to meet project requirements. Quantity and points contents to be approved by Owner prior to installation.

.1 Local Control Units (LCU) shall be utilized for primary mechanical and electrical systems such as Air handling equipment, vemtilation systems, Boiler System Control, System Control type of applications.

.2 Terminal Control Units (TCU) shall be utilized for terminal equipment, such as Variable Air Volume, Fan Coil, Heat Pump, Roof Top type of applications.

.3 Each LCU and TCU controller shall have a minimum of 10% spare capacity of each point type for future points. As a minimum, each controller shall have one spare of each point type available on the controller.

.4 Each NCU and each LAN shall have the capability of accepting 20% additional LCU/TCU(s) without the necessity of adding additional LAN controllers or LAN wiring.

.5 The LCU and TCU controller programming or configuration tools (see section 23 09 13 2.7.30 LCU / TCU Programming Software) shall be fully accessible through the Operator Workstation and Web Browser Client.

.6 All LCUs and TCUs shall be furnished with extended memory. No LCU/TCU shall be provided with less than 128 MB of RAM. The number of controllers attached to any NCU shall not exceed the following limits:

Combined Memory	Maximum Number of Controllers
128 MB SDRAM / 64 MB Serial Flash	25
256 MB DDR RAM / 128 MB Serial Flash	50
1 GB DDR2 RAM / 1 GB Serial Flash	125

.2

.3 Regardless of the maximum number of controllers indicated above, it is ultimately the exclusive responsibility of the systems integrator/building controls contractor to ensure that the NCU has adequate resources for the number of controllers attached to it.

.4 Niagara4 Network Manager Server software shall be furnished and installed on a server grade PC for applications requiring two or more NCUs.

1.8 Building Automation System (BAS)

.1 The contractor shall be responsible for the hardware and software for the enterprise framework and system integration required for the complete Building Automation System.

.2 The BAS shall be comprised of Network Control Units (NCU) connected to the Building Automation System local area network (BAS LAN).

.1 Access to the BAS, either through a Workstation on the BAS LAN, within the building or through a Wireless Application Protocol device, or remotely through the Internet, shall be accomplished through a standard Web browser.

.2 Each NCU shall communicate to BTL Listed BACnet controllers provided under the Programmable Controllers section.

.3 Each NCU shall communicate to LonMark Certified LonWorks controllers provided under the Programmable Controllers section.

.3 The system includes software and programming of the NCU(s), Operator Workstation(s) (OWS) software and hardware, development of all graphical screens, setup of schedules, trends, logs and alarms, network management and connection of the NCU(s) to the local area network.

1.9 System Design

.1 The system shall consist of a network of Network Control Units (NCUs), interoperable Local Control Units (LCUs) and Terminal Control Units (TCUs) (VAV Box Controllers, Fan Coil Unit Controllers, etc.). All controllers for terminal units, air handling units (AHU) and controllers shall communicate and share data, utilizing BACnet communications protocols only

.2 The intent of this specification is to provide a distributed and networked open Building Automation System, the capability to integrate ANSI/ASHRAE Standard 135, BACnet and ISO/IEC 14908-1: Open Data Communication in Building Automation, Controls and Building Management – Control Network Protocol into a unified system in order to provide flexibility for expansion, maintenance, and service of the system.

.3 The proposed system must maintain strict adherence to industry standards including ANSI/ASHRAE Standard 135, Annex L, and Device Profile to assure interoperability between all system components. BACnet system must be tested and listed on BACnet Testing Laboratory (BTL) web site. Systems based on vendor specific proprietary hardware or software will not be considered for this project.

.4 Systems utilizing gateways to proprietary communication systems will not be considered for this project. A gateway is considered to be a device or controller where the sole function is mapping of data points from one protocol to another. A gateway device cannot perform higher-level energy management functions such as Outdoor Air Optimization, Electrical Demand Limiting and the like.

.5 The supplied system software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI/ASHRAE™ Standard 135, BACnet to assure interoperability between all system components is required.

.6 A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a flat single tiered architecture shall not be acceptable. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 10 seconds for network connected user interfaces. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

.7 User Access

.1 The supplied system must incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs.

.8 An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system databases, all controller program graphics and network databases which shall be provided in a Niagara4 Framework format.

.1 This data shall reside on a supplier-installed server for all database access.

.2 Systems requiring proprietary database and user interface programs shall not be acceptable.

.9 Software Tools

.1 All software tools needed for full functional use, including programming of controllers, Niagara4 Framework network management and expansion, and graphical user interface use and development, of the BAS described within these specifications shall be provided to the owner or his designated agent.

.1 The software programming tool shall be free of charge and openly available for download from the internet.

.2 For any manufacturer that does not have a free programming tool the manufacturer must provide the tool with this project for a minimum of 5 years with proof of availability via letter from the manufacturer.

.3 Any licensing required by the manufacturer now and to the completion of the warranty period, including changes to the licensee of the software tools and the addition of hardware corresponding to the licenses, to allow for a complete and operational system for both normal day to day operation and servicing shall be provided.

.4 Any such changes to the designated license holders shall be made by the manufacturer upon written request by the owner or his agent.

.5 Any cost associated with the license changes shall be identified within the BAS submittals.

.10 Software License Agreement

.1 The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract.

.2 Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.

.1 The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s).

.2 In addition, the Owner shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project.

.3 This shall include all custom, job specific software code, databases and documentation for all configuration and programming that is generated for a given project and/or configured for use with the NCU, Server, OWS and any related LAN/WAN/Intranet and Internet connected routers and devices.

.4 Any and all required User IDs and passwords for access to any component or software program shall be provided to the owner.

1.10 Dynamic Data Access

.1 All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.

1.11 Networks

.1 The BAS network(s) must be based on Open Systems.

.2 Niagara4 shall be used at the network levels as the manager(s).

.3 High-speed data transfer rates for alarm reporting, quick report generation form multiple controllers and upload/download efficiency between network devices.

.4 Support of any combination of controllers and operator workstations directly connected to the local area network. A minimum of 50 devices shall be supported on a single local area network.

.5 Detection and accommodation of single or multiple failures of workstations, controller panels and the network media. The network shall include provisions for automatically reconfiguring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.

.6 Message and alarm buffering to prevent information from being lost.

.7 Error detection, correction, and retransmission to guarantee data integrity.

.8 Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.

.9 Commonly available, multiple sourced, networking components shall be used to allow the system to coexist with other networking applications such as office automation. Ethernet to IEEE 802.3 standard is the only acceptable technology.

.10 Synchronization of the real-time clocks in all NCU panels shall be provided.

.11 The BAS LAN shall be a 100 Megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, SOAP, OBIX, SNMP and SMTP Protocols for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Control Units (NCUs), user workstations and where specified, a local server. Local area network minimum physical and media access requirements:

.1 Ethernet; IEEE standard 802.3

.2 Cable; 100 Base-T, UTP-8 wire, category 5

.3 Minimum throughput; 100 Mbps

.4 Provide access to the BAS LAN via a Wireless Application Protocol (WAP) device. Through this connection the BAS LAN will provide authorized staff with the ability to monitor and control the BAS from any location within the through a web browser, or web enabled devices.

.5 Provide access to the BAS LAN from a remote location, via the Intranet or Internet. The owner shall provide (in future) a connection to the Internet to enable access via high-speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or access to an Internet Service Provider (ISP). If required, the owner will provide a switch/firewall between the building LAN and the BAS LAN. Through this connection the BAS LAN will provide authorized staff with the ability to monitor and control the BAS from a remote location through a web browser, or web enabled devices.

.12 Controller Local Area Network (BAS sub LAN)

.1 Provide a network of stand-alone, distributed direct digital controllers that operate on the following protocol using the specified physical layers:

.1 Controllers using proprietary protocols or protocols other than listed herein are unacceptable.

.2 The design of the BAS sub LAN shall network Local Control Unit (LCU) and Terminal Control Unit (TCU) to a Network Control Unit (NCU).

.3 This level of communication shall support a family of application specific controllers and shall communicate bi-directionally with the network through DDC Controllers for transmission of global data.

.4 Terminal Control Unit (TCU) shall be arranged on the BAS sub LAN's in a functional relationship manner with Local Control Unit (LCU). Ensure that a Variable Air Volume (VAV) Terminal Control Unit (TCU) is logically on the same LAN or segment as the Local Control Unit (LCU) that is controlling its corresponding Air Handling Unit (AHU).

PART 2 - PRODUCTS

2.1 Quality Assurance

.1 Supplementing 23 09 00 2.1 Quality Assurance requirements.

.1 The manufacturer of the Building Automation System digital controllers shall provide documentation supporting compliance with ISO 9001:2000 (Model for Quality Assurance in Design/Development, Production, Installation and Servicing).

.2 Provide a copy of the registration certificate that contains the ISO 9001:2000 Certification bearing the name of the registered auditor.

.3 Control products such as direct digital controllers, control valves, actuators, sensors and transmitters shall be provided from a single manufacturer.

.1 Provide product literature that bears the name of the manufacturer on all direct digital controllers, control valves, actuators, sensors and transmitters.

.4 Provide satisfactory operation without damage at 110% above and 85% below rated voltage and at 3 hertz variation in line frequency. Provide static, transient, and short circuit protection on all inputs and outputs. Communication lines shall be protected against incorrect wiring, static transients and induced magnetic interference. Bus connected devices shall be AC coupled, or equivalent so that any single device failure will not disrupt or halt bus communication.

.5 All controllers provided as part of this system and used for indoor applications shall operate under ambient environmental conditions of 32 ˚F to 122 ˚F dry bulb and 5% to 90% relative humidity, non-condensing as a minimum.

.6 All controllers provided as part of this system and used for outdoor applications shall operate under ambient environmental conditions of -40 ˚F to 158 ˚F dry bulb and 5% to 90% relative humidity, non-condensing as a minimum.

2.2 Acceptable System Manufacturers

.1 Provide a building automation system supplied by a company regularly engaged in the manufacturing and distribution of building automation systems. The BAS Manufacturer shall meet the following qualifications as a minimum:

.1 The manufacturer of the hardware and software components must be primarily engaged in the manufacture of building automation systems as specified herein, and must have been so for a minimum of five (5) years.

.2 The manufacturer of the hardware and software components as well as its subsidiaries must be a member in good standing of the BACnet International and all controllers used shall be BACnet Listed with documentation on the BACnet website (https://www.bacnetinternational.net/btl/search.php)

.3 At least 75% of the manufactured product line shall be produced under their own direction, including R&D and assembly. Rebranding of another manufacture product shall not qualify.

.2 The manufacturer of the hardware and software components shall have a technical support group accessible via a toll free number that is staffed with qualified personnel, capable of providing instruction and technical support service for networked control systems.

.3 Acceptable Manufacturers

.1 Distech Controls.

.4 If a manufacturer or vendor, other than those listed in '. Acceptable Manufacturers' wishes to seek equivalency to any of the above controls offerings, then the manufacturer or vendor will be subject to the original pre-qualification criteria that were used to qualify the 'Acceptable Manufacturers'. Failure to meet the qualifications will render the proposed solution by such a manufacturer or vendor as ineligible.

PART 3 - EXECUTION

3.1 Preliminary Design Review

.1 Supplementing 23 09 00 3.8 Preliminary Design Review requirements.

.1 The BAS contractor shall submit a preliminary design document for review. This document shall contain the following information in addition to the requirements of 23 09 00:

.1 Provide product brochures and a technical description of the Server, Operator Workstation, and Network Control Unit (NCU) software required to meet this specification. Provide a description of software programs included.

.2 Open Protocols - For all direct digital controller hardware BACnet Protocol Implementation Conformance Statement PICS. Provide complete description and documentation of any proprietary services and/or objects where used in the system.

.3 Submit the Niagara Compatibility Statement (NiCS) via a letter from the manufacturer. The NiCS shall have no connectivity restrictions and all aspects of the Niagara Framework will be provided to maintain an Open System Design. The System as provided shall confirm with the following NiCS properties (Station Compatibility In, Station Compatibility Out, Tool Compatibility In, AND Tool Compatibility Out shall each have a value of "All").

.2 .3

.4 .5

.6 .7

.8 .9

.10 .11

.12

.13 Provide a description and samples of Operator Workstation graphics and reports.

.14 Provide a URL address for the engineer to view the proposed functionality via a web based BAS through a standard web browser.

3.2 Submittals

.1 Supplementing 23 09 00 3.9 Submittals requirements.

.1 Control System Shop Drawings

.1 Detailed system architecture and points list showing all points associated with each controller, controller locations, and describing the spare points capacity at each controller and BAS LAN.

.2 Direct Digital Control System Hardware

.1 BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of BACnet controller.

.2 Bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.

.3 Manufacturer's description and technical data such including product specifications and installation and maintenance instructions for items listed herein:

.1 Direct digital controllers (BACnet and LonWorks)

.2 Sensors and Transmitters

.3 Transducers

.4 Actuators

.5 Automatic Control Valves

.6 Automatic Control Dampers

.7 Air Flow Stations

.8 Control panels

.9 Operator interface equipment

.10 Ancillary equipment such as relays, power supplies and wiring

.4 Riser diagrams showing control network layout, communication protocol, and wire types.

.3 Building Automation System Server and Operator Workstation (OWS)

.1 Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.

.2 Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:

.1 Central Processing Unit (CPU) or web server

.2 Monitors

.3 Keyboards

.4 Uninterruptible Power supplies

.5 Network switches, hubs and routers.

.6 Interface equipment between CPU or server and control panels

.7 Operating System software

.8 Operator interface software

.9 Color graphic software

.10 Third-party software

.3 Network diagram of control, communication, and power wiring for BAS Server and OWS installation.

End of Section

SECTION 23 09 93 BAS Sequences of Operations

PART 1 - GENERAL

1.1 Sequences of Operation

.1 RTU rooftop units full control of scheduling and temperature setpoints. Full monitoring of system functions.

.2 FC/AHU/CU temperature and system function monitoring.

.3 BOILER & PUMPS full control of scheduling and setpoints. Full monitoring of system functions.

.4 UH temperature and system function monitoring.

PART 2 - PRODUCTS

2.1 Not applicable

PART 3 - EXECUTION.

End of Section