SECTION 25 05 00
BASIC MATERIALS AND METHODS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, for, Division 23 and other Division 1 Specification Sections, apply to this Section.

B. LEED™ REQUIREMENTS, Refer to Section 018113 – SUSTAINABLE DESIGN REQUIREMENTS

1.2 PROVISIONS INCLUDED

A. Include GENERAL REQUIREMENTS Section 01 00 00, for conditions and requirements which may affect the work of this Section

B. Examine all other Sections of the specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

C. Coordinate work with that of all other Trades affecting, or affected by work of this Section. Cooperate with such Trades to ensure the steady progress of all work under the Contract.

1.3 DEFINITIONS

A. Words in the singular shall also mean and include the plural, wherever the context so indicates and words in the plural shall mean the singular, wherever the context so indicates.

B. Wherever the terms "shown on drawings" are used in the specifications, they shall mean "noted", "indicated", "scheduled", "detailed", or any other diagrammatic or written reference made on the drawings.

C. Wherever the term "provide" is used in the specifications it will mean "furnish" and "install", "connect", "apply", "erect", "construct", or similar terms, unless otherwise indicated in the specifications.

D. Wherever the term "material" is used in the specifications it will mean any product", "equipment", "device", "assembly", or "item" required under the Contract, as indicated by trade or brand name, manufacturer's name, standard specification reference or other description.

E. The terms "approved", or "approval" shall mean the written approval of the Architect.

F. The term "specification" shall mean all information contained in the bound or unbound volume, including all "Contract Documents" defined therein, except for the drawings.

G. The terms "directed", "required", "permitted", "ordered", "designated", "prescribed" and similar words shall mean the direction, requirement, permission, order, designation or prescription of the Architect. The terms "approved", "acceptable", "satisfactory" and similar words shall mean approved by, acceptable or satisfactory to the Architect. The terms "necessary", "reasonable", "proper", "correct" and similar words shall mean necessary, reasonable, proper or correct in the judgment of the Architect.

H. "Piping" includes in addition to pipe or mains, all fittings, flanges, unions, valves, strainers, drains, hangers and other accessories relative to such piping.

I. "Concealed" means hidden from sight in chases, furred spaces, shafts, hung ceilings, embedded in construction or in crawl spaces.

J. "Exposed" means not installed underground or "concealed" as defined above.

K. "Invert Elevation" means the elevation of the inside bottom of the pipe.

L. "HVAC, Plumbing, and/or Fire Protection Contractor" shall refer to the Contractor or his Subcontractors responsible for furnishing and installation of all work indicated on the HVAC, Plumbing, and/or Fire Protection drawings and specifications, as applicable and or referenced to each Trade in the Architectural and/or Structural documents.

M. "Mechanical Contractor" shall refer to the Fire Protection, Plumbing, HVAC and ATC Contractors, as applicable.

N. "Architect" shall refer to the Architect “Studio NOVA" and/or Engineer "Bard, Rao + Athanas Consulting Engineers, LLC" and/or Owner.

O. "Owner" shall refer to the designated representatives of the Project Owner.

P. "General Contractor" shall refer to the Contractor(s) performing work under other sections of the Contract Specifications.

Q. “Commissioning Agent (CA)” shall refer to the party employed by the Owner to witness the demonstration of all systems according to the commissioning plan.

1.4 CODES, STANDARDS AND REFERENCES

A. All materials and workmanship shall comply with all applicable Codes, Specifications, Local and State Ordinances, Industry Standards and Utility Company Regulations, latest editions.

B. In case of difference between Building Codes, State Laws, Local Ordinances, Industry Standards and Utility Company Regulations and the Contract Documents, the Mechanical Contractor, as applicable, shall promptly notify the Architect in writing of any such difference.

C. In case of conflict between the Contract Documents and the requirements of any Code or Authorities having jurisdiction, the most stringent requirements of the aforementioned shall govern for budgetary purposes. However, no work will proceed until the Architect determines the correct method of installation.

D. Should any Contractor, as applicable, perform any work that does not comply with the requirements of the applicable Building Codes, State Laws, Local Ordinances, Industry Standards and Utility Company Regulations, he shall bear all costs arising in correcting the deficiencies, as approved by the Architect.

E. Applicable Codes and Standards shall include all State Laws, Local Ordinances, Utility Company Regulations and the applicable requirements of the following accepted Codes and Standards, without limiting the number, as follows:

1. National Electrical Code (NEC)
2. Environmental Protection Agency (EPA)
3. LOUISIANA Environmental Air Quality Protection Agency
4. LOUISIANA Energy Code
5. LOUISIANA Building Code/BOCA (Latest Adopted Edition), including all adopted LOUISIANA Supplements
6. LOUISIANA Fire Prevention Regulations and Elevator Regulations
7. Local Ordinances, Regulations of the Local Building Department and Fire Department
8. Recommendations of the National Fire Protection Association (NFPA), latest applicable edition adopted, in general and in particular:

    a. Life Safety, NFPA 101
    b. HVAC, NFPA 90A, 90B
    c. Removal of Smoke and Grease Laden Vapors from Commercial Cooking Equipment, NFPA 96

9. Recommendations of ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers), including:

    a. ASHRAE 90.1
    b. ANSI/ASHRAE 62-Ventilation for Acceptable Indoor Air Quality
    c. ANSI/ASHRAE 15-Safety Code for Mechanical Refrigeration
    d. ANSI/ASHRAE 110-Method of Testing Performance of Laboratory Fume Hoods
    e. ANSI/ASHRAE 55-Thermal Environmental Conditions for Human Occupancy

F. In these specifications, references made to the following Industry Standards and Code Bodies are intended to indicate the accepted volume or publication of the Standard. All equipment, materials and details of installation shall comply with the requirements and latest revisions of the following Bodies, as applicable:

1.	AMCA	Air Moving and Conditioning Association
2.	ANSI	American National Standards Institute
3.	ARI	American Refrigeration Institute
4.	ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
5.	ASME	American Society of Mechanical Engineers
6.	ASTM	American Society of Testing Materials
7.	AWS	American Welding Society
8.	CS	Commercial Standards, U.S. Department of Commerce
9.	FM	Factory Mutual
10.	FS	Federal Specification, U.S. Government
11.	MSS	Manufacturers Standardization Society of the Valve and Fittings Industry
12.	NEMA	National Electrical Manufacturers Association
13.	SMACNA	Sheet Metal and Air Conditioning Contractor's National Association
14.	UL	Underwriters' Laboratories, Inc.

G. Each Contractor for the work under his charge, shall give all necessary notices, obtain and pay for all permits, pay all governmental taxes, fees and other costs in connection with his work; file for necessary approvals with the jurisdiction under which the work is to be performed. Each Contractor shall obtain all required Certificates of Inspection for his work and deliver same to the Architect before request for acceptance of his portion of work and before final payment is made.

H. All equipment shall be installed per manufacturer's recommendations and requirements. The Contractor shall notify the Engineer in writing when they intend to deviate from manufacturer's installation guidelines. The Engineer shall advise if the installation is acceptable prior to installation.

1.5 SUBMITTALS

A. Submit detailed shop drawings or brochures for approval of equipment and material proposed to be used on this project. Furnish the number of copies required by General Conditions.

B. Documents submitted shall show the following:

1. Principal dimensions and details of construction.
2. Operating and maintenance clearances.
3. Weights of principal parts and total weights with information required for the design of supports and foundations.
4. Sizes and location of piping and connections.
5. Performance data, including pump and fan curves; sound data including sound power dB levels in 1/3 octave bands.
6. Data on electric motors, including brake horsepower of driven equipment, nameplate ratings and classes, sound data, starting and running full load currents, required starter size and recommended overload heater ratings.
7. Approval stamp of Underwriters' and other authorities having jurisdiction of Contract Drawings requiring such approval.
8. Certified performance guarantees.
9. Calculations and details for refrigeration for field assembled systems including description of specialties and pressure drops, layout of piping with lengths fittings, and refrigerant specialties, and capacity curves for evaporator and compressor showing balance points.
10. Minimum scale for sheet metal plans and piping plans shall be ¼ inch equal 1 foot.

C. Submit brochures that contain only that information which is relative to the particular equipment or materials to be furnished. Do not submit catalogs that describe several different items other than those items to be used unless irrelevant information is marked out and relevant material is clearly marked.

D. Specifications Compliance Statement

1. The manufacturer shall submit a point by point statement of compliance with the specifications.
2. The statement of compliance shall consist of a list of all paragraphs (line by line).
3. Where the proposed system complies fully, such shall be indicated by placing the word "comply: opposite the paragraph number.
4. Where the proposed system does not comply, or accomplishes the stated function in a manner different from that described, a full description of the deviation shall be provided.
5. Where a full description of a deviation is not provided, it shall be assumed that the proposed system does not comply with the paragraph in question.

6. Submissions which do not include a point by point statement of compliance as specified shall be disqualified.

1.6 WARRANTY

A. Labor and materials for control systems shall be warranted for a period as specified under Warranty in Section 01 00 00, GENERAL REQUIREMENTS.

B. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no cost or reduction in service to the owner. The system includes all computer equipment, transmission equipment, and all sensors and control devices.

C. The on-line support service shall allow the Controls supplier to dial out over telephone lines to monitor and control the facility's building automation system. This remote connection to the facility shall be within two (2) hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekend and holidays. If the problem cannot be resolved with on-line support services, the Controls supplier shall dispatch the qualified personnel to the job site to resolve the problem within 24 hours after the problem is reported.

D. Controls and Instrumentation subcontractor shall be responsible for temporary operations and maintenance of the control systems during the construction period until final commissioning, training of facility operators and acceptance of the project by VA.

1.7 EXTENDED GUARANTEE PERIOD SERVICES

A. Refer to article, EXTENDED GUARANTEE PERIOD SERVICES, Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION for additional experience requirements of the control contractor.

B. Comprehensive maintenance and repair related services shall be provided for the automatic controls provided on the project. The items of equipment and systems covered under semi-annual service shall be:

1. The Engineering Control Center (ECC) and associated peripherals (e.g., keyboard, mouse, printer, monitor, hard disks, floppy disks, operating and instructional manuals).
2. The field data gathering distribution digital control panels and pneumatic local temperature control panels for the HVAC systems.
3. Automatic control systems for all chillers, chilled water pumps, including variable speed drive packages, differential pressure controllers and chilled water control valves.
4. Automatic control systems for all steam and hot water systems.
5. Automatic temperature control systems for all occupied areas.
6. Miscellaneous HVAC control systems and subsystems that are in communications with the ECC. Examples: Mechanical equipment rooms, electrical equipment rooms, elevator machine rooms, emergency generator rooms, telephone equipment rooms, transformer/switchgear rooms, vestibules and special exhaust systems.
7. All automatic control systems interfacing with the central ECC system and other disciplines (e.g., plumbing and electrical trades for measuring and controlling temperature, flow rate, quantities, pressure, demand, and maintaining alarms).

C. Qualifications: See Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

D. Replacement Parts: See Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

E. Maintenance of Computer Software Programs: The Contractor's Supplier shall maintain all software programs included in the ECC and the digital controllers. In addition, all factory upgrades to the system and subsystem software shall be added to the systems, when they become available, at no additional cost to the government throughout the warranty period. New features, such as modification in the hardware system are not considered upgrades in this context.

F. Maintenance of ECC and Local Field Panels: The Contractor's Supplier shall inspect, repair, replace, adjust, and calibrate, as required, the Operator's Workstation, associated peripheral equipment, and local data gathering panels. The controls Supplier shall then furnish a report describing the status of the equipment, problem areas (if any) noticed during service work, and description of the corrective action taken. The report shall clearly certify that the software package is in working condition and all sensors are duly calibrated.

1.8 COMMISSIONING

A. The TBA Contractor must also include sufficient man-hours within their bids, for their participation with the Commissioning Team and the rebalancing/readjusting/resetting all device setpoints, as required.

B. Commissioning of a system or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the VAMC operation and maintenance personnel, is required in cooperation with the VA Resident Engineer and the Commissioning Authority. Project Closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019113, Commissioning, for detailed commissioning procedures.

1.9 THE CONTRACTOR

A. Each Contractor shall base his bid on site examinations performed by him. This requirement is mandatory. Each Contractor shall visit the proposed site where work is scheduled to be performed and ascertain for himself the amount of work required to fulfill the intent of his Contract and the complexity of the installation. Each Contractor shall not hold the Architect, his Consultants, agents or employees responsible for or bound by, any schedule, estimate or for any plan thereof. Each Contractor shall study all Contract Documents (HVAC, Plumbing, Fire Protection, Electrical, Communications, Architectural, Structural), etc., included under each Contract, to determine exactly the extent of work to be provided under each Section, and in installing new equipment and systems and coordinating the work with the other Trades and existing conditions.

B. Each Contractor shall faithfully execute his work according to the terms and conditions of the Contract and specifications and shall take all responsibility for and bear all losses resulting to him in the execution of his work.

C. Each Contractor shall be responsible for the location and performance of work provided under his Contract as indicated on the Contract Documents. All parties employed directly or indirectly by each Contractor shall perform their work according to all the conditions as set forth in these specifications.

D. Each Contractor shall furnish all materials and perform all work in accordance with the project specifications and any supplementary documents provided by the Architect. The work shall include every item shown on the drawings and/or required by the specifications as interpreted by the Architect. All work and materials furnished and installed shall be new and of the best quality and workmanship. Each Contractor shall cooperate with the Architect so that no error or discrepancy in the Contract Documents shall cause defective materials to be used or poor workmanship to be performed.

1.10 COORDINATION OF WORK

A. Each Contractor shall compare his drawings and specifications with those of other Trades and report any discrepancies between them to the Architect and obtain from the Architect written instructions for changes necessary in the mechanical or electrical work, to ensure that all work is installed in coordination and cooperation with other Trades installing interrelated work. Before installation, each Contractor shall make proper provisions to avoid interferences in a manner approved by the Architect. All changes required in the work of each Contractor caused by his negligence, shall be corrected by him at his own expense, to the Architect's satisfaction.

B. Locations of piping, ductwork, conduits and equipment shall be adjusted to accommodate the new work with interferences anticipated and encountered during installation. Each Contractor shall determine the exact routing and location of his systems prior to fabrication or installation of any system component. Accurate measurements and coordination drawings will have to be completed to verify dimensions and characteristics of the various systems' installations.

C. Lines which pitch shall have the right-of-way over those which do not pitch. For example, waste piping shall normally have the right-of-way. Lines whose elevations cannot be changed shall have the right-of-way over lines whose elevations can be changed.

D. Offsets, transitions and changes of direction in all systems shall be made as required to maintain proper headroom and pitch of sloping lines whether or not indicated on the drawings. Each Contractor shall provide manual air vents and drains as required for his work to affect these offsets, transitions and changes in direction, as applicable.

E. All work shall be installed in a way to permit removal (without damage to other parts) of coils, filters, control appurtenances, fan shafts and wheels, filters, belt guards, sheaves and drives and all other system components provided under this Contract requiring periodic replacement or maintenance. All piping shall be arranged in a manner to clear the openings of swinging overhead access doors, ceiling tiles and cleaning access doors in ductwork.

1. Access to any and all components requiring servicing, adjustment, calibration, maintenance or periodic replacement shall be provided so that the Owner's operations personnel can freely gain access without removal of any materials other than the access panel or ceiling tile. Access shall be understood to mean free, clear and unobstructed from the floor up to the device and/or component being serviced. Access panels for VAV/CV boxes shall be 24" x 24" minimum.
2. Fire rated access doors with closers shall be provided for all rated assemblies.

F. The Contract Drawings are diagrammatic only intending to show general runs and locations of piping, ductwork, equipment, terminals and specialties and not necessarily showing all required offsets, details and accessories and equipment to be connected. All work shall be accurately laid out with other Trades to avoid conflicts and to obtain a neat and workmanlike installation which will afford maximum accessibility for operation, maintenance and headroom.

G. Where discrepancies in scope of work as to what Trade provides items, such as starters, disconnects, flow switches, electric control components, etc., exist, such conflicts shall be reported to the Architect prior to signing of the Contract. If such action is not taken, each Contractor, as applicable, shall furnish such items as part of his work, for complete and operable systems and equipment, as determined by the Architect.

H. Where drawing details, plans and/or specification requirements are in conflict and where pipe or duct sizes of same pipe or duct run are shown to be different between plans and/or between plans and sections or details, the most stringent requirement will be included in the Contract. HVAC systems and equipment called for in the specification and/or shown on the drawings shall be provided under this Contract as if it were required by both the drawings and specifications. However, prior to ordering or installation of any portion of work which appears to be in conflict, such work shall be brought to Architect's attention for direction as to what is to be provided.

I. Final location of all air distribution devices, thermostats, heaters, control devices, sprinkler heads, etc., shall be coordinated with the Architectural reflected ceiling plans and/or other Architectural details, as applicable. (**Note**: Sprinkler head locations shall provide the specified coverage rating and water flow density, and shall be in accordance with all applicable Codes and in full compliance with the requirements of the Owner's insurance carrier.) Offsets of ductwork, added sheet metal, fittings, elbows, flexible connections, etc., shall be provided as required to comply with the Architectural reflected ceiling plans and/or installation details. Obtain approval of locations of all devices from Architect in the field, prior to installation.

J. Kitchen equipment and/or hoods, dishwashers, etc., or other type of equipment shown on the Plumbing, Fire Protection, HVAC and/or Architectural drawings to be provided with services, such as exhaust ductwork, piping, traps, drains, valves, etc., shall be included under this Contract as applicable, including all piping or ductwork connections to systems, to make equipment completely operable. Additional sheet metal, flexible fittings, etc., shall be provided to accomplish the above requirement, as required, all as part of this Contract, at no additional cost to the Owner.

1.11 COORDINATION DRAWINGS

A. Refer to section 23 05 11.10 3D BUILDING INFORMATION MODELING. The BAS Contractor shall be part of this process and coordinate all control panel location and include them on the drawings. The BAS Contractor shall also coordinate all access requirements for their equipment as part of this process.

B. Before materials are purchased, fabricated or work is begun, each Contractor shall prepare coordination drawings in cooperation with all trades for all floors/areas, including buried systems/services (all-Trade-composite at ¼" scale), showing the size and location of his equipment and lines, in the manner described herein under General Requirements.

C. The HVAC Contractor shall take the lead in the coordination drawing process to produce the Architectural backgrounds. A detailed drawing schedule shall be produced to conform to the scale drawing requirements as herein listed and submitted for review. Coordination drawings are for the GC and Architect's/Engineers use during construction and shall not be construed as shop drawings or as replacing any shop drawings. The coordination drawings, when corrected for actual "as-built" conditions, will be reviewed by the Architect, corrected and become the Record Drawings to be submitted to the Owner for his use.

D. The cost of producing and reproducing the drawings will be included under the Contract of each Trade, including the cost or preparation of the Architectural building outlines. This process may include multiple revisions to these drawings which will be included in the cost. The intent is to provide a fully coordinated set of documents between trades no matter how many times they may have to be redone. The HVAC Contractor shall take the lead to produce the Architectural backgrounds, show all ductwork, piping, etc., and circulate the drawings to any of his Subcontractors and the other Trades (Plumbing, Fire Protection, Electrical), so that they can indicate all their work as directed by the GC and Architect as required, to result in a fully coordinated installation.

E. In addition to the regular coordination drawing review, the mechanical work will also be reviewed by the Architect/Engineer to ensure that the system and equipment arrangements are suitable to provide maintenance access and service as follows:

1. All BAS control panels.
2. All BAS control panels shall be coordinated with all other trades.

F. Prepare a complete set of computer based AutoCad (Latest Version) drawings at scale not less than ¼" scale equals 1'-0", showing basic layout for the structure and other information as needed for preparation of Coordination Drawings. The drawings shall indicate the layout of all specialty tradework as indicated herein and shall be designated as Coordination Drawings. The Contractor shall provide a minimum of two (2) weeks notice to the Engineer for preparation of the disk. A signed liability release form will be required from the Contractor prior to the release of the disk from the Engineer.

1. Prepare a complete set of computer based drawings:
2. Format shall be either:

   a. AutoCAD (Latest Version)
   b. REVIT (Latest Version)

3. Scale not less than ¼" scale equals 1'-0", showing basic layout for the structure and other information as needed for preparation of Coordination Drawings.
4. The drawings shall indicate the layout of all specialty tradework as indicated herein and shall be designated as Coordination Drawings.
5. Any drawing provide to assist the contractor will require:
6. A signed liability release form will be required from the Contractor prior to the release of the disk from the Engineer.
7. Section 23 05 11.10 3D BUILDING INFORMATION MODELING for additional information

G. Highlight all fire rated partitions on the Coordination Drawings for appropriate coordination.

H. The main paths for the installation or removal of equipment from mechanical and electrical rooms shall be clearly indicated on the Coordination Drawings.

I. Each of the specialty trades shall add its work to the base drawings with appropriate elevations and grid dimensions. Specialty trade information shall be required for fan rooms and mechanical rooms, horizontal exits from duct shafts, crossovers and for spaces it the above ceilings where congestion of work may occur such as corridors and, where required, entire floors. Drawings shall indicate horizontal and vertical dimensions to avoid interference with structural framing, ceilings, partitions and other services. Indicate elevations relative to finish floor for bottom of ductwork and piping and conduit 6" greater in diameter.

1. Specialty Trade shall include:

a. Plumbing system.
b. HVAC piping and associated control systems.
c. Electrical.
d. Sheet Metal Work.
e. Fire Protection system.
f. Automatic Temperature Control
g. Fire Alarm
h. Security
i. Telecommunications
j. Commissioning

J. Upon completing their portion of the Coordination Drawings, each specialty trade shall sign, date and return Coordination Drawings to the Contractor.

K. Where conflicts occur with placement of materials of various trades, the General Contractor shall be responsible to coordinate the available space to accommodate all trades. Any resulting adjustments shall be initialed and dated by the affected specialty trade Subcontractor. The General Contractor shall then final date and sign each drawing.

L. Fabrication shall not start until Coordinate Drawings have been distributed to all parties as indicated herein.

M. Format: Coordination Drawings (plans only) shall be done using CAD in AutoCAD (Latest Version), in either IBM or Mac Format. Disks shall be given to the Architect for future transfer to Owner. Coordination Drawings will be used as base for as-built drawings.

N. Distribution of Coordination Drawings:

1. The General Contractor shall provide one print of each Coordination Drawing to:

a. Each specialty trade Subcontractor.
b. Owner.
c. General Contractor.
d. Architect (for record purposes).

O. After distribution:

1. Resolve all interference's not previously identified.

P. Coordination Drawings include but are not necessarily limited to:

1. Structure.
2. Partition/room layout, including indication of smoke and fire resistance rated partitions.
3. Ceiling layout and heights.

4. Light fixtures.
5. Access panels.
6. Sheet metal, heating coils, heat pumps, grilles, diffusers, etc.
7. All heating piping and valves.
8. Smoke and fire dampers.
9. Soil, waste and vent piping.
10. Major water and gases.
11. Major electrical conduit runs, panelboards, feeder conduit and racks of branch conduit. Motor control centers, starters and disconnects.
12. Sprinkler piping and heads.
13. All equipment, including items in the Contract as well as O.F.C.I. and O.F.I. items.
14. Equipment located above finished ceiling requiring access for maintenance and service. In locations where acoustical lay-in ceilings occur indicate areas in which the required access area may be greater than the suspected grid systems.
15. Rainwater Piping.
16. Existing conditions, including, but not limited to, Mechanical, Plumbing, Fire Protection and Electrical items.
17. ATC panels.

Q. The Architect's response to all requests for information (RFI's) generated by the trade contractors shall be distributed to all other affected trades as if this information was contained in the original contract documents. In other words, the party that issues an RFI is responsible for distributing the information to all affected parties. RECORD DRAWINGS

R. Each Contractor shall maintain, current at the site, a set of Contract Drawings for his portion of the work on which he shall accurately show the actual installation of all work provided under his Contract indicating any variation from the Contract Drawings, in accordance with the General Conditions and Supplementary General Conditions. Changes whether resulting from formal change orders, requests for information, or other instructions issued by the Architect shall be recorded. Include changes in sizes, location and dimensions of piping, ducts, equipment, etc.

S. Each Contractor shall indicate progress by coloring-in various pipes, ducts and associated appurtenances exactly as they are erected. This process shall incorporate both the changes noted above and all other deviations from the original drawings whether resulting from job conditions encountered or from any other causes.

T. The marked-up and colored-up prints will be used as a guide for determining the progress of the work installed. They shall be inspected periodically by the Architect and Owner's representatives and they shall be corrected if found either inaccurate or incomplete. This procedure is mandatory. Marked up drawings shall include all flow diagrams, schedules, details and control diagrams.

U. Each Contractor shall meet at a minimum on a monthly basis, with the Owner's representative to transfer the information from his HVAC, Plumbing, Fire Protection, etc., marked-up and colored-up prints to a set which will become the basis for preparation of as-built drawings.

V. Upon completion of the project, each Contractor shall submit his marked-up drawings to the Architect for review and comment. After the Architect reviews and comments on this set of documents, each Contractor shall prepare as-built drawings on CAD using AutoCad (Latest Version). When the work is completed, each Contractor shall provide 2 hard copies to the Architect for submittal to the Owner and disks with all documentation and a set of reproducible drawing plots marked "As-Built" drawings. The Contractor shall bear all costs of producing the CAD "As-Built" drawings, providing all necessary drawing changes and printing the reproducible drawings for the work under his charge.

1.12 GIVING INFORMATION

A. Each Contractor shall keep himself fully informed as to the shape, size and position of all openings required for his apparatus and shall give information to the Architect and other Contractors [or Subcontractors] sufficiently in advance of the work so that all openings may be built in advance.

B. The manufacturers listed within this specification have been preselected for use on this project. No submittal will be accepted from a manufacturer other than those specified. Should any Contractor wish to propose a substitution during the bid period, such request shall be made in writing to the Architect, at least (15) working days, prior to bid date. If substitutions are deemed acceptable, such items shall be issued as an Addendum, prior to bid due date. The above requirement is mandatory.

1.13 CUTTING AND PATCHING

A. Each Contractor shall be responsible for all core drilling, as required for work under his Contract, but in no case shall he cut into any structural elements without the written approval of the Architect.

B. All cutting, rough patching and finish patching, shall be provided under this Contract.

C. All concrete and masonry equipment bases shall be provided under this Contract.

1.14 USE OF PREMISES

A. Each Contractor shall confine all of his apparatus, storage of materials and construction to the limits indicated on the drawings and directed by the Architect and he shall not encumber the premises with his materials.

B. In storing materials within areas (structure or ground), or when used as a shop, each Contractor shall consult with the General Contractor and shall restrict his storage to space designated for such purposes. Each Contractor will be held responsible for repairs, patching or cleaning arising from any unauthorized use of premises.

C. Notwithstanding any approvals or instructions which must be obtained by each Contractor from the Architect in connection with use of premises, the responsibility for the safe working conditions at the site shall remain each Contractor's. The Architect or Owner shall not be deemed to have any responsibility or liability in connection therewith.

D. Air handling unit or cooling tower sections shall not be used for storage of materials. The HVAC Contractor will be responsible for securing, and maintaining the equipment clean. The above requirement is mandatory.

1.15 PROTECTION/CLEANLINESS

A. All materials such as valves, fittings, piping, ductwork, plenums, grilles, registers, diffusers, etc., shall be properly protected from the accumulation of dirt, dust, debris or any other contaminants. All ductwork and piping openings shall be temporarily closed by each Contractor [or Subcontractor] installing same, so to prevent obstruction and damage, as a minimum at the end of each working day or more often if required by job conditions. Each Contractor shall take precautions to protect his materials from damage and theft.

B. Each Contractor shall furnish, place and maintain proper safety guards for the prevention of accidents that might be caused by the workmanship, materials, equipment or electrical systems provided under his Contract.

1.16 DAMAGE CORRECTION AND EXTRA WORK

A. Each Contractor shall be held responsible and shall pay for all damages caused by his work to the new and existing building structures and new and existing equipment, piping, duct systems, etc., and all work and finishes installed under this Contract in the new or in existing building. Repair of such damage shall be done as herein before specified, at the expense of each Contractor and to the Architect's satisfaction.

B. Each Contractor shall promptly correct all work provided under his Contract and rejected by the Architect as defective or as failing to conform to the Contract Documents whether observed before or after completion of work and whether or not fabricated, installed or completed. Each Contractor shall bear all costs of correcting such rejected work.

C. No claim for extra work will be allowed unless it is authorized by the Architect in writing before commencement of the extra said work.

1.17 TOUCH-UP PAINTING

A. Each Contractor shall thoroughly clean all equipment and systems provided under this Contract from rust, splatters and other foreign matter or discoloration, leaving every part of each system in an acceptable prime condition. Each Contractor, for the work under his Contract, shall refinish and restore to the original condition all equipment and piping which has sustained damage to the manufacturer's prime and finish coats of paint and/or enamel.

1.18 HOUSEKEEPING PADS

A. Coordinate housekeeping pads for:

1. All equipment indoors or outdoors
2. All floor supports or braces

B. Pads shall be 4" above the finished floor.

C. Each pad shall be a minimum of 6" larger then the equipment, support or isolation base in all directions.

D. Pads shall be formed, poured with concrete, and tooled by the General Contractor.

1.19 DUCT AND PIPE SLEEVES, PLATES AND ESCUTCHEONS, FIRESTOPPING AND SMOKEPROOFING

A. Where piping and/or ductwork pass through masonry or concrete walls or drywall partitions or floors, each Contractor shall provide and set individual sleeves for each pipe or duct and all other work under his charge, as necessary for passage of all pipes and/or ducts. Sleeves shall be of sufficient size to provide 1/2" air space around the pipe or duct passing through (including insulation where pipes or ducts are internally/externally insulated).

All openings shall be sealed, smokeproofed and made tight. Each Contractor shall be responsible for the exact location of sleeves provided under his Contract and shall coordinate all requirements for piping and ductwork sleeves.

B. Each Contractor, for work under his charge, shall determine the required inside diameter of each individual wall opening or sleeve before ordering, fabrication or installation.

C. Sleeves and inserts shall not be used in any portions of the building, where their use would impair the strength or construction features of the building. Elimination of sleeves must be approved by the Architect.

D. Provide chrome plated brass escutcheons with set screw for exposed piping, in all areas except in mechanical rooms. In this area use plain brass or cast iron escutcheons suitable for painting. All escutcheons shall be sized to fit the bare pipe or insulation in a snug and neat manner. They shall be of sufficient size to cover sleeved openings for the pipes and of sufficient depth to cover sleeves projecting above floors. Escutcheons shall be as manufactured by Beaton & Caldwell, Dearborn Brass, or Grinnell.

E. Pipe or duct sleeves shall be made of Schedule 40 pipe, 20 gauge galvanized steel or 16 gauge steel as follows:

1. Sleeves on pipes passing through masonry or concrete construction shall be Schedule 40 pipe.
2. Sleeves on ducts passing through concrete construction shall be 20 gauge steel unless required otherwise by item 4. below.
3. Sleeves on pipes or ducts passing through fire rated partitions shall be 16 gauge steel.

F. Pipe or duct sleeves shall be set as follows:

1. Set sleeves 1" above finish floor, (except set sleeves, 6" above finish floor at penthouses or mechanical rooms and 6” above finished roof) and flush on each side of walls. Coordinate roof penetrations with roof Subcontractor.
2. Sleeves shall be set securely in place before concrete is poured when placed in concrete construction.
3. Provide sheet metal sleeves for all duct penetrations and cover with sheet metal plates all penetrations after ductwork has been installed through walls/floors.

G. Each Contractor shall fire stop, smoke stop, and/or acoustically seal the space between the sleeves provided under his Contract and piping or ductwork as applicable, as follows:

1. See specification Section 078400 Firestopping.

H. Except as otherwise specified, underground piping passing through exterior walls or foundation slabs on grade, shall have penetration closures of the modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening. Links shall be loosely assembled with bolts to form a continuous belt around the pipe and with a pressure plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tightening of the bolts shall cause the rubber sealing elements to expand and provide an absolutely watertight seal between the pipe and wall, reducing chances of cathodic reaction between these members. Each Contractor for work under his charge shall determine the required inside diameter of each individual wall opening or sleeve before ordering, fabrication or installation. The inside diameter of the wall opening shall be sized to fit the pipe and ensure a watertight joint. Where applicable, when installing seals, take into account the pipe O.D. if non-standard due to coating or jacketing.

1.20 MISCELLANEOUS IRON AND STEEL

A. Each trade shall provide all primary and secondary steel supports and hangers as shown on the drawings and/or as required to support equipment, ductwork, piping, exhaust fans, or any other materials provided under the work of this Section.

B. The work of this Section of designing, furnishing and installing all miscellaneous metal work associated with the system, and related items as indicated on the drawings and/or as specified herein, and includes, but is not limited to the items listed herein below.

C. The scope of work shall include:

1. Control equipment support platforms including ship ladders, steel grating for decking, cross-bracing and floor stands.
2. Intermediate beams to hang equipment and piping from the roof. All piping and ductwork must be hung from beam or supported from the floor. Provide supplemental steel for support of equipment.
3. Support of equipment and piping in shafts in addition to support provided by structure.
4. Support via floor stands as required.
5. Piping support in underground concrete trench and manholes.
6. Pipe anchors in the building.
7. Hangers, brackets, angel irons or rods required for the support and protection of control equipment.
8. Field prime painting of galvanized steel and field finish painting.

D. Shop Drawings for General Miscellaneous Items

1. Submit Shop Drawings of all miscellaneous metal items to Architect for approval, showing sizes and thickness of all members, types of materials, methods of connection and assembly, complete dimensions, clearances, anchorage, relationship to surrounding work by other Trades, shop paint, and other pertinent details of fabrication and installation.

E. The Subcontractor shall engage the services of a Professional Engineer registered within the state wherein the project is located to prepare complete Design Drawings and structural design computations based on, and closely following, the design and details on the Drawings. The Design Drawings and structural design computations, with the Engineer's seal affixed thereto, shall be submitted to the Architect for review. The structural design computations shall provide a complete structural analysis, including anchors and fastening devices, and shall certify as to conformation to governing laws and codes. These submittals, upon review, must be sufficient, when taken in conjunction with this Specification to provide the complete basis of the fabrication and erection.

F. Samples

1. Submit duplicate samples of all materials to be furnished under this Section if, and in size and form, requested by Architect.

G. Do not order materials or begin fabrication until Architect's approval of submittals has been obtained.

H. In addition to the governing laws and codes, the following Specifications and Codes form a part of this Specification:

1. American Iron and Steel Institute applicable standards.
2. American Institute of Steel Construction "Code of Standard Practice for Steel Buildings and Bridges" and "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings".
3. American Welding Society Code: Standard Code for Arc and Gas Welding in Building Construction.

I. All materials shall be new stock, free from defects impairing strength, durability or appearance and of best commercial quality for each intended purpose.

1. Unless other wise specifically called for, work of this Section shall be fabricated of structural steel conforming to ASTM Specification A36.
2. Steel pipe shall be seamless steel pipe conforming to ASTM Specification A53, Schedule 40.
3. Steel tubing shall be seamless steel tubing conforming to ASTM Specifications A500 to A501.
4. Non-ferrous metals shall be as specified under descriptions of specific items, herein below.

J. Provide all anchors, bolts, sockets, sleeves, and other parts required for securing each item of work of this Section to the construction, including furnishing to concrete workers all required insets and sleeves for use at concrete.

1. All exposed fastenings shall be of the same material and finish as the metal to which applied, unless otherwise noted.
2. Welding rods shall conform to AWS Standards and the recommendation of the welding rod manufacturer.

K. Metal surfaces shall be clean and free from mill scale, flake, rust and rust pitting. metal work shall be well formed and finished to required shape and size, true to details, with straight, sharp lines and angles and smooth surfaces. Curved work shall be true radii. Exposed sheared edges shall be eased.

L. Weld all permanent connections. Welds shall be continuous on all exposed surfaces and where required for strength on concealed surfaces. Exposed welds shall be ground flush and smooth, with voids filled with metallic filling compound (metallic filling compound not permitted on surfaces to receive hot-dip galvanizing). Tack-welding will not be permitted unless specifically called for. Do not use screws or bolts where they can be avoided. Where used, heads shall be countersunk, screwed up tight, and threads nicked to prevent loosening.

M. Fastenings shall be concealed where practicable. Thickness of metal and details of assembly and supports shall give ample strength and stiffness. Joints exposed to weather shall be formed to exclude water.

N. Do all cutting, punching, drilling and tapping required for attachment of anchor bolts and other hardware and for attachment of work by other Trades. All such cutting, punching, drilling, etc., shall be done prior to hot-dip galvanizing of the various components.

O. Live loads shall be not less than the minimum required by law. Where specific live load are not set forth in the laws and codes applicable to this work, and are not given on the Drawings or in this Specification, designs shall be such as to support the live loads which may normally be imposed without failure, without deflection of more than 1/360 of length of any member, and without permanent deformation, all with a factor of safety of not less than 2 1/2 to 1.

P. Shop Painting

1. All ungalvanized ferrous metals under this Section shall be given a shop coat of rust inhibitive primer of type specified above.

    a. Immediately before shop painting, remove all rust, loose mill scale, dirt, weld flux, weld spatter, and other foreign material with wire brushes and/or steel scrapers. Power tool clean in accordance with SSPC SP-3 (Power Tool Cleaning). Remove all grease with oil by use of solvent recommended by paint manufacturer. Sandpaper exposed surfaces as required to produce smooth, even finishes.
    b. Apply paint by spray process in strict accordance with manufacturer's printed instructions to uniform thickness(es) recommended by manufacturer. Apply thoroughly and evenly and work well into corners and joints taking care to avoid sags and runs.
    c. Do not paint surfaces to be embedded in concrete, or to be welded in the field. After field welds are complete, grind smooth and flush, thoroughly clean and then apply specified primer over all unprimed in the field by brush roller.
    d. After erection, sand smooth and retouch all portions of the shop coats chipped or damaged during erection, and coat all field welds and connections with primer equivalent to that used for the shop coat.

Q. Installation

1. All materials shall be carefully handled and stored under cover in manner to prevent deformation and damage to the materials and to shop finishes, and to prevent rusting and the accumulation of foreign matter on the metal work. All such work shall be repaired and cleaned prior to erection.
2. Work shall be erected square, plumb and true, accurately fitted, and with the tight joints and intersections. All anchors, inserts and other members to be set in concrete or masonry shall be furnished loose by this Trade to be built-into concrete and masonry and by those Trades as the work progresses. Later cutting or drilling shall be avoided wherever possible.
3. All metal work shall be rigidly braced and secured to surrounding construction, and shall be tight and free of rattle, vibration, or noticeable deflection after installed.
4. Where members, other than expansion bolts or inserts, are fastened into concrete, set such members in holes formed as specified below, and secure permanently in place by installation of proprietary-type expanding grout manufactured specifically for such purpose, used strictly in accordance with manufacturer's directions. Holes to receive members shall be formed with galvanized sheetmetal sleeves, expanded polystyrene foam, or other approved method to provide at least 1/2 inch clearance around entire perimeter. At exposed applications, hold expanding grout back 1/2 inch from finish surface and fill voids with Portland cement grout to match color and texture of surrounding concrete surface.
5. Electrolytic Isolation

    a. Where dissimilar metals are to come into contact with one another, isolate by application of a heavy coating of bituminous paint on contact surfaces in addition to shop coat specified above. Do not permit the bituminous paint in any way to remain on surfaces to be exposed or to receive sealant.

R. Description of Major Items

1. The items described below constitute the major part of the work of this Section, but are not intended or implied to cover each and every item that may be required to properly complete the work. Carefully review the Drawings to determine the full extent of the miscellaneous metal work required.

S. Steel Ladders/Platforms

1. Fabricate and install interior steel ladder at fans, air handling units, filter racks and all equipment requiring service. Ladders shall have a safety cage as required by OSHA regulations.
2. Except as may be otherwise indicated on the Drawings, ladder shall be minimum 16 inches wide, fabricated of minimum 3/8 inch by 2 1/2 inches hot rolled steel rails and minimum 3/4 inches outside diameter steel pipe rungs. Rungs shall be spaced 12 inches on center and shall be continuously welded to the rails. Provide a pair of steel clip angles or wall brackets at bottom and steel anchor plates or wall brackets at top, welded to the rails, as indicated.
3. Exterior steel ladders shall be hot dip galvanized after fabrication as specified hereinbefore. Rungs are to have non-slip surfaces.
4. All shall be OSHA and ANSI compliant.

T. Gratings and Frames

1. Fabricated and install steel gratings and frames at fan platforms.
2. Steel grating frames shall consist of a steel angle perimeter frame constructed of steel angles, at least 4 inches by 4 inches by 3/8 inches carried around perimeter with coped or mitered, full-welded corners. Perimeter frames shall be anchored with 7/16 inch minimum diameter expansion bolts or other suitable devices of adequate capacity, at corners, two (2) per beam end, and spaced not more than 2 feet on center around full perimeter.
3. Steel Gratings shall be pressure-locked type, with bearing bars spaced 1 3/16 inch on center and cross-bars spaced 4 inches on center. Sizes of bars shall be as required by manufacturer's loading tables to limit deflection of any member across any span to 1/240th of the span at live load of 100 pounds per square foot. Gratings shall be as manufactured by Borden Metal Products, Co., Irving Subway Grating Co., Reliance Steel Products Co., approved by Architect.
4. All (gratings and) frames shall be hot-dip galvanized after fabrication as specified hereinbefore (aluminum, FRP).

U. Miscellaneous Items

1. Carefully review all Drawings for miscellaneous metal items required but not specifically listed above, such as miscellaneous steel clip angles, miscellaneous steel bracketing, and other miscellaneous metal items as indicated on the Drawings, reasonably implied therefrom, or reasonably necessary for the thorough completion of the work.
2. Provide rigid and secure anchorage of all components whether or not specifically described in complete detail on the Drawings.

V. Piping supports shall be coordinated with the building structure and shall span between roof beams as required.

1.21 WATERPROOFING, FLASHING AND COUNTERFLASHING

A. Unless specifically indicated otherwise on the drawings, each Contractor shall provide all counterflashing and waterproofing of all piping, ductwork and equipment provided by him, which pierce roofs, walls and other weatherbarrier surfaces. All work under this paragraph shall be coordinated with the (GC).

B. All work shall be performed in a workmanlike manner to ensure weatherproof installation. Any leaks developed due to each Contractor's work shall be repaired at his expense, to the Architect's satisfaction.

C. Pipes passing through slabs shall have the sleeve extended above floors as hereinbefore specified to retain any water and the space between the pipe and sleeve caulked waterproof fire stopping. The top and the bottom shall be sealed with monolastic caulking compound.

D. All flashing required for ductwork and piping penetrations shall be provided by the (GC).

1.22 PARTS LIST AND INSTRUCTIONS FOR OPERATION AND MAINTENANCE

A. Each Contractor shall thoroughly instruct the representative(s) of the Owner, to the complete satisfaction of the Architect, in the proper operation of all systems and equipment provided by him. Each Contractor shall make arrangements, via the GCas to whom the instructions are to be given in the operation of the basic and auxiliary systems and the periods of time in which they are to be given. The Architect shall be completely satisfied that the representative of the Owner has been thoroughly and completely instructed in the proper operation of all systems and equipment before final payment is made. If the Architect determines that complete and thorough instructions have not been given by each Contractor to the Owner's representative, then each Contractor shall be directed by the Architect to provide whatever instructions are necessary until the intent of this paragraph of the specification has been complied with. All time required for Owner's instruction to satisfy the above requirements shall be included in this Contract. No extra compensation for such instructions will be allowed.

B. Each Contractor, including but not limited to, the HVAC Contractor, shall submit to the Architect for approval, a total of (6) typed sets, bound neatly in loose-leaf binders, of all maintenance and operating instructions for the installation, operation, care and maintenance of all equipment and systems. All data and literature furnished shall be specific for the make and model of the equipment furnished. General non-specific catalog data will not be acceptable. Information shall indicate possible problems with equipment and suggested corrective action. The manuals shall be indexed for each type of equipment. Each section such as fans, valves, plumbing fixtures, hot water heaters, boilers, air handling units, etc., shall be clearly divided from the other sections. A sub-index for each section shall also be provided. The methodology of setting-up the manuals shall be submitted to the Architect and Owner through the General Contractor for approval prior to final submission of manuals.

C. The instructions shall contain information deemed necessary by the Architect and shall include, but not be limited to, the following:

1. Instructional classes on equipment and systems operation for Owner's representative and maintenance personnel, by engineering staff of each Contractor. Minimum of 48 hours of instruction for minimum of (6) people. Instruction shall include:

a. Explanation of manual and its use.
b. Summary description of the HVAC systems.

c. Purpose of systems.

2. System

a. Detailed description of all systems.
b. Illustrations, schematics, block diagrams, catalog cuts and other exhibits.

3. Operations

a. Complete detailed, step-by-step, sequential description of all phases of operation for all portions of the systems, including start-up, shutdown, adjusting and balancing. Include all posted instruction charts.

4. Maintenance

a. Parts list and part numbers.
b. Maintenance, lubrication and replacement charts and manufacturer's recommendations for preventive maintenance, as applicable to his work.
c. Troubleshooting charts for systems and components.
d. Instructions for testing each type of part.
e. Recommended list of on-hand spare parts.
f. Complete calibration instructions for all parts and entire systems.
g. Instruction for charging, filling, draining and purging, as applicable.
h. General or miscellaneous maintenance notes.

5. Manufacturer's Literature

a. Furnish complete listing for all parts required for models actually furnished.
b. Names, addresses and telephone numbers of manufacturers and suppliers.
c. Describe and operation of all models actually furnished.
d. Furnish all and only pertinent brochures, illustrations, drawings, cuts, bulletins, technical data, certified performance charts and other literature with the model actually furnished to be clearly and conspicuously identified.
e. Internal wiring diagrams and engineering data sheets for all items and/or equipment furnished under each Contract.
f. Guarantee and warranty data.

6. Each Contractor shall furnish instructions for lubricating each piece of equipment installed by him. Instructions shall state type of lubricant, where and how frequently lubrication is required. Frame instructions under glass and hang in a location as directed by Architect.

1.23 MANUFACTURER'S REPRESENTATIVE AND COMMISSIONING OF SYSTEMS

A. Each Contractor shall provide, at appropriate time or as directed by the Architect, the on-site services of a competent factory trained Engineer or authorized representative of particular manufacturer of equipment provided under his Contract, such as for the air handling units, automatic temperature controls, building automation system (BAS), fire pump, domestic hot water heaters, boilers, etc., provided under this Contract, to instruct the Owner, inspect, adjust and place in proper operating condition any item provided by him, as applicable.

B. The HVAC Contractor, as applicable, shall commission and set in operating condition all major equipment and systems, such as the condenser water, hot water and all air handling systems, etc., in the presence of the applicable equipment manufacturer's representatives, and the Owner and Architect's representatives. In no case will major systems and equipment be commissioned by any of the Contractor's forces alone, without the assistance or presence of the equipment manufacturers.

C. A written report shall be issued by the particular equipment manufacturer and the Mechanical Contractor summarizing the results of the commissioning and performance of each system for the Architect's record. No additional compensation will be allowed for any Contractor for such services.

D. The Contractor shall prepare and submit to the Architect for acceptance, a schedule of anticipated system commissioning. No system shall be commissioned without prior acceptance of the schedule by the Architect and Owner. No systems shall be commissioned prior to submittal and acceptance of Operation and Maintenance Manuals.

E. Functional Performance & Integrated Systems Testing Functional Performance & Integrated Systems Testing is part of the Commissioning Process. Functional Performance & Integrated Systems Testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority. Refer to Section 019113. Commissioning, for functional performance and integrated systems testing and commissioning requirements.

F. Training of the of the VAMC operation and maintenance personnel is required in cooperation with the VA Resident Engineer. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 017900, Demonstration and Training, and Section 019113, Commissioning for contractor training requirements.

PART 2 – PRODUCTS

2.1 NOT USED

PART 3 – EXECUTION

3.1 NOT USED

- - - END - - -

SECTION 25 10 00
DIRECT DIGITAL / AUTOMATIC TEMPERATURE CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Basic Material and Methods, Section 25 05 00, Division 23 and other Division 1 Specification Sections, apply to this Section.

B. LEED™ REQUIREMENTS, Refer to Section 018113 – SUSTAINABLE DESIGN REQUIREMENTS

1.2 DESCRIPTION

B. The control system(s) shall be as indicated on the project documents, point list, drawings and described in these specifications. This scope of work shall include a complete and working system including all engineering, programming, controls and installation materials, installation labor, commissioning and start-up, training, final project documentation and warranty.

C. Engineering Control Center (ECC) shall include:

1. Operator Workstation Web-Browser User Interface (UI).
2. Ethernet, IP Supervisory Network.
3. Portable Laptop servicing device with software.
4. Graphic Operational Interface.
5. Software Configuration Tools (SCT).
6. Scheduling and Alarm Management software.
7. Network Automation Nodes (NAN)
8. Network Application Controllers (NAC).
9. Data and File Server (DFS).
10. Unitary Application Controller (UAC).
11. ANSI/ASHRAE Standard 135-2008 BACnet compliant controllers.
12. Connected I/O devices.
13. Third party system Data Integration.

D. The Controls Contractor's work shall include all labor, materials, special tools, equipment, enclosures, power supplies, software, software licenses, Project specific software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, submittals, testing, verification, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, Warranty, specified services and items required by the Contract for the complete and fully functional Controls Systems.

E. Following control devices and systems shall be used to provide the functional requirements of HVAC equipment and systems.

1. Direct Digital Control (DDC) of HVAC equipment and systems with electric or electronic positioning of valves and dampers.

2. Terminal units including VAV Boxes, Fan Coil Units, and similar units for control of room environment conditions may be equipped with integral controls furnished and installed by the equipment manufacturer or field mounted. Refer to equipment specifications and as indicated in project documents.

F. The control subcontractor shall supply as required, all necessary hardware equipment and software packages to interface between new system Network Automation Node/Network Application Controller (NAN/NAC) as part of this contract. Number of area controllers required is dependent on the type and quantity of devices, hardware and software points provided. Network area controllers are same as remote controller units (RCU).

G. The control systems shall be designed such that each mechanical system shall operate under stand-alone mode. Temperature Controls contractor shall provide controllers for each mechanical system. In the event of a network communication failure, or the loss of any other controller, the control system shall continue to operate independently. Failure of the ECC shall have no effect on the field controllers, including those involved with global strategies.

H. The Top End of the NAN/NAC shall communicate using American Society of Heating and Refrigerating Engineers/American National Standards Institute (ASHRAE/ANSI) Standard 135(BACnet) protocol. The NAN/NAC shall reside on the BACnet/IP Ethernet (ISO 8802-3) local area network, and provide information via standard BACnet object types and application services. The Bottom End of the NAC, the unit level controllers and all other field devices shall reside on the BACnet MS/TP protocol. The intent of this specification is to provide a peer-to peer networked, stand-alone, distributed control system.

I. The control system shall accommodate 10 users simultaneously, and the access to the system should be limited only by operator password. Note: Final number of users shall be confirmed by the Owner.

1.3 WORK INCLUDED

A. Furnish and install a complete system of automatic temperature controls to make a fully operational and controllable building HVAC system.

B. The system shall be all electric DDC (direct digital control).

C. All system components shall be installed in accordance with local and State codes.

D. Secure all permits and local/State approval for all components and installation as specified under this Section.

E. Provide complete commissioning for all control system components and sequences of operation.

F. Preparation and submission of shop drawings.

1.4 RELATED SECTIONS

A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

B. Division 21

C. Division 22

D. Division 23

E. Division 25

F. Division 26

G. Section 28 31 00, FIRE DETECTION AND ALARM.

H. Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

I. Section 21 10 00, WATER-BASED FIRE-SUPPRESSION SYSTEMS.

J. Section 235235 PACKAGED GAS-FIRED HYDRONIC BOILERS

K. Section 23 64 00, PACKAGED WATER CHILLERS.

L. Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.

M. Section 23 36 00, AIR TERMINAL UNITS.

N. Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS.

O. Section 23 31 00, HVAC DUCTS AND CASINGS.

P. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

Q. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

R. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.

S. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW).

T. Section 26 27 26, WIRING DEVICES.

U. Section 26 32 13, ENGINE GENERATORS.

1.5 DEFINITIONS

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

B. ACU: Auxiliary Control Unit (ACU) used for controls of air handling units, reports to RCU.

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

D. BACnet: Building Automation Control Network Protocol, ASHRAE Standard 135.

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

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

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

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

I. Control Unit (CU): Generic term for any controlling unit, stand-alone, microprocessor based, digital controller residing on secondary LAN or Primary LAN, used for local controls or global controls. In this specification, there are three types of control units are used; Unitary Control Unit (UCU), Auxiliary Control Unit (ACU), and Remote Control Unit (RCU).

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

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

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

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

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

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

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

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

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

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

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

U. GIF: Abbreviation of Graphic interchange format.

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

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

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

Y. I/P: Internet Protocol-global network, connecting workstations and other host computers, servers etc. to share the information.

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

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

BB. Network: A set of computers or other digital devices communicating with each other over a medium such as wire, coax, fiber optics cable etc.

CC. Network Area Controller: Digital controller, supports a family of auxiliary control units and unitary control units, and communicates with peer-to-peer network for transmission of global data.

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

EE. MS/TP: Master-slave/token-passing.

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

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

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

II. Peer-to-Peer: A networking architecture that treats all network stations as equal partners.

JJ. PICS: Protocol Implementation Conformance Statement.

KK. UAC: Unitary Application Controller, digital controller, dedicated to a specific piece of terminal equipment, such as VAV boxes, fan coil units, etc.

1.6 REFERENCES

A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.

B. Material standards shall be as specified or detailed hereinafter and as follows:

1. NFPA 70 – National Electric Code.
2. UL-916 – Energy Management Systems.
3. UL-873 – Temperature Indication and Regulating Equipment.
4. FCC; Part 15, Subpart J – Class A computing Equipment.
5. UL-864 – Fire and Smoke Control.

1.7 SYSTEM DESCRIPTION

A. Furnish and install, as hereinafter specified, a combination direct digital/ electric/electronic temperature control system and Building Automation System (BAS). The system shall be comprised of a network of various independent Stand-alone Digital Controllers, electric/electronic control equipment, thermostats, sensors, controllers, valves, dampers, actuators, panels and related hardware, software and other accessory equipment, along with a complete system of electrical control wiring, and software generation to fill the intent of the specifications and provide for a complete and operable system.

B. The control systems shall be installed by competent control mechanics and electricians regularly employed by the manufacturer of the control equipment. All control equipment shall be the product of one (1) manufacturer and all components shall be capable of interfacing with the HVAC equipment. The factory trained Contractor must maintain adequate staff and offer standard services to fully support the owner in the timely maintenance, repair, and operation of the control system. Contractors who do not maintain such staff and offer services or must develop some for this project are not acceptable.

C. Bids from franchised dealers or others whose principal business is not the manufacture, installation and service of temperature control systems will not be acceptable.

D. The Contractor shall submit a copy of the manufacturer's standard software and firmware licensing agreement for the owner's signature. 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 constrained within such software.

E. All products of the Building Automation System shall be provided with the following agency approvals. With the submittal documents, verification that the approvals exist for all submitted products shall be provided. Systems or products not currently offering the following approvals are not acceptable.

1. UL-916; Energy Management Systems

2. UL-873; Temperature Indication and Regulating Equipment UL-864; Subcategories UUKL, QVAX, UDTZ; Fire and Smoke Control Systems
3. FCC; Part 15, Subpart J, Class A Computing Devices

F. All products shall be labeled with the appropriate approval markings. System installation shall comply with NFPA, NEMA, Local and National Codes.

1.8 SUBMITTALS

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

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

1. A wiring diagram for each type of input device and output device including DDC controllers, modems, repeaters, etc. Diagram shall show how the device is wired and powered, showing typical connections at the digital controllers and each power supply, as well as the device itself. Show for all field connected devices, including but not limited to, control relays, motor starters, electric or electronic actuators, and temperature pressure, flow and humidity sensors and transmitters.
2. A diagram of each terminal strip, including digital controller terminal strips, terminal strip location, termination numbers and the associated point names.
3. Control dampers and control valves schedule, including the size and pressure drop.
4. Installation instructions for smoke dampers and combination smoke/fire dampers, if furnished.
5. Catalog cut sheets of all equipment used. This includes, but is not limited to DDC controllers, panels, peripherals, airflow measuring stations and associated components, and auxiliary control devices such as sensors, actuators, and control dampers. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted. Each submitted piece of literature and drawings should clearly reference the specification and/or drawings that it supposed to represent.
6. The sequence of operation for each HVAC system and the associated control diagrams shall be provided. The sequence should include normal operation along with failure modes of operation detailing any software lockouts that require user intervention. Equipment and control labels shall correspond to those shown on the drawings. Equipment and control labels shall correspond to those shown on the drawings.
7. The Controls Contractor shall be responsible for coordinating a meeting with the Owner, Construction Manager, Commissioning Agent to review and finalize the following information which shall then be submitted for approval:
   a. Owner naming convention for all points.
   b. Provide Graphic templates for every system type along with Graphic penetration schemes to be reviewed by the Owner.
   c. Review and finalize the points to be trended and derive the trend method and frequency of trends. The Controls Contractor shall then review this for any potential Network bandwidth issues and make the appropriate configurations to prevent communication bottle necks.
   d. Confirm space temperature setpoints along with configurations for providing space control with deadband or without deadband.
   e. Review and finalize all point alarm limits.
   f. Review and finalize all User Security groupings.
   g. Confirm hours of operation for Occupied/Unoccupied scheduling strategies.
8. Furnish PICS for each BACNET compliant device.

9. Provide Electrical load calculations for the entire ATC system as follows.

    a. Electrical Load calculation sheets shall be provided as part of this submittal package. Provide on a panel by panel basis grouping the loads by floor providing a total for the floor.
    b. This shall also apply to VAV box loading when utilizing step down transformers for 24VAC distribution.
    c. The ATC contractor shall review the Electrical power plans for the dedicated ATC circuits and indicate in the initial submittal the panels/controllers that will be on each circuit with the panel and circuit number depicted.
    d. The KVA and Electrical Panel/Circuit number will also be shown on the ATC controller Network riser diagrams showing totals for panels and totals for floors.
    e. If additional circuits are required, the ATC contractor shall indicate this in the submittal and demonstrate by the load calculations the quantity of additional circuits that are required.
    f. The Electrical Load Calculations shall be updated and submitted with the final as-built documents.

10. All UUKL components shall be depicted and identified.

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

D. As Built Control Drawings:

1. Furnish three (3) copies of as-built drawings for each control system. The documents shall be submitted for approval prior to final completion.
2. Furnish one (1) stick set of applicable control system prints for each mechanical system for wall mounting. The documents shall be submitted for approval prior to final completion.
3. Furnish one (1) CD-ROM in CAD DWG and/or .DXF format for the drawings noted in subparagraphs above.

E. Operation and Maintenance (O/M) Manuals):

1. Submit in accordance with Article, INSTRUCTIONS, in Specification Section 01 78 23, GENERAL REQUIREMENTS.
2. Include the following documentation:

    a. General description and specifications for all components, including logging on/off, alarm handling, producing trend reports, overriding computer control, and changing set points and other variables.
    b. Detailed illustrations of all the control systems specified for ease of maintenance and repair/replacement procedures, and complete calibration procedures.
    c. One copy of the final version of all software provided including operating systems, programming language, operator workstation software, and graphics software.
    d. Complete troubleshooting procedures and guidelines for all systems.
    e. Complete operating instructions for all systems.
    f. Recommended preventive maintenance procedures for all system components including a schedule of tasks for inspection, cleaning and calibration. Provide a list of recommended spare parts needed to minimize downtime.
    g. Licenses, guaranty, and other pertaining documents for all equipment and systems.

h. Training Manuals: Submit the course outline and training material to the Owner for approval three (3) weeks prior to the training to VA facility personnel. These persons will be responsible for maintaining and the operation of the control systems, including programming. The Owner reserves the right to modify any or all of the course outline and training material.

F. Submit Performance Report to Resident Engineer prior to final inspection.

1.9 QUALITY ASSURANCE

A. Criteria:

1. The Controls and Instrumentation System Contractor shall be a primary equipment manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Facility Management Systems of similar size, scope and complexity to the EEC specified in this Contract. Distributors, manufacturer's representatives and wholesalers will not be acceptable.
2. Single Source Responsibility of subcontractor: The Contractor shall obtain hardware and software supplied under this Section and delegates the responsibility to a single source controls installation subcontractor. The controls subcontractor shall be responsible for the complete design, installation, and commissioning of the system. The controls subcontractor shall be in the business of design, installation and service of such building automation control systems similar in size and complexity.
3. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in production and installation of HVAC control systems. Products shall be manufacturer's latest standard design and have been tested and proven in actual use.
4. The controls subcontractor shall provide a list of no less than five similar projects which have building control systems as specified in this Section. These projects must be on-line and functional such that the Department of Veterans Affairs (VA) representative would observe the control systems in full operation.
5. The controls subcontractor shall have (minimum of three years) experience in design and installation of building automation systems similar in performance to those specified in this Section. Provide evidence of experience by submitting resumes of the project manager, the local branch manager, project engineer, the application engineering staff, and the electronic technicians who would be involved with the supervision, the engineering, and the installation of the control systems. Training and experience of these personnel shall not be less than three years. Failure to disclose this information will be a ground for disqualification of the supplier.
6. The controls subcontractor shall have in-place facility within 50 miles with technical staff, spare parts inventory for the next five (5) years, and necessary test and diagnostic equipment to support the control systems.
7. Provide a competent and experienced Project Manager employed by the Controls Contractor. The Project Manager shall be supported as necessary by other Contractor employees in order to provide professional engineering, technical and management service for the work. The Project Manager shall attend scheduled Project Meetings as required and shall be empowered to make technical, scheduling and related decisions on behalf of the Controls Contractor.

B. Codes and Standards:

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

3. Peer-to-peer controllers, unitary controllers shall conform to the requirements of UL 916, Category PAZX.

1.10 PERFORMANCE

A. The system shall conform to the following:

1. Graphic Display: The system shall display up to 4 graphics on a single screen with a minimum of (20) dynamic points per graphic. All current data shall be displayed within (10) seconds of the request.
2. Graphic Refresh: The system shall update all dynamic points with current data within (10) seconds. Data refresh shall be automatic, without operator intervention.
3. Object Command: The maximum time between the command of a binary object by the operator and the reaction by the device shall be (10) seconds. Analog objects shall start to adjust within (3) seconds.
4. Object Scan: All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or work-station will be current, within the prior (10) seconds.
5. Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed (10) seconds.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every (5) seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
7. Performance: Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every five (5) seconds. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
8. Multiple Alarm Annunciations: All workstations on the network shall receive alarms within (5) seconds of each other.
9. Reporting Accuracy: Listed below are minimum acceptable reporting accuracies for all values reported by the specified system:

Measured Variable	**Reported Accuracy**
Space temperature	±0.5 degrees C (±1 degrees F)
Ducted air temperature	±1.0 degrees C [±2 degrees F]
Outdoor air temperature	±1.0 degrees C [±2 degrees F]
Water temperature	±0.5 degrees C [±1 degrees F]
Relative humidity	±2 percent RH
Water flow	±5 percent of full scale
Air flow (terminal)	±10 percent of reading
Air flow (measuring stations)	±5 percent of reading
Air pressure (ducts)	±25 Pa [±0.1 "W.G.]
Air pressure (space)	±3 Pa [±0.001 "W.G.]
Water pressure	±2 percent of full scale *Note 1
Electrical Power	5 percent of reading
CO2	+3% of reading [±40 ppm]

Note 1: for both absolute and differential pressure

1.11 WARRANTY

A. Labor and materials for control systems shall be warranted for a period as specified under Warranty in Section 01 00 00, GENERAL REQUIREMENTS.

B. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no cost or reduction in service to the owner. The system includes all computer equipment, transmission equipment, and all sensors and control devices.

C. The on-line support service shall allow the Controls supplier to dial out over telephone lines to monitor and control the facility's building automation system. This remote connection to the facility shall be within two (2) hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekend and holidays. If the problem cannot be resolved with on-line support services, the Controls supplier shall dispatch the qualified personnel to the job site to resolve the problem within 24 hours after the problem is reported.

D. Controls and Instrumentation subcontractor shall be responsible for temporary operations and maintenance of the control systems during the construction period until final commissioning, training of facility operators and acceptance of the project by VA.

1.12 EXTENDED GUARANTEE PERIOD SERVICES

A. Refer to article, EXTENDED GUARANTEE PERIOD SERVICES, Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION for additional experience requirements of the control contractor.

B. Comprehensive maintenance and repair related services shall be provided for the automatic controls provided on the project. The items of equipment and systems covered under semi-annual service shall be:

1. The Engineering Control Center (ECC) and associated peripherals (e.g., keyboard, mouse, printer, monitor, hard disks, floppy disks, operating and instructional manuals).
2. The field data gathering distribution digital control panels and pneumatic local temperature control panels for the HVAC systems.
3. Automatic control systems for all chillers, chilled water pumps, including variable speed drive packages, differential pressure controllers and chilled water control valves.
4. Automatic control systems for all steam and hot water systems.
5. Automatic temperature and humidity control systems for all occupied areas.
6. Miscellaneous HVAC control systems and subsystems that are in communications with the ECC. Examples: Mechanical equipment rooms, electrical equipment rooms, elevator machine rooms, emergency generator rooms, telephone equipment rooms, transformer/switchgear rooms, vestibules and special exhaust systems.
7. All automatic control systems interfacing with the central ECC system and other disciplines (e.g., plumbing and electrical trades for measuring and controlling temperature, flow rate, quantities, pressure, demand, and maintaining alarms).

C. Qualifications: See Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

D. Replacement Parts: See Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

E. Maintenance of Computer Software Programs: The Contractor's Supplier shall maintain all software programs included in the ECC and the digital controllers. In addition, all factory upgrades to the system and subsystem software shall be added to the systems, when they become available, at no additional cost to the government throughout the warranty period. New features, such as modification in the hardware system are not considered upgrades in this context.

F. Maintenance of ECC and Local Field Panels: The Contractor's Supplier shall inspect, repair, replace, adjust, and calibrate, as required, the Operator's Workstation, associated peripheral equipment, and local data gathering panels. The controls Supplier shall then furnish a report describing the status of the equipment, problem areas (if any) noticed during service work, and description of the corrective action taken. The report shall clearly certify that the software package is in working condition and all sensors are duly calibrated.

1.13 INSTRUCTIONS

A. Instructions to VA operations personnel: Perform in accordance with Article, INSTRUCTIONS, in Specification Section 01 79 00, GENERAL REQUIREMENTS, and as noted below. Contractor shall also video tape instruction sessions noted below.

1. First Phase: Formal instructions to the VA facilities personnel for a total of 48 hours, conducted sometime between the completed installation and prior to the performance test period of the control system, at a time mutually agreeable to the Contractor and the VA.
2. Second Phase: This phase of training shall comprise of on the job training during start-up, checkout period, and performance test period. VA facilities personnel will work with the Contractor's installation and test personnel on a daily basis during start-up and checkout period. During the performance test period, controls subcontractor will provide 48 hours of instructions to the VA facilities personnel.
3. The O/M Manuals shall contain approved submittals as outlined in SUBMITTALS. The Controls subcontractor will review the manual contents with VA facilities personnel during second phase of training.

B. Training by independent or franchised dealers who are not direct employees of the controls supplier will not be acceptable.

1.14 PROJECT CONDITIONS (ENVIRONMENTAL CONDITIONS OF OPERATION)

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

B. The CUs and associated equipment used in controlled environment shall be mounted in NEMA 1 enclosures for operation at 0 to 50 degrees C (32 to 122 degrees F) at a relative humidity of 10 to 90 percent non-condensing.

C. The CUs used outdoors shall be mounted in NEMA 4 waterproof enclosures, and shall be rated for operation at –40 to 65 degrees C (-40 to 150 degrees F).

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

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

1.15 APPLICABLE PUBLICATIONS

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

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

1. Standard 135-04 .....BACNET Building Automation and Control Networks

C. American Society of Mechanical Engineers (ASME):

1. B16.18-01.....Cast Copper Alloy Solder Joint Pressure Fittings.
2. B16.22-01.....Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
3. BPVC-CC-N-04 .....Boiler and Pressure Vessel Code

D. American Society of Testing Materials (ASTM):

1. B32-04.....Standard Specification for Solder Metal
2. B88-03.....Standard Specifications for Seamless Copper Water Tube
3. B88M-05.....Standard Specification for Seamless Copper Water Tube (Metric)
4. B280-03.....Standard Specification for Seamless Copper Tube for Air-Conditioning and Refrigeration Field Service
5. D2737-03 .....Standard Specification for Polyethylene (PE) Plastic Tubing

E. Federal Communication Commission (FCC):

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

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

1. 802.3-05 .....Information Technology-Telecommunications and Information Exchange between Systems-Local and Metropolitan Area Networks- Specific Requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access method and Physical Layer Specifications

G. Instrument Society of America (ISA):

1. 7.0.01-1996 .....Quality Standard for Instrument Air

H. National Fire Protection Association (NFPA):

1. 70-05 .....National Electric Code
2. 90A-02 Standard for Installation of Air-Conditioning and Ventilation Systems

I. Underwriter Laboratories Inc (UL):

1. 94-06 .....Tests for Flammability of Plastic Materials for Parts and Devices and Appliances
2. 294-05 .....Access Control System Units
3. 486A/486B-04- .....Wire Connectors
4. 555S-03.....Standard for Smoke Dampers
5. 916-Rev 2-04 .....Energy Management Equipment
6. 1076-05 Proprietary Burglar Alarm Units and Systems

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PART 2 - PRODUCTS

2.1 BUILDING AUTOMATION SYSTEM ARCHITECTURE

A. General

1. The Building Automation System shall consist of a number of Nodes and associated equipment connected by industry standard network practices. All communication between Nodes shall be by digital means only.
2. The Building Automation System network shall at minimum comprise of the following:

   a. Operator Workstations –
   b. Network System Server
   a. Alternate for Combination Operator Workstation/Network Server
   c. Portable Operators Terminal
   d. Network processing, data storage and communication equipment including file servers.
   e. Routers, bridges, switches, hubs, modems and the like communications equipment.
   f. Active processing Nodes including field panels.
   g. Intelligent and addressable elements and end devices.
   h. Third-party equipment interfaces.
   i. Other components required for a complete and working Building Automation System.

3. The Building Automation System shall be accessible via Enterprise Intranet and Internet browser with security protection for user access.
4. The Building Automation System shall support auto-dial/auto-answer communications to allow Building Automation System Nodes to communicate with other remote BAS Nodes via standard telephone lines.
5. The PC Workstations, File servers and principal network equipment shall be standard products of recognized major manufacturers available through normal PC vendor channels. “Clones” are not acceptable.
6. Provide 10 site licenses for all software residing in the Building Automation System and transfer these licenses to the Owner prior to completion.

B. Network

1. The Building Automation System shall incorporate a primary Tier 1 and Tier 2 networks. At the Contractor’s option, the Building Automation System may also incorporate integrated tertiary Tier 3 network.

   a. The Tier 1 portion of the Network shall comprise the Operator Workstations, Network File Servers, Network Application Nodes (NAN), Network Application Controllers (NAC), Web Servers and IP based Integration Controllers. This shall be the main backbone of the system which shall be an Ethernet 10/100bT LAN/WAN, using BACnet/IP as the communications protocol.
   b. The Tier 2 portion of the Network shall comprise the various Unitary Application Controllers (UAC). These shall communicate via BACnet MS/TP field buses managed by the NAN/NAC’s. Minimum speed shall be 76.8kbps. The Level 2 field bus consists of an RS485, token passing bus.

2. The Building Automation System Network shall utilize an open architecture capable of:

   a. Utilizing standard Ethernet communications of 10/100/1000/10000 MB/sec with a minimum speed of 100Mb/sec. This shall be the Tier 1 level of the Network and all communication components shall comply with the following at a minimum:

      1) Redundant Server communication rate shall be 10 Gbps between servers
      2) Fiber Optic communication rate shall be a minimum of 1 Gbps.
      3) CAT 6 internal building communication rate between Tier 1 controllers shall be a minimum of 100 Mbps.

   b. Connecting via BACnet.

3. The Building Automation System network shall support both copper and optical fiber communication media. As a minimum provide CAT 6 cabling within the building for Tier 1 communication. For any connections between buildings fiber optic cabling shall be used or as shown on the contract drawings.

C. Third-Party Interfaces

1. Building Automation System Contractor shall integrate real-time data from systems supplied by other trades as required.
2. The Building Automation System shall include necessary Building Automation System hardware equipment and software to allow data communications between the Building Automation System and systems supplied by other trades.
3. The trade contractor supplying other systems will provide their necessary hardware and software and will cooperate fully with the Building Automation System Contractor in a timely manner at their cost to ensure the complete data integration.
4. The Building Automation System Contractor shall provide all necessary coordination with vendors, contractors, owners, engineers, and other representatives at no additional cost to the Owner. Provide a completed fully functional, operational, integrated and seamless communicating infrastructure system.

D. Power Fail / Auto Restart

1. Provide for the automatic, orderly and predefined shutdown of parts or all of the Building Automation System following total loss of power to parts or all of the Building Automation System.
2. Provide for the automatic, orderly and predefined startup of parts or all of the Building Automation System following total loss of power to those parts or all of the Building Automation System. Archive and annunciate time and details of restoration.
3. Provide for the orderly and predefined scheduling of controlled return to normal, automatically time scheduled, operation of controlled equipment as a result of the auto restart processes.
4. Maintain the Building Automation System real-time clock operation during periods of power outage for a minimum of 72 hours.

E. Downloading and Uploading

1. Provide the capability to generate Building Automation System software-based sequences, database items and associated operational definition information and user-required revisions to same on designated Operator Workstations and the means to download same to the associated Application Nodes.

2. Provide the capability to upload Building Automation System operating software information, database items, sequences and alarms to the designated Operator Workstations with automatic archiving of same on the Operator Workstations. The functions of this Part shall be governed by the codes, approvals and regulations applying to each individual Building Automation System application.
3. The entire control system shall be approved and listed by UL 916 - Energy Management.
4. All DDC panels shall be powered through uninterruptible power sources (UPS) with sufficient capacity to ride through a (2) minute power interruption between transfers from normal to emergency power. UPS's and wiring shall be provided by the ATC Contractor.
5. Uploading or downloading functions performed at any location shall not affect controllers, communications, inputs, outputs at any location or address within the Building Automation Control Architecture nor shall any controller level functions be disrupted in any manner.

F. Network Automation Nodes (NAN)

1. (NAN) Network Application Nodes shall be stand-alone, multi-tasking, multi-user, real-time digital processor complete with all hardware, software, and communications interfaces, power supplies. The Controls System shall be designed and implemented entirely for use and operation on the Internet. NANs shall have access to data within the industry standard IT network to the Data Server and other NANs as needed to accomplish required global control strategies. The Network Automation Nodes shall be designed, packaged, installed, programmed and commissioned in consideration of their specific service and prevailing operating conditions. They shall be proven standard product of their original manufacturer and not a custom product for this Project.

   a. A failure at a Network Automation Node shall not cause failures or non-normal operation at any other system Network Automation Node other than the possible loss of active real-time information from the failed Network Automation Node.
   b. Ancillary Network Automation Node equipment, including interfaces and power supplies, shall not be operated at more than 80% of their rated service capacity.
   c. NANs shall provide both standalone and networked direct digital control of mechanical and electrical building system controllers as required by the Specifications. The primary NAN shall support a minimum of [5,000] field points together with all associated features, sequences, schedules, applications required for a fully functional distributed processing operation.
   d. NANs shall monitor and report communication status to the Controls Systems Application. The Controls Systems shall provide a system advisory upon communication failure and restoration.
   e. All NANs on the network shall be equipped with all software functionality necessary to operate the complete user interface, including graphics, via a Browser connected to the Node on the network or directly via a local port on the NAN.
   f. All NAN shall be provided with face mounted LED type annunciation to continually display its operational mode, power and communications.
   g. The controllers shall reside on the BACnet Ethernet (ISO 8802-3) local area network and provide Read (Initiate) and Write (Execute) services as defined in Clauses 15.5 and 15.8, respectively of ASHRAE Standard 135, to communicate BACnet objects. Objects supported shall include: Analog input, analog output, analog value, binary input, binary output, binary value, and device. The NAN's shall be tested and certified by the BACnet Testing Laboratory (BTL) as Building Controllers (B-BC).

h. Each NAN shall be provided with the necessary un-interruptible power facilities to ensure its continued normal operation during periods of line power outages of, at minimum, 1-minute duration. Normal functionality shall include all normal software processing, communication with powered field devices and network communications with other powered Controls Systems NAN, Data Servers and OWS. Each NAN shall report its communication status to the Application. The Application shall provide a system advisory upon communication failure and restoration. Each NAN shall retain program, control algorithms, and setpoint information in non-volatile memory in the event of a power failure, and shall return to normal operation upon restoration of power.

i. Each NAN shall have sufficient memory to support its operating system, database, and program requirements, including the following:

1) Data sharing.
2) Device and network management.
3) Alarm and event management.
4) Scheduling.
5) Energy Management.

j. Each NAN shall support firmware upgrades without the need to replace hardware and shall have a minimum of 15 percent spare capacity of secondary system controllers, point capacity and programming functions.

k. Each NAN shall continuously perform self-diagnostics, communication diagnosis, and provide both local and remote annunciation of any detected component failures, low battery condition; and upon failure shall assume the predetermined failure mode.

l. Each NAN shall monitor the status of all overrides and inform the operator that automatic control has inhibited, and allow the operator to manually override automatic or centrally executed command.

m. Provide the capability to generate and modify the Controls Systems Application software-based sequences, database elements, associated operational definition information and user-required revisions to same at any designated Workstation together with the means to download same to the associated System Controllers.

n. In the event of loss of normal power, there shall be orderly shutdown of the controllers to prevent the loss of database or software programming. When power is restored flash memory, battery backup or super capacitor will be automatically loaded into non-volatile flash memory and shall be incorporated for all programming data.

G. Network Application Controller (NAC)

1. The Network Application Controller (NAC) shall provide the same abilities of the NAN to reside on the Ethernet along with Web based interface. The main differences will be in a lower controller count for the Tier 2 network but this controller shall have direct hardwired input/output capabilities. The NAC's shall be tested and certified by the BACnet Testing Laboratory (BTL) as Building Controllers (B-BC).

a. Each NAC shall have a minimum of 24 hardwired input/output points.

b. Each NAC shall have an integral Input/Output communication bus for point expansion. The input/output expansion modules shall be for point IO only and all control processing algorithms shall reside in the NAC.

c. The NAC's shall be utilized for large systems control and the contractor shall provide an NAC for each of the following systems:

1) Air Handling Unit

2) Chiller Plant (based on the size of the plant, more than a single controller may be required for redundant operation).
3) Boiler plant (based on the size of the plant, more than a single controller may be required for redundant operation).
4) Heat Exchanger Systems for Processed Chilled Water, Reheat/Radiation/Radiant Hot Water, etc.

H. Unitary Application Controller (UAC)

1. Unitary Application Controller (UAC) shall provide both standalone and networked direct digital control of HVAC systems. The UAC's shall be tested and certified by the BACnet Testing Laboratory (BTL) as Advanced Application Controllers (B-AAC) or Application Specific Controllers (B-ASC).
2. A dedicated UAC shall be configured and provided for each terminal HVAC system (VAV Box, Unit Heater, Fan Coil Unit, CV Box)
3. Each UAC shall be able to retain program, control algorithms, setpoints, logic and command information through the use of non-volatile memory (flash, EEPROM). Other information such as trend data, historical data schedules will be maintained for at least 72 hours in the failure and shall return to normal operation upon restoration of power.
4. Each UAC shall report its communication status to the Building Automation System. The Building Automation System shall provide a system advisory upon communication failure and restoration.
5. Each UAC shall support firmware upgrades without the need to replace hardware and shall have a minimum of 15 percent spare capacity of I/O functions. The type of spares shall be in the same proportion as the implemented functions on the controller, but in no case there shall be less than one point of each implemented I/O type.
6. Provide a means to prevent unauthorized personnel form accessing setpoint adjustments and equipment control functions.
7. The UAC shall provide the ability to download and upload configuration data, both locally at the Node and via the FMS communications network.
8. Each UAC shall be a dedicated controller without the need to use expansion modules to accomplish the entire primary control sequences. Sharing controller, sensor, input/output data over any high level or low level network to accomplish the specified control sequences is unacceptable. Global sharing of general data such as OA-T, OA-RH OA-CO^2 levels between controllers over the BMS network is acceptable as long as speed of transmitting the data des not impact the UAC controller ability to perform in any mode of operation.
9. If it is determined that the UAC controller cannot perform specified sequence of operation because of dependency for shared information that Contractor shall provide a higher level controller at no additional cost. This change shall be identified by separate submittal to Design Engineers.

2.2 PORTABLE OPERATOR'S TERMINAL

A. Acceptable Manufacturers subject to compliance with the specification:

1. Dell
2. Compaq
3. Toshiba
4. IBM

B. Provide three (3) portable operator terminal with a minimum LCD display of and a full featured keyboard. The portable operator's terminal shall be hand-held and plug directly into individual distribution control panels as described below. Provide a user friendly, English language prompted interface for quick access to system information, not codes requiring look-up charts.

C. General

1. Furnish portable operator's terminal for system. Portable operator's terminal shall allow for local accessing of program information.
2. Laptop terminal portable operator's terminal shall have the following features:

   a. Intel Pentium Core 2 Duo 2.53 GHz w/3 MB cache
   b. Full active matrix color display with minimum 1024 x 680 resolution, 15".
   c. AC adapter
   d. Battery pack / battery charger
   e. 250 GB fixed disk drive
   f. 3.0 GB of RAM
   g. 8X DVD +/- RW drive
   h. Internal modem
   i. Audio built in
   j. Latest version of Microsoft Windows
   k. Internal Ethernet Adapter Card with UTP/BNC connector
   l. Equipped with both 1 Type III or 2 Type II PCMCIA Slots

      1) Type III 4
      2) Type II PCMC1A Slots

   m. Integrated pointing device

D. Functionality of the portable operator's terminal connected at any high or lower level controller:

1. Access all controllers on the network.
2. Backup and/or restore controller data bases for all system panels, not just the DDC controller.
3. Display all point, selected point and alarm point summaries.
4. Display trending, historical and totalization information.
5. Add, modify, and/or delete any existing or new system point.
6. Command, change setpoint, enable/disable any system point vertical or physical.
7. Program and load custom control sequences as well as standard energy management programs.

E. Connection of a POT on controller to a distributed control processor shall not interrupt nor interfere with normal network operation in any way, prevent alarms from being transmitted or preclude centrally-initiated commands and system modification.

F. Portable operator terminal access to controller shall be password-controlled and menu-driven.

2.3 OPERATOR WORKSTATION/SERVER

A. Basic Interface Description

1. Command Entry/Menu Selection Process: Operator Workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software. The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

2. Graphical and Text-Based Displays: At the option of the user, Operator Workstations shall provide consistent graphical or text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all workstations.

B. Computer System Access Operation Control Stations (OCS) Description: This system access workstation is also referred to as the Building Automation System “Front end”.

C. Provided Workstation with:

1. Workstation shall be general purpose, commercially available, personal computer with sufficient memory and processor capacity to perform all functions described in this specification.
2. Sufficient hard drive memory storage shall be provided to accommodate all fully configured point data bases, all application databases, all graphics data bases, all user-defined reports, and all historical data archival as described in this specification.
3. Each shall include the following:

   a. Intel Core 2 Duo 3.0 GHz, 6 MB cache with 4 GB DDR2 SDRAM memory.
   b. 19" color monitor 1280x1024(SGVA).
   c. SVGA video output (256 MB RAM).
   d. 250 GB fixed disk.
   e. HI-RES bus mouse.
   f. (1) Printer for alarms, minimum 240 characters/seconds.
   g. (1) Printer for reports, minimum Laser printer similar to HP 4000.
   h. 16X DVD +/- RW drive
   i. Telephone modem (56K)
   j. 1 Gbps Ethernet network interface card
   k. Server type platform shall have at a minimum a RAID level 1 array with multiple fixed hot swappable disks for redundancy. Provide minimum two fixed disks.

4. The operator functions provided by the system access Operator Terminal shall include, but not be limited to, the following:

   a. Start and Stop Points
   b. Modify Setpoints
   c. Modify PID Loop Setpoints
   d. Override PID Control
   e. Change Time/Date
   f. Add/Modify Start/Stop Weekly Scheduling
   g. Add/Modify Setpoint Weekly Scheduling
   h. Enter Temporary Override Schedules
   i. Define Holiday Schedules
   j. View Analog Limits
   k. Enter/Modify Analog Warning Limits
   l. Enter/Modify Analog Alarm Limits
   m. Enter/Modify Analog Differentials
   n. View Point History Files

5. A power conditioning class UPS system with one hour backup.
6. The workstation shall provide access to all real or calculated points in the controller to which it is connected, or any other controller in the network. This capability shall not be restricted to a subset of predefined "global points", but shall provide totally open exchange of data between the operator terminal and any DDC panel in the network.

7. Provide English language prompting to eliminate the need for the user to remember command formats or point names. Prompting shall be provided consistent with a user's password clearance and the types of points being displayed, to eliminate the possibility of operator error. Operator shall not require the use of special templates for navigation.
8. On-line, interactive user's "Help" manuals and tutorials shall be provided. Based upon operator request, the "help" function shall provide general system operating instructions, and specific descriptions of commands available in the currently displayed menus.
9. Identification for all real or calculated points shall be consistent for all network devices.
10. In addition to instantaneous summaries, the Operator's Terminal shall allow a user to view a Point History file for system points. Point History files shall provide a record of value of analog points over the last 24 hours, at 30 minute intervals, or a record of the last (10) status changes for binary type points.

D. Dynamic Color Graphic Displays: Color graphics shall be provided as specified in the Execution portion of this specification to optimize system performance analysis and speed alarm recognition.

1. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration drill down scheme, menu selection, and text-based commands.
2. Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.
3. Windowing: The windowing environment of the workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
4. Graphics Definition Package: Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.

   a. The Contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.
   b. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:

      1) Define symbols
      2) Position and size symbols
      3) Define background screens
      4) Define connecting lines and curves
      5) Locate, orient and size descriptive text
      6) Define and display colors for all elements
      7) Establish correlation between symbols or text and associated system points or other displays.

   c. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout, or any other logical grouping of points which aids the operator in the analysis of the facility. To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC panels, including application specific controllers used for DDC unitary or VAV terminal unit control.

5. Graphic

a. Provide graphic screens of each system for this project.
b. Provide the following as a minimum:

1) Each air handling unit and exhaust air handling unit.
2) Chilled water system.
3) Steam system.
4) Hot water system.
5) Each heat exchanger.
6) Each chiller.
7) Each hot water system.
8) Each exhaust fan.
9) Each piece of equipment.
10) Each controlled system.

c. Provide graphic representation of building's form and site plans locating all equipment and panels.
d. Each hardware point shall be represented on graphic screen.
e. Provide floor plan graphics based on as-built backgrounds of each floor of each building and shall include the following:

1) HAVC Floor Plan Graphics

a) Room Temperature, Humidity and CO2 where applicable.
b) If the actual value is outside the alarm parameters or any alarm associated with that sensors UAC is in alarm that value will flash red.
c) Double clicking on the sensor value shall bring up a subsequent graphic screen representing the configuration of that UAC and with setpoint values.
d) If this UAC is served by another major piece of mechanical equipment such as an AHU, HW Heat Exchanger, etc, there shall be a hot link to that units/equipments graphic screen.
e) Scheduling shall also be available from the graphic screen.

2) Lighting Control Floor Plan Graphics

a) Boundary outlines for each lighting control group by lighting control panel as shown on the Electrical Lighting Plans.
b) Each group's occupancy status shall be displayed along with the current occupancy command, delighting status.
c) The lighting control groups local override switch shall be shown in the coordinated location on the floor plan with the current status of the switch.
d) Scheduling of the group shall be possible by double clicking the group along with a separate matrix showing all groups on a floor.
e) Electrical Site Lighting plans shall be utilized for exterior lighting.

f. Selected software points shall be represented on respective process system graph as determined by the Owner. Examples of these software points are:

1) Control loop setpoint value.
2) Control loop auto/manual selection.
3) Lead/lag selection for pumps and other motors.

4) Campus chilled water global points.
5) Calculated points such as run time.
6) Other vertical software points as required.

g. The Contractor shall coordinate all required graphical modes, features, binding, logic, etc., for a complete fully functional graphical operating system. All graphical schemes shall be submitted and approved by Architect/Engineer and Owner prior to programming.

E. Database Configuration

1. Provide database configuration for each hardware and software point.
2. Specific point parameters, such as alarm limits, alarm message, point name and point description shall be as approved by the Owner.

F. Trends

1. Provide real time and historical trends for hardware and software points as directed by the Owner.
2. Archiving or transfer of trend and historical data information shall not interfere, reduce communication throughout stow network speed or reduce local controller operation by any measure, due to trend or historical data capture rates and storage routines.

G. Internet / Intranet Browser

1. A multi-user color graphics and textual interface shall be provided that allows customers to access their Building Automation System data via the Internet or Intranet.
2. Browser shall:

a. Automatically reflect any changes made to the Building Automation System without additional programming.
b. When installed behind a corporate firewall, shall work in conjunction with other security measures that have been implemented.
c. Allow the user to navigate and command the Building Automation System using the same format as the Operator Workstation.
d. Be an industry-standard browser
e. Provide user password access control.
f. Provide the means by which the user can create, edit and view groups of BAS data points.
g. Provide navigation tools for moving between the views. In addition, it shall provide tools for gaining access to help and for logging out of the system.

H. Paging

1. Provide the means of automatic alphanumeric paging of personnel for user-defined Building Automation System events.

a. System shall support both numeric and alpha-numeric pagers, using Alphanumeric, PET, or IXO Protocol at the owner's option.
b. Users shall have the ability to modify the phone number or message to be displayed on the pager through the system software.
c. System shall utilize pager schedules to send pages to the personnel that are "on-call".
d. Contractor shall be responsible for providing a modem for connection to the paging service.

I. Reports

1. Provide real time reports for hardware and software points as directed by the Owner.
2. The ATC Contractor shall program and test all alarming and alarm report routing to final devices such as printer, computers, pagers, monitors, cell phones, www, etc. Alarming requirements and routing shall be coordinated with the Owner by first compiling and all points listing for Owner's review prior to any programming.

J. Network Speed and Transmission

1. The Fiber Optic Backbone shall be a minimum 1 Gigabit per second (GBPS) transmission rate.
2. Network speed (communication rate) 100 megabits per second (MBPS) for all Tier 1 controllers.
3. Network configurations shall be Star, Bus or mixed (Star and Bus).

2.4 DIAL-UP COMMUNICATIONS

A. Auto-dial/auto-answer communications shall be provided to allow stand-alone DDC panels to communicate with remote operator stations on an intermittent basis via telephone lines.

1. Dial-Up Stand-Alone DDC Panels: Auto-dial panels shall automatically place calls to workstations to report critical alarms, or to upload trend and historical information for archiving.

   a. Stand-alone DDC panels shall analyze and prioritize all alarms to minimize the initiation of calls. Non-critical alarms shall be buffered in memory and reported as a group of alarms, or until an operator manually requests an upload of all alarms.
   b. The auto-dial shall include provisions for handling busy signals, "no answers", and incomplete data transfers. Default devices shall be called when communications cannot be established with primary devices.

2. Dial-Up Workstations: Operators at dial-up workstations shall be able to perform all control functions, all report functions, and all database generation and modification functions as described for workstations connected via the local area network. Routines shall be provided to automatically answer calls, and either file or display information sent from remote DDC panels, The fact that communications is taking place with remote control systems over telephone lines shall be completely transparent to an operator.

   a. An operator shall be able to access remote buildings by selection of any facility by its logical name. The PC dial-up program shall maintain a user-definable cross-reference of buildings and associated telephone numbers, so the user shall not be required to remember or manually dial telephone numbers.
   b. A PC workstation may serve as an operator device on a local area network, as well as a dial-up workstation for multiple auto-dial DDC panels or networks. Alarm and data file transfers handled via dial-up transactions shall not interfere with local area network activity, nor shall local area network activity keep the workstation from handling incoming calls.

3. Modem Characteristics: Dial-up communications shall make use of Hayes compatible 56K modems and voice grade telephone lines. Each stand-alone DDC panel may have its own modem, or a group of stand-alone DDC panels may share a modem.

2.5 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. Provide UPS backup for the follow components of the ATC system. All NAN, NAC and UAC controllers, third party interface devices, communication infrastructure, computers, etc. The ATC contractor shall be responsible for sizing the UPS system/system's that will be required. All additional cabinets required for protection shall be part of this projects scope. Load calculations shall be submitted for review.

B. The battery shall be hot-swappable without disconnecting or disrupting the power to the attached load. The UPS shall be sized for 125% of connected load.

C. The UPS shall be provided with remote monitoring for the battery to allow the user the ability to have an alarm be generated when a battery needs to be changed. The interface and if required additional network for this alarming shall be provided as part of this project by the ATC contractor.

D. The ATC contractor shall include the UPS infrastructure on their Network Riser Diagram and submit for review. The UPS/UPS's shall be shown on the project coordination drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Examine project plans for control devices and equipment locations; and report any discrepancies, conflicts, or omissions to Resident Engineer for resolution before proceeding for installation.
2. Work Coordination: Section 01 00 00, GENERAL REQUIREMENTS.
3. Install equipment, piping, wiring /conduit parallel to or at right angles to building lines.
4. Install all equipment and piping in readily accessible locations. Do not run tubing and conduit concealed under insulation or inside ducts.
5. Mount control devices, tubing and conduit located on ducts and apparatus with external insulation on standoff support to avoid interference with insulation.
6. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
7. Run tubing and wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing.
8. Install equipment level and plum.

B. Piping Installation:

1. All piping associated with smoke control shall be hard drawn copper.
2. Tubing passing through or buried in concrete shall be installed in rigid steel conduit of sufficient strength to prevent damage to tubing.
3. Except for short apparatus connections, non-metallic tubing in all exposed locations, including mechanical rooms shall be protected from damage by installing the tubing in electric conduit or raceways. Provide protective grommet where tubing exits conduit.
4. Non-metallic tubing exposed to outdoors shall be protected by a sleeve or larger tubing.
5. In concealed but accessible locations such as above lay-in ceilings, non-metallic tubing may be run without conduit or raceway.

6. All tubing which is not run in conduit or raceway, both metallic and non-metallic, shall be neatly routed and securely fastened to building structure at not more than 36-IN. intervals.
7. Welding shall be performed in accordance with Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.
8. Label and identify control air piping in accordance with specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

C. Electrical Wiring Installation:

1. Install conduits and wiring in accordance with Specification Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.
2. Install signal and communication cables in accordance with Specification Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW).
3. Install conduit and wiring between operator workstation(s), digital controllers, electrical panels, indicating devices, instrumentation, miscellaneous alarm points, thermostats, and relays as shown on the drawings or as required under this section. All wiring shall be installed in conduits.
4. Install all electrical work required for a fully functional system and not shown on electrical plans or required by electrical specifications. Where low voltage power is required, provide suitable transformers. Install all system components in accordance with local Building Code and National Electric Code.

    a. Splices: Splices in shielded and coaxial cables shall consist of terminations and the use of shielded cable couplers. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties.
    b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 300 mm (12 inches) long. Equipment for fiber optics system shall be rack mounted, as applicable, in ventilated, self-supporting, code gauge steel enclosure. Cables shall be supported for minimum sag.
    c. Cable Runs: Keep cable runs as short as possible. Allow extra length for connecting to the terminal board. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.
    d. Use vinyl tape, sleeves, or grommets to protect cables from vibration at points where they pass around sharp corners, through walls, panel cabinets, etc.

5. Conceal cables, except in mechanical rooms and areas where other conduits and piping are exposed.
6. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
7. Grounding: ground electrical systems per manufacturer's written requirements for proper and safe operation.

D. Install Sensors and Controls:

1. Temperature Sensors:

    a. Install all sensors and instrumentation according to manufacturer's written instructions. Temperature sensor locations shall be readily accessible, permitting quick replacement and servicing of them without special skills and tools.
    b. Calibrate sensors to accuracy specified, if not factory calibrated.
    c. Use of sensors shall be limited to its duty, e.g., duct sensor shall not be used in lieu of room sensor.

d. Install room sensors permanently supported on wall frame. They shall be mounted at 1.5 meter (5.0 feet) above the finished floor.
e. Mount sensors rigidly and adequately for the environment within which the sensor operates.
f. Sensors used in mixing plenum, and hot and cold decks shall be of the averaging of type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
g. All pipe mounted temperature sensors shall be installed in wells.
h. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor reading.
i. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.

2. Pressure Sensors:

a. Install duct static pressure sensor tips facing directly downstream of airflow.
b. Install high-pressure side of the differential switch between the pump discharge and the check valve.
c. Install snubbers and isolation valves on steam pressure sensing devices.

3. Actuators:

a. Mount and link damper and valve actuators according to manufacturer's written instructions.
b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed position.
c. Check operation of valve/actuator combination to confirm that actuator modulates valve smoothly in both open and closed position.

4. Flow Switches:

a. Install flow switch according to manufacturer's written instructions.
b. Mount flow switch a minimum of 5 pipe diameters up stream and 5 pipe diameters downstream or 600 mm (2 feet) whichever is greater, from fittings and other obstructions.
c. Assure correct flow direction and alignment.
d. Mount in horizontal piping-flow switch on top of the pipe.

E. Installation of Network:

1. Ethernet:

a. The fiber optic backbone of the Ethernet LAN architecture shall employ IEEE 802.1w Rapid Spanning Tree Protocol for re-routing speed and redundancy. At each fiber to CAT 6 switch there shall be dual switches to prevent a single point failure from disabling network communication.
b. The network shall directly support connectivity to a variety of cabling types. As a minimum CAT 6 cabling within the building after switches. For any connections between buildings a minimum of 50/125 um graded index multimode fiber optic cabling with 8 strands per cable shall be used.

2. BACnet MS/TP (Master Slave/Token Passing)

   a. The ECC shall employ MS/TP communication.

3. Third Party Interfaces: Contractor shall integrate real-time data from building systems by other trades and databases originating from other manufacturers as specified and required to make the system work as one system. Potential interface protocols shall include at a minimum but no limited to MODBUS IP and MSTP and SCADA.

F. Installation of Digital Controllers and Programming:

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

G. Input/Output Point Allowance

1. The BAS Contractor shall provide an allowance for an additional five hundred (500) input/output points to be utilized at the Owners discretion. Each point shall include the following:

   a. Fifty (50) feet of conduit and wire to connect to a field device.
   b. Man hours to provide Engineering, start-up/checkout and graphic programming.
   c. If an additional field device is required such as a sensor, damper, valve, etc; the cost of the field device shall not be included in this allowance.
   d. There shall be an additional eighty (80) point expansion modules provided if it is required for connection to existing controllers that shall be included in the cost of this allowance.

3.2 PROJECT MANAGEMENT

A. The ATC Contractor shall designate a project manager who will be responsible for the following:

1. Construct and maintain project schedule.
2. On-site coordination with all applicable trades and subcontractors.
3. Authorized to accept and execute orders or instructions from Owner/Architect.
4. Attend project meetings as necessary to avoid conflicts and delays.
5. Make necessary field decisions relating to this scope of work.
6. Coordination/Single point of contact.

3.3 NUMBERING/NAMING CONVENTIONS

A. The Contractor shall collaborate with the Owner directly to determine the Owner's preference for naming conventions, etc. before entering the data in the system.

B. As a minimum the ATC Contractor shall submit to the Architect/Engineer and Owner the layout of the network, identifying all DDC controllers. Each controller will be identified by address and system being served. All physical and software generated objects, points and attributes shall be listed along with a description.

3.4 SYSTEM VALIDATION AND DEMONSTRATION

A. As part of final system acceptance, a System Demonstration is required (see below). Prior to start of this Demonstration, the contractor is to perform a complete Validation of all aspects of the Controls and Instrumentation System.

B. Validation

1. Prepare and submit for approval a Validation Test Plan including Test Procedures for the performance verification tests. Test Plan shall address all specified functions of the Engineering Control Center and all specified sequences of operation. Explain in detail actions and expected results used to demonstrate compliance with the requirements of this specification.

B. Demonstration

1. Functional Performance & Integrated Systems Testing Functional Performance & Integrated Systems Testing is part of the Commissioning Process. Functional Performance & Integrated Systems Testing shall be performed by the contractor and witnessed and document by the Commissioning Authority. Refer to Section 019113. Commissioning, for functional performance and integrated systems testing and commissioning requirements.

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SECTION 253523
DDC CFM TRACKING TERMINAL BOXES (VAV, VCV, CV, VVE, CVE Designations)

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Basic Material and Methods, Section 25 05 00, Division 23 and other Division 1 Specification Sections, apply to this Section.

B. LEED™ REQUIREMENTS, Refer to Section 018113 – SUSTAINABLE DESIGN REQUIREMENTS

1.2 WORK INCLUDED

A. Furnish and install temperature controls.

1.3 RELATED SECTIONS

A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

1.4 SUBMITTALS

A. See Section 250500 and General Conditions for additional requirements.

B. Product Data: Provide data for duct materials.

C. Prepare and submit scaled coordination drawings.

D. Manufacturer's Installation Instructions.

PART 2 – PRODUCTS

2.1 DDC CFM TRACKING TERMINAL BOXES (VAV, VCV, CV, VVE, CVE Designations)

A. General

1. For this project, all air terminal boxes shall be purchased/furnished/installed by the HVAC Contractor. Successful terminal box manufacturer shall receive the terminal box controller and actuator from the Building Automation System Contractor and mount them onto the boxes at the box factory. The HVAC Contractor shall pay for installation of the controllers, actuators, etc. onto the boxes.

The HVAC Contractor shall coordinate the shipment of the components, and the Building Automation System Contractor shall pay for shipment of controllers to the air terminal box manufacturer and provide the controls to the box manufacturer in a coordinated sequence to enhance the construction phase.

2. The DDC CFM tracking air terminals shall be totally integrated with the Building Automation System.
3. The DDC CFM tracking air terminal control manufacturers must certify their company's/product capability and reliability to furnish, install, start-up and maintain their proposed system configuration.
4. The following type of air terminal controllers shall be required:

    a. Variable Air Volume Supply
    b. Constant Volume (with heat coil) Supply
    c. Combination Variable/Constant Volume (with heat coil) Supply

5. The Building Automation System Contractor shall submit to the Architect and Owner for approval, within 60 days of receipt of his Contract, a complete submittal on the proposed airflow control systems, to include, but not be limited to, system flow schematic wiring and tubing diagram, identifying control, instruments listing the manufacturer, model number, and their performance capabilities.
6. The direct digital controller shall comply as a “unitary application controller” as specified in Section 25 10 00 – 2.1.H.
7. The Building Automation System Contractor shall provide all necessary factory and/or field labor for complete calibration and adjustment of the airflow control components and shall be responsible for setting all control setpoints, operating sequences and alarming systems contained within the airflow control centers to produce the following overall system performance.
8. In conjunction with the system start-up, the Building Automation System Contractor shall instruct the Owner's personnel in the proper operation of the airflow control system.
9. The Building Automation System Contractor shall guarantee the proper operation of the airflow control system and shall calibrate the initial system installation.
10. The Building Automation System Contractor shall guarantee the proper operation of the system and furnish all required service for one (1) full year from the date of system acceptance.
11. VAV Box reheat valves are furnished by the Building Automation System Contractor and installed by the HVAC Contractor. Wiring of the reheat valve is by the Building Automation System Contractor
12. The Building Automation System Contractor shall provide auto-zeroing function with all required software, programming, timers, scheduling and controller hardware to prevent terminal boxes and their controllers from disrupting the integrity of the environment being served. Disruption of airflow, room pressure relationship, temperature levels will be unacceptable.

B. Air Terminal Box Controller

1. The Controller shall be as specified above.

C. Room Temperature Sensor (with Setpoint Control)

1. In general, only enclosed private offices shall have open setpoint adjustment sensors. All other areas shall be provided with sensors and occupancy override push buttons only. Room sensors with integral setpoint adjustment shall be provided where shown on the drawings. Controller shall be capable of receiving both adjustments from the sensor and separate EEPROM communications interface. The sensors shall be supplied by the Controller manufacturer. The room temperature sensors shall be an RTD type room temperature sensor and shall have an RS-232C communication port. A single cable interface from RS232 to a RJ48 jack on the space sensor is acceptable. Room sensors shall have an accuracy of ±2% at 70°F with a tolerance of 0.4°F. The unit shall provide room temperature data to the controller. The communication port shall allow for direct communication to both of the pair of air terminals directly associated with the sensor, via a hand-held laptop computer.
2. Control of each pair of terminal boxes shall be stand-alone (one [1] controller) and shall not depend on control information from any other Air Terminal Box Controller for primary control. Failure of any component, including the individual microprocessor controlling the unit, shall not cause interruption of control on any other VAV box controller. The DDC controller shall have programmable parameters stored in a non-volatile EEPROM. Each controller shall be capable of addressing read only memory for a specific integrated circuit containing all logic analog amplifiers with programmable gain and offset, analog to digital converter for RS-485 communication. No battery backup shall be necessary. Controller shall also have capabilities of random access memory operating at a communication rate of 4800 baud as standard. Software capabilities shall have multiple stand-alone control strategies which shall be programmed at the factory through service tool or lap-top computer, or BAS active strategy initiated through BAS communications or physical device such as pressure switches, duct sensors, etc., as indicated. The control system shall be capable of tracking one exhaust box based upon the combined supply airflows of multiple supply boxes.
3. The following information (minimum) shall be communicated into the front end and the local room sensors:

Room		
Item	**Readout (Units)**	**Adjustment**
Room Temperature (Actual)	Yes (°F)	Yes
Supply Volume	Yes (CFM)	Yes
Temperature Setpoint	Yes (°F)	Yes

PART 3 – EXECUTION

3.1 INSTALLATION

A. All work shall be installed per manufacturer's instruction and recommendations.

- - - END - - -

SECTION 25 50 00
INSTRUMENTATION TERMINAL DEVICES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Basic Material and Methods, Section 25 05 00, Division 23 and other Division 1 Specification Sections, apply to this Section.

B. LEED™ REQUIREMENTS, Refer to Section 018113 – SUSTAINABLE DESIGN REQUIREMENTS

1.2 WORK INCLUDED

A. Furnish and install temperature controls.

1.3 RELATED SECTIONS

A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

1.4 SUBMITTALS

A. See Section 250500 and General Conditions for additional requirements.

B. Product Data: Provide data for duct materials.

C. Prepare and submit scaled coordination drawings.

D. Manufacturer's Installation Instructions.

1.5 QUALITY ASSURANCE

A. See Section 250500.

PART 2 – PRODUCTS

2.1 INSTRUMENTATION TERMINAL DEVICES

A. Fan and Pump Status (Under 3 HP)

1. Water/air flow for each pump/fan shall be indicated by means of a differential pressure switch which opens an electrical contact as the differential pressure falls below a pre-adjusted pressure range setting. High pressure differential switch shall be suitable for the flow and pressure of each system.

B. Fan and Pump Status (3 HP and Larger)

1. Verification of all air and water for all fans and pumps shall be by an analog current transformer device, which shall be furnished under the Electrical Section of these specifications. The current transformer output shall be a true analog value. Digital output devices will not be considered acceptable.
2. If the fan or pump is controlled via a VFD, the ATC contractor shall furnish the analog current transformer which shall be located within the VFD. The ATC contractor shall calibrate the current transformer status for belt drive motors by removal of the belt to set the on/off status point.

C. Motor Start/Stop

1. Start/stop relay module shall provide either momentary or maintained switching action as appropriate for the motor being started.
2. All relays shall be plugged in, interchangeable, mounted on a circuit board and wired to numbered terminal strips.

D. Energy Meter Systems (Steam, Chilled Water, Hot Water, Oil and Gas)

1. Steam Meter, Gas and Chilled Water

a. Furnish and install steam and chilled water flow/totalization meters and compatible transmitter systems where shown and as scheduled on the point list. Meter shall be independent from the utility meters. Minimum turn-down 20:1. Meter accuracy for gasses shall be +/- 1.0 % of span and +/- 0.7% of span for fluid. Reporting accuracy shall be total (rms) +/- 1.5% of flow rate.
b. Furnish and install an all welded 316 stainless steel vortex shedding metersuitable for installation into 300 psig rated system.
c. Furnish and install a stainless steel vortex flow water metering devices
d. Each flow processor shall be capable of local display of flow condition plus provide information to the BRBII central automation system. Each processor shall be equipped with a battery to maintain all information for ten (10) days at recordings. RS-232 communication interface hardware shall also be required.
e. The individual outputs of each individual energy meter shall be monitored and totalized by the building automation system CPU. All documentation/information shall be as listed under the software manager package, "Energy".
f. All power and control wiring shall be installed in accordance with manufacturer's wiring diagrams and installed per manufacturer's recommendations.
g. Manufacturer shall provide means and data for on-site testing and verifying of calibration of the primary in-line media flow sensor.
h. The Automatic Temperature Control Contractor shall furnish, mount, wire, and program all devices associated with the "Energy" meters.

i. The flow device connections shall be flanged and installed between two (2) companion flanges as the device and service dictate. There shall be a minimum of six (6) pipe diameters of straight, unobstructed pipe upstream and three (3) pipe diameters of straight pipe downstream of the same pipe diameter as the primary flow sensor. A differential pressure transmitter, temperature transmitter and a pressure transmitter shall be provided and installed as required. The differential transmitter shall include three (3) separate valve manifolds. Temperature transmitter shall be furnished and installed when required with RTD type element and threaded thermowell for installation in the media flow piping downstream from the primary sensor unit. A pressure transmitter shall be furnished and installed when required and shall be installed upstream of the primary flow sensor unit.

j. The individual outputs of each individual energy meter shall be monitored and totalized by the building automation system. The remote mounted control panel shall also have a digital readout of current use rate, and status and alarm indication. Control panel shall be UL and NEMA rated.

k. All power and control wiring shall be installed in accordance with manufacturer's wiring diagram and installed per manufacturer's recommendations.

l. Manufacturer shall provide means and data for on-site testing and verifying of calibration of the primary in-line media flow sensor.

2. Steam Condensate, Domestic Water Meters

a. Furnish and install flow meters and compatible transmitter systems where shown and as scheduled on the point list. Meter shall be independent from the utility meters. Minimum turn-down 20:1. Meter accuracy shall be +/- 1.0 % of actual flow. Repeatability shall be no more than 0.2% of actual flow rate. Meter shall be designed to minimize vibration effect and to provide elimination of this effect.

b. The meter shall be an all welded flanged 316 stainless steel magnetic flow meter suitable for installation into 300 psig rated system.

c. The meter shall be suitable for 25% warmer than the fluid operating temperature and for 25% higher than the piping system’s safety valve set pressure, whichever is higher.

d. Each flow processor shall be capable of local display of flow condition plus provide information to the BRBII central automation system. Each processor shall be equipped with a battery to maintain all information for ten (10) days at recordings. RS-232 communication interface hardware shall also be required.

e. The individual outputs of each individual energy meter shall be monitored and totalized by the building automation system CPU. All documentation/information shall be as listed under the software manager package, "Energy".

f. All power and control wiring shall be installed in accordance with manufacturer's wiring diagrams and installed per manufacturer's recommendations.

g. Manufacturer shall provide means and data for on-site testing and verifying of calibration of the primary in-line media flow sensor.

h. The Building Automation System Contractor shall furnish, mount, wire, and program all devices associated with the "Energy" meters.

i. The flow device connections shall be flanged and installed between two (2) companion flanges as the device and service dictate. There shall be a minimum of six (6) pipe diameters of straight, unobstructed pipe upstream and three (3) pipe diameters of straight pipe downstream of the same pipe diameter as the primary flow sensor. A differential pressure transmitter, temperature transmitter and a pressure transmitter shall be provided and installed as required. The differential transmitter shall include three (3) separate valve manifolds. Temperature transmitter shall be furnished and installed when required with RTD type element and threaded thermowell for installation in the media flow piping downstream from the primary sensor unit. A pressure transmitter shall be furnished and installed when required and shall be installed upstream of the primary flow sensor unit.

j. The individual outputs of each individual energy meter shall be monitored and totalized by the building automation system. The remote mounted control panel shall also have a digital readout of current use rate, and status and alarm indication. Control panel shall be UL and NEMA rated.
k. All power and control wiring shall be installed in accordance with manufacturer's wiring diagram and installed per manufacturer's recommendations.
l. Manufacturer shall provide means and data for on-site testing and verifying of calibration of the primary in-line media flow sensor.

E. Low Limit Alarms

1. Electric low temperature warning sensors shall be provided and shall have 20’-0″ low point sensitive elements installed to cover the entire coil area. Provide a minimum of one freezestat per 30 sq.ft. of coil area. Where there are multiple coils, provide one (1) freezestat per coil. Sensors shall be wired to their respective monitoring panel (for freeze alarm) and, separately, to shut down the fan motor. Assure that the bottom 6" of each coil is protected by a freezestat. Capillary shall be serpentine such that the distance between capillary runs shall not exceed 24”.
2. Where there are multiple coils, provide one (1) freezestat per coil. Sensors shall be wired to their respective monitoring panel (for freeze alarm) and, separately, to shut down the fan motor. Provide dual contact device to allow for status and safety circuit wiring without need for additional relay device. Assure that the bottom 6" of each coil is protected by a freezestat.

F. Pressure Transmitters

1. Pressure sensors and transmitters shall be selected to operate within pressure ranges of the systems as specified. Sensors and transmitters shall be mounted at the pipe tap as specified and wired to the digital system controller. Sensor shall be accurate to 0.5% across full pressure span. Sensor shall maintain integrity between 20°F and 75°F.
2. Dirty filter shall be sensed by an electric differential pressure relay with adjustable setpoint for each filter bank. Range shall be as required to meet project requirements. These points shall be mapped back to the network manager for alarm annunciation.
3. Air flow switch shall be sensed by an electric differential pressure relay with adjustable setpoint. Range shall be as required to meet project requirements. Provide dual contact device to allow for status and safety circuit wiring (ex. Humidifier airflow switch) without need for additional relay device.

G. Actuators

1. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action under all environmental conditions (temperature, low power voltage fluctuations, tight seal damper design, maximum air and water flow forces).

a. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
b. Non spring-Return Motors for Valves Larger Than NPS 2-1/2”: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
c. Spring-Return Motors for Valves Larger than NPS 2-1/2”: Size for running and breakaway torque of 150 in. x lbf.
d. Non spring-Return Motors for Dampers Larger than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.

e. Spring-Return Motors for Dampers Larger than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.

2. Electronic Damper and Valve Actuators: Direct-coupled type non-hydraulic designed for minimum 100,000 full-stroke cycles at rated torque. The actuator shall have rating of not less than twice the thrust needed for actual operation of the damper or valve

a. Coupling: V-bolt and V-shaped, toothed cradle.
b. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
c. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.
d. Actuators shall have the ability to be tandem mounted.
e. All spring-return actuators shall have a manual override. Complete manual override shall take no more than 10 turns.
f. Power Requirements (Two-Position Spring Return): 24V ac or dc, Maximum 10VA.
g. Power Requirements (Modulating): Maximum 15 VA at 24V ac.
h. Modulating Signal:
   1) Proportional: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal. Vivarium valves to be fail closed.
   2) Incremental: Dual motor 24V ac drive open, drive closed. For terminal unit control at UAC level only.
i. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
j. Temperature Rating: -22°F to 140ºF.
k. Run Time: 200 seconds open, 40 seconds closed.
l. All actuators shall have a 5 year warranty
m. Valve Actuators:

   1) Size for torque required for valve close-off at maximum pump differential pressure (regardless of water loop system pressures).
   2) Valve and Actuators shall come from the factory fully assembled and tested for functionality, close off, and leakage.
   3) Spring Return Manual Override shall come with a 10 Degree Valve Preload to assure tight close off.
   4) All valve actuators shall have manual override

n. Damper Actuators:

   1) Size for running torque calculated as follows:

      a) Parallel-Blade Damper with Edge Seals: 7 inch-pounds/sq. ft. of damper.
      b) Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. of damper.
      c) Parallel-Blade Damper without Edge Seals: 4 inch-pounds/sq. ft. damper.
      d) Opposed-Blade Damper without Edge Seals: 3 inch-pounds/sq. ft. of damper.
      e) Dampers with 2 to 3 Inches wg. of Pressure Drop or Face Velocities of 1000 to 2500 FPM Multiply the minimum full-stroke cycles above by 1.5.
      f) Dampers with 3 to 4 Inches wg. of Pressure Drop or Face Velocities of 2500 to 3000 FPM Multiply the minimum full-stroke cycles above by 2.0.

2) Spring Return Manual Override actuators shall a factory set 5 Degree Damper Preload.

3. Tracking conventional VAV box damper actuators shall be electronic and shall mount on the damper shaft and shall provide complete modulating control of the damper.

   a. The actuator motor shall de-energize when the damper has reached the operator or system determined position.
   b. Damper actuator position status shall be monitored from the central or remote operator's terminal and shall be displayed in percent open notation. Systems which provide only end switch feedback are not acceptable.
   c. Laboratory air valve actuators shall be electronic.

H. Control Valves

1. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated. REFER to specification section 232113 for valve construction requirements and system service class.
2. Globe Valves NPS 2” and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure. Valves shall have allowable media temperature of 20°F to 281°F to assure that the valve packing will have a long life (valves with narrower allowable media temperatures have no reserve packing capability for long term watertight seal).
3. Globe Valves NPS 2-1/2” and Larger: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc. 2-way valves shall have a rangeability of at least 100:1 and minimum ANSI Class IV leakage.
4. Hydronic system globe valves shall have the following characteristics:

   a. Rating: Class 125 for service at 125 psig. and 250°F operating conditions.
   b. Internal Construction: Replaceable plugs and seats of stainless steel or brass.
   c. Sizing: 3 psig. maximum pressure drop at design flow rate.
   d. Temperature Requirements: Valve and actuator assembly shall be able to operate in ambient temperatures of -22°F to 140°F
   e. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics. Operators shall close valves against pump shutoff head.
   f. Product Life: Valve and actuator assembly shall be rated for a minimum of 200,000 cycles and tested for close off and leakage prior to delivery.

5. Steam system globe valves shall have the following characteristics:

   a. Rating: Class 125 for service at 125 psig. and 250°F operating conditions.
   b. Temperature Requirements: Valve and actuator assembly shall be able to operate in ambient temperatures of -22°F to 140°F.
   c. Product Life: Valve and actuator assembly shall be rated for a minimum of 200,000 cycles and tested for close off prior to delivery.
   d. Internal Construction: Replaceable plugs and seats of stainless steel.
   e. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
   f. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
   g. Sizing:

      1) 10 psig. inlet pressure and 5 psig. pressure drop.

2) Pressure drop across steam valve at a maximum flow of 80 percent of inlet pressure for low-pressure systems and 42 percent for high-pressure systems.
3) 15 psig steam maximum inlet pressure for bronze body globe valves ½" to 2".
4) 35 psig steam maximum inlet pressure for cast iron globe valves 2 ½" to 6".

6. Control Ball Valves NPS 3" and smaller (2" for 3-way valves): Forged brass body, chrome plated brass ball, blowout proof stem and EPDM o-rings with minimum 600 psi body rating. Valve shall contain glass filled ball insert capable of providing equal percentage flow. Valves shall have allowable media temperature of -20°F to 250°F. Flow Characteristics: 2 way valves shall have equal percentage characteristics. 3 way valves shall have an equal percentage characteristic through the control port and a linear characteristic through the bypass port. Coordinate 3-way portions with piping contractor.

   a. Rating: No less than 360 psi at 250°F operating conditions.
   b. Rangeability: 2-way valves shall have a rangeability of at least 100 to 1.
   c. Medium: Valves shall be used with hot water or cold water with up to 50% glycol.
   d. Temperature Requirements: Valve and actuator assembly shall be able to operate in ambient temperatures of -22°F to 140°F.
   e. Sizing:

      1) Minimum 100 psi close off on 2 way valves and 70 psi on 3 way valves.
      2) Maximum differential pressure shall be 35 psi or less to ensure quiet operation.

7. Ball valves over 3": Characterized, v-ported, carbon steel, minimum class 150 flanged body. Carbon or Stainless Steel body, stainless steel ball, leak proof stem and RPTFE seats. Valves shall have allowable media temperature of -20°F to 250°F. Flow Characteristics: 2 way valves shall have equal percentage characteristics.

   a. Rangeability: 2-way valves shall have a rangeability of at least 200 to 1.
   b. Medium: Valves shall be used with hot water or cold water with up to 50% glycol.
   c. Temperature Requirements: Valve and actuator assembly shall be able to operate in ambient temperatures of -22°F to 140°F.

8. Product Life: Valve and actuator assembly shall be rated for a minimum of 200,000 cycles and tested for close off and leakage prior to delivery.

9. Butterfly Valves: 200 psig. maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals. NOTE: **Butterfly valves are not acceptable for modulating applications. Ball valves must be used for this application. All 3-way applications must be coordinated with the piping contractor.**

   a. Body Style: Wafer, Lug, or Groove
   b. Disc Type: Nylon coated ductile iron.
   c. Disc Attachment: Disc shall be permanently mounted to shaft. External pins are not acceptable.
   d. Sizing: 1 psig. maximum pressure drop at design flow rate.

10. Terminal Unit Control Valves: 360 psi forged yellow brass body, nickel plated brass ball, with optimizer insert for modulating applications, blow-out resistant stem, two or three-port as indicated, and threaded ends for chilled or hot water, up to 50% glycol solutions.

Actuators shall be as noted above with 5 year warranty. Spring return is required for all Unit Ventilator heating valves and other terminal equipment that has an outside air source. All non-spring return valves must have manual override ability built in to the actuator.

a. Rating: ANSI class IV, maximum static pressure of 250 psig., minimum fluid temperature of 20ºF and maximum of 250ºF operating conditions.
b. Sizing: 4 psig. maximum pressure drop at design flow rate, to close against pump shutoff head.
c. Flow Characteristics: Two-way and three-valves shall have equal percentage characteristics.

I. Electrical Power Consumption and Demand Meters

1. The building shall have multiple electric power services. The Electrical Subcontractor shall furnish and install new consumption and demand initiation devices on each of the new building electric consumption and demand check meters. The Automatic Temperature Control Contractor shall wire and program the above devices such that electricity consumption (FWH) and demand (kW) are read and recorded by the Building Automation System (BAS)
2. The pulse rate shall be determined by the Electrical Subcontractor.

J. Room Type Instruments

1. DDC room sensors shall be linear precision resistance elements with an accuracy of ±0.5%. Local setpoint adjustment shall be available to change setpoint ±4°F. This setpoint shall be capable of being overridden by the Building Automation System.
2. Mechanical and electric room thermostats shall be of the heavy duty, all-metal type.
3. Provide electric/electronic thermostats as required to suit the control application as outlined herein.

K. Smoke Detection System

1. The HVAC Contractor shall install smoke detectors furnished by the Electrical Subcontractor in all ductwork and/or equipment, as applicable. The Automatic Temperature Control Contractor shall provide all interlocking of air handling units to shut down upon activation (units and fans with capacity of 2000 cfm and larger). Alarm connection of the smoke detectors to building fire alarm system shall be by the Electrical Contractor.
2. All supply and return ventilation systems 2000 cfm and larger shall automatically stop when the in-duct smoke detectors are activated, except where return systems are utilized for smoke exhaust.
3. For supply systems 15,000 cfm and larger, the HVAC Contractor shall provide normally open smoke dampers. Automatic Temperature Control Contractor shall provide all interlocking required controlled in a way that upon fan shutdown, due to fire and/or smoke detection, the smoke dampers will automatically close. The reverse sequence shall occur where dampers are called for to be normally closed.
4. Smoke dampers (at air handling units) shall be properly controlled in a way that the system fans shall not start until dampers are open, except where coordination for fan start-up is required in the Sequences of Operation and system fans shall be shut off before smoke dampers are fully closed. All end switches, damper switches, etc., required shall be provided by the Automatic Temperature Control Contractor.

L. Dampers

1. All automatic dampers shall be furnished by the Automatic Temperature Control Contractor. Dampers shall be single or multiple blades as required. Dampers shall be installed by the Sheet Metal Subcontractor, under the supervision of the Temperature Control Subcontractor. All blank-off plates and conversions necessary to install smaller or larger than duct size dampers shall be the responsibility of the Sheet Metal Subcontractor.
2. All damper frames shall be constructed of extruded aluminum with 5"x1"x1.25" extruded aluminum and shall have flanges for duct mounting. All multiple damper sections must have jackshafts.
3. Damper blades shall not exceed 6" in width. All blades shall be of extruded aluminum airfoil type construction, fabricated from 6063-T5 aluminum. Blades shall be suitable for high velocity performance, ultra-low leakage type, with leakage not greater than 6.2 cfm/sq.ft. at 4" w.g. pressure differential for 48"x48" damper size, as published and certified under AMCA Certified Ratings Program. Damper leakage shall be less than 0.1% of total CFM at maximum damper system velocity.
4. All damper bearings shall be made of nylon or molded synthetic, bushings that turn in the bearings are to be oil impregnated sintered metal.
5. Replaceable butyl rubber seals shall be provided with the damper. Seals shall be installed along the top, bottom and sides of the frame and along each blade edge. Seals shall provide a tight closing, low leakage damper. Leakage and flow characteristic charts must be submitted to the Engineer prior to approval of dampers.
6. The HVAC Contractor shall provide an access door upstream and downstream of each automatic damper location.
7. Dampers: AMCA-rated, parallel, opposed blade designs; 0.1084 inch minimum, galvanized-steel frames with holes for duct mounting; damper blades shall not be less than 0.0635 inch galvanized steel with maximum blade width of .8 inches.

    a. Blades shall be secured to 1/2-inch diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
    b. Operating Temperature Range: -40°F to 200°F
    c. For standard applications, include optional closed-cell neoprene edging.
    d. For low-leakage applications, use parallel- or opposed-blade design with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4 inches wg. when the damper is being held by torque of 50 in. x lbf; when tested according to AMCA 500D.

M. High Static Pressure Sensors (Typical All Air Handling

1. For each fan, provide a pair of analog static pressure sensors located in each of the supply and exhaust fan's suction/discharges, which shall be hardwired to the motor starter to stop the fan(s) upon activation and, in addition, send their signals to the DDC/ system. Provide dual contact device to allow for status and safety circuit wiring without need for additional relay device. One side of each switch shall sense the pressure to be measured and the other side shall reference atmospheric pressure. Should a static pressure be sensed greater than a selected high limit or 6" differential pressure (adj.), the unit shall shut down and an alarm condition shall be annunciated.

N. Airflow/Temperature Measurement Devices

1. General

   a. Each element designed and built to comply with, and provide results in accordance with, accepted practice for duct system traversing as defined in the ASHRAE Handbook of Fundamentals, AMCA publication #203, as well as the Industrial Ventilation Handbook.
   b. The number of sensing element, and the quantity of elements utilized at each installation, shall comply with ASHRAE Standard #111 for equal area duct traversing.
   c. The airflow traverse elements shall produce steady, non-pulsating signals of true flow, with an accuracy of 2% of actual flow for operating velocities as low as 50 feet per minute.
   d. The operating temperature range for the measuring probes shall be -20° F to 140° F. The operating humidity range for the measuring probe shall be 0-99% RH (non-condensing).
   e. The airflow traverse elements shall not induce a pressure drop greater than 0.2 inches of water column at 4000 feet per minute.
   f. The units shall have a self-generated sound rating of less than NC35 and the sound level within the duct shall not be amplified, nor shall additional sound be generated.

2. Products Included in this Section:

   a. Duct and plenum mounted airflow measurement devices
   b. Fan inlet mounted airflow measurement devices

3. Provide airflow/temperature measurement devices where indicated on the plans. Fan inlet sensors shall not be substituted for duct or plenum sensor probes indicated on the plans.

   a. Duct and plenum mounted sensors shall be fabricated of anodized aluminum alloy tube with 303/304 stainless steel mounting brackets.
   b. Fan inlet probes shall be field adjustable to fit the fan inlet and have 303/304 stainless steel mounting feet.

4. Each measuring device shall consist of one or more multi-point measuring probes and a single microprocessor-based transmitter. Each transmitter shall have an LCD display capable of displaying airflow and temperature. Airflow shall be field configurable to be displayed as a velocity or volumetric rate. Each transmitter shall operate on 24 VAC.
5. Each sensing point shall independently determine the airflow rate and temperature, which shall be equally weighted and averaged by the transmitter prior to output. Devices, which average multiple non-linear sensing point signals, are not acceptable. Pitot tube arrays are not acceptable.
6. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter at a given measurement location. Probes and transmitters shall not require field matching for proper operation.
7. The operating airflow range shall be 50-5,000 FPM unless otherwise indicated on the plans.
8. The operating temperature range for the measuring probes shall be -20° F to 140° F. The operating humidity range for the measuring probe shall be 0-99% RH (non-condensing).

9. The operating temperature range for the transmitter shall be -20° F to 120° F. The transmitter shall be protected from weather and water.
10. Each independent airflow sensor shall have a laboratory accuracy of +/-2% of reading over the entire operating airflow range and be wind tunnel calibrated or verified against standards that are traceable to NIST.

    a. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.

11. Each independent temperature sensor shall have a laboratory accuracy of +/-0.15° F over the entire operating temperature range and be calibrated or verified against standards that are traceable to NIST.

12. The number of sensors for each location shall be as follows:

    a. Ducts and plenums:

Area (sq.ft.)	Sensors
<=1	2
>1 to <4	4
4 to <8	6
8 to <12	8
12 to <16	12
>=16	16

    b. Fan inlets: 2 per inlet

13. The airflow/temperature measuring device shall be capable of displaying the airflow and temperature readings of each sensor on the transmitter's LCD display.
14. The transmitter shall fully communicate with the host controls and the ATC utilizing the following interfaces:

    a. Linear analog output signals for airflow and temperature: Field selectable, fuse protected and electrically isolated from all other circuitry, 0-5VDC / 0-10VDC / 4-20mA (4-wire)

    b. RS-485: Field selectable BACnet-MS/TP, Modbus-RTU.

        1) BACnet devices shall provide analog variables for airflow and temperature containing individual sensor airflow rate and temperature data.

15. Airflow/Temperature measuring devices shall be UL listed as an entire assembly.
16. The manufacturer's and or there authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer's placement requirements.

O. Remote/Duct Mounted Static Pressure Sensing Stations (SPSS)

1. The Automatic Temperature Control Contractor shall provide static pressure measuring stations as described herein. Units shall be compatible with the Automatic Temperature Control system provided.

2. The air SPSSs shall be complete with components to provide straightening, multi-sensoring, self-equalizing, equal area traverse, stationary velocity pressure signals. Single-point sensing will not be acceptable. They shall be of all metal construction, 16 gauge minimum galvanized steel casings, aluminum sensors and manifolds, aluminum straightening tubes or honeycombs. Units mounted in fume hood/ganged general exhaust ductwork shall be fully Type 316 stainless steel construction.
3. Flow Measuring Stations for the remote static pressure sensing in the ductwork and at fans shall be furnished, wired and piped by the Automatic Temperature Control Contractor. Units shall be installed in the ductwork and at fans by the HVAC Contractor. Units shall have a minimum of three (3) static pressure sensors per square foot. Interconnecting sensor equipment, based on ASHRAE equal area traverse for the averaging of observations, into one (1) metering port of each (total and static) pressure. The manifold mounting hardware shall be so constructed as to eliminate any possible violation of the integrity of the total or static pressure measurements. The tubing for the equalized total and static pressures shall not be exposed to internal pressures. Tubing for units serving fume hood fans shall be acid/chemical/corrosion resistant. Except for meter connecting ends, all tubing shall be internal. The converted airflow measurement signal shall have an accuracy within 2% of the full scale throughout the static pressure range.
4. Resistance to airflow shall not exceed 0.15 times velocity head for FMS units. The FMS shall not amplify the sound level within the ducts. The range of the transmitter shall be 0-5" w.g.
5. SPSS shall be provided for each variable volume supply, return and exhaust air handling system. SPSSs shall be mounted 2/3 to 3/4 of the way along the longest duct run(s) for each system. SPSS for radioisotope fume hood exhaust system fans shall be mounted in the vertical riser 2/3 to 3/4 of the way along the duct riser, in a fully accessible location, constructed of stainless steel. All Flow Measuring Stations and SPSS's shall be fully accessible.

P. Temperature Sensors (Air Handling Units)

1. All air handling unit temperature sensors shall be averaging sensors which cover the entire area of airflow with multiple sensors provided as necessary to assure a maximum distance of 24" between sensor elements. Units shall be RTD type.

Q. Carbon Dioxide (CO_2) Sensors

1. Wall Mounted CO_2 Sensors

   a. Wall mounted transmitter shall incorporate a silicon-based sensor.
   b. Accuracy at 25°C (77°F): <± (40 ppm + 3% of reading). Measurement range of 0 to 2000 PPM for 0 to 100% RH (non-condensing) and -5 to 45°C (23 to 113°F).
   c. Temperature coefficient of no larger than 0.15%FS/°C. Analog outputs must be jumper selectable: 0-20 mA, 4-20 mA, or 0-10V. Power supply shall be 24 VDC/VAC.
   d. Long term stability shall be <+100 PPM per 5yrs. Must be capable of calibration check in place using certified gases or portable meter. Factory recommended calibration frequency of once per five (5) years.

2. Duct Mounted CO_2 Sensors

   a. Duct mounted transmitter shall incorporate a silicon-based sensor..
   b. Transmitter shall not require a separate aspiration assembly. Sensor shall be in duct when installed with transmitter outside of duct.
   c. Accuracy at 25°C (77°F) shall be <± (30 ppm + 2% of reading).

d. Measurement range of 0 to 2000 ppm for 0 to 100% RH (non-condensing) and -5 to 45°C (23 to 113°F). Unit shall be capable of being calibrated for other ranges: 0-5000 ppm, 0-10,000 ppm, 0-20,000 ppm. Temperature coefficient no larger than 0.15%FS/°C.
e. Analog outputs shall be jumper selectable: 0-20 mA, 4-20 mA, or 0-10V.
f. Power supply must be 24 VDC/VAC.
g. Long term stability shall be <+100 ppm per 5yrs. Must be capable of calibration check in place using certified gases or a portable meter. Factory recommended calibration frequency of once per five (5) years.

R. Oxygen (O_2) Sensors

1. Wall Mounted O_2 Sensors for MRI spaces

a. The system shall be comprised of a wall mounted control panel with local audible and visual alarm including remote monitor and alarming feature for reporting to the ECC.
b. Shall use a sample draw pump system that uses no metal components near or inside the MRI room, eliminating RF interference from the MRI system.
c. Shall provide local audible and visual alarms. Remote monitoring and alarming shall be provided for each sensor MRI space.
d. Accuracy ± 2% of full scale. Temperature range of -20 to 50°C (-4 to 122°F) for 0 to 100% RH (non-condensing) and.
e. Long term stability shall be <± 3% of full scale per 2yrs. Must be capable of calibration check in place using certified gases or portable meter.

2. The ATC contractor shall mount panel in MRI Control Room and pipe sample tube to MRI room. The ATC contractor shall coordinate the location of the panel and the sample tube location per the MRI representative and manufacturers recommended installation instructions.

S. Mushroom Button “Panic” Switch

1. The switch shall be a wall mounted mushroom style switch. When the switch is depressed it shall lock in the depressed position and shall pull to release to the normal position.
2. The switch shall be rated for 24VAC/DC service and shall comply with UL Standards.
3. When depressed the switch shall have an illuminated red LED core to provide positive local indication.
4. The switch shall have 1 normally open and 1 normally closed set of contacts.
5. Mushroom head shall be a minimum of 1 3/4 inches in diameter.

T. Space Pressure Monitor

1. Space pressure monitor shall be as located on the drawings.
2. The space pressure monitor shall measure the differential pressure between two individual spaces utilizing industrial quality differential pressure transducer technology and shall issue a 0-10VDC or 4-20mA control output signal utilizing a 3-mode (P, I, 1/D) controller circuitry to maintain the desired differential pressure between these two areas.
3. The space pressure monitor shall provide an analog output linear to the space pressure being monitored and a digital output to indicate the alarm status of the space for remote monitoring purposes.

a. Remote alarm status shall be via a Form C dry contact.
b. Local, high visibility, LED space pressure status lights

c. Audible alarm with alarm acknowledge (silence) button
d. Local indication shall display the measure differential pressure to the ten thousandth of an inch of water column.

4. The space pressure monitor shall be factory configured for either positive or negative space pressure monitoring based on the room's scheduled usage.
5. The positive/negative pressure alarm activation value, control setpoint value, and alarm activation delay value are to be field adjustable.
6. Switch selectable control mode values shall allow for an in operation @ adjustment of proportional band, reset (integral), and inverse derivative to match system dynamics.
7. Differential pressure transducer performance shall be as follows:

a.	Accuracy:	±0.5% F.S. Terminal Point / ±0.35% F.S. BFSL
b.	Hysteresis:	±0.05%
c.	Linearity:	±0.4%
d.	Repeatability:	±0.1%
e.	Temperature Effects:	< ±0.03% F.S./EF
f.	Over-pressure:	5 PSIG Proof
g.	Response:	< 0.25 seconds for full span input
h.	Noise Filtration:	Low Pass Filter, factory set @ 3.2Hz

8. Three mode differential pressure controller performance shall be as follows:

a.	Proportional Band:	Adjustable from 1% to 100%
b.	Reset:	Adjustable from 0.6 to 6 repeats per minute
c.	Inverse derivative:	Adjustable from 0.5 to 7 minutes per repeat
d.	Hysteresis and dead band:	Within .01% of span
e.	Repeatability:	Within .01% of span.
f.	Control accuracy:	±0.1% of span.

PART 3 – EXECUTION

3.1 INSTALLATION

A. General:

1. Examine project plans for control devices and equipment locations; and report any discrepancies, conflicts, or omissions to Resident Engineer for resolution before proceeding for installation.
2. Work Coordination: Section 01 00 00, GENERAL REQUIREMENTS.
3. Install equipment, piping, wiring /conduit parallel to or at right angles to building lines.
4. Install all equipment and piping in readily accessible locations. Do not run tubing and conduit concealed under insulation or inside ducts.
5. Mount control devices, tubing and conduit located on ducts and apparatus with external insulation on standoff support to avoid interference with insulation.
6. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
7. Run tubing and wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing.
8. Install equipment level and plum.

B. Piping Installation:

1. All piping associated with smoke control shall be hard drawn copper.
2. Tubing passing through or buried in concrete shall be installed in rigid steel conduit of sufficient strength to prevent damage to tubing.
3. Except for short apparatus connections, non-metallic tubing in all exposed locations, including mechanical rooms shall be protected from damage by installing the tubing in electric conduit or raceways. Provide protective grommet where tubing exits conduit.
4. Non-metallic tubing exposed to outdoors shall be protected by a sleeve or larger tubing.
5. In concealed but accessible locations such as above lay-in ceilings, non-metallic tubing may be run without conduit or raceway.
6. All tubing which is not run in conduit or raceway, both metallic and non-metallic, shall be neatly routed and securely fastened to building structure at not more than 36-IN. intervals.
7. Welding shall be performed in accordance with Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.
8. Label and identify control air piping in accordance with specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

C. Electrical Wiring Installation:

1. Install conduits and wiring in accordance with Specification Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.
2. Install signal and communication cables in accordance with Specification Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW).
3. Install conduit and wiring between operator workstation(s), digital controllers, electrical panels, indicating devices, instrumentation, miscellaneous alarm points, thermostats, and relays as shown on the drawings or as required under this section. All wiring shall be installed in conduits.
4. Install all electrical work required for a fully functional system and not shown on electrical plans or required by electrical specifications. Where low voltage power is required, provide suitable transformers. Install all system components in accordance with local Building Code and National Electric Code.

    a. Splices: Splices in shielded and coaxial cables shall consist of terminations and the use of shielded cable couplers. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties.
    b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 300 mm (12 inches) long. Equipment for fiber optics system shall be rack mounted, as applicable, in ventilated, self-supporting, code gauge steel enclosure. Cables shall be supported for minimum sag.
    c. Cable Runs: Keep cable runs as short as possible. Allow extra length for connecting to the terminal board. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.
    d. Use vinyl tape, sleeves, or grommets to protect cables from vibration at points where they pass around sharp corners, through walls, panel cabinets, etc.

5. Conceal cables, except in mechanical rooms and areas where other conduits and piping are exposed.
6. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
7. Grounding: ground electrical systems per manufacturer's written requirements for proper and safe operation.

D. Install Sensors and Controls:

1. Temperature Sensors:

   a. Install all sensors and instrumentation according to manufacturer's written instructions. Temperature sensor locations shall be readily accessible, permitting quick replacement and servicing of them without special skills and tools.
   b. Calibrate sensors to accuracy specified, if not factory calibrated.
   c. Use of sensors shall be limited to its duty, e.g., duct sensor shall not be used in lieu of room sensor.
   d. Install room sensors permanently supported on wall frame. They shall be mounted at 1.5 meter (5.0 feet) above the finished floor.
   e. Mount sensors rigidly and adequately for the environment within which the sensor operates.
   f. Sensors used in mixing plenum, and hot and cold decks shall be of the averaging of type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
   g. All pipe mounted temperature sensors shall be installed in wells.
   h. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor reading.
   i. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.

2. Pressure Sensors:

   a. Install duct static pressure sensor tips facing directly downstream of airflow.
   b. Install high-pressure side of the differential switch between the pump discharge and the check valve.
   c. Install snubbers and isolation valves on steam pressure sensing devices.

3. Actuators:

   a. Mount and link damper and valve actuators according to manufacturer's written instructions.
   b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed position.
   c. Check operation of valve/actuator combination to confirm that actuator modulates valve smoothly in both open and closed position.

4. Flow Switches:

   a. Install flow switch according to manufacturer's written instructions.
   b. Mount flow switch a minimum of 5 pipe diameters up stream and 5 pipe diameters downstream or 600 mm (2 feet) whichever is greater, from fittings and other obstructions.
   c. Assure correct flow direction and alignment.
   d. Mount in horizontal piping-flow switch on top of the pipe.

E. Installation of Digital Controllers and Programming:

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

3.2 PROJECT MANAGEMENT

A. The ATC Contractor shall designate a project manager who will be responsible for the following:

1. Construct and maintain project schedule.
2. On-site coordination with all applicable trades and subcontractors.
3. Authorized to accept and execute orders or instructions from Owner/Architect.
4. Attend project meetings as necessary to avoid conflicts and delays.
5. Make necessary field decisions relating to this scope of work.
6. Coordination/Single point of contact.

3.3 NUMBERING/NAMING CONVENTIONS

A. The Contractor shall collaborate with the Owner directly to determine the Owner's preference for naming conventions, etc. before entering the data in the system.

B. As a minimum the ATC Contractor shall submit to the Architect/Engineer and Owner the layout of the network, identifying all DDC controllers. Each controller will be identified by address and system being served. All physical and software generated objects, points and attributes shall be listed along with a description.

3.4 SYSTEM VALIDATION AND DEMONSTRATION

A. As part of final system acceptance, a System Demonstration is required (see below). Prior to start of this Demonstration, the contractor is to perform a complete Validation of all aspects of the Controls and Instrumentation System.

B. Validation

1. Prepare and submit for approval a Validation Test Plan including Test Procedures for the performance verification tests. Test Plan shall address all specified functions of the Engineering Control Center and all specified sequences of operation. Explain in detail actions and expected results used to demonstrate compliance with the requirements of this specification.

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