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DIVISION 23 – HEATING, VENTILATION AND AIR-CONDITIONING

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. Conditions of the Contract and Division 1, General Requirements, shall be made part of this Section.

B. Refer to the drawings for further definition of location, extent, and details of the work described herein.

C. Cooperate and coordinate with all trades in execution of the work described in this Section and so as to provide clearance for equipment maintenance operation.

D. Where referred to, standard specifications of technical Societies, Manufacturer's Associations, and Federal Agencies shall include all amendments current as the date of issue of these Specifications.

E. It is intended, for the guidance of the bidders, that the Manufacturer's name used first throughout this Section of the Specification, is that used in the design of the HVAC system. All material submitted shall be equal in all respects to that used in the design.

F. The Subcontractor for work of this Section shall become familiar with other Sections of the Specifications to determine the type and extent of work there under which affects the work of this trade, whether or not such work is specifically mentioned in this Section.

1.2 WORK INCLUDED

A. The scope of the work under this Division, without limiting the generality thereof, consists of furnishing all labor, material, equipment, scaffolding, power, tools and rigging, except as otherwise specified, and performing all work as necessary to fully complete the HVAC work indicated. Note that the Drawings and the Specifications are complementary. Provide work drawn, but not specified, and work specified, but not drawn, as if explicitly indicated in both ways.

B. Examine all Drawings and other Divisions of the Specifications for requirements affecting work under this Division.

C. The HVAC work shall include but not be limited to the following:
1. Selective Demolition
2. Hoisting and rigging for equipment and materials specified herein.
3. Core drilling, cutting and channeling for holes six (6) inches and smaller in diameter.
4. Fire watch, as required.
5. Furnishing and maintenance, in safe and adequate condition, of all staging and scaffolding required for work under this Division.
6. Maintenance of proper building indoor air quality during construction.
7. Proper protection of all stored and partially installed equipment, piping, ductwork and accessories.
8. Submittals and coordination drawings.
9. Equipment and Systems:
    a. HVAC motors, starters and interlocking device.

b. HVAC variable frequency drives.
c. HVAC vibration isolation and seismic restraint.
d. Supply, return and / or exhaust air ductwork systems.
e. Ductwork and / or equipment insulation.
f. Ductwork and / or equipment identification.
g. Factory-fabricated air handling units.
h. Automatic temperature controls and monitoring.

10. Fire and smoke stopping. Coordinate materials and methods with Division 7.
11. Ductwork system cleaning, including air moving equipment and airstream coils.
12. Hydronic system cleaning, flushing, chemical treatment and water quality report.
13. Ductwork leak testing.
14. Testing, adjusting and balancing of all air and / or water systems.
15. System demonstration / Start-up / Manufacturer representation.
16. Operations and maintenance manual(s).
17. Record drawings

1.3 RELATED WORK

A. Examine all other sections of the Specifications and all drawings for the relationship of the work under this Section and the work of other trades. Cooperate with all trades and coordinate all work under this section therewith. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. The following related items are included under sections listed below:
1. Concrete bases and thrust blocks, housekeeping pads and filling inertia pads for HVAC equipment. DIVISION 3 - CAST IN PLACE CONCRETE.
2. Excavation and backfilling. DIVISION 31 - EARTHWORK.
3. Except as specified herein, cutting shall be the responsibility of the General Contractor and patching shall be performed by the respective trades. Refer to the respective sections.
4. The HVAC Subcontractor shall provide all hoisting and rigging for equipment and materials specified herein.
5. Core drilling, cutting and channeling for HVAC equipment for holes six (6) inches and less in diameter.
6. Furnish and maintain in safe and adequate condition, all staging and scaffolding that is required for work of this section.
7. Fuel, water and electricity for all tests and temporary operation of HVAC equipment. – DIVISION 1 - TEMPORARY FACILITIES AND CONTROLS.
8. Temporary heat. DIVISION 1 - TEMPORARY FACILITIES AND CONTROLS.
9. Openings for Air Devices: In APPLIABLE SECTIONS, in which they occur.
10. Undercut doors and door louvers. DIVISION 8 – OPENINGS.
11. Woodgrounds (Blocking) for fastening air devices and radiation. Refer to Architectural drawings and DIVISION 6 -, ROUGH CARPRENTRY to determine if these items are provided. Secure to woodgrounds if provided or directly to wall or ceiling surface if not provided. Provide expansion bolts for masonry - concrete - block wall mounting.
12. Flashing of ductwork, Equipment Supports and Roof Curbs for HVAC equipment. DIVISION 7 - THERMAL AND MOISTURE PROTECTION.
13. Painting of all exposed ductwork and other mechanical equipment not having enameled surfaces, stainless steel or chromed finishes. DIVISION 9 - PAINTING
14. City water piping and fittings including insulation and backflow prevention on plumbing piping systems connecting to HVAC equipment. DIVISION 22 - PLUMBING.
15. In general, all wiring required for equipment provided by the HVAC Contractor that requires Automatic Controls and all interlock wiring and accessories for this HVAC equipment that is not shown or indicated on the Electrical Drawings of DIVISION 26 - ELECTRICAL, shall be provided under DIVISION 23 – HEATING, VENTILATION, AND AIR CONDITIONING.

16. HVAC Motor Starters, Disconnects and Variable Frequency Drives provided under this section shall be installed under DIVISION 26 – ELECTRICAL.
17. HVAC Commissioning: DIVISION 23 - HVAC COMMISSIONING, DIVISION 1– HVAC COMMISIONING REQUIREMENTS.
18. Fire and Smoke stopping at penetrations through fire-rated assemblies. Fire-stop materials and methods are specified in DIVISION 7.

C. Furnish the following materials to be installed under other specification sections.
1. Prefabricated roof curbs and prefabricated equipment supports installed and flashing installed under DIVISION 7 - THERMAL AND MOISTURE PROTECTION.
2. Access Doors and Panels to be installed under applicable sections.

D. Install the following materials to be furnished under other SECTIONS.
1. Duct installed smoke detectors furnished and wired under DIVISION 28 – FIRE ALARM. Refer to fire alarm drawings for exact number and general locations.

1.4 INTENT

A. Description in the Specifications, or the indication on the Drawings of equipment, materials, operation and methods, required that such items shall be of the quantity required, and the systems complete in every respect.

B. The Specifications shall be considered an integral part of the accompanying Drawings. Any item or subject omitted from one or the other, but which is either mentioned or reasonably implied, shall be considered as properly and sufficiently specified. In the case of a conflict, the more demanding item shall apply.

C. The HVAC Contractor shall be completely responsible for the acceptable condition and operation of all systems, equipment and components forming part of the installation or directly associated with it. The HVAC Contractor shall provide fully qualified personnel to fulfill this requirement. The HVAC Contractor shall be responsible for prompt replacement of defective materials, equipment and parts of equipment and related damages.

1.5 STANDARD OF MATERIALS AND WORKMANSHIP

A. Refer to Part A and Division 1 of Part B for general instructions and, in addition, adhere to the following:
1. Workmanship and installation methods shall conform to the highest standard practice. Work shall be performed by skilled tradesmen under the direct supervision of fully qualified personnel.
2. Install equipment in strict accordance with manufacturer’s published recommendations.
3. When requested, submit samples of materials proposed for review before proceeding with the work.
4. Install equipment and materials to present a neat appearance. Install piping, ducts and conduit parallel with or perpendicular to building planes.
5. Conceal piping, ducts and conduit in finished areas. Install work so as to require a minimum amount of furring.
6. Make provisions for neat insulation finish around equipment and materials. Do not mount piping or equipment within insulation depth.
7. Equipment, materials and work shall comply with the requirements of generally recognized agencies, including, but not limited to, agencies listed under DIVISION 23 – HEATING VENTILATION AND AIR-CONDTIONING Article STANDARDS- REFRENCES and shall

conform to and be installed in strict accordance with Federal, State and Town requirements and shall meet all of the requirements of all authorities having jurisdiction.

1.6 ABBREVIATIONS AND DEFINITIONS

A. "HVAC" or "HV" or "AC" as mentioned herein means specifically "Heating, Ventilating and Air Conditioning" or "Heating and Ventilating" or "Air Conditioning" respectively, when used in conjunction with contractor, equipment, work or articles within this specification.

B. A.T.C. as mentioned herein means specifically Automatic Temperature Control as it refers to the manufacturer or description of work and equipment

C. "Provide" may be used in place of "furnish and install" and where used shall mean to deliver, furnish, erect, and connect up complete in readiness for regular operation, the particular work or equipment referred to, unless otherwise specified.

D. "Concealed" shall be defined as areas where piping or ducts are located in chases, shafts, and above ceilings whether furred or lay-in type.
1. All other ductwork and piping shall be considered "exposed".

E. The term "Applicable Section Contractor" or "A.S.C." shall be understood to refer to a contractor or contractors other than the HVAC Contractor or any HVAC Subcontractor or HVAC Sub-subcontractor.

1.7 EXAMINATION

A. Before submitting bid, visit and examine the site where work is to be carried out and become familiar with all features and characteristics which affect the work of this SECTION.

B. Examine the Specifications and Drawings, including the Specifications and Drawings of other DIVISIONS before bid.

C. Report in writing, any discrepancies or deficiencies which may adversely affect the work, at least six days prior to close of bid.

D. No allowance will be made for any difficulties encountered due to any features of the building, site or surrounding public and private property which existed up to the time of bid.

1.8 REFERENCES

A. All material and workmanship shall comply with all applicable codes, local and state ordinances, industry standards, and utility company regulations.

B. All materials, equipment and apparatus shall be Underwriters Listed or Labeled for all components where such listing or label are available. Items which are not UL Listed or Labeled are not acceptable if labeled or listed equipment can be obtained from another acceptable manufacturer. Assemblies or components not labeled or listed shall be furnished with certification by the manufacturer that the wiring complies with UL safety requirements.

C. STANDARDS: Except as modified by governing codes or this specification, applicable standards (latest editions regardless of years listed below) produced by the following organizations shall

apply to materials, equipment and installation of components and systems furnished and / or installed as part of this Section:

1. ASHRAE – American Society of Heating, Refrigeration and Air-conditioning Engineers
   a. Special Attention is required for:
      1) ASHRAE Standard 15-2010: Safety Code for Mechanical Refrigeration.
      2) ASHRAE Standard 62.1-2010: Ventilation for Acceptable Indoor Air Quality.
      3) ASHRAE Standard 111-2008: Practices for Measurement, Testing, Adjusting and balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.
      4) ASHRAE Standard 90.1-2010: Energy Standard for Buildings Except Low-Rise Residential Builidings
2. NFPA – National Fire Protection Association
   a. Special Attention is required for:
      1) NFPA 31: Installation of Oil Burning Equipment.
      2) NFPA 37: Installation and Use of Stationary Combustion Engines and Gas Turbines.
      3) NFPA 45: Laboratories Using Chemicals.
      4) NFPA 54: National Fuel Gas Code.
      5) NFPA 90A: Installation of Air Conditioning and Ventilation Systems.
      6) NFPA 90B: Installation of Warm Air Heating and Air-Conditioning Systems
      7) NFPA 91: Blower and Exhaust Systems.
      8) NFPA 96: Ventilation, Control, and Fire Protection of Commercial Cooking Operations.
      9) NFPA 99: Standard for Health Care Facilities
3. SMACNA – Sheet Metal and Air Condition Contractors Nation Association, Inc.
   a. Special Attention is required for:
      1) SMACNA Duct Construction Standards Metal and Flexible.
      2) SMACNA Fire, Smoke, Radiation, Damper Installation Guide for HVAC Systems.
      3) SMACNA Ducted Electric Heat Guide for Air Handling Systems.
      4) SMACNA Air Duct Leakage Test Manual.
      5) SMACNA IAQ Guidelines for Occupied Buildings Under Design and Construction
      6) SMACNA Duct cleanliness for New Construction Guidelines
      7) SMACNA HVAC Systems Testing, Adjusting & Balancing
4. OSHA – Occupational Safety & Health Administration
5. UL – Underwriter's Laboratory
6. EPA – Environmental Protection agency
7. AIA – American Institute of Architects
8. AGA - American Gas Association
9. ANSI – American Nation Standards Institute
10. ASME – American Society of Mechanical Engineers
    a. Special Attention is required for:
       1) ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear appropriate ASME label.
11. AWWA – American Water Works Association
12. ARI – American Air Conditioning and Refrigeration Institute
13. IEEE- Institute of Electrical and Electronics Engineers
14. IPCEA – Insulated Power Cable Engineers Association
15. ADA –American Standards Association
16. FM – Factory Mutual Engineering Division
17. CS – Commercial Standard of NBS (US Department of Commerce)
18. NADCA - National Air Duct Cleaners Association – ACR 2006
19. NEMA – National Electrical Manufacturers Association
20. ASTM – American Society of Testing and Materials

21. AMCA – Air Moving and Conditioning Association
22. ADC – American Diffuser Council

D. CODES and ORDINANCES: Conform with the provisions of the latest editions of the following:
1. Massachusetts State Building Code, 780 CMR, 9th Edition
2. Massachusetts State Fuel and Gas Code, 248 CMR
3. Massachusetts State Electrical Code, 527 CMR
4. City of Worcester, MA fire protection codes and / or ordinances

1.9 DRAWINGS

A. The Drawings are schematic in nature and are intended to show approximate locations of apparatus, fixtures, piping and duct runs in diagrammatic form. The Drawings are not intended to show Architectural and Structural details.

B. Do not scale drawings. Obtain any information requiring accurate dimensions from Architectural and Structural Drawings or from site measurements. Check locations and elevations before proceeding with work.

C. At no additional cost to the Owner, make all changes or additions to materials and/or equipment necessary to accommodate structural and architectural conditions.

D. Leave areas clear and unobstructed where space is indicated as reserved for future equipment.

E. Whether shown on the Drawings or not, provide adequate space and provision for servicing of equipment and removal and reinstallation of replaceable items such as motors, coils, filters and tubes.

F. Provide all ceiling mounted components, including air terminals, access doors and panels, in strict accordance with reflected ceiling plans.

1.10 FABRICATION OF MATERIALS

A. Before prefabricating ductwork or piping for installation, make certain that such items can be installed as shown on the coordination drawings without interfering with the structure or the work of other trades. Any problems that cannot be solved in agreement with other trades affected, shall be submitted for decision.

B. If ductwork or piping is prefabricated prior to the investigation and reaching of a solution to possible interference problems, necessary changes in such prefabricated items shall be made at no extra cost to the Owner.

C. In case of any discrepancies between the Specifications and Drawings, or where the Specifications or Drawings are not clear or definite, the subject shall be referred to or decided by the Architect whose decision shall be final. Otherwise, make adjustments at no expense to the Owner.

1.11 PERMITS, FEES, INSPECTION CERTIFICATES

A. Apply for, obtain and pay for all permits, inspections and fees required.

B. Be fully acquainted with and obey all Federal, State, and Municipal laws, by-laws, codes and regulations, and all authorities having jurisdiction. Provide fire dampers and smoke dampers in air handling systems as described herein.

C. Before starting any work, submit the required specifications and Drawings to the Governing Authorities for their approval. Comply with any requested changes as part of the Contract, and give any notification immediately of such changes.

D. Where the Specifications, Instructions, or the Governing Authorities require any work to be tested, inspected or approved, give sufficient notice of its readiness for inspection, and, if the inspection is by a Governing Authority, of the date and time set for such inspection.

E. Inspection will be made promptly. If any work is covered up without consent, it shall, if required, be uncovered for examination and the required corrections made at not extra cost to the Owner.

F. Furnish any certificates necessary as evidence that the work conforms to the requirements of all authorities having jurisdiction.

G. Make changes, if required, to make the work conform to all laws, bylaws, codes, and regulations, as part of this SECTION work.

1.12 RECORD DRAWINGS

A. Refer to DIVISION 1 – GENERAL REQUIREMENTS and DIVISION 1 - PROJECT CLOSEOUT.

B. All costs for Record Drawings shall be borne by the HVAC Subcontractor.

C. Purchase and maintain at the job site at all times, a complete set of blackline prints of the HVAC drawings. As the work progresses, mark all changes made, whether resulting from addenda, formal change orders or other instructions issued by the Architect. Color in the various ductwork, piping, equipment, apparatus and associated appurtenances exactly as they are erected.

D. The accurate location, depth, size and type of all concealed items shall be recorded before concealment to ensure accurate and direct future access doors and panels. Show inverts of all services at key points within the building, or buried items, and entering and leaving the building. Show dimensions from building grid lines.

E. The record drawings will be reviewed at regular intervals by the Architect and will be taken into consideration when reviewing the monthly applications for payment submitted by the HVAC Subcontractor.

F. When this procedure has been accomplished to the satisfaction of the Architect, the Record Drawing information shall be transferred to a set of CAD drawings by this Subcontractor and printed to PDF file format. The CAD file(s), in format .DWG 2004, and PDF file shall be submitted to the Architect, as directed in DIVISION 1, PROJECT CLOSEOUT. Electronic files shall be included with Mechanical System Operation and Maintenance Data as submitted to the Owner.

1.13 OPERATION AND MAINTENANCE DATA

A. Refer to DIVISION 1 - PROJECT CLOSEOUT

B. Assemble three copies of indexed hard cover manuals entitled “Operating and Maintenance Instructions for Mechanical System”.

C. Submit one copy for review at least two months before instructions to Owner are commenced. Instruct the Owner for one week (40 hours) as to the Operation-Maintenance of the System. This, and all instructional sessions, shall be videotaped and three (3) copies made and submitted to the Architect. Refer to DIVISION 1, PROJECT CLOSEOUT.

D. Ensure that the terminology used in various sections of the manual is consistent.

E. Refer to PART 1 – STANDARD REPORTING REQUIREMENTS, this document, for general information. Each manual shall contain the following:
1. Description of each system, with description of each major component of the system.
2. Complete sets of approved page-size equipment shop drawings including temperature control drawings.
3. A lubrication schedule of all specified equipment.
4. Spare parts list.
5. Equipment identification list with serial numbers.
6. Page-size valve tag schedule and flow diagrams.
7. Final balancing reports.
8. Water treatment procedure and tests.
9. Names and telephone numbers of all equipment parts suppliers.
10. Control commissioning report
11. Equipment start-up reports
12. Two (2) “snap-shots” of the DDC points of the Automatic Temperature Control system. This data shall be compiled and recorded with the system in the “occupied” and “unoccupied” modes of each zone. Also include the schedule for these modes as established by the Owner.
13. CAD and PDF drawings in electronic format as described in DIVISION 23, RECORD DRAWINGS

1.14 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fan Belts: One set for each belt-drive fan.
2. Filters: One set of filters for each unit.

1.15 SUBMITTALS

A. Refer to DIVISION 1 - SUBMITTAL PROCEDURES and specifications for submittal requirements. Without limiting the generality thereof, the HVAC Subcontractor shall also submit the additional information noted herein.

B. Present, not later than three (3) weeks after award of the Contract, a list of submittals to be submitted with the name of each manufacturer and supplier. Failure to submit this list will result in the necessity for the Contractor to use that equipment which is scheduled.

C. Submittals for equipment furnished under this Section shall include, but not be limited to all items listed in DIVISION 23 – HEATING VENTILATION AND AIR-CONDITIONING Article - WORK INCLUDED and listed within this specification. Refer to each article of this section for additional specific submittal requirements.

D. Do not manufacture, deliver or install equipment and materials until final review of Shop Drawings has been completed.

E. Separate submittals based on trade and equipment (specification section and sub-section or sub-sections). Do not combine various disparate products together under one submittal title.

F. Submit a minimum of seven (7) copies of certified submittals of all equipment, materials, equipment wiring, diagrams, motors, starters, controls and schedules. Ensure that submittals have adequate clear space for all stamps. When requested, resubmit promptly.
1. If submitting electronically, provide email notification to ftconadmin@f-t.com with submittal file(s) attached in industry standard ".pdf" file format. If the submittal file(s) are too large for email transfer, provide hyperlink to files allowing both download and upload of files over internet connection without requiring use of usernames or passwords.

G. Identification: In addition to the information required by DIVISION 1 - SUBMITTAL PROCEDURES indicate:
1. Name and address of supplier.
2. Name of manufacturer.
3. Reference specification section number, article number, article name and page number (e.g. 23 00 00 - 2.10 - VIBRATION ISOLATION AND SIESMIC RESTRAINT – Page 23 00 00 - 14)
4. Identify if submittal is a resubmission of previous reviewed equipment.
5. Distribution list of all Trade subcontractors and manufacturers who will receive the Engineer's reviewed comments.

H. Do not manufacture, deliver or install equipment and materials until final review of Submittals has been completed.

I. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.

1. If information must be specially prepared for submittal because standard printed data are not suitable for use, submit as Shop Drawings, not as Product Data.
2. Mark each copy of each submittal to show which products and options are applicable.
3. Include the following information, as applicable:
   a. Manufacturer's written recommendations.
   b. Manufacturer's product specifications.
   c. Manufacturer's installation instructions.
   d. Dimensions and Required clearances
   e. Equipment Shipping and Operating weights and Structural Loads.
   f. Components required for field installation.
   g. Method of field assembly, components, and location and size of each field connection.
   h. Field electrical and mechanical connection requirements.
   i. Notation of coordination requirements.
   j. Wiring diagrams showing field-installed wiring, including power, signal, and control wiring
   k. Material gages and finishes.
   l. Standard color charts.
   m. Manufacturer's catalog cuts.
   n. Wiring diagrams showing factory-installed wiring.
   o. Certified performance curves for each fan, air handling unit and pump, showing duty and horsepower with design operating points over the components entire range indicated clearly.
   p. Certified performance ratings with system operating conditions indicated.
   q. Certified compliance with specified referenced standards. Testing by recognized testing agency.
   r. Motor ratings, electrical characteristics, and motor accessories.
   s. Filters with performance characteristics.

t. Equipment Manufacturer supplied Dampers, housings, linkages, and operators.
u. Equipment Manufacturer supplied valves and operators.
v. All available specialties, options and accessories. Clearly indicated furnished specialties, options and accessories.
w. Standard product operation and maintenance manuals.
x. Notation of coordination requirements.
y. Submit certified discharge and radiated sound power levels for:
1) Air terminal units
2) Air moving equipment – fans, air handlers, roof top units, etc.
3) Equipment with compressors
4) Boilers/burners
5) Water moving equipment – pumps
6) Steam pressure reducing stations.

J. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data. Prepare shop drawings for all custom equipment such as air handlers, roof top units, custom roof curbs, cooling towers, pressure reducing stations, and any equipment that standard manufacturers printed data is not suitable for use.
1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:
a. Dimensions.
b. Equipment Shipping and Operating weights.
c. Identification of products.
d. Fabrication and installation drawings.
e. Roughing-in and setting diagrams.
f. Wiring diagrams showing field-installed wiring, including power, signal, and control wiring.
g. Design calculations.

K. Testing Plans and Reports:
1. Submit a report template with representative sheets for each test to be included in the project. Template report shall include the design and or specification data per the documents.
2. Submit preliminary testing field reports.
3. Submit final testing field reports. Incorporate engineers' review comments.

L. Compliance with specified standards. Be responsible for presenting the processing of submittals to suit manufacturing schedule of equipment and construction schedule of building.

M. Be responsible for the accuracy of equipment dimensions relative to available space, the performance and the electrical characteristics. When required, submit a complete comparison between accepted alternative equipment and materials, and that which is specified.

N. Each submittal shall indicate clearly the correct name and address of the project, the intended use and location of the equipment, and the specified and/or scheduled designation tag/number.

O. Upon receipt of approved Submittals, distribute copies to all trades and manufacturers affected. Submit approved Submittals to authorities having jurisdiction when requested.

P. Keep one set of reviewed Submittals on the site at all times.

Q. Bind one set of the corrected, reviewed and approved Submittals in each Operation and Maintenance Instructions Manual. Refer to DIVISION 1 - SUBMITTALS, DIVISION 1 - PROJECT

CLOSEOUT and DIVISION 23 - HEATING VENTILATION AND AIR CONDITIONING article – OPERATION AND MAINTENANCE DATA.

R. Prior to submission of Submittals, the HVAC Subcontractor shall thoroughly check each shop drawing to ascertain that it complies with the Contract requirements; that the electrical characteristics are correct; and that the dimensions of work submitted fit the available space. Any deviations from the Contract requirements shall be clearly noted on the submittals. The HVAC Subcontractor shall stamp each submittal with his firm's name, date and approval, thereby representing that the above has been complied with. Shop Drawings not so checked and stamped, shall be returned without being examined. Review of the Shop Drawings shall not relieve the HVAC Subcontractor from the responsibility for departures from the Contract Documents. Errors in shop drawings shall be the sole responsibility of the HVAC Subcontractor whether the drawings are reviewed or not.

S. The HVAC Subcontractor shall submit to the General Contractor, for transmittal to the Owner, any samples requested by the Owner. Submittal, review, and approval of samples shall be in accordance with the Conditions of the Contract.

T. Drawings not stamped by the General Contractor shall be returned without being examined.

1.16 STANDARD REPORTING REQUIREMENTS

A. All reports shall be submitted in electronic and hardcopy format.
   1. Electronic reports shall be provided in PDF format.
   2. All reports must provide the following general information, at a minimum. Refer to individual specification paragraphs for additional reporting requirements.
      a. Project Location
      b. Date of report completion.
      c. Personnel involved in completing reports.

1.17 COORDINATION DRAWINGS

A. Prepare Coordination Drawings in accordance to the requirements of DIVISION 1 - SUBMITTAL PROCEDURES. Before work progresses, in addition to the shop drawings listed herein, coordination drawings shall be created and prepared by the HVAC and Sheetmetal Subcontractors in AutoCAD DWG electronic format. The Coordination Drawings once completed by the HVAC and Sheetmetal contractors shall be delivered to the Plumbing Contractor, Fire Protection Contractor and lastly the Electrical Contractor for inclusion of their respective equipment and systems. Provide drawings in electronic format, one 3/8 inch scale reproducible and one 3/8 inch scale blue print of coordination drawings.

B. Prepare Coordination Drawings in accordance to Division 1 and, in addition, adhere to the following:
   1. Indicate temporary relocation, phasing, sequencing and moving of large equipment in the building during construction.
   2. Floor plans and details, including the following:
      a. HVAC Coordination Drawings shall include, as a minimum, all supply, return and exhaust ductwork, VAV Boxes, air-handlers, fans, piping, pumps, isolation valves, thermostats and other similar controls and sensors, and all other equipment installed under this Section showing the adjoining work of the other trades at all floors, Mechanical Rooms and duct shafts. Refer to articles throughout this SECTION for additional coordination requirements.
      b. HVAC Sub-contractor shall note apparent conflicts and suggest alternate solutions.

c. Composite systems coordination drawings showing how HVAC systems are to be installed where conflicts with the work of other trades may occur.
d. Access Door and Panel Coordination: Show sizes and locations of all access panels and doors on coordination drawings.

C. The Contractor, before transmittal of the Coordination Drawings to the Owner for approval, may require the HVAC and Sheetmetal Subcontractors to revise the composite coordination drawings and shop drawings and to make reasonable modifications in the layout of the HVAC work, so that the HVAC work may be properly accommodated without the interference with work of other trades. The HVAC and Sheetmetal Subcontractors shall make such revisions to composite systems coordination drawings, when requested, without extra charge. For example, note that ductwork aspect ratio changes (up to a maximum of 5 to 1 width to height ratio) shall be considered reasonable changes and therefore made at no cost to the owner.

D. The HVAC Contractor shall be responsible for the cost for changes in the HVAC and adjoining work where an approved substitution of the HVAC equipment requires such changes in the HVAC work or in the adjoining work of any other trade. Provide coordination drawings showing all changes.

E. Sheetmetal ductwork installed in floor areas which may be in conflict with ceiling system. The Ceiling Contractor and the Sheetmetal Contractor shall coordinate the method of support and access for the ceiling. In no case shall the ductwork be used to support the ceiling construction nor shall it fall on the grid or its cross points unless the specific areas of conflict are allowed by the Architect/Engineer.

F. The Contractor, before transmittal of the Coordination Drawings to the Owner for approval, shall review with and obtain sign-off from the following contractors indicating that the work of their trade is fully coordinated:
1. General Contractor
2. HVAC contractor
3. Sheetmetal Contractor
4. ATC Contractor
5. Testing and Balancing Contractor
6. Air Duct and System Cleaning Contractor
7. Plumbing Contractor
8. Electrical Contractor
9. Low voltage wiring contractor
10. Fire Protection Contractor

1.18 REQUESTS FOR INTERPRETATION (RFIs)

A. Prepare Requests for Interpretation (RFIs) in accordance to Division 1 and, in addition, adhere to the following:
1. RFIs shall originate with the Contractor. RFIs submitted directly by sub-contractors will be returned with no response. RFIs sent directly to engineer will be returned with no response. Incomplete RFIs will not be reviewed and will be returned for additional information.
2. If email RFI submissions are allowed by Division 1 then the RFI and Attachment(s) shall be in Adobe Acrobat PDF format.
3. Submit RFIs in format specified and in addition include:
a. Specification Section number and title and related paragraphs, as appropriate.
b. Drawing number, room name, structural grid coordinates and detail references, as appropriate.
c. Field dimensions and conditions, as appropriate.

d. Contractor's suggested solution(s). If Contractor's solution(s) impact the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
e. Attachments: Include 8 ½" x 11" copies of construction documents highlighting areas requiring interpretation. Include drawings, descriptions, measurements, photos, Product Data, Shop Drawings, and other information necessary to fully describe items needing interpretation and suggested solution(s).
f. Supplementary drawings prepared by Contractor shall be to scale and shall include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments.

1.19 TEMPORARY SERVICES

A. Refer to DIVISION 1 - TEMPORARY FACILITIES AND CONTROLS.

B. Operations necessary for checking, testing and balancing shall be done after written approval is given to start up systems. Before then, ensure that care is taken to protect equipment from damage, and to prevent distribution of dust through duct systems. Cap and seal ducts and cap pipes as required to prevent construction debris from entering.

C. Permanent heating or air conditioning systems shall not be used for temporary heating, except with written permission of the Architect. It is intended that the HVAC Subcontractor shall schedule his work so as to be able to utilize the permanent heating system for temporary heat when the building is totally enclosed. When the permanent heating system is utilized for temporary heat, the boiler plant shall be operated as designed with all accessory equipment and systems operative. Upon completion of the temporary heating phase, the equipment shall be inspected and cleaned as required to bring it to as new condition. Under no circumstances shall the boilers, air handlers, or any permanent equipment be operated without feed water, chemical treatment or air filters.

D. Where air systems are used the associated Ductwork System shall be protected with return air filters at all duct openings or air inlets. Prior to balancing the system for permanent use replace air filters, and clean and test the air system including but not limited to ductwork, air handler, air terminals. Refer to AIR DUCT AND SYSTEM CLEANING for cleaning and testing requirements.

1.20 IDENTIFICATION OF MECHANICAL SERVICES

A. After finish painting complete, identify all mechanical services. Use terminology consistent with the Drawings and Specifications. Refer to Division 1. A line item on the schedule of values for equipment identification shall be included.

B. Prepare flow diagrams (same size as record documents) of piping systems to identify equipment and valves. Include these diagrams in record drawings.
1. Insert page-size copies of diagrams into each Operating and Maintenance Manual.
2. Install schematic piping flow diagrams, framed under glass, on equipment room walls. Final location shall be as directed on site by Owner. All valves shall be identified in these diagrams.
3. A line item in the schedule of values shall be dedicated to flow diagrams of mechanical services.

C. Provide typewritten master lists in Operating and Maintenance Instruction Manuals; and shop equipment numbers on Record Prints and sepias.

D. Identification shall be consistent with Owner's standard methods of identification.

1.21 PROTECTION

A. Protect all mechanical work from damage. Keep all equipment dry and clean at all times.

B. Cover openings in equipment, and pipes, with caps or heavy gauge plastic sheeting until final connections are made.

C. Correct at no cost to the Owner, any damage caused by improper storage, handling, or installation of equipment and materials.

D. Protect equipment, piping and temporary services installed within this SECTION from weather damage.

E. Ductwork systems:
1. Contractor shall maintain duct cleanliness to the “Intermediate level” as defined by the SMACNA, “Duct cleanliness for New Construction Guidelines.” This level of cleanliness shall include, but not be limited to, providing duct sections in plastic wrap from the manufacturer, and maintaining the wrapped sections in storage in good condition until installed. At the end of each day after installation, the ends of installed ductwork shall be capped.
2. Owner will obtain independent NADCA ACR 2006 Vacuum testing at their discretion to ensure the duct cleanliness is maintained. To be considered clean by the NADCA Vacuum Test, the net weight of the debris collected on the filter media must not exceed 0.75 mg/100 cm^2. If the installed systems do not meet the specified cleanliness then the HVAC contractor shall hire a NADCA certified independent duct cleaning contractor at no cost to the owner. Duct cleaning contractor shall clean ductwork and verify specified cleanliness level is obtained.

F. Provide temporary sheetmetal caps on all ductwork, air terminals and sound attenuators delivered, stored and partially installed at the site.

1.22 COORDINATION

A. Fully coordinate with other trades to ensure that work is carried out in the best interests of all concerned. Install work in proper sequence to conserve headroom and space.

B. Coordinate work with other trades to provide maximum accessibility for maintenance and operation of all equipment installed by all trades.

C. Give notices of requirements for holes, recessed openings, pits and chases before structure is to be erected.

D. Set all necessary sleeves and inserts before concrete is scheduled to be poured.

E. Furnish all items to be built-in, in ample time to allow schedules progress of work.

F. Refer to the Coordination Drawing Section of Specification for Coordination drawing process.

G. Provide the Electrical contractor and Plumbing Contractor with all requirements within Two (2) weeks from date of Contract to allow proper coordination of trades by the Contractor.

H. Verify with the Electrical contractor available electrical characteristics before ordering any equipment.

I. Verify with the Plumbing contractor available natural gas pressure before ordering any equipment.

J. Verify Smoke and Smoke/Damper actuator requirements with Fire Alarm and/or electrical contractor before ordering any equipment.

K. Verify Smoke detector and Fire Alarm interlock requirements before ordering any equipment.

L. Furnish to the Electrical Contractor all starters, control devices, relays, pilot lights, accessories, contactors, wiring diagrams, and the like required for proper operation, connection and control of motorized equipment, as specified and/or shown on the drawings.

M. Electrical Contractor shall be responsible for the following:
1. Mount and connect starters, controllers and disconnects, except where specified to be factory wired and mounted on the equipment.
2. Provide all required power connections for all motor driven equipment.
3. Provide power wiring to control transformers and control panels.

N. HVAC contractor provides low and line voltage control wiring to all equipment requiring control unless specifically called for on the Electrical Drawings or Specifications.

O. General contractor shall provide all roof openings. Roof openings shall be the minimum size required for duct and/or pipe penetrations. Roof openings for roof curbs shall be the minimum allowable for duct and pipe passage. Under no circumstances shall the roof opening be as large as the roof curb. Openings shall be sealed tight to duct or piping penetrating the roof or roof structure. Roof openings shall not be cut until show drawings are approved.

1.23 GUARANTEE

A. Conform to the requirements of DIVISION 1 - Project Close-out.

B. All equipment, material and workmanship shall be unconditionally guaranteed, as set forth in the Contract, or for longer periods when stated in the Specifications. Extensions to the standard equipment warranty periods shall be arranged by the HVAC Subcontractor to enable the period to commence upon beneficial usage by the Owner.

C. If any equipment or material does not match the manufacturer’s published data or specifically supplied rating schedules during performance tests, replace without delay the defective equipment or materials. Bear all associated costs and adjust all components at no charge to the Owner and adjust all components to achieve the proper rating.

D. Correct defects and deficiencies, and pay for resulting damage to Mechanical or other work, and to property and person, which appear or originate during the guaranteed period

E. The Owner shall give notice of observed defects promptly in writing.

1.24 DRAIN PANS OVER ELECTRIC EQUIPMENT AND MOTORS

A. Wherever piping runs above motor control centers, panels or other electrical equipment due to field conditions or coordination process, a copper drip pan with drain outlet shall be provided.

B. Indicate on coordination drawings the locations where piping passes over motors and electric panels.

C. Drip pans shall have lips 2 inch high, stiffened and braced, supported to prevent sagging, and shall be pitched to a ¼" per foot toward the drain outlet. Drain outlet shall be piped, with approved piping, to nearest floor drain or other indirect waste connection. Width of pan shall extend 6 inches beyond piping, but shall not be less than 18 inches wide. All seams shall be soldered and watertight.

1.25 CONNECTIONS TO EQUIPMENT

A. The HVAC Subcontractor shall provide all duct and/or pipe connections to equipment provided under other sections of the specifications as shown on the contract documents and herein specified including final connections to equipment to result in a complete system, fully operational. Coordinate the locations of all equipment with Architect. Obtain installation diagrams and methods of installation of all equipment from manufacturers. Follow instructions strictly.

1.26 SEISMIC DESIGN

A. DESCRIPTION
1. General
   a. This section provides vibration isolation, wind restraint and seismic restraint provisions for mechanical components and distributed systems.
2. Intent
   a. It is the intent of the seismic and wind restraint portion of this specification to provide restraint of non-structural building components. Seismic restraints shall be provided per code and specification. Wind restraints are required for all components located on the roof or outside of the building structure.
   b. All connections between components and structure must be positive, frictional forces due to the weight of the component are not acceptable.
   c. Any supplementary supports must be capable of transferring the seismic and/or wind loads to the structure without failure.
   d. Screening walls or obstructions do not reduce the code required wind load on components.
3. The work in this section includes the following:
   a. Vibration isolation elements for equipment and distributed systems.
   b. Equipment isolation bases, support stands and rails.
   c. Pipe flex connectors.
   d. Seismic and wind restraint for distributed systems, isolated and non-isolated equipment.
   e. Certification of seismic and wind restraint designs, installation supervision as required.
4. Definitions.
   a. The word component will be used throughout this specification and shall include all non-structural HVAC equipment AND distributed systems such as piping and duct.
   b. Components buried underground are excluded but entry of services through the foundation wall is included.
   c. IBC: International Building Code
   d. Life safety systems:
      1) All components involving fire protection.
      2) All components connected to an emergency power supply.
      3) All medical and life support components.
      4) Fresh air relief systems.
   e. Positive attachment.
      1) Welded, steel bolted, through bolted and concrete anchored connections.
      2) Double sided beam clamps loaded perpendicular to the beam.
5. The work in this section includes the following:

a. Vibration isolation elements for equipment.
b. Equipment isolation bases.
c. Pipe and Duct Supports.
d. Piping flexible connectors.
e. Seismic restraints for isolated equipment.
f. Seismic restraints for non-isolated equipment.
g. Certification of seismic restraint designs and installation supervision.
h. Equipment support stands, bases or rails.
i. Structural design of all vibration isolation, supports and seismic restraints.

B. OEM EQUIPMENT ISOLATION PACKAGES FOR INTERIOR EQUIPMENT
1. Internal vs. external systems.
a. Interior equipment with internal isolation is acceptable in lieu of the specified external isolation in this section provided that the internal isolation is equal to or better than the specified external isolation.
b. If seismic is applicable the internal isolation must be a restrained type capable of resisting the code required forces; the equipment as a unit must still be seismically attached to the structure.

C. MANUFACTURER'S RESPONSIBILITY
1. Manufacturer of vibrations isolation, wind, seismic & thermal control equipment shall have the following responsibilities:
a. Determine vibration isolation, seismic, thermal and wind support/anchorage requirements for all components.
b. Vibration isolation shall be provided as specified in the applications section of this document. In the event of conflict between specification and contract drawing the stricter requirements will drive design unless otherwise allowed in writing by the mechanical engineer of record for the project.
c. Manufacturer to guarantee submitted isolation systems meet specified deflection requirements.
d. Manufatcurer to provide installer with detailed installation instructions, drawings and, if required, field supervision/field training to insure installation and performance of all submitted systems.

D. RELATED WORK
1. Housekeeping Pads
a. Housekeeping pad attachment to structure design shall be by the project structural engineer. Material and labor required for attachment and construction shall be by the concrete section contractor.
b. Housekeeping pads shall be coordinated with the Restraint Supplier and sized to provide the detailed minimum edge distance required to achieve full anchor ratings.
2. Supplemental Support Steel
a. Contractor shall supply supplementary support steel and connections for all equipment, piping, ductwork, etc. Including roof mounted equipment, as required or specified.
b. Where support for equipment requires stands, bases, rails, etc. these devices shall be designed and fabricated by Restraint Supplier to ensure the seismic capability of the entire installation.
3. Attachments
a. Contractor shall provide restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. as directed by the Seismic Restraint Supplier.
4. Special Inspections
a. If an independent inspection agency has been hired by the owner or owners representative the contractor must inform the inspecting agency of any installation work for seismic restraints a minimum of (1) week prior to preforming the work.

b. Contractor to make allowances for inspector to be on site during installation or to allow access to the location after installation for post-installation inspection.
c. Contractor may be required to provide educational experience, welding certifications or training experience for workers involved in seismic restraint installations.

E. CODE REQUIREMENTS
1. Comply with all local, city and state building codes as referenced by the structural drawings.
2. Comply with the seismic and wind restraint requirements of the current IBC edition unless requirements of this section are more stringent.
3. Wind Restraint Loading:
   a. Determine basic wind speed, building classification category and wind exposure category.
   b. Minimum 10 psf wind loading for all outdoor components.
4. Seismic Restraint Loading
   a. Determine the Seismic Design Category (SDC) from the structural drawings.
   b. For renovations where a site specific soil profile is not known it is allowable to use a default Site Class D to determine the SDC provided there is no reason to suspect the soil profile may be designated as E or F.
   c. SDC=A & B: Seismic restraints are not required for mechanical and electrical components and distributed systems.
   d. SDC=D, E & F: Seismic restraints are required for all mechanical and electrical components and distributed systems.
   e. SDC=C: Seismic restraints are only required for mechanical and electrical components designated with an Importance Factor (I_P) equal to 1.5.
      1) All mechanical and electrical components involved with life safety, emergency power shall be designated $I_P = 1.5$.
      2) All components connected to emergency power shall be designated $I_P = 1.5$.
      3) For essential facilities assigned to Use Group IV on the structural drawings ALL components shall be designated $I_P = 1.5$ unless otherwise noted here.

F. NON CODE REQUIRED SEISMIC DESIGN
1. Although not required by code, it is a project requirement that the following types of buildings or occupancies within buildings shall have all non-structural HVAC components seismically braced:
   a. Data centers
   b. Elective outpatient surgery centers
   c. Inpatient hospitals
   d. Smoke evacuation and stairwell pressurization systems
2. Any HVAC system that serves occupancies with different seismic design categories shall be designed to the more stringent category.

1.27 HVAC BASIS OF DESIGN

A. For major pieces of HVAC equipment, including but not limited to chillers, boilers, cooling towers, rooftop units, air handlers, Registers Grilles & Diffusers(RGDs), and VAV terminals the engineers basis of design is the unit shown on the plans and listed in the schedules. The contractor may submit an alternate unit from the list of approved manufacturers in this specification IF he ensures that such unit has thermal and acoustical performance equal or better than the scheduled unit and IF he ensures that the unit fits within the allotted mechanical space.

B. For roof mounted equipment, the contractor must ensure that his submitted unit either weighs less than the scheduled unit or can be supported by the roof structure.

C. For all outdoor mounted equipment, which differs from that shown on the schedules, the contractor must ensure that his submitted equipment does not violate any local noise ordinances.

D. Electrical characteristics of submitted equipment must match those of scheduled equipment. This means that voltages, phases and hertz of submitted equipment must be the same as scheduled equipment and that current draws (amperage) must be equal or less than scheduled equipment.

1.28 IAQ PROCEDURES FOR OCCUPIED BUILDINGS UNDER CONSTRUCTION

A. For renovation work taking place in occupied buildings the mechanical contractor shall designate an individual to be indoor air quality coordinator. This individual shall be available at the job site during working hours and he or she shall be thoroughly familiar with the procedures for maintaining indoor air quality detailed in the SMACNA publication “IAQ Guidelines for Occupied Buildings Under Construction.” On commencement of the project the contractor shall provide the name of this individual to the Architect and Engineer.

B. Before commencing any work in an occupied building, including demolition work the mechanical contractor shall submit to the Architect and Engineer for review, a plan for maintaining indoor air quality in the occupied space. The plan shall be based on the procedures in Chapter 3 of the SMACNA IAQ manual referenced above. At a minimum the plan shall address the specifics of how the following procedures are to be carried out (or if they are not to be implemented - why not):
   1. Keeping the construction area under negative pressure. State specific balancing procedures to be followed.
   2. Keeping the occupied area under positive pressure. State specific balancing procedures to be followed.
   3. Erecting barriers between the construction area and the occupied area. State type of barrier and sealing method.
   4. Exhausting the construction area. State where exhaust is directed to and whether filtration on exhaust is to be provided
   5. Sealing of ductwork openings.
   6. Protection of sheetmetal sections not yet installed from dust and water.
   7. Protection of equipment not yet installed from dust and water.
   8. Cleaning of ductwork and terminal boxes after construction is complete.
   9. Provision of temporary filters on return air systems. State efficiency of filters.
   10. Provision of fan powered air cleaners.
   11. Any other procedure not listed above which the contractor is implementing to maintain adequate levels of indoor air quantity.

1.29 MANUFACTURERS REPRESENTATIVE

A. Provide, at the appropriate time and/or as directed by Architect, the services of a competent factory-trained Engineer of each piece of equipment. Manufacture representative shall inspect, adjust, troubleshoot and place in proper operating condition any and all items of the manufacturer.

B. No additional compensation will be allowed Contractor for such services.

C. Refer to the individual specification paragraphs for additional Manufacturer representative requirements.

D. Site visits and Field/Startup Reports
   1. Refer to PART 1 – STANDARD REPORTING REQUIREMENTS, this document, for general information.

2. Prepare field/startup reports in accordance to Division 1 and, in addition, adhere to the following:
   a. Provide field report as for each site visit.
   b. Manufacturer shall check-in with owner or project representative at each field visit.
   c. Report shall include at a minimum:
      1) Date, Time and weather conditions
      2) Present during visit
      3) Reason for visit
      4) Standard manufacturer's startup forms/checklists
      5) Results of visit
      6) Any deficiencies requiring repair/replacement
      7) Follow-up actions required
3. Submit reports for approval.
4. Include approved reports in close out documents.

1.30 HVAC SYSTEM DEMONSTRATION

A. At completion of the HVAC system installation, testing and balancing and start up, the mechanical contractor shall demonstrate to the owner and to the engineer the proper operation of all major HVAC systems. This shall include but not be limited to temperature controls, chillers and cooling towers, air handlers, boilers, rooftop units, kitchen make up and exhaust systems, fan systems, pumps, terminal units and computer room units. Allow minimum of one full day (8 hours) for this demonstration.

B. Provide owner and engineer at least one week notice before demonstration is to begin. Mechanical contractor shall ensure the presence of personnel from local manufacturer's representative for the specific pieces of equipment involved as well as for the automatic temperature controls contractor who shall be present throughout the entire procedure.

C. If a piece of equipment has an occupied/unoccupied cycle or otherwise has two speed operations all control cycles and speeds are to be demonstrated.

D. If any piece of equipment or control cycle does not operate as specified then this contractor shall remedy the deficiency and repeat the demonstration in the owner's and engineers presence.

1.31 ALTERNATES

A. Examine DIVISION 1 - ALTERNATES for scope of work which may affect the work of this section and include any deletions or additions in the form for sub bid under the appropriate alternate.

1.32 APPROVED EQUALS

A. For projects bid under the Commonwealth of Massachusetts Public Bid Laws Only.
   1. Proprietary: Where items are listed as proprietary the owner has demonstrated that it is in the owner's best interest to use the specified product without any substitutes.
   2. Items not listed as proprietary: Massachusetts General Law - Chapter 30, Section 39m requires that public bid projects allow for additional manufacturers beyond the listed acceptable manufacturers/installers/technicians.
   3. The mechanical contractor may submit manufacturers and sub-contractors which differ from the Acceptable manufacturers/installers listed in these specification sections as "Approved Equals".

4. Documentation must be submitted showing that the proposed equipment and/or installer meets the following (1) it is at least equal in quality, durability, appearance, strength and design, (2) it will perform at least equally the function imposed by the general design for the work being contracted for or the material being purchased, and (3) it conforms substantially, even with deviations, to the detailed requirements of the specifications
5. The Engineer shall have sole discretion to determine whether the substitution is in fact equal to the specified manufacturer's product. The Engineers determination shall be final.

1.33 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATION, SUPPORTS AND SEISMIC RESTRAINT

A. ACCEPTABLE MANUFACTURERS
1. Novia Associates, Inc.
2. Mason Industries Inc.
3. Vibration Mountings and Controls, Inc.

B. GENERAL
1. All vibration isolation, supports and seismic devices described in this section shall be the product of a single supplier. NAI (Novia Associates, Inc.) is the Basis of Design of these specifications; products of other suppliers may be acceptable provided their systems strictly comply with intent, structural design, performance and deflections of the Basis of Design.
2. It is the intent of the seismic restraint portion of this specification to provide restraint of non-structural building components. Restraint systems are intended to withstand the stipulated seismic accelerations applied through the component's center of gravity.
3. Each and every support attachment to the structure of equipment that meets the requirements of this specification must be positive, including equipment that may be excluded from auxiliary seismic bracing as noted in Part 3.

C. SUBMITTALS
1. General
   a. Provide an itemized schedule listing the tags and quantities of all components included in the submittal package.
   b. Schedule shall indicate vibration isolation type and deflection for all isolated components.
   c. Schedule shall indicate calculations and tie down details for all components subject to wind or seismic loading regardless of whether the component is isolated or not.
   d. Submittal shall include detailed cut sheets on all vibration isolation devices including component tag, rated deflections, rated loads dimensions and material finish.
   e. For equipment requiring seismic or wind restraint the submittal shall include detailed calculations indicating equipment tag, wind loads and/or seismic loads, applicable load combinations and calculations indicating minimum tie down requirements.
   f. Submittal shall include tie down details as required.
   g. Similar equipment may be grouped into a "worst case" calculation.
2. Shop Drawings

a. For all supplemental steel bases, rails and supports the submittal shall include drawings indicating the component tag, dimensions, structural member sizes and support point locations.
b. Provide specific details for all seismic and/or wind restraint devices and anchors including minimum quantity, size and location for each piece of equipment.
c. Provide coordinated or contract drawings marked up with all distributed system seismic restraints including type, size and orientation.
    1) Provide minimum braced and unbraced rod lengths for each restraint location.
    2) Assigned load at each location shall be clearly identified.
    3) Minimum elevation view installation angle 30 degrees from vertical.
d. All ceiling suspended equipment requiring seismic restraint shall include details in the restraint type and size.
    1) Provide minimum braced and unbraced rod lengths for each piece of equipment.
    2) Assigned seismic load must be clearly indicated.
    3) Minimum elevation view installation angle of 30 degrees from vertical.
    4) Similar equipment may be grouped into a “worst case” calculation.
e. Calculate thrust for fan heads. Provide thrust restraints for any situation where the fan thrust exceeds 10% of the fan weight, the fan and duct are flexibly connected and either the fan, duct or both are not restrained from movement.
f. For equipment subject to seismic loads and for all outdoor equipment provide seismic and/or wind load restraint details including anchor quantity, size type and location.

3. Certifications
    a. Seismic restraint as required.
        1) Seismic restraint calculations must be provided for all component attachments to the structure.
        2) Supplemental supports, bases, rails, stands, curbs, etc. must be certified as capable of transferring the seismic load from the component to the structure without failure.
        3) For outdoor equipment see wind restraint section, worst case wind or seismic load to be used as basis for design.
        4) Calculations supporting restraint details, anchorage and material selections must be stamped by a professional engineer registered in the state in which the project is located.
        5) An in-force professional Errors & Omissions insurance certificate must accompany submittals. Manufacturer’s product liability insurance certificates are not acceptable.
    b. Wind restraint as required.
        1) Wind restraint calculations must be provided for all outdoor component attachments to the structure.
        2) Supplemental supports, bases, rails, stands, curbs, etc. must be certified as capable of transferring the wind load from the component to the structure without failure.
        3) For equipment subject to seismic loads see seismic restraint section, worst case wind or seismic load to be used as basis for design.
        4) Calculations supporting restraint details, anchorage and material selections must be stamped by a professional engineer registered in the state in which the project is located.
        5) An in-force professional Errors & Omissions insurance certificate must accompany submittals. Manufacturer’s product liability insurance certificates are not acceptable.
    c. Pipe risers as required.
        1) Thermal expansion/contraction calculations showing anticipated movement at each support location, initial loads on structure, final loads on structure and variable spring support deflections must be provided as required.

2) Riser system must be certified as not exceeding allowable pipe stress as defined by MSS SP-58.
3) Calculations supporting anchorage, guides and variable spring support selections must be stamped by a professional engineer registered in the state in which the project is located.
4) An in-force professional Errors & Omissions insurance certificate must accompany submittals. Manufacturer's product liability insurance certificates are not acceptable.

D. RELATED WORK
1. Housekeeping Pads
a. Housekeeping pad attachment to structure design shall be by the project structural engineer. Material and labor required for attachment and construction shall be by the concrete section contractor.
b. Housekeeping pads shall be coordinated with the Seismic Restraint Supplier and sized to provide a minimum edge distance of 13 bolt diameters of clearance all around the outermost anchor bolt to allow for the use of full anchor ratings.
2. Supplementary Support Steel
a. Contractor shall supply supplementary support steel and connections for all equipment, piping, ductwork, etc. Including roof mounted equipment, as required or specified.
b. Where support for equipment requires stands, bases, rails, etc. these devices shall be designed and fabricated by Seismic Restraint Supplier to ensure the seismic capability of the entire installation.
3. Attachments
a. Contractor shall provide restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. as directed by the Seismic Restraint Supplier.

E. SEISMIC RESTRAINTS AND VIBRATION ISOLATION TYPES
1. Seismic-restraint devices shall have horizontal and vertical load testing and analysis performed according to the Office of Statewide Health Planning & Development for the State of California (OSHPD) and shall bear anchorage preapproval "R" number, from OSHPD or another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If pre-approved ratings are not available, submittals based on independent testing are preferred.
2. General
a. All isolation and seismic restraint devices shall be capable of accepting, without failure, the "G" forces as determined by the seismic certification and calculations as described in the "SUBMITTAL DATA REQUIREMENTS" section of these specifications.
b. Corrosion protection for outdoor applications shall be as follows:
1) Springs shall be cadmium plated, zinc electroplated or powder coated.
2) Hardware shall be cadmium or zinc plated.
3) All other metal parts shall be hot spray or hot dipped galvanized or zinc electroplated.
c. All seismic restraint devices
1) Shall maintain the equipment in a captive position and not short circuit isolation device during normal operating conditions.
2) Shall have provisions for bolting and/or welding to the structure.
d. Welding of springs to isolator housing, base plates, etc. is strictly prohibited.
3. Seismic Restraint Types
a. TYPE I: Same as Type B isolator.
b. TYPE II: Where required, each corner or side of equipment base shall incorporate a seismic restraint snubber having an all directional resilient neoprene pad limit stops.

Restraints shall be fabricated of plate, structural members or square metal tubing. Model “SS” as manufactured by NAI.

c. TYPE III: Restraints for suspended systems.
   1) Vibration isolated systems shall be braced with multiple 7 x 19 galvanized steel cables with approved attachment devices (such as thimbles and wire rope clips) to equipment and structure.
   2) Non-isolated systems shall be braced with structural steel strut or cable with approved attachment devices to equipment and structure.
   3) Steel angles (by contractor) shall be provided to prevent rod bending of hung equipment where indicated by the Seismic Restraint Supplier’s submittals. Steel angles shall be attached to the rods with a minimum of three clamps model “SRC” at each restraint location. Welding of support rods to angles is not acceptable.

d. TYPE IV: Double deflection neoprene.
   1) Mountings shall be fabricated to resist the wind or seismic forces. Model “RNM” as manufactured by NAI.

e. TYPE V: Rigid attachment to structure utilizing wedge type expansion anchors for bolting and steel plates, either cast-in or anchored with wedge type expansion bolts, for welding. Powder shots are not acceptable. Concrete anchor bolt spacing shall be in accordance with anchor manufacturer’s published standards.

F. EQUIPMENT BASES, CURBS & SUPPORTS

1. GENERAL
   a. All curbs, roof rails, isolators and supports are to be bolted or welded to the structure to attain the higher of the specified acceleration criteria or a minimum 30 PSF wind load or snow load applied to the largest face area.
   b. All non-galvanized materials shall be prime paint finished.
   c. Review roof top mounted equipment sections of these specifications and contract drawings for supplementary conditions and/or requirements.
   d. Operating height for roof mounted supports & curbs shall be as shown on the drawings.
   e. Provide pre-drilled holes for all roof mounted curbs and rails for attachment to the building structure.

2. BASE TYPES
   a. TYPE B-3: Spring Roof Curb
      1) Spring isolation curbs that bear directly on the roof structure and are flashed and waterproofed into the roof's membrane waterproofing system. Equipment manufacturers’ or field fabricated curbs shall not be used.
      2) Curbs shall include the following features:
         a) Curbs shall be manufactured from 12 gauge G60 galvanized sheetmetal, reinforced and cross braced as required. All side & end seams between sheets shall be continuously welded, corner joints to be bolted.
         b) Springs pockets shall have all of the features of TYPE B isolator.
         c) The combination floating top rail and top flashing shall be fabricated of two formed and nested layers of 12 gauge G60 galvanized steel and shall be factory insulated with 1-1/2” thick 3# density fiberglass board. Note Well: Curb perimeter shall have no more than ¾” high un-insulated area on sides and ends from bottom of the curb to the top of the top rail.
         d) All spring locations shall have removable waterproof galvanized steel covers to allow for spring adjustment and/or replacement.
         e) Curbs shall be externally factory insulated with 2” thick R-14.3 foam insulation, FM Class 1 and UL Class A Ratings, with bonded fiber reinforced facer.

f) Waterproofing and air tightness shall be achieved by use of a continuous flexible air and water seal attached to the bottom counter flashing. The seal shall be protected from exposure to the elements by the top flashing. NOTE WELL: Neoprene weather seals exposed to sunlight are not acceptable. Metal flashing that must be rigidly attached to the floating and non-floating portions of the curb which would short circuit the isolation effectiveness of the curb are not acceptable.
g) Wood nailers around the full perimeter of the curb and around each spring pocket.
h) Overhung condensing units shall be supported by TYPE B isolators. These isolators shall in turn be supported on cross braced structural steel pedestals that are attached to the building structure and provide a consistent mounting height relative to the RTU. Field built pedestals for condensing units are not acceptable.
i) Galvanized steel duct supports shall be provided as required. Supports shall be capable of supporting the ductwork with a maximum deflection over the width of the curb of L/360.
j) All duct supports shall be provided with attached flexible connectors. Connectors shall be constructed of 3” wide coated woven nylon with double lock gripping finger attachment to metal.
k) Provide 22 gauge galvanized pans for roof top units that require pans under condensing sections.
l) Removable lifting lugs.
m) The curb shall maintain the same installed and operating height with or without the equipment load and shall be capable of being utilized as a blocking device.
n) Curbs shall be fully assembled at the factory and shipped as one piece.
o) Curbs shall be capped with 7 mil shrink wrap for weather protection.
p) Provide flexible connections for all piping connected to RTU. See paragraph 3.03 A. 6. & 7. for requirements.
q) Model “VibCurb” as manufactured by NAI.

G. FLEXIBLE CONNECTORS
1. All connectors shall be installed on the equipment side of shutoff valves; horizontal and parallel to equipment shafts whenever possible. Piping shall be supported and/or anchored to resist pipe movement beyond the allowable movement of the flexible connector. Installations must include check valves and/or other design and installation precautions to reduce the threat to life safety when subjected to the specified seismic accelerations.
2. TYPE FC-1: Spherical Elastomer connector
   a. Manufactured of EPDM.
   b. Sizes 2" and larger shall have two spheres reinforced with an external ring between spheres. Bolted-on strap type reinforcing is not acceptable. Sizes 16" to 24" may be single sphere.
   c. Threaded one piece bolted flange assemblies with female threaded ends for sizes 3/4" to 1-1/2".
   d. Rated at 250 psi up to 1700 F, with a uniform drop in allowable pressure to 170 psi at 2500 F for sizes through 14". 16" through 24" single sphere minimum ratings are 180 psi at 1700 F and 130 psi at 2500 F.
   e. Connectors shall be installed in piping gaps equal to the length of the connector under pressure.
   f. Control rods are required in unanchored installations where the installation exceeds the pressure limitation without control rods.
      1) Control rods shall have ½" thick Neoprene washer bushings large enough in diameter to take the thrust at 1,000 psi maximum on the washer area.

g. Connectors bolted to Victaulic type coupling or gate, butterfly or check valves to have a minimum 5/8" flange spacer (by others) installed between the connector and the coupling flange. Connectors must mate to a flat-faced flange in all instances.

2.2 MOTORS AND MOTOR STARTERS

A. MOTOR ACCEPTABLE MANUFACTURERS

1. General Electric
2. Baldor
3. Lincoln

B. GENERAL CONSTRUCTION AND REQUIREMENTS

1. Motors Less Than 250 Watts, for Intermittent Service: Equipment manufacturer's standard and need not conform to these specifications.
2. Single Phase Motors: PSC where available.
3. Electrical Service:
4. Refer to DIVISION 26 – ELECTRICAL for required electrical characteristics.
5. Open drip-proof type except where specifically noted otherwise.
6. Design for continuous operation in 40 degrees C environment.
7. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
8. Motors connected to variable frequency drives shall meet requirements of NEMA MG-11, Part 31 and stated as frequency drive compatible. Motors shall be suitable for use with repeated voltage peaks of 1600 volts with rise time of 0.1 microseconds or greater.
9. Explosion-Proof Motors: UL approved for hazard classification.
10. Visible Nameplate: Indicating manufacturer's name and model number, motor horsepower, RPM, frame size, voltage, phase, cycles, full load amps, insulation system class, service factor, maximum ambient temperature, temperature rise at rated horsepower, minimum efficiency.
11. Wiring Terminations:
    a. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
    b. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

C. SINGLE PHASE POWER - SPLIT PHASE MOTORS

1. Starting Torque: Less than 150 percent of full load torque.
2. Starting Current: Up to seven times full load current.
3. Breakdown Torque: Approximately 200 percent of full load torque.
4. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.
5. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

D. SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

1. Starting Torque: Exceeding one fourth of full load torque.
2. Starting Current: Up to six times full load current.
3. Multiple Speed: Through tapped windings.
4. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.

E. SINGLE PHASE – ELECTRONICALLY COMMUTATED MOTORS (ECM)

1. Variable speed, constant torque brushless DC motor
2. Motor shall be provided with potentiometer to vary speed.
3. UL and CSA compliant
4. NEMA enclosure

F. SINGLE PHASE POWER - CAPACITOR START MOTORS
1. Starting Torque: Three times full load torque.
2. Starting Current: Less than five times full load current.
3. Pull-up Torque: Up to 350 percent of full load torque.
4. Breakdown Torque: Approximately 250 percent of full load torque.
5. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
6. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve ball bearings.
7. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

G. THREE PHASE POWER - SQUIRREL-CAGE MOTORS
1. Starting Torque: Between 1 and 1-1/2 times full load torque.
2. Starting Current: Six times full load current.
3. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
4. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B energy efficient motors.
5. Insulation System: NEMA Class B or better.
6. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
7. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay with wiring to terminal box.
8. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum AFBMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt centre line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
9. Sound Power Levels: To NEMA MG 1.
10. Part Winding Start Where Indicated: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.
11. Weatherproof Epoxy Sealed or Treated Motors: Epoxy seal windings using vacuum and pressure to coat windings with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.
12. Nominal Efficiency: Unless noted otherwise, all motors provided under this project shall be premium efficient meeting the requirements of NEMA MG-1 Table 12-12 and Table 12-11 as well the Independence and Security Act of 2007.

Efficiency (Open Motor)

HP	2 Pole (1200 RPM)	4 Pole (1800 RPM)	6 Pole (3600 RPM)
1	82.5	85.5	77
1.5	86.5	86.5	84
2	87.5	86.5	85.5
3	88.5	89.5	85.5
5	89.5	89.5	86.5

7.5	90.2	91	88.5
10	91.7	91.7	89.5
15	91.7	93	90.2
20	92.4	93	91
25	93	93.6	91.7
30	93.6	94.1	91.7
40	94.1	94.1	92.4
50	94.1	94.5	93
60	94.5	95	93.6
75	94.5	95	93.6
100	95	95.4	93.6

H. MAGNETIC & MANUAL MOTOR STARTERS
1. ACCEPTABLE MANUFACTURERS
   a. General Electric Company
   b. Square D Company
2. Allen-Bradley CompanyStarters shall be in NEMA type 1 general purpose wall-mounted enclosures, except NEMA type 3R enclosures shall be used where the starter is exposed to the weather and NEMA type 7 enclosures shall be used in all hazardous locations.
3. Starters shall be sized per NEMA standards to match motor voltage and horsepower.
4. Overload relays shall be provided in each conductor to the motor. These relays shall be of the bi-metallic “inverse-time” type. Heaters shall be provided of the correct size for the motor controlled.
5. Two (2) sets of auxiliary contacts shall be provided with each starter in addition to those needed for normal operation, or in addition to those required by the wiring diagrams. These auxiliary contacts shall be form C, “normally open/closed”.
6. Start-stop momentary pushbuttons shall be located in the covers of manual motor starter enclosures unless other type of starting switches are required.
7. Red and green pilot lights shall be located in the cover of the starter enclosure to indicate position of main contacts.
8. H-O-A switches shall be included in the starter for all mechanical equipment with automatic control signals.

I. SHAFT GROUNDING RINGS
1. All motors operated on variable frequency drives shall be equipped with a maintenance-free, conductive microfiber shaft grounding ring to meet NEMA MG-1, 3.4.4.4.3 requirements, with a minimum of two rows of circumferential microfibers to discharge damaging shaft voltages away from the bearings to ground.
   a. Motors up to 100 HP: Provide one (1) shaft grounding ring installed on either the drive end or non-drive end.
   b. Motors over 100 HP: Provide an insulated bearing on the non-drive end and a shaft grounding ring on the drive end of the motor.
2. Grounding rings shall be provided and installed by the motor manufacturer or contractor and shall be installed in accordance with the shaft grounding ring manufacturer’s recommendations.

J. HIGH-FREQUENCY BONDING
1. All motors operated on variable frequency drives shall be bonded from the motor foot to system ground with a high-frequency ground strap made of flat braided, tinned copper with terminations to accommodate motor foot and system ground connection. High-frequency grounding straps must be used to ensure the proper grounding of all inverter-driven induction motor frames.

2. Provide AEGIS HF Ground Straps, or equal.

2.3 VARIABLE SPEED DRIVES

A. ACCEPTABLE MANUFACTURERS
1. ABB
2. Allen Bradley
3. Danfoss
4. Square D

B. VARIABLE MOTOR SPEED DRIVES
1. Provide adjustable frequency motor drives consisting of pulse width modulation inverter for use on standard NEMA induction motors.
2. Provide ventilated enclosure for installation as free standing or wall mounted unit.
3. Logic shall be microprocessor based.
4. Power factor shall be not less than 0.95 through full range of frequencies.
5. Input: Refer to drawings for VAC and phase, plus or minus 10%.
6. Output: Refer to drawings for VAC and phase, 6 - 60 Hz.
7. Digital Displays:
   a. Out frequency, voltage and amps.
   b. Overcurrent - OC.
   c. Overvoltage - OV.
   d. Current Limit - CL.
   e. Voltage Limit - VL.
   f. IIT Protection - MT.
   g. Ground Fault - GF.
   h. Improper Input Voltage Selected - LO-V, HI-V.
   i. Minimum and Maximum Speed Improper Selection - MNMX.
   j. Overtemperature - OT.
8. Field setable adjustments, controls and outputs:
   a. Adjustable Current Limit (60-110% of drive's rated current).
   b. Adjustable volts per hertz (V/Hz) +10%, -10%.
   c. Adjustable Acceleration Rate.
   d. Adjustable Deceleration Rate.
   e. Speed-adjustment by face-mounted potentiometer with Software Lockout.
   f. Adjustable Maximum Speed 0 to 100%.
   g. Adjustable Minimum Speed 0 to 100%.
   h. Adjustable Speed Input Gain 1:1 to 10:1.
   i. Adjustable Speed Input Offset 0 - 50%.
   j. Speed Command Inverting Switch.
   k. Adjustable Analog Output of 0-1 to 0-10 VAC proportional to volts amps or hertz.
   l. Digital Output of 12 VDC.
   m. Adjustable Output Boost.
   n. Adjustable Thermal overload protection 60% to 100% of drive rating.
   o. Three sets of single pole double throw contacts indicating run, trip and current limit.
   p. Automatic restart after a fault to a maximum of 5 attempts.
   q. Set point mode of operation from a transducer input signal.
   r. RS232 Port Communication Capacity.
9. Acceptable Inputs:
   a. DC voltage 0-10 VDC.
   b. DC current 0-50 MaDC.
10. Acceptable Start/Stop Commands:
   a. Closure of contact or switch.
11. Enclosures:
   a. Enclosure shall be designed to maintain operation at 50 degrees C.

b. Outdoor: NEMA 250, Type 3R,
c. Indoor: NEMA 250, Type 12K.
d. If VFD is to be located in a kitchen area, other wet or damp space, or hazardous location, refer to electrical specification for appropriate enclosure requirements.

12. Options to be provided:
    a. Prewired H-O-A switch.
    b. 5% line reactor

2.4 HANGERS AND SUPPORTS

A. ACCEPTABLE MANUFACTURERS

1. Carpenter and Patterson, Inc.
2. Elcen Metal Products Co.
3. ITT Grinnell Corp.

B. GENERAL:

1. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.
2. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."
3. Coordinate provision of all Hangers and Supports with the seismic restraints portion of this specification. Hangers and Supports provided shall not compromise the ability of the piping system to resist seismic loads.

C. PIPE HANGERS AND SUPPORTS

1. Hangers for Pipe Sizes 1/2 Inch to 1-1/2 Inch: Adjustable steel band hanger; MSS Type 7.
2. Hangers for Pipe Sizes 2 Inch to 3 Inch: Carbon steel, adjustable, clevis; MSS Type 1.
3. Hangers for Pipe Sizes 4 Inch to 5 Inch: Steel adjustable, cast iron roll, single hanger; MSS Type 43.
4. Hangers for Pipe Sizes 6 Inch and Over: Single cast iron pipe roll, double hangers; MSS Type 41.
5. Shields for insulated all cold piping and insulated hot piping size 3 inch and less: Galvanized steel shield over insulation in 180 deg. segments, minimum 12 inch long at pipe supports.
6. Shield for all hot piping 4 inch and larger: Steel pipe covering protection saddle; MSS Type 39. Fill void with insulating cement.
7. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods; cast iron roll and stand for hot pipe sizes 6" and over.
8. Wall Support for Pipe Sizes 4 Inch and Over: Welded steel bracket and wrought steel clamp; adjustable steel yoke and cast iron roll for hot pipe sizes 6 inch and over.
9. Vertical Support: Steel riser clamp.
10. Floor Support for Pipe Sizes to 4 Inch and All Cold Pipe Sizes: Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.
11. Floor Support for Pipe Sizes to 6 Inch and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
12. Provide copper plated hangers and supports for copper piping systems.
13. Shields for Vertical Copper Pipe Risers: Sheet lead.
14. Manufactured Piping Systems: Provide hangers and supports per manufacturer’s recommendations for press-fit and grooved mechanical fitting piping systems (if allowable).

D. HANGER RODS

1. Steel Hanger rods: Continuous threaded.

E. INSERTS AND BUILDING ATTACHMENTS

1. Inserts: Malleable iron case of steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.
2. Provide: Provide steel beam clamps, C-clamps, and steel brackets as required to accept threaded rods.

2.5 MECHANICAL IDENTIFICATION

A. ACCEPTABLE MANUFACTURERS

1. Allen Systems, Inc.
2. Brady (W.H.) Co.; Signmark Div.
3. Seton Name Plate Corp.

B. SUBMITTALS

1. Product Data: For each type of product indicated.
2. Valve numbering scheme.
3. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

C. GENERAL

1. Identification shall be consistent with Owner's standard methods of identification.
2. Labeling of new systems added to existing systems shall be consistent with the existing numbering system and terminology. Do not use valve numbers that have already been used.
3. Provide typewritten valve tag list in Operating and Maintenance Instruction Manuals.
   a. List shall be printed on 8.5x11 letter size paper.
   b. Provide one aluminum framed plastic shielded copy for mounting in the main mechanical room.
   c. List shall indicate each valve number, service, size and location
4. Flow arrows shall be solid black. Arrows shall be six (6) inches long by two (2) inches wide.

D. MATERIALS

1. Unless specified otherwise, comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.
2. Plastic Nameplates: Laminated three-layer plastic with engraved black letters on light contrasting background.
3. Brass Valve Tags: Brass with stamped letters; tag size minimum 1-1/2-inch diameter with smooth edges; four-inch brass chain.
4. Valve Tag Chart: Aluminum frame sized for 8.5x11 for chart, plastic lens.
5. Plastic Pipe Markers: Factory fabricated, flexible, semi rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and fluid being conveyed.
   a. On piping diameters (including insulation) up to 2-1/4", use 0.75 inch high capital letters.
   b. On piping diameters (including insulation) between 2-1/2" and 6", use 1.5 inch high capital letters.
   c. On piping diameters (including insulation) between 7" and 10", use 2.5 inch high capital letters.
   d. On piping diameters (including insulation) above 10", use 3.5 inch high capital letters.
6. Plastic Tape Duct Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings. On ductwork (including insulation) lettering shall be two (2) inches high capitals.

7. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape of not less than 6 inch wide by 4 mil thick, manufactured for direct burial service.
8. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment. Provided by equipment manufacturers.
   a. Data:
      1) Manufacturer, product name, model number, and serial number.
      2) Capacity, operating and power characteristics, and essential data.
      3) Labels of tested compliances.
   b. Location: Accessible and visible.
   c. Size: Manufacturers standard
   d. Fasteners: As required to mount on equipment.
9. Equipment Markers: Engraved, 1 1/6" thick color-coded engraved phenolic. Include contact-type, permanent adhesive.
   a. Terminology: Match schedules as closely as possible.
   b. Data:
      1) Name and plan number.
      2) Equipment service.
   c. Location: Accessible and visible.
   d. Size: 2-1/2 by 4 inches (64 by 100 mm) for control devices, dampers, and valves; 4-1/2 by 6 inches (115 by 150 mm) for equipment or as required to be secured to equipment.
   e. Letter Size: Minimum 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances.
10. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.
    a. Size: Approximately 4 by 7 inches (100 by 178 mm).
    b. Fasteners: Reinforced grommet and wire or string.
    c. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
    d. Color: Yellow background with black lettering.
11. Ceiling Grid Markers: White plastic with adhesive backing and min ½-inch tall lettering for attachment to ceiling t-bar grid.
12. Access Panel and Door Markers: 1/16-inch- thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment. Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.6 ACCESS DOORS AND FRAMES

A. ACCEPTABLE MANUFACTURERS

1. Milcor Div.; Inryco Inc.
2. Miami Carey
3. Way Loctor

B. SUBMITTALS

1. Product Data: For each type of access door and frame indicated. Include construction details, fire ratings**,** materials, individual components and profiles, and finishes.
2. Shop Drawings: Show fabrication and installation details of access doors and frames for each type of substrate. Include plans, elevations, sections, details, and attachments to other work.
3. Access Door and Frame Schedule: Provide complete access door and frame schedule, including types, locations, sizes, latching or locking provisions, and other data pertinent to installation.
4. Coordination Drawings: Refer to "COORDINATION DRAWINGS" this SECTION.

C. GENERAL:
1. Furnish for installation by others access doors for access to all concealed valves or equipment requiring accessibility for maintenance or proper operation, when such elements are located behind building surfaces or enclosures. Access Door Fire rating shall match wall or ceiling assembly fire rating.
2. Instruct appropriate panel installation contractor as to the proper location of all doors. Locate doors so that valve or element served can be easily reached. Size of doors shall be sufficient to serve intended purpose but in no case less than 9 inch by 9 inch. Doors located in corridors, lobbies or other habitable areas shall be reviewed by Architect as to location.
3. Provide prime painted Flush Access Doors and Trimless Frames prime painted with flush screw driver operated cam locks and concealed hinges.
4. Type of panels shall be based on:
   a. GYPSUM Board Surfaces "Milcor Type K"
   b. Masonry Construction "Milcor Type M"

2.7 DUCTWORK INSULATION

A. ACCEPTABLE MANUFACTURERS
1. CertainTeed Corp.
2. Knauf / Manson Fiber Glass
3. Owens Corning Fiberglas Corp.
4. Johns Manville

B. GENERAL
1. Refer to PART 3 – INSTALLATION OF DUCTWORK INSULATION for required thinknesses/R value.

C. GLASS FIBER FLEXIBLE
1. Insulation: ASTM C553; flexible, noncombustible blanket.
   a. 'K' value: ASTM C518, 0.25 at 75 degrees F.
   b. Maximum service temperature: 350 degrees F.
   c. Maximum moisture absorption: 0.50 percent by volume.
2. Vapor Barrier Jacket:
   a. Kraft paper with glass fiber yarn and bonded to aluminized film.
   b. Moisture vapor transmission: ASTM E96; 0.02 perm.
   c. Secure with pressure sensitive tape.
3. Vapor Barrier Tape:
   a. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.
4. Tie Wire: Annealed steel, 16 gauge.

D. GLASS FIBER, RIGID
1. Insulation: ASTM C612; rigid, noncombustible blanket.
   a. 'K' value: ASTM C518, 0.24 at 75 degrees F.
   b. Maximum service temperature: 350 degrees F.
   c. Maximum moisture absorption: 0.20 percent by volume.
   d. Density: 3.0 lb/cu ft.
2. Vapor Barrier Jacket:
   a. Kraft paper with glass fiber yarn and bonded to aluminized film.
   b. Moisture vapor transmission: ASTM E96; 0.04 1.3 perm.
   c. Secure with pressure sensitive tape two coats of vapor barrier mastic and glass tape.
3. Vapor Barrier Tape:
   a. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.
4. Indoor Vapor Barrier Finish:

a. Cloth: Untreated; 9 oz/sq. yd. weight, glass fabric.
b. Vinyl emulsion type acrylic, compatible with insulation, white color.

E. RIGID FOAM INSULATION
1. Johns Manville ISOfoam APF or similar product
2. Insulation: ASTM C1289; Type 1, Class 1.
a. 'K' value: ASTM C518, 0.16 at 75 degrees F.
b. Maximum service temperature: 250 degrees F.
c. Maximum moisture absorption: 0.1 percent by volume.Water Vapor Permeance: 0.05 Perms in accordance with ASTM E96

F. DUCT FIRE WRAP
1. Product shall be equal to UNIFRAX FyreWrap Elite 1.5 ADS flexible duct wrap enclosure encapsulated in foil scrim. Wrap shall provide a 2 hour rating when tested in accordance with ASTM E-814 and 119. Wrap shall have a smoke developed rating of <50 and flame spread rating of <25 when tested in accordance with ASTM E84/UL723. Wrap shall be rated at zero clearance to combustibles.

G. DUCT FIRE WRAP FOR HAZARDOUS DUCT SYSTEMS
1. Product shall be equal to UNIFRAX FyreWrap Elite 1.5 Hazardous Duct flexible duct wrap enclosure encapsulated in foil scrim. Wrap shall provide a 2 hour rating when tested in accordance with ASTM E-814 and 119. Wrap shall have a smoke developed rating of <50 and flame spread rating of <25 when tested in accordance with ASTM E84/UL723. Wrap shall be tested in accordance with UL-1978 for internal fire. Wrap shall be rated at zero clearance to combustibles

H. JACKETS
1. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.
a. Adhesive: As recommended by insulation material manufacturer.
b. PVC jackets are available in several colors. Colored jackets may be used to replace field painting. Ultraviolet rays fade colors. Some colors (black, gray, and white) do not fade as quickly as other colors (red, orange, and green).
c. PVC Jacket Color: Off-white.
2. Exterior Rubber Jacket System (Aluminum).
a. Vapor, UV and weather protection
b. Color: Silver
c. Rubberized Bitumen Membrane
d. Laminated "Peel and Stick" to insulation face
e. Self healing if punctured
f. Cold weather activator
g. Acceptable Manufacturers & Products:
1) Polyguard Alumaguard
2) VentureClad
3. Exterior Rubber Jacket System (White).
a. Vapor, UV and weather protection
b. Color: White
c. Rubberized Bitumen Membrane
d. Laminated "Peel and Stick" to insulation face
e. Self healing if punctured
f. Cold weather activator
g. Acceptable Manufacturers & Products:
1) Polyguard ALUMAGUARD Cool Wrap
2) VentureClad 1577CW-WM

I. ACCESSORIES

1. Provide staples, bands, wires, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.
2. Provide cements, adhesives, coatings, sealers, protective finishes, and similar compounds as recommended by insulation manufacturer for applications indicated.

2.8 AUTOMATIC TEMPERATURE CONTROLS – FACILITIES MANAGEMENT SYSTEM

A. ACCEPTABLE MANUFACTURERS

1. Alerton

B. EXTENSION OF EXISTING BUILDING AUTOMATION SYSTEM

1. The work shall be an extension of the existing facilities management system. Provide all necessary components for a complete operational system.
2. Contractor shall become familiar with existing FMS sequences and shall coordinate all new sequences with the Owner's existing FMS protocol.
3. Provide new or updated graphics and User Interface software as necessary to control the new components from the existing User Interface.
4. Extend the existing Local Area Network as necessary.

C. GENERAL

1. The Automatic Temperature Control (ATC) Contractor shall be the primary manufacturer-owned or certified installer branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Facilities Management Systems (FMS) of similar size, scope and complexity to the FMS specified in this Contract.
2. The ATC Contractor shall be a recognized national manufacturer, installer and service provider of FMS. Distributors, manufacturer's representatives and wholesalers will not be acceptable.
3. The ATC Contractor shall have a branch facility within a 50-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis. This branch facility shall provide the work for this project. This support facility shall have spare parts and all necessary test and diagnostic equipment required to install, commission and service the specified FMS.
4. As evidence and assurance of the contractor's ability to support the Owner's system with service and parts, the contractor must have been in the ATC business for at least the last ten (10) years and have successfully completed total projects of at least 10 times the value of this contract in each of the preceding five years.
5. The FMS architecture shall consist of the products of a manufacturer regularly engaged in the production of Facility Management Systems, and shall be the manufacturer's latest standard of design at the time of bid.
6. FMS Manufacturers system shall be Direct Digital Control (DDC) BACNET compatible. Comply with ASHRAE 135 for FMS control components.

D. SYSTEM DESCRIPTION

1. The Basis of Design Is Alerton.
2. The FMS shall be a complete Direct Digital Control (DDC) system designed for use on Intranets and the Internet. This functionality shall extend into the equipment rooms. Primary nodes located in equipment rooms and similar shall be fully IT compatible devices that mount and communicate directly on the IT infrastructure.
3. All points of user interface shall be on standard PCs that do not require the purchase of any special software from the ATC manufacturer for use as a building operations terminal. The primary point of interface on these PCs will be a standard Web Browser such as Internet Explorer.
4. The ATC work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples,

submittals, testing, verification, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items as Specified in these Division documents which are required for the complete, fully functional and commissioned system.

a. The ATC contractor shall field-install all components requiring field installation. All items required for a complete operating system, not provided by the manufacturer shall be by this contractor. The ATC contractor shall fully coordinate all control components, sequences and requirements with the manufacturer before submitting his shop drawings.
b. The ATC contractor shall provide all interlock wiring and controls between the energy recovery units and their associated air cooled condensing units.

5. Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software and configurations to be provided for this Project.
6. Manage and coordinate the ATC work in a timely manner in consideration of the Project schedules. Coordinate cooperatively with the associated work of other trades so as to assist the progress and not impede or delay the work of associated trades.
7. The FMS as provided shall incorporate, at minimum, the following integrated features, functions and services:
   a. Operator information, alarm management and control functions at User Interface without the need to purchase special software from the ATC manufacturer for those consoles.
   b. Enterprise-level information and control functions.
   c. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.
   d. Diagnostic monitoring and reporting of FMS functions.
   e. Offsite monitoring and management
   f. Energy management
8. The FMS shall be designed entirely for use on intranets and internets. All networking technology used at the Tier 1 level shall be off the shelf, industry standard technology fully compatible with other owner provided networks in the facility.
9. All aspects of the user interface shall be via browsers. Any PCs used as User Interface points shall not require any more than the software indicated under User Interface in order to provide the complete user interface as described throughout this section.
10. The user interface will be complete as described herein, providing complete tool sets, operational features, multi- panel displays, and other display features. Systems which merely provide HTML based web pages as the User Interface will not be acceptable.
11. The primary components of the system will be the Control Units located at the highest level of the network architecture.
12. The FMS shall consist of a number of control units and associated equipment connected by industry standard network practices. All communication between control units shall be by digital means only.
13. The FMS network shall at minimum comprise of the following:
    a. Network processing, data storage and communication equipment.
    b. Routers, bridges, switches, hubs, modems and like communications equipment.
    c. Active processing Nodes including field panels.
    d. Intelligent and addressable elements and end devices.
    e. Third-party equipment interfaces.
    f. Other components required for a complete and working FMS.
14. All FMS features shall be accessible via Enterprise Intranet and Internet browser with equivalent FMS access control for user access.
15. The FMS shall support auto-dial/auto-answer communications to allow FMS nodes to communicate with other remote FMS Nodes via standard telephone lines - DSL or voice grade.

16. Provide licenses for all software residing in the FMS and transfer these licenses to the Owner prior to completion.
17. Power Fail / Auto Restart
    a. Provide for the automatic orderly and predefined shutdown of parts or all of the FMS following total loss of power to parts or all of the FMS.
    b. Provide for the automatic orderly and predefined startup of all parts of the FMS following total loss of power to those parts or all of the FMS. Archive and annunciate time and details of restoration.
    c. 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.
    d. Maintain the FMS real-time clock operation during periods of power outage for a minimum of 72 hours.
18. Downloading And Uploading
    a. Provide the capability to generate FMS software-based sequences, database items and associated operational definition information and user-required revisions to same at the User Interface, and the means to download same to the associated control units.

E. SUBMITTALS
1. Shop Drawings, Product Data, and Samples
2. The ATC Contractor shall submit a list of all shop drawings with submittal dates within 30 days of contract award.
3. Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved by the Architect for Contract compliance.
1. Organize FMS submittal within the following three basic sections: 1. Component factory data sheets, component-specific diagrams, and component schedules; 2. Systems sequences, and system diagrams; and 3. Graphic User Interface (GUI) screen graphics. Provide full table of contents indicating specific page-number or drawing-number location of each component type, component schedule, system sequence, system diagram, and each GUI screen graphic.
4. Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the ATC Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Architect.
5. At a minimum, submit the following:
    a. FMS network architecture diagrams including all nodes and interconnections.
    b. Detailed coordinated controls submittal including any packaged factory supplied controls and the ATC contractor supplied controls.
    c. Thermostat and other controls and sensor locations shall be indicated on the project coordination drawing submittal.
    d. Schematics and flow diagrams.
    e. Sequences of Operation
        1) The specific sequences described below in “SEQUENCE OF OPERATION” are provided only to indicate the design intent. The ATC contractor shall use these as the basis for development of full, narrative style, system logic based control sequences by the automatic temperature controls (ATC) contractor.
        2) Final sequences written by the ATC contractor shall specifically reference actual sensor names and point designations within the provided enterprise system. Sequence language shall follow system logic and include all criteria included in specific sequence listed below.
    f. Copying and pasting of the engineers sequence of operations is prohibited and shall result in rejection of the submittal.

g. Points schedule for each real point in the FMS, including: Tag, Point Type, System Name and Display Units. <Node Type, Address, Cable Destination, Module Type, Terminal ID, Panel, Slot Number, Reference Drawing, and Cable Number.>
h. Samples of Graphic Display screen types and associated menu penetrations to show hierarchy and functional interrelationships.
i. Detailed Bill of Material list for each Node, identifying quantity, part number, description, and optional features.
j. Control Damper Schedule including a separate line for each damper and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Blade Type, Bearing Type, Seals, Duct Size, Damper Size, Mounting, and Actuator Type.
k. Control Valve Schedules including a separate line for each valve and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Calculated CV, Design Pressure, Actual Pressure, and Actuator Type.
l. Room Schedule including a separate line for each VAV box and terminal unit indicating minimum/maximum cfm, pickup gain, box area, and bias setting.
m. Details of all FMS interfaces and connections to the work of other trades.
n. Product data sheets for all products including software.
o. Training provided, including outlines for each session.

F. RECORD DOCUMENTATION
1. Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the FMS provided:
a. Table of contents.
b. As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal. Include locations of all thermostats and other controls and sensors.
c. Manufacturers product data sheets for all products including software.
d. System Operator’s manuals.
e. Archive copy of all site-specific databases and sequences.
f. network diagrams.
g. Wiring termination schedules.
h. Interfaces to all third-party products and work by other trades.
2. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the project record drawings and data sheets. A logically organized table of contents shall provide dynamic links to view and print all project record drawings and product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents. The CD-ROM(s) shall contain adequate space for future system updates.
3. On-line Documentation: After completion of all the tests and adjustments listed above, the contractor shall install the following information on the FMS:
a. "AS BUILT" drawing files
b. Detailed catalog data on all installed system components with address and phone number of factory repair service.

G. WARRANTY
1. Provide a one-year labor and material warranty on the FMS.
2. If within twelve (12) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the ATC Contractor at the cost of the ATC Contractor.

3. Maintain an adequate supply of materials within 100 miles of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during ATC Contractor's normal business hours.
4. Maintain an on-site record of all work done, all items removed from site, all items returned to site, all new replacement items installed and all remedial programming and database entry work undertaken including software revisions installed. Maintain a record of all re-calibrations required as a result of Warranty service.

H. COMMISSIONING
1. Refer to PART 1 – STANDARD REPORTING REQUIREMENTS, this document, for general information.
2. Fully commission all aspects of the Facility Management System work.
3. Acceptance Check Sheet
   a. Prepare a check sheet that includes all points for all functions of the FMS
   b. Submit the check sheet to the Engineer for approval one month prior to testing.
   c. Complete the check sheet for all items and functions of the FMS and initial each entry with time/date as record of having fully calibrated and tested the FMS. Submit to Engineer.
4. The Engineer will use the check sheet as the basis for acceptance testing with the ATC Contractor.
5. VAV box performance verification and documentation:
   a. The ATC Contractor shall test each VAV box for where the dampers in one half of a group of boxes are stepped towards full open while the other half are stepped towards full closed. At each step, after a settling time, box air flows and damper positions will be sampled. Following the cycle, a pass/fail report indicating results shall be produced. Possible results are Pass, No change in flow between full open and full close, Reverse operation or Maximum flow not achieved. The report shall be submitted as documentation of the installation.
   b. The ATC Contractor shall issue a report based on a sampling of the VAV calculated loop performance metrics. The report shall indicate performance criteria, include the count of conforming and non-conforming boxes, list the non-conforming boxes along with their performance data, and shall also include graphical representations of performance. The sampling shall take place after completion of Test and Balance, when design cooling and heating media have been available and occupied conditions approximated for five consecutive days.
6. Provide all necessary specialist labor, materials and tools to demonstrate to the Engineer that the FMS has been commissioned and is operating in compliance with the contract. Prepare a list of noted deficiencies signed by both the Engineer and the ATC Contractor.
7. Promptly rectify all listed deficiencies and submit to the Engineer that this has been done.

I. Distributed Web-Based User Interface, or User Interface
1. All features and functions defined in this ATC specification section as accessible via a user interface shall be available to a user on any facility computer connected directly to the network, or any computer connected to the internet via a wide area or virtual private network (WAN/VPN) to the automation network, and shall be conformed to the following specifications.
   a. The software shall run on the Microsoft Internet Explorer (6.0 or higher) browser and support the following functions:
      1) Configuration
      2) Commissioning
      3) Data Trending and Archiving
      4) Monitoring
      5) Alerting/Alarming
      6) Commanding
      7) System Diagnostics

b. The user interface will function on standard owner computers with the following minimum hardware characteristics:
   1) 512 MB RAM
   2) 2.0 GHz Clock Speed Pentium 4 Microprocessor
   3) 100.0 GB Hard Drive.
   4) 1 Keyboard with 83 keys (minimum).
   5) SVGA 1024x768 resolution display with 64K colors and 16 bit color depth
   6) Mouse or other pointing device
c. Access to the distributed web based user interface environment shall be by multiple users simultaneously via multiple user-name sign-ins, with associated passwords, and assigned security levels.

J. OPERATOR STATION
2. Work Station:
   a. Configuration: Microsoft Office compatible, utilizing the latest standard Intel Duo-Core based microcomputer system.
   b. Minimum memory: 8 GB RAM.
   c. Memory clock speed: Min 2.5 GHz.
   d. Cache memory: 256 kbyte.
   e. Display: 20 inch LCD color monitor.
   f. Keyboard: Low profile, detachable, having Qwerty layout plus a 10 key numeric keypad, dedicated function keys.
   g. Hard disk drive: 720 GB.
   h. Mouse: Software supported mouse with support software including self building menus and displays of system operations and functions.
   i. Printer: Support color printer.
   j. Operating System: Windows XP or Windows 7
3. Printer:
   e. 600 DPI, 6 PPM color Laser Printer.
4. Portable Operators Terminal:
   k. Provide one portable operators terminal with keypad and carrying case. Terminal shall be able to plug in to any DDC panel to monitor and/or change all setpoints. Keyboard entry commands shall be in English with full written instructions made available as to how to use terminal.
5. System Support: Minimum ten (10) work stations connected to multi-user, multi-tasking environment with concurrent capability to:
   l. Access DDC network.
   m. Access or control same control unit.
   n. Access or modify same control unit data base.
   o. Archive data, alarms, and network actions to hard disk regardless of what application programs are being currently executed.
   p. Develop and edit data base.
   q. Implement and tune DDC control.
   r. Develop graphics.
   s. Control facility.
6. Uninterruptible power supply (UPS):
   a. Sized for 50% spare capacity.
   b. The UPS shall be complete with batteries, external bypass and line conditioning.

K. CONTROL UNITS
1. Units: Modular in design and consisting of processor board with programmable RAM memory, local operator access and integral interface equipment.
2. Memory shall be backed up with non-volatile EEPROM.
3. Control Units Functions:
   a. Monitor or control each input/output point.

b. Completely independent with hardware clock/calendar and software to maintain control independently.
c. Acquire, process, and transfer information to User Interface or other control units on network.
d. Accept, process, and execute commands from other control unit's or devices or User Interface.
e. Access both data base and control functions simultaneously.
f. Record, evaluate, and report changes of state or value that occur among associated points. Continue to perform associated control functions regardless of status of network.
g. Perform in stand-alone mode:
    1) Start/stop.
    2) Duty cycling.
    3) Automatic Temperature Control.
    4) Demand control via a sliding window, predictive algorithm.
    5) Event initiated control.
    6) Calculated point.
    7) Scanning and alarm processing.
    8) Full direct digital control.
    9) Trend logging.
    10) Global communications.
    11) Maintenance scheduling.

4. Global Communications:
    a. Broadcast point data onto network, making that information available to all other system control units.
    b. Transmit any or all input/output points onto network for use by other control units and utilize data from other control units.
5. Input/Output Capability:
    a. Discrete/digital input (contact status).
    b. Discrete/digital output.
    c. Analog input.
    d. Analog output.
    e. Pulse input (5 pulses/second).
    f. Pulse output (0-655 seconds in duration with 0.01 second resolution).
6. Monitor, control, or address data points. Mix shall include analog inputs, analog outputs, pulse inputs, pulse outputs and discrete inputs/outputs, as required. Install control unit's with minimum 30 percent spare capacity.
7. Point Scanning: Set scan or execution speed of each point to operator selected time from 1 to 250 seconds.
8. Upload/Download Capability: Download from or upload to using the User Interface. Upload/Download time for entire control unit database maximum 10 seconds on hard wired LAN, or 60 seconds over voice grade phone lines.
9. Test Mode Operation: Place input/output points in test mode to allow testing and developing of control algorithms on line without disrupting field hardware and controlled environment. In test mode:
    a. Inhibit scanning and calculation of input points. Issue manual control to input points (set analog or digital input point to operator determined test value) from work station.
    b. Control output points but change only data base state or value; leave external field hardware unchanged.
    c. Enable control actions on output points but change only data base state or value.
10. Local display and adjustment panel: Portable or Integral to control unit, containing digital display, and numerical keyboard. Display and adjust:
    a. Input/output point information and status.
    b. Controller set points.
    c. Controller tuning constants.
    d. Program execution times.

e. High and low limit values.
f. Limit differential.
g. Set/display date and time.
h. Control outputs connected to the network.
i. Automatic control outputs.
j. Perform control unit diagnostic testing.
k. Points in "Test" mode.

11. Uninterruptible power supply (UPS):
    a. Each Control unit shall be equipped with the necessary UPS such that it will not cease operation during minor power outages, including those that occur upon transfer to emergency generator or other local power source not provided by the utility.

L. LOCAL AREA NETWORKS (LAN)
1. Provide communication between control units over local area network (LAN).
2. LAN Capacity: Not less than 60 stations or nodes.
3. Break in Communication Path: Alarm and automatically initiate LAN reconfiguration.
4. LAN Data Speed: Minimum 10 Mbs.
5. Communication Techniques: Allow interface into network by multiple operation stations and by auto-answer/auto-dial modems. Support communication over telephone lines utilizing modems.
6. Transmission Median: Fiber optic or single pair of solid 24 gauge twisted, shielded copper cable.
7. Network Support: Time for global point to be received by any station, shall be less than 3 seconds. Provide automatic reconfiguration if any station is added or lost. If transmission cable is cut, reconfigure two sections with no disruption to system's operation, without operator intervention.

M. OPERATING SYSTEM SOFTWARE
1. Input/Output Capability From User Interface:
    a. Request display of current values or status in tabular or graphic format.
    b. Command selected equipment to specified state.
    c. Initiate logs and reports.
    d. Change analog limits.
    e. Add, delete, or change points within each control unit or application routine.
    f. Change point input/output descriptors, status, alarm descriptors, and engineering unit descriptors.
    g. Add new control units to system.
    h. Modify and set up maintenance scheduling parameters.
    i. Develop, modify, delete or display full range of color graphic displays.
    j. Automatically archive select data even when running third party software.
    k. Provide capability to sort and extract data from archived files and to generate custom reports.
    l. Support two printer operations.
    m. Alarm printer: Print alarms, operator acknowledgements, action messages, system alarms, operator sign-on and sign-off.
    n. Data printer: Print reports, page prints, and data base prints.
    o. Select daily, weekly or monthly as scheduled frequency to synchronize time and date in digital control units. Accommodate daylight savings time adjustments.
    p. Print selected control unit data base.
2. Operator System Access: Via software password with minimum 30 access levels at work station and minimum 3 access levels at each control unit.
3. Data Base Creation and Support: Changes shall utilize standard procedures. Control unit shall automatically check work station data base files upon connection and verify data base match. Minimum capability shall include:
    a. Add and delete points.

b. Modify any point parameter.
c. Change, add, or delete English language descriptors.
d. Add, modify, or delete alarm limits.
e. Add, modify, or delete points in start/stop programs, trend logs, etc.
f. Create custom relationship between points.
g. Create or modify DDC loops and parameters.
h. Create or modify override parameters.
i. Add, modify, and delete any applications program.
j. Add, delete, develop, or modify dynamic color graphic displays.

4. Dynamic Color Graphic Displays:
   a. Utilizes custom symbols or system supported library of symbols.
   b. Sixteen 256 colors.
   c. Sixty (60) outputs of real time, live dynamic data per graphic.
   d. Dynamic graphic data.
   e. 1,000 separate graphic pages.
   f. Modify graphic screen refresh rate between 1 and 60 seconds.
5. User Interface:
   a. Accept data from LAN as needed without scanning entire network for updated point data.
   b. Interrogate LAN for updated point data when requested.
   c. Allow operator command of devices.
   d. Allow operator to place specific control units in or out of service.
   e. Allow parameter editing of control units.
   f. Store duplicate data base for every control unit and allow down loading while system is on line.
   g. Control or modify specific programs.
   h. Develop, store and modify dynamic color graphics.
   i. Provide data archiving of assigned points and support overlay graphing of this data utilizing up to four (4) variables.
6. Alarm Processing:
   a. Off normal condition: Cause alarm and appropriate message, including time, system, point descriptor, and alarm condition. Select alarm state/value and which alarms shall cause automatic dial-out.
   b. Critical alarm or change-of-state: Display message, stored on disk for review and sort, or print.
   c. Print on line changeable message, up to 60 characters in length, for each alarm point specified.
   d. Display alarm reports on video. Display multiple alarms in order of occurrence.
   e. Define time delay for equipment start-up or shutdown.
   f. Allow unique routing of specific alarms.
   g. Operator specifies if alarm requires acknowledgement.
   h. Continue to indicate unacknowledged alarms after return to normal.
   i. Alarm notification:
      1) Automatic print.
      2) Display indicating alarm condition.
      3) Selectable audible alarm indication.
      4) Electronic notification to facility manager’s email
7. Event Processing: Automatically initiate commands, user defined messages, take specific control actions or change control strategy and application programs resulting from event condition. Event condition may be value crossing operator defined limit, change-of-state, specified state, or alarm occurrence or return to normal.
8. Automatic Restart: Automatically restart field equipment on restoration of power. Provide time delay between individual equipment restart and time of day start/stop.
9. Messages:
   a. Automatically display or print user-defined message subsequent to occurrence of selected events.

b. Compose, change, or delete any message.
c. Display or log any message at any time.
d. Assign any message to any event.

10. Reports:
    a. Manually requested with time and date.
    b. Long term data archiving to hard disk.
    c. Automatic directives to download to transportable media such as floppy diskettes for storage.
    d. Data selection methods to include data base search and manipulation.
    e. Data extraction with mathematical manipulation.
    f. Data reports shall allow development of XY curve plotting, tabular reports (both statistical and summary), and multi-point timed based plots with not less than four (4) variables displayed.
    g. Generating reports either normally at operator direction, or automatically under work station direction.
    h. Reports may either manually displayed or printed, or may be printed automatically on daily, weekly, monthly, yearly or scheduled basis.
    i. Include capability for statistical data manipulation and extraction.
    j. Provide capability to generate four types of reports: Statistical detail reports, summary reports, trend graphic plots, x-y graphic plots.
11. Parameter Save/Restore: Store most current operating system, parameter changes, and modifications on disk or diskette.
12. Data Collection:
    a. Automatically collect and store in disk files.
    b. Daily electrical energy consumption, peak demand, and time of peak demand for up to electrical meters over 2 year period.
    c. Daily consumption for up to 30 meters over a 2 year period.
    d. Daily billable electrical energy consumption and time for up to 1024 zones over a 10 year period.
    e. Provide archiving of stored data for use with system supplied custom reports.
13. Graphic Display: Support graphic development on work station with software features:
    a. Page linking.
    b. Generate, store, and retrieve library symbols.
    c. Single or double height characters.
    d. Sixty (60) dynamic points of data per graphic page.
    e. Pixel level resolution.
    f. Animated graphics for discrete points.
    g. Analog bar graphs.
    h. Display real time value of each input or output line diagram fashion.
14. Dynamic Color Graphics
    a. Provide dynamic 256 color graphics for the following systems:
        1) Boiler Plant including pumps.
        2) Chiller plant including pumps and cooling tower
        3) Each air handling unit.
        4) Floor plans including each terminal box on each floor.
    b. User Interface shall update in real time and shall include every point which is monitored or controlled. Ie a cooling tower graphic shall include entering and leaving condenser water temperature, fan(s) status, fan(s) speed and bypass valve position (if a bypass valve is used).
    c. All access to graphics shall be via mouse input - no keyboard input shall be required. Each point shall be a maximum of three mouse clicks away ie choose desired floor plan, click on volume box on floor plan, click on point on volume box to be accessed.
    d. Schematics included with the construction documents shall be used as a basis for producing the graphics. Points which are in alarm shall be clearly indicated on each graphic.

e. Graphics of variable volume boxes shall be included on each floor plan and shall reference the variable volume box number on the contract documents HVAC schedule. Graphics shall list for each box the rooms or areas served by the box.

15. Maintenance Management:
    a. Run time monitoring, per point.
    b. Maintenance scheduling targets with automatic annunciation, scheduling and shutdown.
    c. Equipment safety targets.
    d. Display of maintenance material and estimated labor.
    e. Target point reset, per point.
16. Advisories:
    a. Summary which contains status of points in locked out condition.
    b. Continuous operational or not operational report of interrogation of system hardware and programmable control units for failure.
    c. Report of power failure detection, time and date.
    d. Report of communication failure with User Interface, field interface unit, point, programmable control unit.

N. LOAD CONTROL PROGRAMS
1. General: Support inch-pounds and S.I. metric units of measurement.
2. Demand Limiting:
    a. Monitor total power consumption per power meter and shed associated loads automatically to reduce power consumption to an operator set maximum demand level.
    b. Input: Pulse count from incoming power meter connected to pulse accumulator in control unit.
    c. Forecast demand (kW): Predicted by sliding window method.
    d. Automatically shed loads throughout the demand interval selecting loads with independently adjustable on and off time of between one and 255 minutes.
    e. Demand Target: Minimum of 3 per demand meter; change targets based upon (1) time, (2) status of pre-selected points, or (3) temperature.
    f. Load: Assign load shed priority, minimum "ON" time and maximum "OFF" time.
    g. Limits: Include control band (upper and lower limits).
    h. Output advisory if loads are not available to satisfy required shed amount, advise shed requirements and requiring operator acknowledgement.
3. Automatic Time Scheduling:
    a. Self-contained programs for automatic start/stop/scheduling of building loads.
    b. Support up to seven (7) normal day schedules, seven (7) "special day" schedules and two (2) temporary day schedules.
    c. Special days schedule shall support up to 30 unique date/duration combinations.
    d. Any number of loads assigned to any time program; each load can have individual time program.
    e. Each load assigned at least 16 control actions per day with 1 minute resolution.
    f. Time schedule operations may be:
        1) Start.
        2) Optimized Start.
        3) Stop.
        4) Optimized Stop.
        5) Cycle.
        6) Optimized Cycle.
    g. Minimum of 30 holiday periods up to 100 days in length may be specified for the year.
    h. Create temporary schedules.
    i. Broadcast temporary "special day" date and duration.
4. Start/Stop Time Optimization:

a. Perform optimized start/stop as function of outside conditions, inside conditions, or both.
b. Adaptive and self-tuning, adjusting to changing conditions unattended.
c. For each point under control, establish and modify:
1) Occupancy period.
2) Desired temperature at beginning of occupancy period.
3) Desired temperature at end of occupancy period.

5. Night Setback/Setup Program: Reduce heating space temperature setpoint or raise cooling space temperature setpoint during unoccupied hours; in conjunction with scheduled start/stop and optimum start/stop programs.
6. Calculated Points: Define calculations and totalization computed from monitored points (analog/digital points), constants, or other calculated points.
a. Employ arithmetic, algebraic, Boolean, and special function operations.
b. Treat calculated values like any other analog value, use for any function that a "hard wired point" might be used.
7. Event Initiated Programming: Event may be initiated by any data point, causing series of controls in a sequence.
a. Define time interval between each control action between 0 to 3600 seconds.
b. Output may be analog value.
c. Provide for "skip" logic.
d. Verify completion of one action before proceeding to next. If not verified, program shall be able to skip to next action.
8. Direct Digital Control: Each control unit shall provide Direct Digital Control software so that the operator may customize control strategies and sequences of operation by defining the appropriate control loop algorithms and choosing the optimum loop parameters.
a. Control loops: Defined using "modules" that are analogous to standard control devices.
b. Output: Paired or individual digital outputs for pulse-width modulation, and analog outputs, as required.
c. Firmware:
1) PID with analog or pulse-width modulation output.
2) Floating control with pulse-width modulated outputs.
3) Two-position control.
4) Primary and secondary reset schedule selector.
5) Hi/Lo signal selector.
6) Single pole double throw relay.
7) Single pole double throw time delay relay with delay before break, delay before make and interval time capabilities.
d. Direct Digital Control loops: Downloaded upon creation or on operator request. On sensor failure, program shall execute user defined failsafe output.
e. Display: Value or state of each of the lines which interconnect DDC modules.
9. Fine Tuning Direct Digital Control PID or floating loops:
a. Display information:
1) Control loop being tuned
2) Input (process) variable
3) Output (control) variable
4) Setpoint of loop
5) Proportional band
6) Integral (reset) Interval
7) Derivative (rate) Interval
b. Display format: Graphic, with automatic scaling; with input and output variable superimposed on graph of "time" vs "variable".
10. Trend logging:
a. Each control unit will store samples of control unit's data points.
b. Minimum of 7 days historical data shall be stored.
c. Update file continuously at discretely assignable intervals.

d. Automatically initiate upload request and then store data on hard disk.
e. Time synchronize sampling at operator specified times and intervals with sample resolution of one minute.
f. Co-ordinate sampling with on/off state of specified point.
g. Display trend samples on work station in graphic format. Automatically scale trend graph with minimum 60 samples of data in plot of time vs data.
h. Provide trending operations during the commissioning process as needed to trouble shoot system dis-functions.

O. PROGRAMMING APPLICATION FEATURES
1. Trend Point:
a. Sample up to 500 points, real or computed, with each point capable of collecting samples at intervals specified in minutes, hours, days, or month.
b. Output trend logs as line graphs or bar graphs. Output graphic on terminal, with each point for line and bar graphs designated with a unique pattern or color vertical scale either actual values or percent of range, and horizontal scale time base. Print trend logs up to 12 columns of one point/column.
2. Alarm Messages:
a. Allow definition of messages.
b. Assign alarm messages to system messages including point's alarm condition, point's off-normal condition, totalized point's warning limit, hardware elements advisories.
c. Output assigned alarm with "message requiring acknowledgement".
d. Operator commands include define, modify, or delete; output summary listing current alarms and assignments; output summary defining assigned points.
3. Weekly Scheduling:
a. Automatically initiate equipment or system commands, based on preselected time schedule for points specified.
b. Provide program times for each day of week, per point, with one minute resolution.
c. Automatically generate alarm output for points not responding to command.
d. Provide for holidays, minimum of 366 consecutive holidays.
e. Operator commands:
1) System logs and summaries.
2) Start of stop point.
3) Lock or unlock control or alarm input.
4) Add, delete, or modify analog limits and differentials.
5) Adjust point operation position.
6) Change point operational mode.
7) Open or close point.
8) Enable/disable, lock/unlock, or execute interlock sequence or computation profile.
9) Begin or end point totalization.
10) Modify totalization values and limits.
11) Access or secure point.
12) Begin or end HVAC or load control system.
13) Modify load parameter.
14) Modify demand limiting and duty cycle targets.
f. Output summary: Listing of programmed function points, associated program times, and respective day of week programmed points by software groups or time of day.
4. Interlocking:
a. Permit events to occur, based on changing condition of one or more associated master points.
b. Binary contact, high/low limit of analog point or computed point shall be capable of being utilized as master. Same master may monitor or command multiple slaves.
c. Operator commands:
1) Define single master/multiple master interlock process.

2) Define logic interlock process.
3) Lock/unlock program.
4) Enable/disable interlock process.
5) Execute terminate interlock process.
6) Request interlock type summary.

P. SENSORS
1. Electronic Sensors: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
2. Thermistor temperature sensors as follows:
   a. Accuracy: Plus or minus 0.36 deg F at calibration point.
   b. Wire: Twisted, shielded-pair cable.
   c. Insertion Elements in Ducts and equipment: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. .
   d. Averaging Elements in Ducts and equipment: 72 inches long, flexible use where prone to temperature stratification or where ducts are larger than 9 sq. ft. (1 sq. m); length as required.
   e. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
   f. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
   g. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.
3. Resistance Temperature Detectors: Platinum.
   a. Accuracy: Plus or minus 0.2 percent at calibration point.
   b. Wire: Twisted, shielded-pair cable.
   c. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (1 sq. m).
   d. Averaging Elements in Ducts: 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 9 sq. ft. (1 sq. m); length as required.
   e. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
   f. Room Sensors refer to construction and accessories below.
   g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
4. Humidity Sensors: Bulk polymer sensor element.
   a. Accuracy: 5 percent full range with linear output.
   b. Room Sensors: Span of 25 to 90 percent relative humidity with 2% accuracy.
   c. Duct and Outside-Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.
5. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
   a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   b. Output: 4 to 20 mA.
   c. Building Static-Pressure Range: 0 to 0.25 inch wg
   d. Duct Static-Pressure Range: 0 to 5 inches wg.
6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.
7. Equipment operation sensors as follows:
   a. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg.
   b. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig
   c. Status Inputs for Electric Motors: Current-sensing relay with current transformers, adjustable and set to 175 percent of rated motor current.
8. Low-Temperature Thermostats: Remote bulb with vapor-filled sensing element.
   a. Range: 15°F-55°F

b. Manual reset
c. Main and separate reverse-acting contacts to deactivate motor / close OA damper and activate alarm condition.
d. Adjustable setpoint at unit.

9. Electronic Valve/Damper Position Indication: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

Q. HORN & STROBE ALARMS
1. Acceptable Manufacturers
a. Edwards Series 51
b. Approved Equal
2. Low voltage 24V AC or DC power connection.
3. Adjustable volume, min 85 dBA at 10 feet.
4. Red shatter resistant polycarbonate lens with guard.
5. UL 1638 listed.

R. AIRFLOW/TEMPERATURE MEASUREMENT DEVICES
1. Manufacturer
a. The model numbers and components below are based on the IAQ Gold Series system by Ebtron Inc. This specification is meant to establish a standard of quality only and is not meant to limit competitive bidding by other manufacturers. Requirements below for data logging may be performed at DDC panel if desired.
2. Provide airflow/temperature measurement devices where indicated on the plans and/or specifications. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices indicated on the plans.
3. Each measurement device shall consist of one or more sensor probe assemblies and a single microprocessor-based transmitter. Each sensor probe assembly will contain one or more independently wired sensor housings. Multiple sensor housings shall be equally weighted and averaged by the transmitter prior to output. Pitot tubes and arrays are not acceptable. Vortex shedding flow meters are not acceptable.
4. All Sensor Probe Assemblies
a. Each sensor housing shall be manufactured of a U.L. listed engineered thermoplastic.
b. Each sensor housing shall utilize two hermetically sealed, bead-in-glass thermistor probes to determine airflow rate and ambient temperature. Devices that use “chip” type thermistors are unacceptable. Devices that do not have 2 thermistors in each sensor housing are not acceptable.
c. Each sensor housing shall be calibrated at a minimum of 16 airflow rates and have an accuracy of +/-2% of reading over the entire operating airflow range. Each sensor assembly shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).
1) 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.
d. The operating temperature range for the sensor probe assembly shall be -20° F to 160° F. The operating humidity range for the sensor probe assembly shall be 0-99% RH (non-condensing).
e. Each temperature sensor shall be calibrated at a minimum of 3 temperatures and have an accuracy of +/-0.15° F over the entire operating temperature range. Each temperature sensor shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).
f. Each sensor probe assembly shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to a remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.
g. Each sensor assembly shall not require matching to the transmitter in the field.

h. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter at a given measurement location.

5. Duct and Plenum Sensor Probe Assemblies
   a. Sensor housings shall be mounted in an extruded, gold anodized, 6063 aluminum tube probe assembly.
   b. The number of sensor housings provided for each location shall be determined by the manufacturer based on the requirements of the application.
   c. Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:
      1) Insertion mounted through the side or top of the duct
      2) Internally mounted inside the duct or plenum
      3) Standoff mounted inside the plenum
   d. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.
6. Fan Inlet Sensor Probe Assemblies
   a. Sensor housings shall be mounted on 304 stainless steel blocks.
   b. Mounting rods shall be field adjustable to fit the fan inlet and constructed of nickel plated steel.
   c. Mounting feet shall be constructed of 304 stainless steel.
   d. The operating airflow range shall be 0 to 10,000 FPM unless otherwise indicated on the plans.
7. Transmitters
   a. The transmitter shall have an LCD display capable of displaying airflow and temperature. Airflow shall be field configurable to be displayed as a velocity or a volumetric rate.
   b. The transmitter shall be capable of displaying the individual airflow and temperature readings of each sensor on the LCD display.
      1) The transmitter shall operate on 24 VAC. The transmitter shall not require an isolated power source.
   c. The operating temperature range for the transmitter shall be -20° F to 120° F. The transmitter shall be protected from weather and water.
   d. The transmitter shall be capable of communicating with the host controls using one of the following interface options:
      1) Linear analog output signal: Field selectable, fuse protected and isolated, 0-10VDC and 4-20mA (4-wire)
      2) RS-485: Field selectable BACnet-MS/TP, ModBus-RTU and Johnson Controls N2 Bus
      3) 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, ModBus-TCP and TCP/IP
      4) LonWorks Free Topology
8. The measuring device shall be UL listed as an entire assembly.
9. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans and/or called for in specifications. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer's placement requirements. Refer to PART 1 – STANDARD REPORTING REQUIREMENTS, this document, for general information.

S. DAMPERS:
1. The mechanical contractor shall coordinate with the ATC contractor which equipment is being provided with automatic control dampers and actuators. Any equipment not provided with automatic control dampers or actuators by the manufacturer, but requiring them per the sequence of operation, shall be provided by the ATC contractor.
2. Automatic dampers, furnished by the Control Contractor shall be single or multiple blade as required. Dampers are to be installed by the sheetmetal contractor under the supervision of the temperature control contractor. All blank-off plates and conversions

necessary to install smaller than duct size dampers are the responsibility of the sheetmetal contractor.

a. All damper frames are to be constructed of 13 gauge galvanized sheetmetal and shall have flanges for duct mounting.
b. Damper blades shall not exceed 6" in width. All blades are to be of corrugated type construction, fabricated from two (2) sheets of 22 galvanized sheet steel, spot welded together. Blades are to be suitable for high velocity performance.
c. When damper assemblies (damper, accessories and hardware) are required in stainless ductwork, provide assembly with all stainless construction.
d. All damper bearings are to be made of nylon. Bushings that turn in the bearings are to be oil-impregnated sintered metal.
e. Replaceable butyl rubber seals are to be provided with the damper. Seals are to 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.
f. All dampers serving openings integral to the building envelope shall be Class I motorized, leakage rated dampers with a maximum leakage of 4 CFM per square foot at 1.0 in. w.g. when tested in accordance with AMCA 500D
g. Gravity dampers shall be permitted in buildings less than three stories in height above grade

T. DAMPER OPERATORS:

1. Electronic direct-coupled actuation shall be provided.
2. The actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assembly shall be of a “V” bolt design with associated “V” shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a “V” clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or set screw type fasteners are not acceptable.
3. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
4. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.
5. All spring return actuators shall be capable of both clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
6. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control input and provide a 2 to 10 VDC or 4 to 20 mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is acceptable. All actuators shall provide a 2 to 10 VDC position feedback signal.
7. All 24 VAC/VDC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC or more than 8 watts for DC applications. Actuators operating on 120 VAC power shall not require more than 10 VA. Actuators operating on 230 VAC power shall not require more than 11 VA.
8. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque capacity shall have a manual crank for this purpose.
9. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.
10. Actuators shall be provided with a conduit fitting and a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.

11. Actuators shall be Underwriters Laboratories Standard 873 listed and Canadian Standards Association Class 4813 02 certified as meeting correct safety requirements and recognized industry standards.
12. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of installation. Manufacturer shall be ISO9001 certified.

U. DDC COMPONENT INSTALLATION
1. EXAMINATION
   a. Verify that conditioned power supply is available to the control units and to the User Interfaces within the owner facility . Verify that field end devices, and wiring is installed prior to installation proceeding.
2. INSTALLATION
   a. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
   b. Contractor shall group and centrally locate all control transformers. Refer to electrical drawings for designated locations.
   c. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation.
   d. Provide with 120v AC, 15 amp dedicated emergency power circuit to each programmable control unit.
   e. All electric wiring and wiring connections, either line voltage or low voltage, required for the installation of the temperature control system, as herein specified, shall be provided by the temperature control contractor unless specifically shown on the electrical drawings or called for in the electrical specifications. The wiring installation shall be in accordance with National and Local Codes and with the Electrical portion of these specifications. All wiring shall be run concealed wherever possible. Exposed wiring shall be run in raceways. Raceways shall be Wiremold 200 series with all elbows, raceways, covers, mounting stops, box extensions and wiring for a complete and neat installation.
   f. All wiring shall comply with the requirements of the DIVISION 26 – ELECTRICAL.
3. MANUFACTURER'S FIELD SERVICES
   a. Start and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.
   b. Provide service engineer to instruct Owner's representative in operation of systems plant and equipment period as specified in INSTRUCTIONS TO OWNER paragraph of these specifications.
   c. Provide basic operator training for persons on data display, alarm and status descriptors, requesting data, execution of commands and request of logs. Include dedicated instructor time as specified in INSTRUCTIONS TO OWNER paragraph of these specifications. Provide training on site.

V. SEQUENCE OF OPERATION
1. GENERAL
   a. All setpoints and time delays mentioned in the following sequences shall be adjustable by the operator without any hardware or software revisions.
   b. All sequences of operations shall be performed by direct digital control (DDC) panels. Software in the DDC panels shall determine occupied and unoccupied modes of operation. Names for all points and variables shall be coordinated with Owner and / or Engineer.
   c. Whenever a piece of HVAC equipment is off, whether per control system command, main power manual shut-off, or loss of main power, each unit control device shall go to its fail-safe position.
   d. Air handling unit supply and return smoke isolation dampers shall be normally closed. Provide end switches to verify position of dampers when commanded open, prior to starting air handling unit fans.

e. Air handling unit outdoor, supply and return air flow measuring stations (AFMS) shall be used to monitor respective air flow volumes and display on both attached magnehelics (calibrated in CFM) and the control system's central PC display, via transducers. The airflows shall be used to control the return fan by tracking the supply fan, to measure outside air and ensure that required minimum ventilation is maintained, and to ensure that building pressurization is maintained at a point determined during system balancing.

f. All control points indicated in the following sequences shall be capable of sending an alarm to the system should the value read beyond the range of the adjustable minimum and maximum set points.

g. ATC contractor is responsible for providing all required system points (and associated sensors and equipment) to display all required information as listed in for applicable systems herein.

2. FIRE ALARM INTERLOCKS

a. Smoke Control System Sequences

1) Air Handler Smoke Control: Smoke detector, located within supply and return air ducts signals alarm, stops fans, when products of combustion are detected in airstream.

3. **AIR HANDLING UNIT SEQUENCES (AHU-6**

a. The ATC contractor shall be responsible for the implementation of all controls, monitored points and alarmed points required by this section. System shall be a combination of manufacturer-furnished packaged AHU controls and controls provided by the ATC contractor. The ATC contractor shall install all controls furnished by the RTU manufacturer. The ATC contractor shall coordinate as required with unit manufacturer to ensure all monitored points and alarmed points indicated in this section are provided at FMS graphic user interface. Accessibility of any required points only via local unit controller is not acceptable.

b. Supply Fan Control:

1) The FMS shall start fan to run continuously during occupied periods.

2) Prior to starting of fan(s), associated smoke damper(s) shall open and be proven open via end switch.

3) The FMS shall monitor supply, return and outdoor airflows via airflow measuring stations at fans and outdoor air intakes.

4) Variable-speed fan drive shall modulate to maintain supply duct static pressure. Set point shall be determined via demand-based reset:

a) Initial maximum static pressure set point shall be determined during balancing as the pressure required to provide design airflow at all terminals in the system.

b) Initial minimum static pressure set point shall be 0.5" w.g. (adj.).

c) Operational static pressure set point shall be determined, within the range of the initial minimum and maximum set points, by a continuously polling control loop whose control point is the damper position of the most open VAV damper and whose set point is 90% open.

d) Variable-speed fan drive shall ramp slowly upon commands for start and stop and for speed reset. Rate of change shall be 1 Hz / s (adj.).

5) Set variable-speed drive to minimum speed when fans are stopped.

c. Return Fan Control:

1) The FMS shall start fan to run continuously during occupied periods.

2) Prior to starting of fan(s), associated smoke damper(s) shall open and be proven open via end switch.

3) The FMS shall monitor supply, return and outdoor airflows via airflow measuring stations at fans and outdoor air intakes.

4) Variable-speed fan drive shall modulate to maintain supply airflow differential set point. Airflow differential shall be equal to the building / zone exhaust system airflow plus that airflow required to maintain a positive building

pressure differential of 0.01” w.g. (adj.). Set point shall be determined during balancing.

a) Variable-speed fan drive shall ramp slowly upon commands for start and stop and for speed reset. Rate of change shall be 1 Hz / s (adj.).

5) Building Pressure Differential Monitoring (Airflow Differential Reset):

a) The FMS shall monitor building pressurization as the average of all differential pressure sensors and reset the supply airflow differential set point via return air fan variable-speed drive modulation when the building pressurization is outside the range of 0.005” w.g. (adj.) to 0.015” w.g. (adj.). When average building pressurization is below range, the airflow differential set point shall be increased in 5% (adj.) increments every 5 minutes (adj.), to a maximum reset of 15% (adj.). When average building pressurization is above range, the reverse shall occur.

b) The FMS shall monitor building pressurization via multiple sensors.

c) The FMS shall monitor sensor function and consistency, and initiate an alarm for sensor failure and for significant inconsistency, e.g., a sensed value greater than 0.025” w.g. (adj.), or a negative reading, for 5 minutes (adj.).

6) Set variable-speed drive to minimum speed when fans are stopped.

d. Ventilation Air Control:

1) The FMS shall monitor supply, return and outdoor airflows via airflow measuring stations at fans and outdoor air intakes.

2) During occupied periods, the outdoor air damper shall modulate to maintain minimum outdoor airflow set point. Minimum outdoor airflow set point shall be the greater of the following:

a) The airflow quantity representing the minimum percentage of supply airflow as indicated on the AHU schedule, OR

b) The supply airflow differential set point, i.e., the building / zone exhaust system airflow plus that airflow required to maintain the desired positive building pressure differential.

3) The building static pressure sensor shall be located at the main floor entrance lobby

e. Discharge Air Temperature Set Point:

1) The FMS shall operate unit per the following sequences to maintain set point. Provide control functions as required. During normal, occupied operational periods, set point shall be 55°F (adj.).

2) During mixed air economizer periods, when outside air enthalpy is lower than return air enthalpy, discharge air temperature set point shall be determined via demand-based reset:

a) Initial maximum discharge air temperature set point shall be 65°F (adj.).

b) Operational discharge air temperature set point shall be determined, within the range of the initial and maximum set points, by a continuously polling control loop whose control point is the airflow percentage of the VAV terminal operating in cooling mode at the highest airflow percentage, relative to the maximum set during balancing, and whose set point is 75% (adj.).

f. Mixed Air Control:

1) The FMS shall modulate outside air, return air and relief air dampers to maintain discharge air temperature set point.

a) During occupied periods, the FMS shall modulate outside air dampers between minimum position and 100% open.

b) When unit is in heating, outside air dampers shall be set to minimum position.

c) When outside air temperature exceeds return air temperature, outside air dampers shall be set to minimum position.

d) When outside air enthalpy exceeds return air enthalpy, outside air dampers shall be set to minimum position.
e) During unoccupied periods, outside air and relief air dampers shall be closed and return air dampers shall be set to 100% open.

g. Cooling Control:
1) The FMS shall stage DX cooling to maintain discharge air temperature set point.

h. Dehumidification Control:
1) The FMS shall stage DX cooling to maintain discharge air dewpoint set point.

i. Unoccupied Periods:
1) The FMS shall maintain setback temperature set points during unoccupied periods. The unoccupied space temperature range shall be 60°F (adj.) to 80°F (adj.). The unit shall be off.
2) Upon any space temperature falling below the unoccupied set point, the FMS shall operate radiant heating in the space, where applicable, to return the space temperature to within range. Upon a further drop in temperature, the unit shall be energized and heating sequences engaged to maintain discharge air temperature set point. Once space temperature sensor is satisfied, unit shall be de-energized.
a) Unoccupied heating discharge air temperature set point shall be 70°F (adj.). The FMS shall operate zone re-heat in on-off fashion as required in each space.
3) Upon any space temperature rising above the unoccupied set point, the unit shall be energized and cooling sequences engaged to maintain discharge air temperature set point. Once space temperature sensor is satisfied, unit shall be de-energized.
a) Unoccupied cooling discharge air temperature set point shall be 55°F (adj.).
4) During the morning warm-up period, the space temperature set points shall revert to the occupied period settings.
a) Morning warm-up heating discharge air temperature set point shall be 80°F (adj.). The FMS shall operate space heating sequences as during occupied periods.
b) Once any space temperature sensor is satisfied, the FMS shall revert to normal, occupied control.

j. The ATC contractor shall provide all sensors and programming to indicate the following on operator's Graphic User Interface display:
1) System graphic.
2) Unit status (each unit)
3) Unit mode (occupied / unoccupied, warm-up, etc.) (each unit).
4) Supply fan status (each fan).
5) Supply fan VFD speed (each unit).
6) Supply fan airflow rate (each fan).
7) Supply fan inlet static pressure indication (each fan).
8) Supply fan discharge static pressure indication (each fan).
9) Discharge air temperature indication (each unit).
10) Discharge air temperature set point (each unit).
11) Discharge air dewpoint indication (each unit).
12) Discharge air dewpoint set point (each unit).
13) Supply duct static pressure indication (each system).
14) Supply duct static pressure set point (each system).
15) Supply duct static pressure range (each system).
16) Return fan status (each fan).
17) Return fan VFD speed (each unit).
18) Return fan airflow rate (each fan).
19) Return fan inlet static pressure indication (each fan).

20) Return fan discharge static pressure indication (each fan).
21) Return duct static pressure indication (each system).
22) Return duct static pressure set point (each system).
23) Return duct static pressure range (each system).
24) Return air temperature indication (each system).
25) Return air enthalpy indication (each system).
26) Return air relative humidity indication (each system).
27) Supply / return airflow differential indication (each unit).
28) Supply / return airflow differential set point (each unit).
29) Building differential pressure indication.
30) Building differential pressure range.
31) Outside air temperature indication.
32) Outside air enthalpy indication.
33) Outside air relative humidity indication.
34) Outside air inlet airflow rate (each unit).
35) Outside air damper position (each unit).
36) Relief air damper position (each unit).
37) Return air damper position (each unit).
38) Mixed air temperature indication (each unit).
39) Air-cooled condensing unit status (each unit).
40) Filter differential pressure indication (each filter).
41) Filter differential pressure low limit set point (each filter).
42) Filter differential pressure high limit set point (each filter).

k. Alarms / Safeties:
1) The control system shall initiate alarms in accordance with any of the conditions below, indicate and describe any alarm at the FMS' graphic user interface, and further address any alarm as indicated in the SYSTEM DESCRIPTION and OPERATING SYSTEM SOFTWARE paragraphs above. Unless otherwise noted, each safety indicated shall have its own manual reset accomplished via the FMS workstation rather than at the unit / equipment.
a) Any unit smoke detector is activated. Refer to FIRE ALARM INTERLOCKS paragraph above. Smoke detectors shall be furnished and wired to the fire alarm system by Division 26. Smoke detectors shall be mounted and wired to the FMS by the ATC contractor.
b) Fan discharge static pressure exceeds high limit set point. Initial set point shall be 4.5" w.g. (adj.) for 5 minutes (adj.). The FMS shall shut unit down. The intent is to prevent overpressurization of the unit or ductwork upon closure of any smoke damper.
c) Fan inlet static pressure exceeds low limit set point. Initial set point shall be -2.5" w.g. (adj.) for 5 minutes (adj.). The FMS shall shut unit down. The intent is to prevent collapse of the unit or ductwork upon closure of any smoke damper.
d) Any low-temperature thermostat falls to 38°F (adj.). The FMS shall shut unit down and close outside air and relief air dampers.
e) Any duct high-limit thermostat reaches set point of 200°F (adj.). The FMS shall shut unit down and close outside air and relief air dampers.
f) Any filter pressure transmitter indicates differential pressure outside of range. The FMS shall generate alarm only. Refer to unit schedules for clean and dirty initial filter differential pressure set points.
g) Any condensate pan high limit float switch is activated. The FMS shall disable cooling when pan is near overflow condition.
h) Any fan (supply, return or exhaust) is commanded to run and run status is not sensed via current transformer after a start-up delay of 15 seconds (adj.).
i) Any coil pump is commanded to run and flow is not sensed via flow switch for 5 minutes (adj.). The FMS shall generate alarm only.

j) Any discharge air temperature sensor indicates a variance of 5°F (adj.) above or below set point for 5 minutes (adj.).
k) Any isolation, smoke or combination fire / smoke damper is not fully open during unit operation, as indicated by damper end switch.

2) Whenever a unit is shut down because of one of the safeties, the control system shall retain in memory the reading and set point of each device to help the operator in isolating the reason for the problem.
3) All control system sensors shall have a high and low software alarm limit to indicate temperature problems or a faulty sensor.

l. Coordination:
1) Airflow, mixed air, heating, cooling, safety, and all other controls shall have common inputs and shall not overlap in function.

m. All setpoints and time periods indicated above shall be user-adjustable from the FMS' graphic user interface.

n. The ATC contractor shall field-install all components requiring field installation. All items required for a complete operating system, not provided by the manufacturer shall be by this contractor. The ATC contractor shall fully coordinate all control components, sequences and requirements with the manufacturer before submitting his shop drawings.

o. The ATC contractor shall provide all interlock wiring and controls between the air handling unit(s) and their associated air cooled condensing units.

2.9 PACKAGED ROOF TOP AIR-CONDITIONING UNITS

A. ACCEPTABLE MANUFACTURERS
1. Trane IntelliPak
2. Carrier
3. Daikin
4. Lennox

B. Provide roof top units factory-assembled and tested, designed for roof installation of type, size, accessories and options as schedule on drawings and as follows.

C. Substitute units shall match manufacturer specified in terms of weight and dimensions. All units shall match height, including roof curb, of the specified equipment unless approved by architect and engineer for line of site.

D. CASING: Manufacturers standard casing construction, having corrosion protection coating, and exterior finish. Casings shall have removable panels or access doors for inspection and access to internal parts, a minimum of 1" thick thermal insulation, knockouts for electrical and piping connections, and an exterior condensate drain connection, and lifting lugs.

E. EVAPORATOR FANS: Forward-curved, centrifugal, belt or direct driven fans with adjustable sheaves; and permanently lubricated motor bearings. All motors 1 HP or over shall meet the full load nominal efficiency requirements of EPAct 1992. These standards are the same as those listed in NEMA MG1-1993, Table 12-10. Testing of efficiency shall be performed in accordance with IEEE Standard 112, Test Method B.

F. CONDENSER FANS: Propeller, direct-driven fans with permanently lubricated bearings.

G. COILS:
1. General: Aluminum plate fin and seamless copper tube type. Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes, soldering or tinning shall be used in the bonding process. Coils shall have a galvanized

steel casing. Coils shall be mounted in the coil casing with same end connections accessible for service. Coils shall be removable from the unit through the roof or through the piping enclosure. Coil section shall be completely insulated.

2. Refrigeration cooling coil: have an equalizing type vertical distributor to ensure each coil circuit receives the same amount of refrigerant. Coils shall be proof (450 psig) and leak (300 psig) tested with air pressure under water, then cleaned, dehydrated, and sealed with a holding charge of nitrogen.

H. COMPRESSORS: Direct drive hermetic, or hermetic compressors with integral vibration isolators, and crankcase heaters which de-energize during compressor operation.

I. SAFETY CONTROLS (Minimum Configuration):
1. Low pressure cutout.
2. High pressure cutout.
3. Compressor motor overload protection.
4. Anti-recycling timing device.
5. Evaporator coil freezestat.

J. FILTERS SECTION:
1. Fiberglass throwaway filters in filter rack. 450 FPM maximum velocity.

K. ACCESSORIES
1. ACCESSORIES: Units shall include the following accessories indicated or scheduled:
   a. Roof mounting curb
   b. Control transformer.
   c. Barometric relief damper.
   d. Remote control panel.
   e. Differential Enthalpy economizer. The differential enthalpy economizer shall have the capability of measuring the dry bulb temperature and the relative humidity or wet bulb temperature of both the return air and outside air streams. The differential enthalpy economizer shall have the ability to calculate the enthalpies of both air streams, and position outside and return air dampers based on this information.
   f. Disconnect Switch: Unit shall be provided with a factory installed and wired internal disconnect.

L. COORDINATION
1. Roof curbs for units greater than 12,000 cfm capacity shall be filled with concrete by the General Contractor under the work of Division 3 -Concrete.

PART 3 - EXECUTION

3.1 PROTECTION

A. Be responsible for the care and protection of all work included in this Section until it has been tested and accepted.

B. After delivery and before, during and after installation, protect all equipment, materials and systems from injury or damage of all causes, as well as from theft. Such loss or damage shall be made good without expense to the Owner.

C. Wherever factory finishes of paint, lacquer, baked enamel, etc., have been damaged or deteriorated during construction, use factory furnished painting materials and refinish or touch up the damage or deterioration, to the satisfaction of the Architect. Application shall be by skilled workers experienced in painting and finishing.

3.2 INSTALLATION OF EQUIPMENT - GENERAL

A. Install all equipment and products furnished and make system connections to such equipment in accordance with the manufacturer's instructions.

B. Provide adequate clearances around equipment to permit replacement, normal servicing and maintenance.

C. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

D. Ground equipment: Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

E. Install with required clearance for service and maintenance.

F. Locate all roof mounted equipment a minimum of 10’-0” from the edge of the roof to the service clearance requirement. Equipment can be located near to edge of roof if equipment screen, guard rail or parapet of code required height is provided.

G. Install piping and ductwork adjacent to machine to allow service and maintenance.

3.3 CUTTING, PATCHING AND CORE DRILLING

A. This contractor shall perform all cutting, channeling and coring up to six (6) inches in diameter required for the work of this section.

B. Provide timely notification to other trades of openings required for mechanical work. Supply accurate details of location and size.

C. Obtain written approval of structural engineer before cutting through structural members.

3.4 WIRING

A. Where the mechanical contractor is to provide wiring including but not limited to wiring provided under the Automatic temperature controls paragraph of this specification, the wiring including conduit and materials, shall conform to the requirements of the National Electrical Code and DIVISION 26.

B. For interface between DIVISION 220000 PLUMBING and DIVISION 210000 equipment and the Building Management System (BMS), the wiring between the equipment and the BMS is to be under this Section.

3.5 PAINTING

A. Supply ferrous metal work, except piping and galvanized steel ductwork, with at least one factory prime coat, or paint one prime coat on the job.

B. Paint all galvanized exterior ductwork that is not insulated or jacketed. Comply with ASTM D6386.

C. Clean and steel brush surfaces of welds. Then prime coat all steel supports and brackets.

D. On uninsulated piping, steel brush and prime coat welds.

E. Touch-up or repaint all surfaces damaged during shipment or installation and prepare surface for finish painting.

F. Paint with flat black, all surfaces visible behind air diffusers and grilles, including surfaces behind grilles provided by others to which sheetmetal connects.

G. Prime coat material and finish painting shall conform to the PAINTING paragraph of the architectural specifications.

H. Paint all exterior piping, supports, accessories, etc. that are not galvanized or stainless, with corrosion prevention coating system. Refer to Division 9. Apply per manufacturers recommendations. Coordinate color with Architect.

3.6 FLASHING AND CURBS

A. Curbs, other than pre-manufactured roof curbs, required for the work of this section will be provided under other sections. Pre manufactured curbs for fans and hoods furnished under this section will be installed by this contractor per the requirements of ROOFING and other divisions of the architectural work.

B. Other curbs required for the work of this section including reinforcing steel. Will be provided by others at the expense of this contractor.

C. Curbs are required for roof mounted equipment, around pipes passing through roof, and surrounding holes where pipes or groups of pipes and/or ducts pass through equipment room floors.

D. All roof curbs shall be a at least eighteen inches (18”) in height.

E. Curbs around holes in equipment room floors shall be concrete of steel, extending at least six inches (6”) above the finished floor. Provide a watertight connection between curb and floor.

F. Fill spaces between curbs and pipes and ducts with firestopping material. Firestopping materials and installation methods are specified in DIVISION 7 Section "Through-Penetration Firestop Systems." Floor penetrations shall be watertight.

G. This contractor shall provide flashing for pipe openings or pre - manufactured roof curbs. Work shall be done in accordance with the requirements of the architectural portion of these specifications.

H. This contractor shall carry out all counter flashing for pipes and ducts passing through the roof. Provide counter flashing over flashing or curb. Pitch pockets are not acceptable.

3.7 CONCRETE

A. Concrete required for the work of this section shall be carried out under the CAST IN PLACE CONCRETE section of the architectural specifications.

B. Other concrete work required for the work of this section, including reinforcing steel and concrete required for inertia bases shall be carried out under the work of the architectural specification at the expense of the mechanical contractor.

C. This contractor shall supply and set in position floating reinforced concrete inertia bases, which are provided under the Vibration Isolation paragraph of this specification.

3.8 LINTELS

A. Lintels required for duct openings and other mechanical components shall be furnished under the MISCELLANEOUS METAL portion of the architectural specifications, and shall be installed under the MASONRY portion of the architectural portion of these specifications.

B. This contractor shall coordinate with the general contractor and the structural engineer to ensure that openings are formed in accordance with requirements of the architectural portions of this specification listed above before proceeding with installation of mechanical work over lintels.

3.9 STEEL

A. Steel which is required for the work of this section, and is not shown on the structural or architectural drawings, shall be furnished and installed by this contractor under the requirements of the appropriate sections of the architectural specifications.

B. Steel shall have adequate strength to support equipment and materials during testing and under all operating conditions.

C. Support suspended equipment from the bottom or from manufacturer’s designated suspension points. Tanks and similar equipment with adequate beam strength shall be supported by saddles with a curvature to exactly match the equipment. Other equipment shall be supported continuously.

D. Steel supports exposed to weather or in contact with water or otherwise in a humid atmosphere shall be either galvanized after fabrication or fabricated from materials having approved corrosion resistance. Welds shall be brushed clean and a coat of rust inhibiting paint applied.

E. This contractor shall ensure that equipment is sufficiently rigid for point support by isolators specified in the VIBRATION ISOLATION paragraph of these specifications. Coordinate with supplier of vibration isolation and provide auxiliary structural support if required.

3.10 INSTALLATION OF VIBRATION ISOLATION, SUPPORTS AND SEISMIC RESTRAINT

A. GENERAL
1. Isolation, support and seismic restraint systems must be installed in strict accordance with the manufacturer's submittal data.
2. Vibration isolators shall not cause any change of position of equipment resulting in stress on equipment connections.

B. EQUIPMENT INSTALLATION
1. Equipment shall be isolated as indicated in TABLE A at the end of this section.

2. Additional Requirements:
   a. The minimum operating clearance under all bases shall be 1".
   b. All bases shall be placed in position and supported temporarily by blocks or shims prior to the installation of the equipment, isolators and restraints.
   c. Spring isolators shall be installed after all equipment is installed without changing equipment elevations.
   d. After the entire installation is complete and under full operational load, the spring isolators shall be adjusted so that the load is transferred from the blocks to the isolators.
   e. Remove all debris from beneath the equipment and verify that there are no short circuits of the isolation. The equipment shall be free in all directions.
   f. Install equipment with flexibility in wiring.
   g. Thrust restraints shall be installed on all cabinet fan heads, axial or centrifugal fans whose thrust exceeds 10% of unit weight.
   h. Housekeeping pads for equipment in this section must be properly doweled or bolted, using wedge type expansion bolts to meet the acceleration criteria. Anchor equipment or isolators to housekeeping pads.

C. PIPING and DUCTWORK ISOLATION
1. Installation:
   a. General
      1) Hanger isolators shall be installed with the hanger box hung as close as possible to the structure. (Without touching)
      2) Hanger rods shall not short-circuit the hanger box.
   b. All piping in mechanical equipment room(s) attached to rotating or reciprocating equipment shall be isolated as follows:
      1) Water and steam piping.
         a) Water piping 1-1/4" to 2" and all steam piping larger than 1" shall be hung with TYPE E isolators with 0.25" deflection.
         b) Water pipe larger than 2" shall be hung with TYPE F isolators with 0.75" deflection.
         c) Horizontal floor or roof mounted water piping 1-1/4" to 2" and all steam piping larger than 1" shall be supported by TYPE P isolators with 0.3" deflection.
         d) Water pipe larger than 2" shall be supported by TYPE B isolators with 0.75" deflection.
      2) Control air piping piping from compressor discharge to receiver shall be suspended by TYPE E isolators with 0.25" deflection or supported by TYPE P isolators with 0.3" deflection.
   c. All ductwork over four square feet face area located within 50' from air moving equipment shall be hung with TYPE C hangers with 0.75" deflection.
   d. Emergency generator exhaust shall be isolated with TYPE C isolators with 0.75" deflection (all neoprene components shall be omitted).
   e. Vertical riser supports for water & steam pipe 4" diameter and larger shall be isolated from the structure using TYPE K guides and anchors.
   f. Install TYPE FC-1 flexible connectors at all connections of pipe to externally isolated equipment.
   g. Install FC-2 or 4 type connectors only at locations which exceed temperature limitations of FC-1 or service requires stainless steel or bronze construction flex. (Such as; spaces without floor drains, or pipes carrying gas, fuel oil, steam or Freon)

D. SEISMIC RESTRAINTS
1. Installation
   a. All floor mounted equipment whether isolated or not shall be snubbed, anchored, bolted or welded to the structure. Calculations that determine that isolated equipment movement may be less than the operating clearance of snubbers

(restraints) do not preclude the need for snubbers. All equipment must be positively attached to the structure.

b. All suspended equipment including, but not limited to; air handling units, pumps, fans, tanks, stacks, VAV boxes, unit heaters, fan powered boxes, cabinet unit heaters, etc. shall be two or four point independently braced with TYPE III restraints. Install cable braces taught for non-isolated equipment and slack with ½" cable deflection for isolated equipment. VAV Boxes (without fans) attached directly to ductwork on the main supply side shall be considered as ductwork for seismic design purposes. Rod bracing shall be installed as per approved submittals and shop drawings. Equipment rigidly connected to ductwork weighing less than 75 lbs. is excluded.

c. All horizontally suspended pipe and duct shall use RESTRAINT TYPE III. Spacing of seismic bracing shall be as per TABLE B at the end of this section.

d. For all trapeze-supported piping, the individual pipes must be attached to the trapeze support at the designated restraint locations.

e. For overhead supported equipment, over stress of the building structure must not occur. Bracing may occur from:
   1) Flanges of structural beams.
   2) Upper truss chords in bar joists.
   3) Cast in place inserts or drilled and shielded inserts in concrete structures.

f. Pipe Risers
   1) Where pipe pass through cored holes, holes must be packed with resilient material or fire stop as specified in other sections of this specification and/or state and local codes. No additional horizontal seismic bracing is required at these locations.
   2) Non-isolated, constant temperature pipe risers through cored holes require a riser clamp at each floor level on top of the slab attached in a seismically approved manner for vertical restraint.
   3) Non-isolated, constant temperature pipe risers in pipe shafts require structural steel attached in a seismically approved manner at each floor level and a riser clamp at each floor level on top of, and fastened to the structural steel. The riser clamp and structural steel must be capable of withstanding all thermal, static and seismic loads.
   4) Isolated and/or variable temperature risers through cored holes require Type K riser resilient Guides and Anchors installed to meet both thermal expansion and seismic acceleration criteria.
   5) Isolated and/or variable temperature risers in pipe shafts require Type K resilient riser guides and anchors installed on structural steel to meet both thermal expansion and seismic acceleration criteria. Each floor level must have a riser clamp that does not interfere with the thermal expansion/contraction of the pipe.

g. Chimneys, stacks and boiler breeching passing through floors are to be bolted at each floor level or secured above and below each floor with riser clamps.

h. Diffusers shall be attached to lay-in ceilings with earthquake clips or other approved means of positive attachment to the T- bar ceiling structure.

i. All non-isolated floor or wall mounted equipment and tanks shall use RESTRAINT TYPE III or V.

j. Where base anchoring of equipment is insufficient to resist seismic forces, restraint TYPE III shall be located above the unit’s center of gravity to suitably resist "G" forces specified.
   1) Vertically mounted tanks and up-blast tubular centrifugal fans, tanks or similar equipment may require this additional restraint.

k. A rigid piping or duct system shall not be braced to dissimilar parts of a building or two dissimilar building systems that may respond in a different mode during an earthquake. Examples: Wall and roof; solid concrete wall and a metal deck with lightweight concrete fill, pipes & duct that cross a building expansion joint.

E. INSPECTION

1. If in the opinion of the project engineer the seismic restraint installation does not meet with the project requirements, an outside consultant will be retained to inspect, verify and submit corrective measures to be taken. The consultant's fees and all work associated with such a review shall be borne by the contractor.

TABLE A VIBRATION ISOLATION & SEISMIC RESTRAINT REQUIREMENTS FOR **HVAC** EQUIPMENT			EQUIPMENT INSTALLATION ATTACHMENT POINT								
EQUIPMENT			**ON GRADE**			**ABOVE GRADE**			**ROOF**		
	SIZE (5) (8)	**MOUNTING**	**ISO L**	**DEFL**	**BASE**	**ISO L**	**DEFL**	**BASE**	**ISO L**	**DEFL**	**BASE**
DX ROOF TOP UNITS AIR HANDLING UNITS AIR CONDITIONING UNITS MAKE UP AIR UNITS HEAT RECOVERY UNITS H&V UNITS (10)	TO 3,000 CFM	CURB MOUNT-ED	- -	- -	- -	- -	- -	- -	- -	0.75	B-3
	3,001 TO 5,000 CFM		- -	- -	- -	- -	- -	- -	- -	1.50	B-3
	OVER 5,000 CFM		- -	- -	- -	- -	- -	- -	- -	2.50	B-3

F. Where applicable and for high rise buildings, the seismic restraint design and construction requirements for equipment and piping incorporated as part of Life Safety Systems shall be such that these systems will remain in place and be functional following a major earthquake, and that the design shall consider lateral drifts between stories as specified by code.

TABLE A NOTES:

GENERAL: **ISOL** = Isolator, **DEFL.** = Deflection, All deflections indicated are in inches.

(1) Units may not be capable of point support. Refer to separate equipment specification section, if base is not provided by that section and external isolation is required, provide Type B-1 base by this section for entire unit.
(2) Static deflection shall be determined on the deflection guide. Deflections indicated are minimums at actual load and shall be selected from manufacturer's nominal 4", 3", 2" and 1" deflection spring series. **R.P.M. is defined as the slowest operating speed of the equipment.**
(3) Single stroke compressors may require inertia bases with thickness greater than 12" max. As described for base B-2. Inertia base mass shall be sufficient to maintain double amplitude of 1/8".
(4) For floor mounted fans substitute base TYPE B-2 for class 2 or 3 or any class fan with static pressure over 5".
(5) Equipment with less than 1/3 H.P. is excluded from vibration requirements. (Seismic requirements still apply)
(6) Utility sets with wheel diameters less than 15" need not have deflections greater than 0.75".
(7) Curb mounted fans with curb area less than nine (9) square feet are excluded.
(8) For equipment with multiple motors, H.P. Classification applies to largest single motor.
(9) Exclude B-2 base for skid mounted pump sets.
(10) Based on Supply Air CFM.

DEFLECTION GUIDE	
R.P.M.	**DEFLECTION**
LESS THAN 400	3.50"
401 TO 600	2.50"
601 TO 900	1.50"
OVER 900	0.75"

TABLE B SEISMIC BRACING TABLE		
EQUIPMENT	**ON CENTER SPACING**	
	TRANSVERSE	**LONGITUDINAL**
DUCT	**30 Feet**	**60 Feet**
PIPE	**40 Feet**	**80 Feet**
Boiler Breeching	**30 Feet**	**60 Feet**
Chimneys & Stacks	**30 Feet**	**60 Feet**

NOTE WELL
Projects that contain large pipe may require that the allowable spacing shown in this Table be reduced to minimize structural loading. All associated costs shall be the responsibility of the contractor. Close coordination and approval by the structural engineer is mandatory for all seismic point loads exceeding 2,000 lbs.

3.11 INSTALLATION OF MECHANICAL IDENTIFICATION

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

B. INSTALLATION
1. Plastic Nameplates: Install with corrosive resistant mechanical fasteners, or adhesive.
2. Metal Tags: Install with corrosive resistant chains.
3. Plastic Pipe Markers: Install in accordance with manufacturer's instructions.
4. Plastic Tape Duct Markers: Install in accordance with manufacturer's instructions.
5. Underground Plastic Pipe Markers: Install 6 to 8 inches below finished grade, directly above buried pipe.
6. Ceiling Gird Markers: Apply directly to ceiling t-grid below equipment being marked.

C. APPLICATION
1. EQUIPMENT NAMEPLATES: Equipment manufacturers shall install and permanently fasten equipment nameplates on each major item of mechanical equipment.
   a. Include markers for the following general categories of equipment:
      1) Air handling or similar type units
      2) Boilers
      3) Chillers
      4) Cooling Towers
      5) Condensing Units
      6) Fans
      7) Terminal units (Fan coils, unit heaters, etc)
      8) Pumps
2. EQUIPMENT MARKERS: Install equipment markers with permanent adhesive on or near each major item of mechanical equipment.
   a. Include markers for the following general categories of equipment:
      1) Automatic temperature control cabinets
      2) Air handling or similar type units
      3) Boilers
      4) Chillers
      5) Cooling Towers
      6) Condensing Units
      7) Fans
      8) Terminal units (Fan coils, unit heaters, etc)
      9) Variable air volume terminals
      10) Pumps
3. WARNING-TAG INSTALLATION: Print required message on, and attach warning tags to, equipment and other items where required.
   a. Include markers for the following general categories of equipment:
      1) Steam or refrigerant safety relief vents
      2) Warning lights, strobes an/or horns

3) MRI quench vents
4) Hazardous exhaust (Patient Isolation, toxic fume, etc)

4. ACCESS PANELS: Identify all access doors and panels.
5. BALANCING DAMPERS:
   a. Identify balancing dampers with a 12 to 18” length of 1” width neon orange ribbon. Secure ribbon to damper handle and allow other end to hang free.
6. VALVES:
   a. Identify valves, except valves within heating or cooling terminals, with metal tags. Install valve tags at each valve.
   b. Attach to valves with four (4) inch brass chains.
   c. Prepare valve tag charts. Provide typewritten list of valves with service and corresponding tag number. Install in location as directed by facility owner.
7. CEILING GRID MARKERS:
   a. Provide markings for all concealed equipment and systems requiring routine maintenance to indicate location of access.
   b. Equipment to be indicated includes but is not limited to:
      1) Terminal boxes
      2) Terminal units
      3) Fans
      4) Reheat coils
      5) Filters
      6) Life safety dampers, control dampers, etc.

A. DUCTWORK
1. Locate Ductwork identification and flow arrows as follows:
   a. Identify ductwork with plastic tape duct markers. Identify as to air handling unit number. Locate at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.
   b. On vertical ductwork approximately seven feet above floor.
   c. Behind each access door and panel.
   d. At each change of direction of ductwork.
   e. On each ductwork branch close to point of connection to main ductwork.
   f. At no greater than intervals of 25 feet on straight runs of ductwork, and on both sides of walls.

3.12 INSTALLATION OF DUCTWORK INSULATION

A. GENERAL
1. Install materials after ductwork has been leak tested and approved.
2. Install materials in accordance with manufacturer's instructions.
3. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.
4. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
5. Keep insulation materials dry during application and finishing.
6. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
7. Apply insulation with the least number of joints practical.
8. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity.
9. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.
10. Maintain integrity of vapor barrier and protect it to prevent puncture and other damage.

11. Interior Wall and Partition Penetrations: Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except fire-rated walls and partitions.
12. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations. For insulation indicated to have vapor retarders, taper termination and seal insulation ends with vapor-retarder mastic.
13. Refer to DIVISION 7 Section "Through-Penetration Firestop Systems."" for firestopping materials and requirements for penetrations through fire and smoke barriers.
14. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor. For insulation indicated to have vapor retarders, taper termination and seal insulation ends with vapor-retarder mastic.
15. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.
    a. Seal penetrations with vapor-retarder mastic.
    b. Apply insulation for exterior applications tightly joined to interior insulation ends.
    c. Seal insulation to roof flashing with vapor-retarder mastic.
16. Provide rigid removable insulated panels for duct access doors. Panel insulation value and materials shall match insulation requirements of duct system.

B. INSTALLATION
1. FLEXIBLE FIBERGLASS
    a. Seal jacket joints with vapor barrier tape to match jacket.
    b. Staple seams 6" O.C. with outward cinching staples, then seal with pressure sensitive tape matching jacket.
    c. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging.
    d. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier tape.
    e. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
2. RIGID FIBERGLASS:
    a. Secure insulation to ductwork using mechanical fasteners with pin spacing no greater than 12 inch on center.
    b. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier tape. Tape joints and edges with 3 inch pressure sensitive vapor barrier tape to match jacket.
    c. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
3. APPLICATION

Ductwork Insulation Application Schedule

RT=Rubber Tube	C=Calcium Silicate	PVC=PVC Jacket	RFB=Rigid Foam Board
FL=Flexible Fiberglass	RF= Rigid Fiberglass	ET=Exterior Jacket	FW=Fire Wrap

System	Out of Package Thickness	Type	Min R Value (a)
Interior Concealed Supply Air	2 3/8”	FL	6
Interior Exposed Supply Air	2 3/8”	RF, PVC	6
Interior Concealed Return Air (d)	2 3/8”	FL	6
Interior Exposed Return Air (d)	2 3/8”	RF, PVC	6

(a) Minimum installed value, accounting for compression derating

(b) Inner layer RT, outer layer FL

(c) As required to meet 2 hour rating

(d) In operating rooms, pharmacy and other clean rooms or areas with temperatures below 70°F

3.13 INSTALLATION OF AIR HANDLING UNITS

A. Install in accordance with ARI 435.

B. Install flexible connections specified in “DUCTWORK ACCESSIORES” this SECTION between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.

C. Install assembled unit on vibration isolator rail. Install isolated fans with resilient mountings and flexible electrical leads. Install restraining snubbers as required. Adjust snubbers to prevent tension in flexible connectors when fan is operating.

D. Provide fixed sheaves required for final air balance.

E. Make connections to coils with unions or flanges.

F. Hydronic Coils:
1. Hydronic Coils: Connect water supply to leaving air side of coil (counterflow arrangement).
2. Provide shut-off valve on supply line and lockshield balancing valve with memory stop on return line.
3. Locate water supply at bottom of supply header and return water connection at top.
4. Provide manual float operated automatic air vents at high points complete with stop valve.
5. Ensure water coils are drainable and provide drain connection at low points.

G. Insulate coil headers located outside air flow as specified for piping.

H. Manufacturer's Field Services
1. Prepare and start systems.
2. Supervise rigging, hoisting, and installation; include eight hour day per Air Handler.
3. Start-up Air Handler in presence of and instruct Owners operating personnel.

3.14 TESTING, ADJUSTING AND BALANCING

A. ACCEPTABLE BALANCERS
1. TAB contractors that may be engaged include, but are not limited to, the following. Contractors not listed shall demonstrate compliance with section B QUALITY ASSURANCE as part of the bid package for review by the design team.
   a. E.L. Barrett
   b. J.F. Coffey
   c. Thomas Young
   d. Leonhardt
   e. Advantage Engineering

B. QUALITY ASSURANCE
1. Testing, Adjusting and Balancing shall be performed by a AABC, NEBB or TABB certified company.
   a. TAB field supervisor and technician shall be certified.
2. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

3. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

C. SUBMITTALS
1. Pre-Award:
   a. List of past 10 jobs including a brief description of the scope.
   b. Applicable agency certification copies.
   c. Letter of recommendation.
2. Construction Phase:
   a. Refer to PART 1 – STANDARD REPORTING REQUIREMENTS, this document, for general information.
   b. Prior to the commencement of testing, adjusting and balancing submit to the engineer for review a template report with test sheets for each equipment, air terminal or system type included in the project. The template report shall include the design test data. Do not begin testing until receipt of approved review from engineer. Comply with REPORT FORMS of this section.
   c. Submit preliminary testing field reports. Report defects and deficiencies noted during performance of services which prevent system balance.
   d. Submit final testing field reports. Make corrections or address items indicated in engineers review of preliminary testing field report. Report defects and deficiencies noted during performance of services which prevent system balance.

D. EXAMINATION
1. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
   a. Systems are started and operating in a safe and normal condition.
   b. Temperature control systems are installed complete and operable.
   c. Proper thermal overload protection is in place for electrical equipment.
   d. Final filters are clean and in place. If required, install temporary media in addition to final filters.
   e. Duct systems are clean of debris.
   f. Fans are rotating correctly.
   g. Fire and volume dampers are in place and open.
   h. Air coil fins are cleaned and combed.
   i. Access doors are closed and duct end caps are in place.
   j. Registers, Grilles and Diffusers are installed and connected.
   k. Duct system leakage is minimized.
   l. Hydronic systems are flushed, filled, and vented.
   m. Pumps are rotating correctly.
   n. Proper strainer baskets are clean and in place. Strainers shall have been blown down by HVAC.
   o. Service and balance valves are open.
2. Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance. Refer to PART 1 – STANDARD REPORTING REQUIREMENTS, this document, for general information.

E. Beginning of work means acceptance of existing conditions.

F. PREPARATION
1. Coordinate atleast two balancing meetings, as follows:
   a. For renovation projects, at the first construction kick off meeting, coordinate a preconstruction balancing meeting which will ensure the provision of preconstruction balancing per paragraph H, “Renovation Pre-construction Testing,” of this section.
   b. Following a construction meeting, prior to post-construction balancing work associated with to this section, when the commissioning agent and engineer are scheduled for attendance, provide a post-construction balancing meeting. Provide

anticipated balancing report format, and troubleshoot in advance any obstacles that could prevent the balancing process from being completed as required.

2. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect/Engineer to facilitate spot checks during testing.
3. Provide additional balancing devices as required.
4. The testing, adjusting and balancing contractor shall review system installation at 50%, 75% and 100% construction completion milestones. The Owner and/or Engineer reserve the right to ask for the TAB contractor to provide a written confirmation that systems were inspected at those times.

G. INSTALLATION TOLERANCES
1. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.
2. Registers, Grilles and Diffusers: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.
3. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

H. ADJUSTING
1. Ensure recorded data represents actual measured or observed conditions.
2. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
3. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
4. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
5. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.
6. Check and adjust systems approximately six months after final acceptance and submit report. Refer to PART 1 – STANDARD REPORTING REQUIREMENTS, this document, for general information.
7. Balancing contractor shall be responsible for any rebalance of air devices (i.e. VAV boxes, diffusers and grilles) post building occupancy. Balancing contractor shall carry a 25% cost allowance for any rebalance of these devices.

I. RENOVATION PRE-CONSTRUCTION TESTING
1. Prior to commencing testing coordinate with owner to ensure the all equipment is operational and spaces are accessible.
2. Prepare a pre-construction balancing report prior to demolition and/or new construction.
    a. Measure and record sound and vibration within spaces being renovated.
    b. Measure and record airflow at all main supply, return and exhaust air ducts at limit of demolition.
    c. Test all associated heating and cooling generation and transfer equipment serving the renovated spaces. Testing technician shall record the physical condition of all equipment being tested. Note condition, maintenance or repairs required.
    d. In addition to renovation area and service equipment testing; pre-renovation measurement of all main riser (or trunk) take-offs for multi-floor (area) systems shall be conducted. The intent of this testing is to document the existing supply, return, and exhaust air flows to all floors or areas outside the renovation area that are served by air handler and/or fan(s) serving the space to be renovated. Balancer shall coordinate with Engineer and Owner regarding locations of riser testing; as-built drawings (to the extent available) will be made available to the pre-construction testing contractor at no cost.
    e. The report is intended to record all air and water flows within the spaces being renovated and all associated equipment supplying, exhausting, or returning air or water from the spaces being renovated.

3. Submit pre-construction testing report for review and approval prior to commencement of demolition.

J. PHASED CONSTUCTION
1. Where project is intended to be constructed in multiple phases perform testing, balancing and submit balancing reports at the completion of each phase.
2. At the completion of the project submit a complete balancing report of all phases.
3. Test and adjust systems making provisions for .Measure and prepare a balancing report prior to demolition and/or new construction.
4. Make provisions for temporary balancing or reduce flows as required.

K. AIR SYSTEM PROCEDURE
1. Balance systems in accordance with latest edition of the SMACNA HVAC Systems Testing, Adjusting & Balancing.
2. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities <at site altitude>.
3. Make air quantity measurements in ducts by Pivot tube traverse of entire cross sectional area of duct.
4. Measure air quantities at registers, grilles and diffusers.
5. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
6. Use volume control devices to regulate air quantities only to the extent that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters. Use of diffuser and register dampers shall be for small adjustment only and dampers shall not be closed more than 15%.
7. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
8. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
9. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
10. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
11. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
12. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.
13. Variable Volume Systems.
    a. Compensate for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts
    b. Work with ATC contractor to determine optimal duct static pressure sensor setpoint: Demand-based Static pressure reset:
        1) Static Pressure shall be determined within the range of 0.5” to MaxP by a continuously polling direct-acting control loop whose control point is the damper position of the most open VAV damper and whose setpoint is 90% open.
        2) MaxP shall be determined by the air balancing contractor in conjunction with the control contractor as required to provide design airflow in all boxes downstream of the duct static pressure sensor.
14. Building Pressurization: Work with ATC contractor to determine optimal differential pressure CFM to maintain building pressure at +0.010” across entire operating range. Test

at full economizer, minimum air flow, all VAV boxes commanded to minimum, and all VAV boxes commanded to full cooling.

15. Space Pressurization: Spaces with Room Differential Control: Work with ATC contractor to determine optimal differential pressure CFM to maintain 0.010" (negative or positive as required) between pressure controlled space and reference space. Test at full economizer, minimum air flow, all VAV boxes commanded to minimum, and all VAV boxes commanded to full cooling.

L. SCHEDULES
1. Equipment requiring sound level, Air, Water, and vibration - testing, Adjusting, and Balancing:
   a. Air Handling Units
2. Sound levels shall be taken at all motor driven equipment greater than 3/4 motor horsepower. Test sound levels at the equipment and in spaces above, below and/or adjacent to the equipment.

M. REPORT FORMS: Refer to PART 1 – STANDARD REPORTING REQUIREMENTS, this document, for general information. Provide sound level, water, air, and vibration - testing, balancing and adjustment. Submit reports in the following format:
1. Title Page:
   a. Name of Testing, Adjusting, and Balancing Agency
   b. Address of Testing, Adjusting, and Balancing Agency
   c. Telephone number of Testing, Adjusting, and Balancing Agency
   d. Project name
   e. Project location
   f. Project Architect
   g. Project Engineer
   h. Project Contractor
   i. Project altitude
   j. Report date
2. Summary Comments:
   a. Design versus final performance
   b. Notable characteristics of system
   c. Description of systems operation sequence
   d. Summary of outdoor and exhaust flows to indicate amount of building pressurization
   e. Nomenclature used throughout report
   f. Test conditions
3. List of all rooms with current temperature and RH
4. Floor Plan(s):
   a. Indicate all air terminals as installed and tested.
   b. Show ductwork mains where traverses are taken.
   c. Indicate terminal balanced airflow on plan for each terminal and duct traverse.
5. Instrument List:
   a. Instrument
   b. Manufacturer
   c. Model number
   d. Serial number
   e. Range
   f. Calibration date
6. General Unit Data: List the following for each piece of equipment
   a. Identification / number
   b. Location
   c. Service
   d. Manufacturer
   e. Model number
   f. Serial Number

7. Electric Motor Data:
   a. Manufacturer
   b. Model/Frame
   c. Nominal horsepower
   d. Phase, voltage, amperage; nameplate, actual, no load
   e. RPM
   f. Service factor
   g. Speed setting for SCR controlled PSC motors or EC motors
8. Fan Data:
   a. Airflow, design and actual
   b. Suction static pressure
   c. Discharge static pressure
   d. Design total static pressure
   e. RPM, design and actual
   f. Sheave size
   g. Sheave position
9. Cooling Coil Data:
   a. Indication of strainer blow-down by HVAC prior to work
   b. Air flow, design and actual
   c. Saturated suction temperature, design and actual
   d. Air pressure drop, design and actual

N. EQUIPMENT AND DEVICE TESTING
1. Test the following parameters of the equipment indicated. Refer to specific requirements listed in REPORT FORMS sub-section above for detailed information in each category.
2. Air Handling Units, Roof Top Units, Energy Recovery Units, Make Up Air Units
   a. General unit data
   b. Electric motor data
   c. Fan Data
   d. Heating coil data
   e. Cooling coil data
   f. Energy recovery defrost mode setpoint
   g. Outdoor air flow, design and actual
   h. Outdoor air temperature
   i. Return air temperature
   j. Outdoor air ratio, design and actual
   k. Static pressure profile across each component
   l. Duct static pressure setpoint for VAV systems
   m. Building pressure control set point or CFM offset for return or exhaust fans
   n. Building pressure, design and actual
3. Duct Traverse:
   a. System zone/branch
   b. Duct size
   c. Area
   d. Design velocity
   e. Design air flow
   f. Test velocity
   g. Test air flow
   h. Duct static pressure
   i. Air temperature
   j. Air correction factor
4. Air Distribution Test Sheet:
   a. Air terminal number
   b. Room number/location
   c. Terminal type
   d. Terminal size

e. Area factor
f. Design velocity
g. Design air flow
h. Test (final) velocity
i. Test (final) air flow
j. Percent of design air flow

5. Space Pressurization Report:
   a. Pressurized (positive or negative) room number/location
   b. Referenced room/location(s)
   c. Pressure relationship
   d. Pressure differential, design and actual
6. Sound Level Report:
   a. Location
   b. Octave bands - equipment off
   c. Octave bands - equipment on
7. Vibration Test:
   a. Location of points:
   b. Fan bearing, drive end
   c. Fan bearing, opposite end
   d. Motor bearing, center (if applicable)
   e. Motor bearing, drive end
   f. Motor bearing, opposite end
   g. Casing (bottom or top)
   h. Casing (side)
   i. Duct after flexible connection (discharge)
   j. Duct after flexible connection (suction)
   k. Horizontal, velocity and displacement
   l. Vertical, velocity and displacement
   m. Axial, velocity and displacement
   n. Normally acceptable readings, velocity and acceleration
   o. Unusual conditions at time of test
   p. Vibration source (if non-complying)

3.15 AIR DUCT AND SYSTEM CLEANING

A. Owner Testing:
   1. Owner will obtain testing of duct cleanliness at their discretion if in the opinion of the owner, engineer or commissioning agent the installed systems have not been properly protected as required by these specifications.
   2. If owner obtained tests show that air duct and system cleanliness fail to meet the industry standards then the contractor will be required to obtain the services of an independent cleaning contractor to clean and verify systems per the procedures specified herein.

B. Engage a certified Air system cleaning specialist (ASCS) to clean the following systems:
   1. Duct mains, branches, elbows, turning vanes, plenums, VAV boxes and sound attenuators.
   2. Air outlets and inlets (registers, grilles, and diffusers).
   3. Supply, return, and exhaust fans including fan housings, plenums (except ceiling return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
   4. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
   5. Coils and related components.
   6. Return-air ducts, dampers, actuators, and turning vanes except in ceiling return plenums.
   7. Supply-air ducts, dampers, actuators, and turning vanes.
   8. Dedicated exhaust and ventilation components and makeup air systems.

C. ASCS Qualifications: A certified member of National Air Duct Cleaners Association (NADCA).
   1. Certification: Employ an ASCS certified by NADCA on a full-time basis
   2. Supervisor Qualifications: Certified as an ASCS by NADCA

D. Experience: Submit records of experience in the field of HVAC systems cleaning.

E. Examination:
   1. Examine systems to determine appropriate methods, tools, and equipment required for performance of work.
   2. Prepare written report listing conditions detrimental to performance of work.
   3. Proceed with work only after unsatisfactory conditions have been corrected.

F. SUBMITTALS
   1. Ductwork cleaning procedures.
   2. Refer to “COORDINATION DRAWINGS” this SECTION. Show location of required access doors for proper system cleaning.
   3. Refer to “RECORD DRAWINGS” this SECTION. Show location of access doors installed during cleaning process.

G. Perform cleaning and testing prior to Testing, Adjusting and Balancing. Upon completion of air duct and system cleaning and prior to Testing, Adjusting and Balancing replace all Air filters.

H. Use duct-mounted access doors, as required, for physical and mechanical entry and for inspection.
   1. Install additional duct-mounting access doors to comply with duct cleaning standards.
   2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection. Replace damaged and deteriorated flexible ducts.
   3. Disconnect and reconnect flexible connectors as needed for cleaning and inspection. Replace damaged and deteriorated flexible connectors
   4. Reseal rigid-fiberglass-duct systems according to NAIMA recommended practices.
   5. Replace damaged fusible links on fire and smoke dampers. Replacement fusible links shall be same rating as those being replaced.
   6. Remove and reinstall ceiling components to gain access for duct cleaning. Clean ceiling components after they have been removed and replaced.

I. Mark position of dampers and air-directional mechanical devices before cleaning, and restore to their marked position on completion.

J. Particulate Collection and Odor Control:
   1. Where venting vacuuming system inside building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron size (or greater) particles.
   2. When venting vacuuming system outside building, use filtration to contain debris removed from the HVAC system and locate exhaust down wind and away from air intakes and other points of entry into building.

K. Clean the following metal-duct system components by removing visible surface contaminants and deposits:
   1. Air outlets and inlets (registers, grilles, and diffusers).
   2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
   3. Air-handling-unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
   4. Coils and related components.

5. Return-air ducts, dampers, and actuators, except in ceiling plenums and mechanical room.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components.

L. Mechanical Cleaning Methodology:
1. Clean metal-duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of ducts so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts or duct liner.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment, and do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide operative drainage system for washdown procedures.
7. Biocidal Agents and Coatings: Apply biocidal agents if fungus is present; use according to manufacturer's written instructions after removal of surface deposits and debris.

M. Cleanliness Verification:
1. Verify cleanliness after mechanical cleaning and before application of treatment, including biocidal agents and protective coatings.
2. Visually inspect metal-duct systems for contaminants.
3. Where contaminants are discovered, reclean and reinspect duct systems.

N. Duct Access
1. Install duct-mounting access doors where access doors do not currently exist to allow for the cleaning of ducts, accessories, and terminal units as follows:
   a. Refer to ACCESS DOORS AND FRAMES this section.
   b. On both sides of duct coils.
   c. Downstream from volume dampers, turning vanes, and equipment.
   d. Adjacent to fire or smoke dampers; reset or install new fusible links.
   e. Before and after each change in direction, at maximum 50-footspacing.
   f. On sides of ducts where adequate clearance is available.

O. Connections
1. Reconnect ducts to fans and air-handling units with existing flexible connectors after cleaning ducts and flexible connectors. Replace existing damaged and deteriorated flexible connectors.
2. For fans developing static pressures of 5-inch wgand higher, cover replacement flexible connectors with loaded vinyl sheet held in place with metal straps.
3. Reconnect terminal units to supply ducts with existing flexible ducts or replace damaged and deteriorated existing flexible ducts with maximum 12-inchlengths of new flexible duct.
4. Reconnect diffusers or light troffer boots to low-pressure ducts with existing flexible ducts or replace damaged and deteriorated existing flexible ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.
5. Reconnect existing and new flexible ducts to metal ducts with adhesive plus sheetmetal screws.

P. Testing/Reporting
1. NADCA ACR 2006 Vacuum Test Method: Sections of metal-duct system, chosen randomly by Owner, Architect, or Engineer shall be tested for cleanliness according to

NADCA vacuum test gravimetric analysis. Test a minimum of 1 location for each 1000 square foot of project area.

a. To be considered clean by the NADCA Vacuum Test, the net weight of the debris collected on the filter media must not exceed 0.75 mg/100 cm^2.
b. If analysis determines that levels of debris are equal to or lower than suitable levels, system shall have passed cleanliness verification.
c. If analysis determines that levels of debris exceed suitable levels, system cleanliness verification will have failed and metal-duct system shall be re-cleaned and re-verified.

2. Verification of Coil Cleaning: Cleaning shall restore coil pressure drop to within 10 percent of pressure drop measured when coil was first installed. If original pressure drop is not known, coil will be considered clean only if it is free of foreign matter and chemical residue, based on thorough visual inspection.
3. Report results of tests in writing.

3.16 SELECTIVE DEMOLITION

A. The extent of the demolition work is shown on the drawings or described in this specification.

B. Refer to DIVISION 1 Sections "CUTTING AND PATCHING" and "SELECTIVE DEMOLITION" for general demolition requirements and procedures.

C. Disconnect, demolish, and remove mechanical systems, equipment, and components indicated to be removed.
1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
8. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.
9. Controls to Be Removed: Remove control panels, devices, wiring and tubing that have been abandoned or serve equipment which has been demolished. When removing wiring and tubing demolish back to nearest active branch and plug or cap.

D. RELATED WORK
1. GENERAL CONTRACTOR
a. Cuts wall and surfaces to provide access to elements to be removed or disconnected.
2. ELECTRICAL CONTRACTOR
a. Disconnects live wiring to all equipment or systems to be removed.
3. PLUMBING CONTRACTOR
a. Disconnects live plumbing and domestic water to all equipment to be removed.

E. CODES, ORDINANCES AND REGULATORY REQUIREMENTS
1. Comply with all state and local codes as to removal and disposal of equipment removed from the site.
2. Comply with governing EPA notification regulations before beginning selective demolition.
3. Comply with hauling and disposal regulations of authorities having jurisdiction.
4. Comply with ANSI A10.6 and NFPA 241.

F. PERMITS
1. Give all required notices, file all required plans and Specifications relating to the work of this Section with the proper authorities and pay for any required permits.

G. SITE EXAMINATION
1. Visit site prior to submitting bid to become familiar with the existing conditions which may affect the removal of systems or products provided as part of the work of this Section.
2. Extra payment or compensation for work required by this Section due to existing conditions that would have been observed during the site examination will not be made.

H. REFRIGERANT RECOVERY
1. All Air-conditioning equipment and systems shall be removed demolished without releasing refrigerants.
2. Refrigerant recovery is to be performed by a Refrigerant Recovery Technician Certified by an EPA-approved certification program.

I. REMOVAL AND DISPOSAL
1. All equipment and systems to be removed or demolished under this Section shall become the property of the contractor. The contractor shall remove all such equipment from the site promptly after detachment from building structure.
2. Storage or sale of removed items or materials on-site is not permitted.
3. Contractor is responsible for all removal and disposal of hazardous / controlled items, such as, but not limited to refrigerant and glycol (including solution).

J. COORDINATION
1. Coordinate the work of this Section with all other project contractors.
2. Provide any special information or requirements needed for the proper and safe removal of equipment.

K. HAZARDOUS MATERIALS
1. It is unknown whether hazardous materials will be encountered in the Work.
2. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify Architect and Owner.

L. UTILITY SERVICE
1. Maintain existing Mechanical/Electrical utilities/services indicated to remain in service and protect them against damage during selective demolition operations.
2. Maintain fire-protection facilities in service during selective demolition operations.
3. If services/systems are required to be removed, relocated, or abandoned, before proceeding with selective demolition provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.

M. EXISTING WARRANTIES
1. Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials so as not to void existing warranties.

3.17 TRIAL USAGE

A. The owner shall be permitted trial usage of systems or parts of systems for the purpose of testing and learning operational procedures.

B. Trial usage shall not be construed as acceptance.

C. Trial usage shall be carried out with the express knowledge and under supervision of the HVAC Subcontractor, who shall not waive any responsibility because of trial usage.

3.18 INSTRUCTIONS TO OWNER

A. Submit to the Owner, lists for each system or piece of equipment indicating that all components have been checked and are complete prior to the instruction period.

B. Thoroughly instruct the Owner's authorized representative in the safe operation of the systems and equipment. This instructional procedure shall be videotaped by this contractor and three copies of the tape submitted to the Architect.

C. Arrange and pay for the services of qualified manufacturer's representatives to instruct Owner on specialized portions of the installation. This shall include 6 hours of instruction in the operation of the water treatment system, 8 hours in the operation of packaged equipment, 24 hours in the operation of built-up custom and semi-custom equipment and 40 hours of operation of the automatic temperature control system. Instruction shall take place on-site at time agreed to by Owner.

D. Submit a complete record of instructions given to the Owner. For each instruction period, supply the following data:
   1. Date.
   2. Duration.
   3. System or equipment involved.
   4. Names of persons giving instructions.
   5. Other people present.

E. Instructional period shall be carried out during a continuous period of five days.

END OF SECTION 23 00 00

Initial Construction Control Document

To be submitted with the building permit application by a
Registered Design Professional
for work per the tenth edition of the
Massachusetts State Building Code, 780 CMR, Section 107

Project Title: Worcester Sullivan MS AHU-6 Replacement **Date:** 8/18/2026

Property Address: 140 Apricot St, Worcester, MA 01603

Project: Check (x) one or both as applicable: ☐ **New construction** ☒ **Existing Construction**

Project description: Replacement of DX Air Handling Unit that services office/administrative areas as the Sullivan Middle School

I Donald Walker MA Registration Number: 59388 Expiration date: 6/30/2028 , am a ***registered design professional***, and I have prepared or directly supervised the preparation of all design plans, computations and specifications concerning[1]:

☐ **Architectural**	☐ **Structural**	☐ **Mechanical**
☐ **Fire Protection**	☒ **Electrical**	☐ **Other: Fire Alarm**

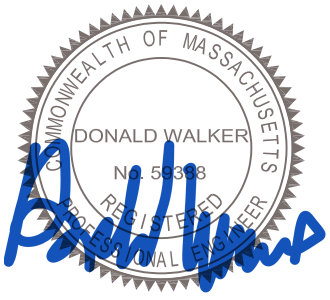
for the above named project and that to the best of my knowledge, information, and belief such plans, computations and specifications meet the applicable provisions of the Massachusetts State Building Code, (780 CMR), and accepted engineering practices for the proposed project. I understand and agree that I (or my designee) shall perform the necessary professional services and be present on the construction site on a regular and periodic basis to:

1. **Review**, for conformance to this code and the design concept, shop drawings, samples and other submittals by the contractor in accordance with the requirements of the construction documents.
2. **Perform** the duties for registered design professionals in 780 CMR Chapter 17, as applicable.
3. **Be present** at intervals appropriate to the stage of construction to become generally familiar with the progress and quality of the work and to determine if the work is being performed in a manner consistent with the approved construction documents and this code.

Nothing in this document relieves the contractor of its responsibility regarding the provisions of 780 CMR 107. When required by the building official, I shall submit field/progress reports (see item 3.) together with pertinent comments, in a form acceptable to the building official.

Upon completion of the work, I shall submit to the building official a **'Final Construction Control Document'**.

Enter in the space to the right a "wet" or electronic signature and seal:



Phone number: (781) 481-0210 **Email: dwalker@f-t.com**

Building Official Use Only

Building Official Name: **Permit No.:** **Date:**

Note 1. Indicate with an 'x' project design plans, computations and specifications that you prepared or directly supervised. If 'other' is chosen, provide a description.

Initial Construction Control Document

To be submitted with the building permit application by a
Registered Design Professional
for work per the tenth edition of the
Massachusetts State Building Code, 780 CMR, Section 107

Project Title: Worcester Sullivan MS AHU-6 Replacement **Date:** 8/18/2026

Property Address: 140 Apricot St, Worcester, MA 01603

Project: Check (x) one or both as applicable: ☐ **New construction** ☒ **Existing Construction**

Project description: Replacement of DX Air Handling Unit that services office/administrative areas as the Sullivan Middle School.

I Edward Hetzel MA Registration Number: 57438 Expiration date: 06/30/2028, am a ***registered design professional***, and I have prepared or directly supervised the preparation of all design plans, computations and specifications concerning[1]:

☐ **Architectural**	☐ **Structural**	☒ **Mechanical**
☐ **Fire Protection**	☐ **Electrical**	☐ **Other: Plumbing**

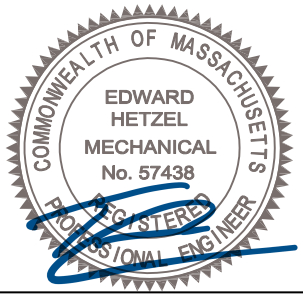
for the above named project and that to the best of my knowledge, information, and belief such plans, computations and specifications meet the applicable provisions of the Massachusetts State Building Code, (780 CMR), and accepted engineering practices for the proposed project. I understand and agree that I (or my designee) shall perform the necessary professional services and be present on the construction site on a regular and periodic basis to:

1. **Review**, for conformance to this code and the design concept, shop drawings, samples and other submittals by the contractor in accordance with the requirements of the construction documents.
2. **Perform** the duties for registered design professionals in 780 CMR Chapter 17, as applicable.
3. **Be present** at intervals appropriate to the stage of construction to become generally familiar with the progress and quality of the work and to determine if the work is being performed in a manner consistent with the approved construction documents and this code.

Nothing in this document relieves the contractor of its responsibility regarding the provisions of 780 CMR 107. When required by the building official, I shall submit field/progress reports (see item 3.) together with pertinent comments, in a form acceptable to the building official.

Upon completion of the work, I shall submit to the building official a **'Final Construction Control Document'**.

Enter in the space to the right a "wet" or electronic signature and seal:



Phone number: (781) 481-0210 **Email: thetzel@f-t.com**

Building Official Use Only

Building Official Name: **Permit No.:** **Date:**

Note 1. Indicate with an 'x' project design plans, computations and specifications that you prepared or directly supervised. If 'other' is chosen, provide a description.