SECTION 23 00 00 – 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, extend, 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. Provide all labor, equipment, and materials, required to furnish and install all HVAC work, complete as shown on the drawings and specified herein. The following are major items of work included:
   1. Selective Demolition
   2. Hoisting and rigging for equipment and materials specified herein.
   3. Core drilling, cutting and channeling for holes five (5) inches and less in diameter.
   4. Furnish and maintain in safe and adequate condition, all staging and scaffolding that is required for work of this section.
   5. Multiple Phase Project: The project is intended for multiple phases. The contractor shall treat each phase as a separate project requiring equipment start-up; testing, adjusting and balancing, reports; system flushing and testing; submittals; coordination drawings; punch lists; etc.
   6. Premium Time: The project requires work to be completed on premium time (outside normal business hours).
   7. Maintain Proper Indoor Air Quality of building during construction.
   8. Properly protect all stored and partially installed equipment, piping and ductwork.
   9. Submittals and Coordination Drawings.
   10. Equipment and Systems:
      a. Fire and Smoke Stopping. Coordinate materials and methods with Division 7.
      b. Factory fabricated air handling units
      c. Chilled water hydronic piping systems.
      d. Hot water hydronic piping systems.

e. Chillers.
f. Low Pressure steam and condensate piping systems
g. High/Medium Pressure Steam and condensate systems
h. Pressure Reducing Station
i. Pumps
j. Humidifiers
k. Air Terminals
l. Terminal Units
m. Condensate drain, piping systems and appurtenances.
n. Chemical treatment systems.
o. Supply, return and exhaust air systems
p. Ductwork
q. Registers, Grilles and Diffusers.
r. Ductwork insulation
s. Piping Insulation
t. Equipment Insulation
u. Mechanical Identification
v. Variable Volume Air Control terminal units
w. HVAC Motor starters and interlocking devices
x. HVAC Variable frequency drives
y. Thermal insulation
z. Sound attenuators
aa. Vibration isolation and Seismic Restraint
bb. Hydronic duct heating coils
cc. Radiant panels
dd. Exhaust, return and supply fans
ee. Automatic Temperature Controls and all interlock wiring and monitoring

11. Hydronic System cleaning, flushing, chemical treatment and Water Quality report.
12. Testing, Adjusting and Balancing of all air and water systems.
13. System Demonstration/Start-up/Manufacturer Representation.
14. Operations and Maintenance Manuals
15. Record Drawings
16. Test and Clean all ductwork, air moving equipment, and coils.

1.3 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.

1.4 RELATED WORK

1. 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, housekeeping pads and filling inertia pads for HVAC equipment. DIVISION 3 - CAST IN PLACE CONCRETE.
2. 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.
3. The HVAC Subcontractor shall provide all hoisting and rigging for equipment and materials specified herein.
4. Core drilling, cutting and channeling for HVAC equipment for holes five (5) inches and less in diameter.
5. Furnish and maintain in safe and adequate condition, all staging and scaffolding that is required for work of this section.
6. Fuel, water and electricity for all tests and temporary operation of HVAC equipment. – DIVISION 1 - TEMPORARY FACILITIES AND CONTROLS.
7. Temporary heat. DIVISION 1 - TEMPORARY FACILITIES AND CONTROLS.
8. Openings for Air Devices: In APPLIABLE SECTIONS, in which they occur.
9. Undercut doors and door louvers. DIVISION 8 – DOORS and.
10. 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.
11. Flashing of ductwork, Equipment Supports and Roof Curbs roof curbs for HVAC equipment. DIVISION 7 - THERMAL AND MOISTURE PROTECTION.
12. Painting of all exposed ductwork and other mechanical equipment not having enameled surfaces, stainless steel or chromed finishes. DIVISION 9 - PAINTING
13. City water piping and fittings including insulation and backflow prevention on plumbing piping systems connecting to HVAC equipment. DIVISION 22 - PLUMBING.
14. 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.
15. HVAC Motor Starters, Disconnects and Variable Frequency Drives installed under DIVISION 26 – ELECTRICAL.
16. 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 26 - ELECTRICAL. Refer to electrical drawings for exact number and general locations.

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 15 – 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, the following applicable standards (latest editions regardless of years listed below) 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 15-92: Safety Code for Mechanical Refrigeration.
        2) ASHRAE Standard 62-89: Ventilation for Acceptable Indoor Air Quality.
        3) ASHRAE Standard 111-1988: Practices for Measurement, Testing, Adjusting and balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.
2. NFPA – National Fire Protection Association
    a. Special Attention is required for:
        1) NFPA 90A: Air Conditioning and Ventilation Systems.
        2) NFPA 91: Blower and Exhaust Systems.
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 Air Duct Leakage Test Manual.
        4) SMACNA IAQ Guidelines for Occupied Buildings Under Design and Construction
4. NEC – NATIONAL ELECTRIC CODE
5. OSHA – Occupational Safety & Health Administration
6. UL – Underwriter's Laboratory
7. EPA – Environmental Protection agency
8. AIA – American Institute of Architects
9. AGA - American Gas Association
10. ANSI – American Nation Standards Institute
11. 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.
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. NEMA – National Electrical Manufacturers Association
19. ASTM – American Society of Testing and Materials
20. AMCA – Air Moving and Conditioning Association
21. ADC – American Diffuser Council
22. American Institute of Architects Academy for Health "Guidelines for Design and Construction of Hospital and Healthcare Facilities" – 2006 Edition

D. CODES and ORDINANCES: Conform with the provisions of the latest editions of the following:
1. The Maine State Building Code
2. 2006 International Building Code.
3. City/Town of Portland, ME fire protection codes and/or ordinances.
4. 2006 International Mechanical Code.
5. 2006 International Plumbing Code
6. The 2008 National Electric Code.

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 not 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 reproducible drawings by this Subcontractor and submitted to the Architect, as directed in DIVISION 1, PROJECT CLOSEOUT.

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 videoed 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. Each manual shall contain the following information:
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.

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 including final filters.

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. 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.

F. Identification: In addition to the information required by DIVISION 1 - SUBMITTAL PROCEDURES indicate:
   a. Name and address of supplier.
   b. Name of manufacturer.
   c. 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)
   d. Identify if submittal is a resubmission of previous reviewed equipment.
   e. Distribution list of all Trade subcontractors and manufacturers who will receive the Engineer's reviewed comments.

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

H. 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) Water moving equipment – pumps
    5) Steam pressure reducing stations.

I. 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.

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

K. 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.

L. 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.

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

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

O. 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.

P. 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.

Q. 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.

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

1.16 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 and return ductwork, VAV Boxes, air-handlers, fans, piping lay-outs 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.

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. Duct Cleaning Contractor
7. Plumbing Contractor
8. Electrical Contractor
9. Low voltage wiring contractor
10. Fire Protection Contractor

1.17 REQUESTS FOR INTERPRETATION (RFIs)

A. Prepare Requests for Interpretation (RFIs) in accordance to Division 1 and, in addition, adhere to the following:

B. 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.

C. If email RFI submissions are allowed by Division 1 then the RFI and Attachment(s) shall be in Adobe Acrobat PDF format.

D. Submit RFIs in format specified and in addition include:
1. Specification Section number and title and related paragraphs, as appropriate.
2. Drawing number, room name, structural grid coordinates and detail references, as appropriate.
3. Field dimensions and conditions, as appropriate.
4. 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.
5. 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).
    a. 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.

1.18 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.

1.19 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.

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

1.21 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.

1.22 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.

1.23 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 stainless steel 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 watertight.

1.24 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.

1.25 SEISMIC DESIGN

A. This project is located within a seismic zone requiring special provisions for the support and restraint of equipment and piping. 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. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer. Testing and calculations must include both shear and tensile loads and 1 test or analysis at 45 degrees to the weakest mode.

B. Submittals: Submit Shop Drawings and Product Data signed and sealed by a qualified professional engineer. Include the following:
   1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
   3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
   4. Seismic-Restraint Details: Detail fabrication and attachment of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
   5. Submittals for Interlocking Snubbers: Include load deflection curves up to 1/2-inch deflection in x, y, and z planes.

C. 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.

1.26 HVAC BASIS OF DESIGN

A. For major pieces of HVAC equipment, including but not limited to chillers, rooftop units and air handlers 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.

1.27 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.

1.28 MANUFACTURERS REPRESENTATIVE

A. Provide, at the appropriate time 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.

1.29 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, air handlers, rooftop units, fan systems, pumps, and terminal 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.

1.30 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.

1.31 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 PIPE AND FITTINGS

A. PIPE AND TUBE
1. Black Steel Pipe: ASTM A 53, A 106 or A 120; except comply with ASTM A 53 or A 106 where close coiling or bending is required
2. Copper Tube: ASTM B 88, Type L, seamless.
3. ACR Copper Tube: ASTM B 280.
4.

B. FITTINGS
1. Cast Iron Flanged Fittings: ANSI B 16.1, including bolting.
2. Cast Iron Threaded Fittings: ANSI B 16.4.
3. Malleable Iron Threaded Fittings: ANSI B 16.3; plain or galvanized as indicated.
4. Malleable Iron Threaded Unions: ANSI B 16.39; selected by installer for proper piping fabrication and service requirements, including style, end connections, and metal to metal seats (iron, bronze or brass); plain or galvanized as indicated.
5. Wrought-Steel Butt welding Fittings: ANSI B 16.9; except B 16.28 for short radius elbows and returns; rated to match connected pipe.
6. Wrought Copper Solder Joint Fittings: ANSI B 16.22.

C. UNIONS AND COUPLINGS
1. Pipe Size 2 inch and under: 150 psi malleable iron for threaded ferrous piping; bronze for copper or brass pipe soldered joints.
2. Pipe Size over 2 inch: 150 psi steel butt weld flanges for ferrous piping; bronze flanges for copper or brass piping.

D. MISCELLANEOUS PIPING MATERIALS/PRODUCTS
1. Welding Materials: Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials.
2. Tin-Antimony Solder (95/5): ASTM B 32, Grade 95TA.
3. Silver-Lead Solder: ASTM B 32, Grade 96TS.
4. Brazing Materials: Comply with SFA-5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials.
5. Gaskets for Flanged Joints: ANSI B 16.21; full faced for cast iron flanges; raised faced for steel flanges, unless other wise indicated.
6. Joint Compound and Tape: Suitable for pipe, system, fluid within system and associated chemical treatment.

2.2 PIPING SPECIALTIES

A. PIPE ESCUTCHEONS
1. General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe or pipe insulation outside diameter. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.
2. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.
3. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.

B. Y-TYPE PIPELINE STRAINERS
1. General: Provide strainers full line size of connecting piping, with ends matching piping systems materials. Select strainers for 125 psi working pressure, with Type 304 stainless steel screens, with 3/64" perforations @ 233 per sq. in.
2. Threaded Ends - 2" and Smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.
3. Flanged Ends - 2-1/2" and Larger: Cast-iron body, bolted screen retainer with off center blowdown fitted with pipe plug.
4. Grooved Ends: Ductile iron body, ASTM A-536, type 304 stainless steel, removable basket with 1/16" diameter perforation.
5. ACCEPTABLE MANUFACTURERS
   a. Armstrong Machine Works.
   b. Hoffman Specialty ITT; Fluid Handling Div.
   c. Spirax Sarco.

C. DIELECTRIC UNIONS
1. General: Provide standard products for use in service indicated, which effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action, and stop corrosion.

D. MECHANICAL SLEEVE SEALS
1. General: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.
2. ACCEPTABLE MANUFACTURERS
   a. Thunderline Corp.

E. FIRE BARRIER PENETRATION SEALS
1. Provide seals for any opening through fire rated walls, floors, or ceilings used as passage for mechanical components and piping.
2. Cracks, Voids, or Holes UP to 4" Diameter: Use putty or caulking, one piece intumescent elastomer, non-corrosive to metal, compatible with synthetic cable jackets, and capable of expanding 10 times when exposed to flame or heat, UL listed.
3. Openings 4" or Greater: Use sealing system capable of passing 3-hour fire test in accordance with ASTM E-814, consisting of wall wrap or liner, partitions, and end caps capable of expanding when exposed to temperatures of 250 to 350 deg. F., UL listed.
4. ACCEPTABLE MANUFACTURERS
   a. Electro Products Div./3M.
   b. Nelson; Unit of General Signal.

F. FABRICATED PIPING SPECIALTIES

1. Pipe Sleeves: Provide pipe sleeves of one of the following:
2. Sheet-Metal: Galvanized sheet steel. Fabricate of following gages: 3" and smaller, 20 gage, 4" to 6", 16 gage, over 6", 14 gauge.
3. Steel-Pipe: Fabricate from schedule 40 galvanized steel pipe; remove burrs.
4. Sleeve Seals: Provide sleeve seals for sleeves located in foundation walls below grade, or in exterior walls.

2.3 VALVES

A. ACCEPTABLE MANUFACTURERS

a. Jenkins
b. Bray
c. Crane Co.
d. Powell (Wm.) Co.
e. Conbraco Ind. Inc., (Apollo)
f. Jamesbury Corp.
g. Mission Mfg. Co.
h. Rockwell Mfg. Co.

B. SUBMITTALS

1. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
2. Shop Drawing: Show valves on Coordination drawings. Refer to 'COORDINATION DRAWINGS" this SECTION.

C. GENERAL

1. Provide valves of same manufacturer throughout where possible.
2. Where a single acceptable manufacturer does not produce all valve types required, multiple manufacturers may be used, but in no case shall the same type valve be provided by different manufacturers.
3. Valve manufacturers and their valve numbers indicated herein are meant to describe type and quality only.
4. ASME Compliance: ASME B31.9 for building services piping valves.
5. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

D. GATE VALVES

1. Type GV2: Bronze, non-rising stem, inside screw, solid wedge, screwed ends, Class 150, (Jenkins Fig. 370).
2. Type GV4: Iron body, bronze trim, OS&Y, solid wedge, rising stem, flanged ends, Class 125, (Jenkins Fig. 651-A).
3. Type GV5: Iron body, bronze trim, OS&Y, solid wedge, rising stem, flanged ends, Class 250, (Jenkins Fig. 204).
4. Type GV6: Bronze, non-rising stem, inside screw, solid wedge, screwed ends, screw-in bonnet, Class 300, (Jenkins Fig. 270).

E. GLOBE VALVES

1. Type GLV2: Bronze, rising stem, renewable composition disc, screw-over bonnet, screwed ends, Class 150, (Jenkins Fig. 106-A).

2. Type GLV3: Iron body, bronze trim, OS&Y, renewable composition disc, rising stem, flanged ends, Class 125, (Jenkins Fig. 142).
3. Type GLV4: Iron body, bronze trim, OS&Y, renewable bronze disc and seat ring, rising stem, flanged ends, Class 250, (Jenkins Fig. 923).
4. Type GLV5: Bronze, rising stem, renewable composition disc, screw-over bonnet, screwed ends, 250 psi, (Jenkins Fig. 801).

F. BALL VALVES
1. Type BLV1: Bronze body and retainer, reinforced Teflon seats and packing, chromium plated ball, soldered ends, full port (Apollo 77-200).
2. Type BLV2: Bronze body and retainer, reinforced Teflon seats and packing, chromium plated ball, screwed ends, full port (Apollo 77-100).
3. Provide extended stems for all valves in insulated piping systems. Stems shall extend to length necessary for full handle exposure outside of insulation system.

G. BUTTERFLY VALVES
1. Type BFV1: Iron lug body, bronze disc, EPDM liner, stainless steel stem, 200 psi WP, -20 to 200 deg. F.
2. Unless otherwise indicated provide lever operators for valves 6" and less and gear operators for valves 8" and larger.

H. CHECK VALVES
1. Type SCV1: Swing check valve, bronze body, regrinding bronze disc, soldered ends, 300 psi, (Jenkins Fig. 122).
2. Type SCV2: Swing check valve, bronze body, regrinding bronze disc, screwed ends, Class 150, (Jenkins Fig. 92-A).
3. Type SCV3: Swing check valve, iron body, regrind-renew bronze disc and seat ring, flanged ends, Class 125, (Jenkins Fig. 624).
4. Type SCV4: Swing check valve, iron body, regrind-renew bronze disc and seat ring, flanged ends, 250 psi, (Jenkins Fig. 339-R).
5. Type LCV1: Lift check valve, bronze body, renewable composition disc, spring loaded, screw over cap, screwed ends, Class 150 (Jenkins Fig. 655-A).
6. Type WCV1: Wafer check valve, iron body, bronze trim, bronze disc, stainless steel spring, (Jenkins Fig. 777).

I. DRAIN VALVES
1. Type DV1: Ball or gate valve with hose end, bronze cap and chain.

J. PLUG VALVES
1. Type PV1: Semi-steel, bolt gland type, (Rockwell Fig. 142 or 143).

K. VALVES FOR HYDRONIC SYSTEMS
1. Valves for hydronic systems shall be as follows:
   a. BALL VALVES:
      1) 2" and Less (Soldered Ends); Type BLV1.
      2) 2" and Less (Screwed Ends); Type BLV2.
   b. BUTTERFLY VALVES
      1) 2-1/2" and Larger; BFV1.
   c. SWING CHECK VALVES
      1) 2" and Less (Soldered Ends); Type SCV1.
      2) 2" and Less (Screwed Ends); Type SCV2.
      3) 2-1/2" and Larger (Flanged Ends Pressure under 125 PSI); SCV3.
      4) 2-1/2" and Larger (Flanged Ends Pressure over 125 PSI); SCV4.
   d. LIFT CHECK VALVES:
      1) 2" and Less; Type LCV1.

e. WAFER CHECK VALVES (For Use on Pump Discharge Services):
   1) All Sizes; WCV1.
f. DRAIN VALVES:
   1) Type DV1.
g. PLUG VALVES:
   1) Type PV1

L. VALVES FOR STEAM SERVICE
1. Valves for steam service shall be as follows:
   a. LOW PRESSURE (0 - 15 PSIG) SERVICE VALVES
      1) Gate Valves (2" & Less): Type GV3.
      2) Gate Valves (2-1/2" and Greater): Type GV4.
      3) Globe Valves (2" & Less): Type GLV2.
      4) Globe Valves (2-1/2" and Larger): Type GLV3.
      5) Ball Valves (2" & Less): Type BLV2.
      6) Check Valves (2" & Less): Type SCV2.
      7) Check Valves (2-1/2" & Larger): Type SCV3.
      8) Drain Valves: Type DV1.
   b. MEDIUM PRESSURE (15 - 100 PSIG) SERVICE VALVES
      1) Gate Valves (2" & Less): Type GV3.
      2) Gate Valves (2-1/2" and Greater): Type GV5.
      3) Globe Valves (2" & Less): Type GLV2.
      4) Globe Valves (2-1/2" and Larger): Type GLV3.
      5) Check Valves (2" & Less): Type SCV2.
      6) Check Valves (2-1/2" & Larger): Type SCV4.
      7) Drain Valves: Type DV1.

2.4 HANGERS AND SUPPORTS

A. ACCEPTABLE MANUFACTURERS
   a. Carpenter and Patterson, Inc.
   b. B-line Company.
   c. 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 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.

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 PIPING INSULATION

A. GLASS FIBER
1. Acceptable Manufacturers:
   a. Knauf.
   b. Manville.
   c. Certainteed.
2. Insulation: ASTM C795; rigid, noncombustible, end grain adhered to jacket.
   a. 'K' value: ASTM C177, 0.24 at 75 degrees F.
   b. Maximum service temperature: 650 degrees F.
   c. Maximum moisture absorption: 0.2 percent by volume.
   d. All fittings shall also be rigid, conformed pieces with integral vapor barrier; basis of design shall be Hamfab insert product.
3. Vapor Barrier Jacket:
   a. ASTM C921, White kraft paper with glass fiber yarn, bonded to aluminized film.
   b. Moisture vapor transmission: ASTM E96; 0.02 perm-inches.
4. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.
5. Vapor Barrier Lap Adhesive:
   a. Compatible with insulation.
6. Insulating Cement/Mastic:
   a. ASTM C195; hydraulic setting on mineral wool.
7. Fibrous Glass Fabric:
   a. Cloth: Untreated; 9 oz/sq yd weight.
   b. Blanket: 1.0 lb/cu ft density.
   c. Weave: 5x5 10x10 10x20.
8. Indoor Vapor Barrier Finish:
   a. Cloth: Untreated; 9 oz/sq yd weight.
   b. Vinyl emulsion type acrylic, compatible with insulation.
9. Outdoor Vapor Barrier Mastic:
   a. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
10. Outdoor Breather Mastic:
   a. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.

11. Insulating Cement:
    a. ASTM C449/C449M.

B. JACKETS
1. General: ASTM C 921, Type 1, unless otherwise indicated
2. PVC Plastic.
    a. PVC Jacket: High-impact, ultraviolet-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; PVC; 20 milsthick; roll stock ready for shop or field cutting and forming.
    b. Adhesive: As recommended by insulation jacket material manufacturer.
    c. PVC Jacket Color: Off-White and Color-code jackets based on system. Color as selected by Architect.
    d. Standard PVC Fitting Covers
        1) Factory-fabricated fitting covers manufactured from 20-mil-thick, high-impact, ultraviolet-resistant PVC to match jacket if available; otherwise, field fabricate.
        2) Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, traps, mechanical joints, and P-traps.
3. Aluminum Jacket (Use on all exterior applications): ASTM B209
    a. Thickness: 0.016 inch sheet.
    b. Finish: Smooth
    c. Joining: Longitudinal slip joints and 2 inch (50 mm) laps.
    d. Fittings: 0.016inch thick die shaped fitting covers with factory attached protective liner.
    e. Metal Jacket Bands: 3/8 inch wide;

C. ACCESSORIES
1. Insulating Cement: ASTM C195; hydraulic setting mineral wool.
2. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.
3. Staples, Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated.

2.6 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. 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. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.

4. 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. On piping three (3) inches diameter (including insulation) and larger, lettering shall be two (2) inches high capitals. On smaller diameter piping, use ¾ inch high capital letters.
5. 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.
6. 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.
7. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.
    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: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.
    d. Fasteners: As required to mount on equipment.
8. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.
    a. Terminology: Match schedules as closely as possible.
    b. Data:
        1) Name and plan number.
        2) Equipment service.
        3) Design capacity.
        4) Other design parameters such as pressure drop, entering and leaving conditions, and speed.
    c. Location: Accessible and visible.
    d. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.
9. Equipment Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.
    a. Data: Instructions for operation of equipment and for safety procedures.
    b. Engraving: Manufacturer's standard letter style, of sizes and with terms to match equipment identification.
    c. Thickness: [1/8 inch], unless otherwise indicated.
    d. Thickness: 1/16 inch for units up to 20 sq. in. or 8 inches in length, and 1/8 inch for larger units.
    e. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive
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.
    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. 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.

D. Flow arrows shall be solid black. Arrows shall be six (6) inches long by two (2) inches wide.

E. Do color coding of pipes with two (2) inch wide bands according to color schedule to be issued by the Owner during the progress of the work.

F. 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.

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

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

I. Provide 1-1/2 inch diameter, 1/16 inch thick brass tags with 3/8 inch die stamped black letters. Attach to valves with four (4) inch brass chains. Brass tags may be omitted on small valves which isolate a single piece of equipment such as unit heater, fan coil unit, and section of radiation.

2.7 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"

2.8 DUCTWORK INSULATION

A. ACCEPTABLE MANUFACTURERS
   1. CertainTeed Corp.
   2. Knauf Fiber Glass
   3. Owens Corning Fiberglas Corp.

B. 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.

C. 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.

D. 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. Canvas Jacket: UL listed.
      a. Fabric: ASTM C921, 6 oz/sq yd , plain weave cotton treated with dilute fire retardant lagging adhesive.
      b. Lagging Adhesive: Compatible with insulation.
   3. Exterior Rubber Jacket System.
      a. Vapor, UV and weather protection
      b. Based on Polyguard Alumaguard 60
      c. Rubberized Bitumen Membrane
      d. Laminated "Peel and Stick" to insulation face
      e. Self healing if punctured

f. Cold weather activator

E. 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.

2.9 EQUIPMENT INSULATION

A. ACCEPTABLE MANUFACTURERS
1. CertainTeed Corp.
2. Knauf Fiber Glass
3. Owens Corning Fiberglas Corp.

B. GLASS FIBER, FLEXIBLE
1. Insulation: ASTM C553; flexible, noncombustible.
   a. 'K' Value: ASTM C177 or ASTM C518, 0.24 at 75 degrees F.
   b. Maximum Service Temperature: 450 degrees F.
   c. Maximum Moisture Absorption: 0.2 percent by volume.
   d. Density: 3.0 lb/cu ft.
2. Vapor Barrier Jacket:
   a. ASTM C921, Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
   b. Moisture vapor transmission: ASTM E96; 0.02 perm.
   c. Secure with self-sealing longitudinal laps and butt strips.
   d. Secure with outward clinch expanding staples and vapor barrier mastic.
3. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.
4. Vapor Barrier Lap Adhesive:
   a. Compatible with insulation.
5. insulating Cement/Mastic:
   a. ASTM C195; hydraulic setting on mineral wool.

C. GLASS FIBER, RIGID
1. Insulation: ASTM C612 or ASTM C592; rigid, noncombustible.
   a. 'K' Value: ASTM C177 or ASTM C518, 0.24 at 75 degrees F.
   b. Maximum Service Temperature: 850 degrees F.
   c. Maximum Moisture Absorption: 0.1 percent by volume.
   d. Density: 3.0 lb/cu ft.
2. Vapor Barrier Jacket:
   a. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film..
   b. Moisture vapor transmission: ASTM E96; 0.02 perm.
   c. Secure with self-sealing longitudinal laps and butt strips.
   d. Secure with outward clinch expanding staples and vapor barrier mastic.
3. Facing: 1 inch galvanized or stainless steel hexagonal wire mesh stitched onto both faces of insulation.
4. Vapor Barrier Lap Adhesive:
   a. Compatible with insulation.
5. Insulating Cement/Mastic:
   a. ASTM C195; hydraulic setting on mineral wool.

D. CELLULAR FOAM
1. Insulation: ASTM C534; flexible, cellular elastomeric, molded or sheet.
   a. 'K' Value: ASTM C177; 0.25 at 75 degrees.

b. Minimum Service Temperature: -40 degrees F.
c. Maximum Service Temperature: 220 degrees F.
d. Maximum Moisture Absorption: ASTM D1056; 1.0 percent by volume.
e. Moisture Vapor Transmission: ASTM E96; 0.05 perm-inches.
f. Connection: Waterproof vapor barrier adhesive.

2. Elastomeric Foam Adhesive:
a. Air dried, contact adhesive, compatible with insulation.

E. JACKETS
1. PVC Plastic:
a. Jacket: ASTM C921, Sheet material, off-white color.
1) Minimum Service Temperature: -40 degrees F.
2) Maximum Service Temperature: 150 degrees F.
3) Moisture Vapor Transmission: ASTM E96; 0.002 perm-inches.
4) Thickness: 30 mil.
5) Connections: Pressure sensitive color matching vinyl tape.
b. Covering Adhesive Mastic:
1) Compatible with insulation.
2. Canvas Jacket: UL listed.
a. Fabric: ASTM C921, 6 oz/sq. yd., plain weave cotton treated with dilute fire retardant lagging adhesive.
b. Lagging Adhesive:
1) Compatible with insulation.
3. Aluminum Jacket: ASTM B209.
a. Thickness: 0.016 inch sheet.
b. Finish: Smooth.
c. Joining: Longitudinal slip joints and 2 inch laps.
d. Metal Jacket Bands: 3/8 inch wide; stainless steel.

F. 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.
3. Jacketing Material (Fiberglass & Calcium Silicate): Presized glass cloth jacketing material, not less than 7.8 ounces per square yard.

2.10 VIBRATION ISOLATION 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 and seismic devices described in this section shall be the product of a single supplier. NAI (Novia Associates, Inc.) is the Base Supplier of these specifications; products of other suppliers may be acceptable provided their systems strictly comply with intent, structural design, performance and deflections of the Base Supplier.
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. The work in this section includes the following:
   1. Vibration isolation elements for equipment.
   2. Equipment isolation bases.
   3. Piping flexible connectors.
   4. Seismic restraints for isolated equipment.
   5. Seismic restraints for non-isolated equipment.
   6. Certification of seismic restraint designs and installation supervision.
   7. Equipment support stands, bases or rails.

D. SUBMITTALS
   1. Product Data sheets on
      a. For each specific vibration isolators and restraints to be utilized detailing compliance with the specification. Reference "TYPE" as per "PRODUCTS" section of this specification.
      b. An itemized list of all isolated and non-isolated equipment including detailed schedules showing isolator and seismic restraints proposed for each piece of equipment, referencing material and seismic calculation drawing numbers.
   2. Shop Drawings
      a. Show base construction for equipment; include dimensions, structural member sizes and support point locations.
      b. When walls and slabs are used as seismic restraint locations, details of acceptable methods for ducts and pipe must be included.
      c. Indicate isolation devices selected with complete dimensional and deflection data before condition is accepted for installation.
      d. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.
      e. Coordinated or contract drawings shall be marked-up with the specific locations and types of restraints shown for all pipe and duct. Rod bracing requirements and assigned load at each restraint location shall be clearly delineated. Any and all tributary loads shall be considered for proper restraint sizing.
      f. For ceiling suspended equipment design restraints for a minimum installation angle of 30^0 from vertical. Indicate maximum installation angle allowed for restraint system as well as braced and unbraced rod lengths at each allowable installation condition.
      g. Calculate thrust for fan heads, axial and centrifugal fans to determine whether thrust restraints are required. (See EQUIPMENT INSTALLATION)
   3. Seismic Certification and Analysis
      a. Seismic restraint calculations must be provided for all connections of equipment to the structure. All performance of products (such as; strut, cable, anchors, clips, etc.) associated with restraints must be supported with manufacturer's data sheets or certified calculations.
      b. For roof mounted equipment both the seismic acceleration and wind loads (30 psf) shall be calculated, the highest load shall be utilized for the design of the restraints and isolators.
      c. Certifications of calculations to support seismic restraint designs must be stamped by a professional engineer registered in the State were the project is located.
         1) Analysis must indicate calculated dead loads, derived loads and materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and weld length.
   4. An in force, Errors and Omissions insurance certificate must accompany submittals. Manufacturer’s product liability insurance certificates are not acceptable.

E. MANUFACTURER'S RESPONSIBILITY
1. Manufacturer of vibration and seismic control equipment shall have the following responsibilities:
   a. Determine vibration isolation and seismic restraint sizes and locations.
   b. Provide equipment vibration isolation and seismic restraints as specified.
   c. Guarantee specified isolation system deflections.
   d. Provide installation instructions, drawings and field supervision to insure proper installation and performance of systems.

F. 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.

G. SEISMIC RESTRAINTS AND VIBRATION ISOLATION TYPES
1. 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.
2. 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.

3. Vibration Isolator Types
a. TYPE A: Spring Isolator - Free Standing
1) Spring shall have a minimum outer diameter to overall height ratio of 0.8: 1 at rated deflection.
2) Reserve deflection (from published load ratings to solid height) of 50% of the rated deflection.
3) Minimum 1/4" thick neoprene acoustical base pad or cup on underside, unless designated otherwise.
4) Model "SM" as manufactured by NAI.

b. TYPE B: Spring Isolator - Restrained
1) Shall be the same as TYPE A with the following additional features.
a) Integral restraining bolts with elastomeric cushions preventing metal-to-metal contact.
b) Internal spring adjusting nut or bolt.
c) Built-in all-directional limit stops with minimum 1/8" clearance under normal operation.
d) Model "RSM" as manufactured by NAI.

c. TYPE C: Spring Hanger Isolator
1) a. Spring element (same as TYPE A) within a steel box with an Elastomer bushing to insulate lower support rod from the hanger box.
2) b. Steel hanger box shall be capable of 30-degree misalignment between the rod attachment to structure and the connection to the supported equipment. Hanger boxes shall withstand three times the rated load without failure.
3) Model "SH" as manufactured by NAI.

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

e. TYPE E: Elastomer Hanger Isolator
1) Molded neoprene element with a bushing to insulate lower support rod from the hanger box.
2) Steel hanger box shall withstand three times the rated load without failure.
3) Model "NH" as manufactured by NAI.

f. TYPE F: Combination Spring/Elastomer Hanger Isolator
1) Spring and neoprene elements in a steel hanger box with the features as described for TYPE C and E isolators.
2) Model "SNH" as manufactured by NAI.

g. TYPE G: Pad type elastomer isolator
1) Neoprene pad shall have 0.50" minimum thickness, deflection rating of 0.1 inch under rated load.
2) 1/16" galvanized steel plate between multiple pad layers.

3) Load distribution plate where attachment to equipment bearing surface is less than 75% of the pad area.
4) When bolting is required for seismic compliance, neoprene and duck washers and bushings shall be provided to prevent short-circuiting of bolt.
5) Model “NP” as manufactured by NAI.

h. TYPE H: Pad type elastomer isolator
1) Laminated canvas duck & neoprene, maximum loading 1000 psi, minimum ½" thick.
2) Load distribution plate where attachment to equipment bearing surface is less than 75% of the pad area.
3) When bolting is required for seismic compliance, neoprene and duck washers and bushings shall be provided to prevent short-circuiting.
4) Model “LNP” as manufactured by NAI.

i. TYPE I: Thrust Restraints
1) A spring element same as TYPE A shall be combined with steel angles, backup plates, threaded rod, washers and nuts to produce a pair of devices capable of limiting thrust movement of air moving equipment to 1/4".
2) Restraints shall be easily converted in the field from a compression type to tension type.
3) Unit shall be factory precompressed.
4) Model “TR” as manufactured by NAI.

j. TYPE J: Telescoping Riser Guide
1) Telescoping arrangement of two sizes of steel tubing separated by a minimum ½" thickness of TYPE H pad.
2) Model “TRG” as manufactured by NAI.

k. TYPE K: Resilient Pipe Anchors and Guides
1) All directional acoustical pipe anchor, consisting of a telescopic arrangement of two sizes of steel tubing separated by a minimum ½" thickness of TYPE H pad.
2) Vertical restraint shall be provided by a similar material arranged to prevent vertical travel in either direction.
3) Allowable loads on neoprene pad shall not exceed 500 PSI and the design shall be balanced for equal resistance in any direction.
4) Model “RAG” as manufactured by NAI.

l. TYPE M: Flashable restrained isolator
1) Shall have all features of TYPE B isolator.
2) Shall have galvanized steel spring pocket covers for adjustment and/or removal and replacement of springs.
3) The combination floating top rail and top flashing shall be fabricated of two formed and nested layers of 12 gauge galvanized steel.
4) Isolator shall be flashed directly into the waterproofing membrane.
5) To be complete with wood nailers, plywood sides, counter flashing and resilient weather seal.
6) Model “FRSM” as manufactured by NAI.

m. TYPE P: Elastomer Isolator
1) Double deflection neoprene compression mountings.
2) Non-skid top and bottom surfaces.
3) Threaded bolting sleeves shall be embedded in the isolator.
4) Drilled tie-down bolt holes shall be provided in the base plate.
5) Model “FMD” by NAI.

H. EQUIPMENT BASES, CURBS & SUPPORTS
1. GENERAL

a. All curbs, roof rails and isolators 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 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-1: Integral Structural Steel Base
      1) Constructed of structural members as required to prevent base flexure at equipment startup and misalignment of driver and driven units. Perimeter members shall be a minimum of 1/10th the longest unsupported span. Centrifugal fan bases shall be complete with motor slide rails and drilled for driver and driven units.
      2) Height saving brackets shall be used to maintain 1" operating clearance under base.
      3) Model “SB” as manufactured by NAI.
   b. TYPE B-2: Concrete Inertia Base
      1) Steel concrete forms for floating foundations. Bases for pumps shall be large enough to support elbows and/or suction diffusers. The base depth shall be a minimum of 1/12 the longest unsupported span, but not less than 6 inches or greater than 12 inches. Forms shall be manufactured from structural steel channel sections and include concrete reinforcement consisting of steel bars welded in place on 8 inch centers both ways in a layer 1-1/2 inches above the bottom.
      2) Height saving brackets shall be used to maintain 1" clearance below the base.
      3) Base shall be furnished with steel templates and anchor bolt sleeves to hold anchors while concrete is being poured.
      4) Model “CIB” as manufactured by NAI.
   c. 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.

d. TYPE B-4: Flashable Roof Rail System - Isolated
1) Spring isolation rails that bear directly on the roof structure and are flashed and waterproofed into the roof's membrane waterproofing system. Field fabricated rails with external isolators shall not be used.
2) Rails shall include the following features:
a) Springs pockets shall have all of the features of TYPE B isolator.
b) The combination floating top rail and top flashing shall be fabricated of two formed and nested layers of 12 gauge G60 galvanized steel. 12 gauge galvanized end rails shall tie the side rails together providing full perimeter support.
c) All spring locations shall have removable waterproof galvanized steel covers to allow for spring adjustment and/or replacement.
d) 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 rail which would short circuit the isolation effectiveness are not acceptable.
e) Plywood sides and ends.
f) Removable lifting lugs.

g) The rails 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.
h) Provide galvanized steel bridging members as required or as shown on the drawings to support equipment mounted between the rails. Bridging steel shall be designed for a maximum deflection at mid-span of L/360.
i) Model “FRR” as manufactured by NAI.

e. TYPE B-5: Non-isolated roof curb
1) 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.
2) Curbs shall have provision for up to 2” external insulation. All exterior insulation is to be furnished and installed by the roofing contractor.
3) 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.
4) Provide 22 gauge galvanized pans for roof top units that require pans under condensing sections.
5) Curbs shall be fully assembled at the factory and shipped as one piece.
6) Model “SeisCurb” as manufactured by NAI.

f. TYPE B-6: Flashable non-isolated roof rails
1) Rails shall be manufactured from 12 gauge G60 galvanized sheetmetal, reinforced and cross braced on ends.
2) Provide galvanized steel bridging members as required or as shown on the drawings to support equipment mounted between the rails. Bridging steel shall be designed for a maximum deflection at mid-span of L/360.
3) Model “FRR-0” as manufactured by NAI

g. TYPE B-7: Steel Rails
1) Steel members of sufficient strength to prevent equipment flexure during operation.
2) Height saving brackets as required to reduce operating height.
3) Model “SR” as manufactured by NAI.

h. TYPE B-8 Spring Roof Curb for Condensing Units.
1) Same as B-3 with the following additional features.
a) The curbs shall have a custom fabricated zinc plated clips that are attached to the top rail of the curb and the condensing unit.
b) Provide a sound barrier package consisting of galvanized angles supported from the top isolated rail and spaced 24” O.C. maximum. These angles shall provide a grid for installation of two layers of 1/2” Durock Cement board and 2” - 3 lbs./sq. ft. fiberglass insulation furnished and installed by the General Contractor.
c) A 60 mil EPDM roofing membrane shall be furnished and installed by others as shown on the contract drawings.
d) 4). Curbs shall be fully assembled at the factory and shipped as one piece.
e) Model “VibCurb” as manufactured by NAI.

I. 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.
3. TYPE FC-2: Flexible Stainless Steel Hose
   a. Stainless steel hose and braid rated with 3:1 safety factor.
   b. 2" diameter and smaller with male nipples, 2-1/2" and larger with fixed flat faced steel flanges.
      1) Lengths shall be: 9" for 2-1/2" to 4", 11" for 5" and 6", 12" for 8", 13" for 10", 14" for 12" to 16".
4. TYPE FC-3: Unbraided Exhaust Hose
   a. Low pressure Stainless steel annularly corrugated with flanged ends.
   b. Maximum temperature of 1500 degrees F.
5. TYPE FC-4: Wire Braid Reinforced Flexible Metal Hose
   a. Metal hose and braid rated with a minimum 3:1 safety factor. (Minimum 150 PSI)
   b. Copper tube ends.

2.11 PIPE EXPANSION FITTINGS AND LOOPS

A. GENERAL
1. Coordinate provision of all expansion compensation devices with the seismic restraints portion of this specification. Expansion compensation devices provided shall not compromise the ability of the piping system to resist seismic loads.

B. SUBMITTALS
1. Product Data: For each type of pipe expansion joint and alignment guide indicated.
2. Shop Drawings
   a. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
   b. Alignment Guide Details: Detail field assembly and attachment to building structure.
   c. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

C. Show pipe expansion fittings loops, anchors, and alignment guides on Coordination drawings. Refer to “COORDINATION DRAWINGS” this SECTION. Refer to detail sheet for valves, vents and other hydronic components not called for by this section of the specification but required for proper installation.

D. EXPANSION JOINTS
1. Acceptable Manufacturers:
   a. Metraflex, Inc.
   b. Adsco
   c. Flexonics
2. Basis of Design: Metraflex, Inc. model HP.
3. Stainless Steel Bellows Type:
   a. Pressure Rating: 200 psig and 250 degrees F.
   b. Maximum Compression: 3 inch.
   c. Maximum Extension: 1/4 inch.
   d. Joint: As specified for pipe joints.
   e. Size: Use pipe sized units
   f. Application: Steel piping 3 inch and under.
4. External Ring Controlled Stainless Steel Bellows Type:
   a. Pressure Rating: 200 psig and 250 degrees F.
   b. Maximum Compression: 1-1/4 inch.
   c. Maximum Extension: 3/8 inch.
   d. Maximum Offset: 5/16 inch.
   e. Joint: Flanged
   f. Size: Use pipe sized units
   g. Accessories: Internal flow liner.
   h. Application: Steel piping over 3 inch.

E. PIPE ALIGNMENT GUIDES
1. Two piece welded steel with enamel paint, bolted, with spider to fit standard pipe, frame with four mounting holes, clearance for minimum 1 inch thick insulation, minimum 3 inch travel.

F. SWIVEL JOINTS
1. Double ball bearing race, field lubricated, with rubber (Buna-N) O-ring seals.

G. MATERIALS FOR ANCHORS
1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.
   a. Stainless-steel studs are available.
   b. Stud: Threaded, zinc-coated carbon steel.
   c. Expansion Plug: Zinc-coated steel.
   d. Washer and Nut: Zinc-coated steel.
5. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.
   a. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
   b. Stainless-steel studs are available.
   c. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
   d. Washer and Nut: Zinc-coated steel.
6. Concrete: Portland cement mix, 3000 psi minimum. Refer to DIVISION 3 - "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.
7. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink, nonmetallic grout; suitable for interior and exterior applications.

a. Properties: Nonstaining, noncorrosive, and nongaseous.
b. Design Mix: 5000-psi, 28-day compressive strength.

2.12 METERS AND GAUGES

A. PRESSURE GAGES

1. Gage: ASME B40.1, with bourdon tube, rotary brass movement, brass socket, front recalibration adjustment, black scale on white background.
   a. Case: Steel
   b. Bourdon Tube: Brass.
   c. Dial Size: 2 inch.
   d. Mid-Scale Accuracy: One percent.
   e. Scale: Psi.

B. STEM TYPE THERMOMETERS

1. Thermometer: ASTM E1, red appearing mercury, lens front tube, cast aluminum case with enamel finish.
   a. Size: 7 inch scale.
   b. Window: Clear glass.
   c. Stem: Brass, 3/4 inch NPT, 3-1/2 inch long.
   d. Accuracy: ASTM E77 2 percent.
   e. Calibration: Degrees F.
   f. Scale shall be 30 – 240 deg. with 2 deg. F. divisions for hot water and 30-180 deg. with 2 deg F divisions for chilled water.

C. TEST PLUGS

1. Test Plug:
   a. 1/4 inch NPT or 1/2 inch NPT brass stainless steel fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with:
   b. Neoprene core for temperatures up to 200 degrees F.
   c. Test Kit:
      1) Carrying case, internally padded and fitted containing:
      2) One 2 inch diameter pressure gages.
      3) Two gage adapters with 1/8 inch probes.
      4) Two one inch 1-1/2 inch dial thermometers.

D. STATIC PRESSURE GAGES

1. Dial Gages:
   a. 3-1/2 inch diameter dial in metal case, diaphragm actuated black figures on white background, front recalibration adjustment, 2 percent of full scale accuracy.
   b. Accessories: Static pressure tips with compression fittings for bulkhead mounting, 1/4 inch diameter tubing.

2.13 DUCTWORK

A. SUBMITTALS

1. Ductwork construction standards.
2. Refer to “COORDINATION DRAWINGS” this SECTION.

B. PRESSURE CLASSIFICATION

CLASS	S.P. ("WG)	TYPE	SEAL CLASS	MAX. VEL.(FPM)
6	4 to 6	POS	A	2500 UP
4	3 to 4	POS	B	2500 UP

3	2 to 3	POS/NEG	B	2500 DN
2	up to 2	POS/NEG	C	1500 DN

C. MATERIALS
1. STEEL DUCTS: ASTM A525 galvanized steel sheet, lock forming quality, having zinc coating of 1.25 oz per sq ft for each side in conformance with ASTM A90.
2. INSULATED FLEXIBLE SUPPLY DUCT:
   a. Interlocking spiral of galvanized steel, stainless steel or aluminum as applicable to installation rated to 2 WG inch positive and 1.5 inch WG negative for class 2 ducts and 15 inch WG positive or negative for Class 3,4,6 and 10 ducts.
   b. Wrap flexible duct with flexible glass fiber insulation, enclosed by seamless aluminum pigmented plastic vapor barrier jacket; maximum 0.23 K value at 75 Deg. F.
3. DOUBLE WALL INSULATED FLEXIBLE SUPPLY DUCTS: Double wall insulated interlocking spiral of galvanized steel. vapor barrier jacket; maximum 0.23 K value at 75 Deg. F.
4. DUCT SEALANT: Non-hardening, non-migrating mastic or liquid elastic sealant as compounded and recommended by duct manufacturer specifically for sealing joints in ductwork.
5. DUCTWORK SUPPORT MATERIALS: Hot dipped galvanized steel fasteners, anchors, rods, straps, trim and angle support for ductwork.
   a. For exposed stainless steel ductwork, provide matching stainless steel support materials.
   b. For aluminum ductwork, provide matching aluminum support materials.

D. Class 2 DUCTWORK
1. Fabricate in accordance with SMACNA Duct Construction Standards. Provide duct gages, reinforcing, and sealing for applicable operating pressures.
2. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where rectangular elbows are used, provide turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.
3. Increase duct sizes gradually, not exceeding 15 deg. divergences wherever possible. Divergence upstream of equipment shall not exceed 30 deg.; convergence downstream shall not exceed 45 deg.
4. Connect fabric flexible duct to metal duct with 22 gauge draw bands.

E. Class 3, 4, and 6 DUCTWORK
1. Fabricate in accordance with SMACNA Duct Construction Standards. Provide duct gages, reinforcing, and sealing for applicable operating pressures.
2. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where rectangular elbows are used, provide turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.
3. Transform duct sizes gradually, not exceeding 15 degrees divergence and 30 degrees convergence. Connect double wall insulated flexible duct to metal duct with adhesives plus sheetmetal screws.

2.14 DUCTWORK ACCESSORIES

A. SUBMITTALS
1. Product Data Sheets: For each type of Ductwork Accessories indicated.
2. Shop Drawings: Show all ductwork accessories on Coordination drawings. Refer to “COORDINATION DRAWINGS” this SECTION.

B. VOLUME DAMPERS

1. Fabricate in accordance with SMACNA Duct Construction Standards.
2. Fabricate splitter dampers of double thickness sheetmetal to streamlined shape. Secure blades with continuous hinge or rod. Operate with min. 1/4 inch diameter rod in self aligning, universal joint action flanged bushing with set screw.
3. Fabricate single blade dampers for duct sizes to 12" x 30".
4. Fabricate opposed blade dampers with maximum blade sizes 12" x 72". Assemble center and edge crimped blades in prime coated or galvanized frame with suitable hardware.
5. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.
6. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
7. On insulated ducts mount quadrant regulators on stand off mounting bracket, bases or adapters.

C. TURNING VANES
1. Fabricated Type: Construct in accordance with SMACNA Duct Construction Standards.
2. Manufactured Type: 1-1/2" wide curved blades set at 3/4" O.C., supported with bars perpendicular to blades set at 2" O.C.
3. Acoustical Type: Airfoil shaped aluminum extrusions with perforated faces and fiberglass fill.

D. FIRE DAMPERS
1. Fabricate in accordance with NFPA 90A and UL 555; provide UL label for 1-1/2 hour rating unless architectural plans call for 3 hour or other rating.
2. Curtain type fire dampers; galvanized steel with interlocking blades; stainless steel closure spring and latches for horizontal installations. Blades out of air stream for all duct pressure classes.
3. Fusible links, UL 33, shall separate at 165 deg. F.
4. Curtain Type Dynamic Fire Dampers shall have UL 555 differential pressure rating for 4 in. W.G. and minimum UL 555 velocity rating of 2000 fpm.
5. Multi-blade Type Dynamic fire dampers shall have UL 555 differential pressure rating for 6 in. W.G. and minimum UL 555 velocity rating of 3000 fpm.
6. Provide means to determine damper position from visual inspection of exterior of duct.

E. SMOKE DAMPERS
1. Fabricate in accordance with NFPA 90A and UL 555S; provide UL label for 1-1/2 hour rating unless architectural plans call for 3 hour or other rating.
2. Multi-blade type dampers; galvanized steel frame and blades; stainless steel sleeve bearings; plated steel blade linkage; stainless steel closure spring, blade stops, lock; 2 inch actuator shaft.
3. Dampers shall be shall have UL 555S differential pressure rating for 6 in. W.G. and minimum UL 555 velocity rating of 3000 fpm.
4. Leakage shall not exceed 30 CFM/SF at 1 in. W.G.
5. Coordinate damper operator power and control requirements with Automatic Temperature Control contractor.
6. Damper shall open with power on; damper closes on interruption of power and resets to open position when power is restored. Provide means to determine damper position from visual inspection of exterior of duct.

F. FLEXIBLE DUCT CONNECTORS
1. Fabricate in accordance with SMACNA Duct Construction Standards.
2. UL listed fire retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 20 oz per sq yd, approximately 6 inches wide, crimped into metal edging strip.
3. Leaded vinyl sheet, minimum 0.55 inch thick, 0.87 lbs per sq ft, 10 dB attenuation in 10 to 10,000 Hz range.

G. DUCT ACCESS DOORS
1. Fabricate in accordance with SMACNA Duct Construction Standards.
2. Provide flush frames for un-insulated ductwork, extended frames for insulated ductwork.
3. Provide one side hinged, other side with one latch type handle for doors 12" high and smaller, 2 handle type latches for larger doors.

2.15 HYDRONIC PIPING SYSTEMS

A. ASME COMPLIANCE:
1. Comply with ASME B31.9, “Building Services Piping,” for materials, products, and installation.

B. PIPE AND FITTINGS
1. Pipe Size 2" and Smaller: Black steel pipe; Schedule 40; Class 125 cast iron fittings; threaded joints.
2. Pipe Size 3" and Smaller: Copper tube, Type L, hard drawn temper; wrought copper fittings; tin-antimony solder (95/5) joints.
3. Pipe Size 2-1/2" and Larger: Black steel pipe; Schedule 40; wrought steel buttweld fittings; welded joints.
4. Pipe Run Within Concrete Construction: Copper tube; Type K, soft annealed temper; no joints or fittings allowed; sleeve tube with continuous length of 3/8" minimum thickness of rubber pipe insulation.

C. VALVES: Unless otherwise indicated provide valves as listed in the "VALVES" and “HYDRONIC SPECIALTIES” paragraphs of this specification.

2.16 HYDRONIC SPECIALTIES

A. SUBMITTALS
1. Product Data Sheets: For each type of Hydronic Specialty indicated.
2. Shop Drawings: Show all Hydronic Specialties on Coordination drawings. Refer to “COORDINATION DRAWINGS” this SECTION.

B. ASME COMPLIANCE:
1. Comply with ASME B31.9, “Building Services Piping,” for materials, products, and installation. Safety valves and pressure vessels shall bear appropriate ASME label.

C. COMBINATION BALANCING AND SHUT-OFF VALVES – 1” AND UNDER
1. Valves shall be of bronze body/brass ball construction with glass and carbon filled TFE seat rings.
2. Valves are to have differential pressure read-out ports across valve seat area. Read-out ports to be fitted with internal EPT inserts and check valves.
3. Valve bodies to have ¼” NPT tapped drain/purge port.
4. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated nameplates to assure specific valve settings.
5. Valves shall be designed for positive shut off.
6. Valves to be provided with preformed insulation to permit access for balance and read-out.
7. Provide extended stems for all valves in insulated piping systems. Stems shall extend to length necessary for full handle exposure outside of insulation system.
8. Valves to be Bell & Gossett Circuit Setter Plus or equivalent by Taco.

D. COMBINATION BALANCING AND SHUT-OFF VALVES – OVER 1”
1. Balancing valves shall be of the “Y” pattern globe style design. Valves shall offer a minimum of four full rotations of the handwheel for accurate adjustments and acceptable flow control ranges.
2. All balancing valves must exhibit an accuracy of ± 5% in the normal operating range of the valve.
3. All balancing valves shall have integral self-sealing metering ports for measuring differential pressure, flow rates and temperature.
4. All balancing valves must be capable of 100% shutoff at pressures up to 250 psi.
5. Valves shall have a hidden preset and tamperproof locking device to prevent unauthorized adjustment and to allow for a return to the original setting after shut off.
6. All balancing valves in sizes up to 2” shall have a digital handwheel for positioning and presetting accuracy. Sizes 2.5” and over shall have a vernier sleeve for readout.
7. Valves up to 2” shall have a drain fill connection with and integral stop valve.
8. Valves up to 2” shall be manufactured from die cast dezincification resistant copper alloy which does not require dielectric fittings. Valves over 2” shall be manufactured from cast iron with all wetted moving parts of dezincification resistant copper alloy.
9. Valves up to 2” to be provided with preformed insulation to permit access for balance and read-out.
10. Provide extended stems for all valves in insulated piping systems. Stems shall extend to length necessary for full handle exposure outside of insulation system.
11. Valves shall be by Tour & Anderson or equivalent by Nibco or Armstrong.

E. BALANCE COCKS
1. Threaded or Soldered Ends (as required) 2" and Smaller: Class 125, bronze body, bronze plug; screwdriver operated, straight or angle pattern.
2. ACCEPTABLE MANUFACTURERS
   a. American Air Filter Co.
   b. B&G ITT; Fluid Handling Div.
   c. Spirax Sarco Co.
   d. Taco, Inc.

F. AIR VENTS
1. Manual: Screwdriver or thumbscrew operated 1/8 inch NPS connection.
2. Automatic: Float principle; stainless steel float and mechanism; cast iron body; 125 psi; 2 inch NPS inlet and outlet connections.
3. ACCEPTABLE MANUFACTURERS
   a. Armstrong Machine Works.
   b. B&G ITT; Fluid Handling Div.
   c. Spirax Sarco Co.

G. AIR SEPARATORS
1. Centrifugal Type: 125 psi; steel construction; Fabricate and Stamp to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1. Tangential inlet and outlet connections; perforated stainless steel air connector; blowdown connection.
2. ACCEPTABLE MANUFACTURERS
   a. B&G ITT; Fluid Handling Div.
   b. Armstrong Pump Inc.
   c. Spirax Sarco Co.

H. DIAPHRAGM-TYPE COMPRESSION TANKS
1. Steel construction; 125 psi; Fabricate and Stamp to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; flexible diaphragm sealed into tank to permanently separate air from water; pressure gage and air charging fitting; drain fitting.
2. ACCEPTABLE MANUFACTURERS

a. B&G ITT; Fluid Handling Div.
b. Armstrong Pump, Inc.
c. Amtrol, Inc.

I. WATER RELIEF VALVES
1. ASME rated, direct spring loaded type, lever operated, nonadjustable factory set discharge pressure.
2. Select relief setting not to exceed 6 psig above maximum allowable working pressure for pressures up to and including 60 psig.
3. ACCEPTABLE MANUFACTURERS
a. B&G ITT; Fluid Handling Div.
b. Spirax Sarco Co.
c. Taco, Inc.

J. PUMP DISCHARGE VALVES
1. Non-slam check valve with spring loaded disc and calibrated flow adjustment feature; positive shut off; 175 psi; flanged cast iron body; straight or angle pattern as indicated. Valve shall be system line size.
2. ACCEPTABLE MANUFACTURERS
a. Armstrong Pump, Inc.
b. B&G ITT; Fluid Handling Div.
c. Taco, Inc.

K. PUMP SUCTION DIFFUSER
1. Angle type suction guide fitting with flanged or threaded cast iron body; 175 psi; steel or cast iron guide vanes; removable stainless steel strainer; blow down and gage tappings; 16 mesh bronze start-up strainer.
2. Suction diffuser shall be non-reducing with both the system side and pump side equivalent to the system line size.
3. ACCEPTABLE MANUFACTURERS
a. Armstrong Pump, Inc.
b. B&G ITT; Fluid Handling Div.
c. Taco, Inc.

L. SHOT FEEDERS
1. 5 Gallon capacity or as otherwise indicated; cast iron or steel construction; 125 psi; funnel valve on top for loading; drain valve in bottom; recirculating valves on side.

2.17 STEAM AND CONDENSATE PIPING SYSTEMS

A. DEFINITIONS
1. LOW PRESSURE: 0 to 15 psig.
2. MEDIUM PRESSURE: Greater than 15; less than 100 psig.

B. LP STEAM PIPE AND FITTINGS
1. Size 2" and Less: SCH. 40 black steel pipe; 125 psi cast iron threaded fittings.
2. Size 2-1/2" and Larger: SCH. 40 black steel pipe; Class 150 wrought steel buttweld fittings.

C. LP CONDENSATE PIPE AND FITTINGS
1. Size 2" and Less: SCH. 80 black steel pipe; 125 psi cast iron threaded fittings.
2. Size 2-1/2" and Larger: SCH. 80 black steel pipe; Class 150 wrought steel buttweld fittings.

D. MP STEAM PIPE AND FITTINGS
1. Size 2" and Less: SCH. 40 black steel pipe; 125 psi cast iron threaded fittings.
2. Size 2-1/2" and Larger: SCH. 80 black steel pipe; 150 wrought steel buttweld fittings

E. MP CONDENSATE PIPE AND FITTINGS
1. Size 2" and Less: SCH. 80 black steel pipe; 125 psi cast iron threaded fittings.
2. Size 2-1/2" and Larger: SCH. 80 black steel pipe; Class 300 wrought steel buttweld fittings.

F. VALVES
1. Unless otherwise indicated provide valves as listed in the “VALVES" paragraph of these specifications.

2.18 STEAM AND CONDENSATE SPECIALTIES

A. SUBMITTALS
1. Product Data Sheets: For each type of steam and condensate Specialty indicated.
2. Shop Drawings: Show all Hydronic Specialties on Coordination drawings. Refer to “COORDINATION DRAWINGS” this SECTION.

B. GENERAL
1. Provide steam and condensate specialties of design pressures equal or greater than that of the piping system to which they are connected.

C. FLOAT AND THERMOSTATIC TRAPS
1. Cast iron or semi-steel body; diaphragm or bellows type thermostatic element with stainless steel valve cone and valve seat; stainless steel or copper float, with positive snap-action valve mechanism, stainless steel valve and renewable seat.
2. ACCEPTABLE MANUFACTURERS
   a. Armstrong Machine Works.
   b. Barnes & Jones, Inc.
   c. Spirax Sarco.

D. INIVERTED BUCKET TRAPS
1. Cast iron body; stainless steel head and seat; stainless steel valve retainer, lever, and guide pin assembly: Stainless steel bucket and inlet strainer. Stainless steel automatic air vent.
2. Minimum pressure rating: 250 psig.
3. ACCEPTABLE MANUFACTURERS
   a. Armstrong Machine Works.
   b. Barnes & Jones, Inc.
   c. Spirax Sarco.

E. STEAM VENTS
1. Automatic; thermostatic balanced pressure type; brass or semi-steel bodies; renewable stainless steel head and seat; phosphor bronze thermostatic bellows, liquid filled.

F. PRESSURE REDUCING VALVES
1. Pilot actuated, diaphragm type; cast semi-steel bodies with stainless steel trim; replaceable valve head and seat; main head stem guide fitted with flushing and pressure arresting device.
2. ACCEPTABLE MANUFACTURERS
   a. Leslie Co.
   b. Spirax Sarco.

c. Spence Engineering co., Inc.

G. PRESSURE REDUCING VALVES
1. Pilot actuated, diaphragm type; cast semi-steel bodies with stainless steel trim; replaceable valve head and seat; main head stem guide fitted with flushing and pressure arresting device.
2. Provide following options on all valves:
   a. Discharge noise suppressor
   b. Manufacturer's removable insulation jacket
3. ACCEPTABLE MANUFACTURERS
   a. Spirax Sarco.
   b. Spence Engineering co., Inc.
   c. Leslie Co.

2.19 STEAM TO HOT WATER CONVERTER

A. ACCEPTABLE MANUFACTURERS:
1. ITT Bell & Gossett
2. Taco
3. Amtrol.

B. GENERAL
1. Furnish and install approximately where shown on plans and with manufacturer's recommendations, Steam to Liquid Heat Exchanger(s), according to the following specifications:

C. TYPE:
1. Shell and Tube, U-bend removable tube bundle.
2. Equipped with mounting legs.

D. MATERIALS:
1. Front Head: Cast Iron (Bonnet)
2. Baffles: Steel
3. Tie Rods/Spacers: Steel
4. Shell: Steel
5. Gasket Material: Compressed Fiber
6. Tubesheet: Steel
7. Tubes: Copper

E. CONSTRUCTION:
1. A manufacturers' data report for pressure vessels, form No. U-1 as required by the provisions of the ASME Code Rules, is to be furnished to the engineer for the owner upon request. This form must be signed by an authorized inspector, holding National Board Commission, certifying that construction conforms to the latest ASME Code for pressure vessels for:
   a. Tube side: 150.0 PSIG design pressure at 375.0 deg. F
   b. Shell side: 150.0 PSIG design pressure at 375.0 deg. F
2. As detailed in form No. U-1. The ASME "U" symbol should also be stamped on the Heat Exchanger(s). In addition, each unit is registered with the National Board of Boiler and Pressure Vessel Inspectors.

2.20 REFRIGERANT PIPING SYSTEMS

A. ACCEPTABLE MANUFACTURERS
1. Alco Controls Div.; Emerson Electric Co.
2. Henry Valve Co.
3. Parker-Hannifin Corp.; R&AC Div.
4. Sporlan Valve Co.

B. SUBMITTALS
1. Piping Valve numbering scheme.
2. Shop Drawings:
   a. Design Calculations: Calculate requirements for refrigerant piping systems.
   b. Schematic diagrams of piping layout and sizing. Include valves and refrigerant specialties.
   c. Refrigerant equipment manufacturers piping, valve and refrigerant specialties requirements.

C. REFRIGERANT PIPE AND FITTINGS
1. Tube size 4-1/8" and Smaller: Copper tube; Type ACR, hard drawn temper; wrought copper solder joint fittings; soldered joints.
2. Solder joints using lead-silver solder, ASTM B 32, Grade 96 TS.

D. SPECIAL REFRIGERANT VALVES
1. Globe Shutoff Valves: Forged brass, packed, back seating, winged seal cap, 300 deg. F. temperature rating, 500 psi working pressure.
2. Check Valves: Forged brass, accessible internal parts, soft synthetic seat, fully guided piston and stainless steel spring, 250 deg. F. temperature rating, 500 psi working pressure.

E. REFRIGERANT SPECIALTIES
1. Strainers: Brass shell and end connections, brazed joints, monel screen, 100 mesh, UL listed, 350 psi working pressure.
2. Moisture Indicator: Forged brass, single port, removable cap, polished optical glass, solder connections, UL listed, 200 deg. F. temperature rating, 500 psi working pressure.
3. Filter-Drier: Corrosion resistant steel shell, steel flange ring and spring, wrought copper fittings, ductile iron cover plate with steel cap screws, replaceable filter-drier core, 500 psi working pressure.
4. Solenoid Valves: Forged brass, conform to ARI 760, normally closed, Teflon valve seat, NEMA 1 solenoid enclosure, 24 volt, 60 Hz., UL listed, 2" conduit adapter, 250 deg. F. temperature rating, 400 psi working pressure; manual operator to open valve.
5. Expansion Valves: Brass body, internal or external equalizer, adjustable superheat setting capillary tube and remote sensing bulb.
   a. Size to avoid being undersized at full load and excessively oversized at partial load.
   b. Select for maximum load at design operating pressure and minimum 43 deg. F. of superheat.
6. Flexible Connectors: Minimum 9" long with bronze fittings; Close pitch corrugated bronze hose with single layer of exterior braiding.

2.21 AC AND HUMIDIFIER CONDENSATE PIPING

A. PIPE AND FITTINGS
1. All Sizes: Copper tube, Type L, hard drawn temper; wrought copper fitting; tin-lead solder (50/50) joints.

2.22 REGISTERS, GRILLES AND DIFFUSERS

A. ACCEPTABLE MANUFACTURERS
1. Anemostat
2. Titus Products Div.; Philips Industries, Inc.
3. Nailor
4. Metal Industries
5. Krueger Mfg. Co.
6. Tuttle & Bailey; Div. of Interpace Corp.

B. SUBMITTALS
1. Product Data: For each product indicated, include the following:
   a. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   b. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.
2. Shop Drawings: Show all register, grilles and diffusers on Coordination drawings. Refer to “COORDINATION DRAWINGS” this SECTION.

C. GENERAL
1. Provide manufacturers standard air outlets and inlets of type, size, materials, and with accessories and options indicated.

D. FINISH
1. Finish of all registers, grilles and diffusers shall be standard color selected by Architect. Provide color samples to Architect for his approval during the submittal process.

E. PERFORATED FACE CEILING REGISTERS AND DIFFUSERS (use for all psychiatric patient access areas).
1. Type: Removable, perforated face. Maximum security, suicide deterrent. 3/16” thick steel plate with 5/32” diameter holes on 7/32” staggered centers. Border with roll-over edge to fit flush to ceiling. Face shall be removable via tamper-proof, face-mounted, screws.
2. Frame: All welded steel construction with angle frame backing. 1-1/2”x1-1/2”x3/16” thick. Support frame from ceiling deck with bracing or rods.
3. Fabrication: Steel, all welded construction. 3/16” steel sleeve. Provide aluminum version for all shower rooms.
4. Paint: Must pass 100 hour ASTM B117 corrosive environment salt spray test without creepage or blistering/deterioration of film. Must pass ASTM D2794 reverse impact cracking test with a 50 inch-pound force applied.
5. Performance data must be tested in a accordance with ANSI/ASHRAE Standard 700-2006.
6. Provide integral volume dampers accessible from grille face (after removal).
7. Basis of design is Anemostat model RRMX-1.

F. PERFORATED FACE CEILING REGISTERS AND DIFFUSERS
1. Type: Perforated face.
2. Frame: coordinate with architectural ceiling plans.
3. Fabrication: Steel with steel or aluminum frame and finish to be coordinated with the Architect.
4. Provide adjustable throw pattern attachment for diffusers and opposed blade damper for both diffusers and registers.
5. Note carefully which diffusers located at the bottom of shafts are to be fire rated and are to be provided with integral fire dampers and be of suitable construction to maintain the fire rating of the ceiling.

G. CEILING SUPPLY REGISTERS/GRILLES
1. Type: Streamlined and individually adjustable curved blades to discharge air along face of grille, one-way or two-way deflection.
2. Frame: coordinate with architectural ceiling plans..
3. Fabrication: Aluminum extrusions with factory finish coordinated with Architect.
4. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

H. CEILING EXHAUST AND RETURN REGISTERS/GRILLES
1. Type: Streamlined blades, 3/4 inch maximum spacing, with blades set at 45 degrees, vertical or horizontal face as indicated on schedules.
2. Frame: coordinate with architectural ceiling plans..
3. Fabrication: Steel with 20 gage minimum frames and 22 gage minimum blades, steel and aluminum with 20 gage minimum frame, or aluminum extrusions, with factory finish to be coordinated with the Architect.
4. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

I. WALL SUPPLY REGISTERS/GRILLES
1. Type: Streamlined and individually adjustable blades, with deflection type as indicated on schedules.
2. Frame: coordinate with architectural plans.
3. Fabrication: Steel (unless otherwise scheduled) with 20 gage minimum frames and 22 gage minimum blades, steel and aluminum with 20 gage minimum frame, or aluminum extrusions, with factory finish to be coordinated with Architect.
4. Damper: Integral, gang-operated opposed blade type with removable key operator, operable from face.

J. WALL EXHAUST AND RETURN REGISTERS/GRILLES
1. Type: Streamlined blades, with spring or other device to set blades.
2. Refer to schedules for fabrication materials.
3. Frame: coordinate with architectural plans.
4. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

K. ACCESSORIES:
1. Equalizing grid.
2. Safety chain.

2.23 ROOF FANS

A. ACCEPTABLE MANUFACTURERS
1. Greenheck
2. Loren Cook Co.
3. Penn Ventilator Co., Inc.

B. GENERAL: Except as otherwise indicated, provide standard prefabricated centrifugal roof fans, curb mounted of the type, size, material, characteristics, performance and with the accessories indicated on the Drawings or specified herein.

C. CODES AND STANDARDS
1. Bear the AMCA certified rating seal.
2. Test in accordance with U.L. 705 "Power Ventilators".

3. Motors and electrical accessories shall comply with NEMA standards. 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.
4. Fans used for kitchen grease removal service shall have U.L. classification YZHW and shall meet the requirements of NFPA Standard 96.

D. FEATURES
1. Sheaves shall be dynamically balanced, bored to fit shafts and keyed. Sheaves shall be of the variable or adjustable pitch type.
2. Provide fan shaft with self-aligning pre-lubricated ball bearings.
3. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inchwood nailer. Size as required to suit roof opening and fan base.
   a. Configuration: Built-in raised cant and mounting flange.
   b. Overall Height: 18 inches.
   c. Sound Curb: Roof curbs shall incorporate sound attenuating baffles to further reduce noise generated from the fan. Sound attenuating baffles to be constructed of a die formed perforated aluminum outer housing and filled with sound absorbing fiberglass wool. Sound attenuating baffles shall have solid, rounded noses to increase noise reduction. Aluminum baffles are to be attached to curb using spring steel wire holding clips that allow for easy removal of each baffle for cleaning or maintenance. Baffles without perforated aluminum outer housing such as fiberglass duct board are unacceptable.
   d. Pitch Mounting: Manufacture curb for roof slope.
   e. Metal Liner: Galvanized steel.
   f. Mounting Pedestal: Galvanized steel with removable access panel.

E. ACCESSORIES
1. Removable bird screen, 1/2 - inch mesh, 16 gauge, aluminum, brass or galv. steel wire.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
3. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

2.24 CHEMICAL WATER TREATMENT

A. MATERIALS
1. All chemicals shall be approved by the Federal Environmental Protection Agency.
2. System Cleaner:
   a. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products ; sodium tripoly phosphate and sodium molybdate.
3. Biocide
   a. Chlorine release agents such as sodium hypochlorite or calcium hypochlorite, or microbiocides such as quarternary ammonia compounds, tributyl tin oxide, methylene bis (thiocyanate), or isothiazolones.
4. Closed System Treatment (Water):
   a. Sequestering agent to reduce deposits and adjust pH ; polyphosphate.
   b. Corrosion inhibitors ; liquid boron-nitrite, sodium nitrite and borax, sodium totyltriazole, low molecular weight polymers, phosphonates, sodium molybdate, or sulphites.
   c. Conductivity enhancers ; phosphates or phosphonates.

B. BY-PASS (POT) FEEDER

1. 6.0 gal quick opening cap for working pressure of 175 psig.

2.25 PACKAGED CHILLER / HYDRONIC SKID

A. ACCEPTABLE MANUFACTURERS

1. York
2. Trane
3. Carrier

B. GENERAL

1. Provide factory assembled and tested chiller and hydronic pump skid package consisting of an air-cooled scroll liquid chiller, chilled water pumps, air separator, expansion tank, shot feeder, 200-gallon buffer tank, and all associated piping to provide single chilled water supply and chilled water return connections.
2. Provide proper vibration isolation for associated piping & wiring according to manufacturer's representatives.
3. All skid components shall be suitable for exterior mounting and shall be factory insulated and jacketed. See applicable specification sections for insulation and jacketing systems.
4. Refer to individual component product and installation specification sections herein for further information regarding requirements for hydronic pumps, air separator, expansion tank, shot feeder, and piping.

C. PACKAGED CHILLER / COMPONENTS

1. GENERAL
   a. Chiller shall be provided with scroll compressors, evaporator, thermal expansion valve, refrigeration accessories, and control panel. Construction and rating shall be in accordance with ANSI/ARI 590.
   b. Refer to chiller installation specification section.
2. HOUSING
   a. The frame shall be heavy duty galvanized structural steel construction. The housing shall be fabricated from heavy gauge aluminum removable panels finished with corrosion and weather-resistant finish.
3. COMPRESSOR(S): Hermetic, 1750 RPM, scroll type designed for indicated refrigerant.
   a. Tip seals to provide efficient axial sealing while preventing scroll tip to base contact.
   b. Controlled Orbit Design for radial sealing to incorporate minimum flank to flank contact for long service life.
   c. Refrigerant flow through the compressor with 100% suction cooled motor.
   d. Large suction side free volume and oil sump to provide liquid handling capability.
   e. Annular discharge check valve and reverse vent assembly to provide low pressure drop, silent shutdown and reverse rotation protection.
   f. Initial Oil charge.
   g. Oil Level sightglass.
   h. Vibration isolator mounts for compressors.
   i. Brazed-type connections for fully hermetic refrigerant circuits.
4. EVAPORATOR
   a. Provide remote or integral evaporator (as indicated on drawings) of shell and tube type, seamless or welded steel construction with cast iron or fabricated steel heads, seamless copper tubes or red brass tubes with integral aluminum fins, rolled or silver brazed into tube sheets. Provide multiple refrigerant circuits.
   b. Design, test, and stamp refrigerant side for 225 PSIG working pressure and water side for 150 PSIG working pressure in accordance with ANSI/ASME SEC 8.
   c. Insulate with 0.75 inch minimum thick flexible expanded polyvinyl chloride insulation with maximum K value of 0.26.

d. Provide water drain connection and thermometer wells for temperature controller and low temperature cutout.

5. CONDENSER
   a. Provide condenser of copper tubes with aluminum plate fins. Fins shall be formed with tube collars and mechanically expanded with fin collars for full contact. Condenser coils shall be tested to 225 psig air pressured.
   b. Casings shall be heavy gauge aluminum. Tube sheets shall be die formed and full collared for tube support. Headers to be constructed of heavy wall seamless copper tubing.
6. CONDENSER FANS
   a. Provide direct drive propeller type with zinc plated chromate dipped blades. Air shall discharge vertically to minimize noise generation and air recirculation.
   b. Fans shall be located within a formed venturi and be provided with a polyvinyl covered fan guard.
   c. Fan motors shall be 3 phase, 1140 RPM, vertical, direct drive motors with permanently lubricated ball bearings and overload protection.
7. REFRIGERANT CIRCUIT
   a. Provide refrigerant circuits, factory supplied and piped.
   b. Provide hot gas bypass for lead compressor circuit.
   c. Provide for each refrigerant circuit:
      1) Liquid line solenoid valve
      2) Filter dryer (replaceable core type)
      3) Liquid line sight glass and moisture indicator
      4) Thermal expansion valve for maximum operating pressure
      5) Charging valve
      6) Insulated suction line
      7) Discharge line check valve
      8) Compressor service valves
      9) Pressure relief device

D. CONTROLS
1. Provide provisions for local control as specified herein, and provisions for remote start/stop capabilities and run status light. Locate on chiller, mount steel control panel, containing starters, power and control wiring, molded case disconnect switch, factory wired with single-point power connection.
2. For each compressor, provide across-the-line starter, non-recycling compressor over load, starter relay, and control power transformer. Provide manual reset current overload protection.
3. Provide the following devices on a Nema 4X control panel face:
   a. Compressor run lights
   b. System start/stop switch
   c. Control power fuse of circuit breaker
   d. Compressor lead/lag switch
4. Provide the following safety controls with indicating lights arranged so that operating any one will shut down machine and require manual reset:
   a. Low chilled water temperature switch
   b. High discharge pressure switch for each compressor
   c. Low suction pressure switch for each compressor
   d. Oil pressure switch
   e. Flow switch in chilled water line
   f. Relay for remote mounted emergency shutdown
5. Provide the following operating controls:
   a. Multi-step leaving chilled water temperature controller which cycles compressor and activates compressor capacity device(s).
   b. Five minute off timer prevents compressor from short cycling.

c. Periodic pumpout timer to pump down on chilled water flow and high evaporator refrigerant pressure.
d. Hot gas bypass sized for minimum compressor loading on all compressor circuits that bypass hot refrigerant gas to evaporator.
e. Automatic start/stop controls for chilled water pump

6. Provide pre-piped gauge board with pressure gauges for suction and discharge refrigerant pressures and oil pressures.
7. Provide alarm package with test button and indicating lights which indicate control circuit is energized and compressor is running and will light an indicating light upon detection of compressor malfunction, low chilled water temperature, or evaporator water flow failure.

E. MANUFACTURERS FIELD SERVICES
1. Prepare and start systems.
2. Supply service of factory-trained representative for a period of one day to supervise testing, dehydration and charging of machine, start-up, and instruction on operation and maintenance to Owner.

2.26 AIR COOLED CONDENSING UNITS

A. ACCEPTABLE MANUFACTURERS
1. York
2. Trane
3. Carrier

B. GENERAL: Provide air cooled condensing unit(s) of sizes, capacities, characteristics and at the locations indicated. Include in basic unit casing, compressor(s), condenser coils, condenser fans and motors, fan and coil guards, refrigerant charge, refrigerant piping and specialties, motor starters, electrical connection box, operating and safety controls. All components shall be factory piped, wired and tested.

C. CASING: Design for outdoor installation, provide weather protection for components and controls. Construct casing of galvanized steel, phosphatized with baked enamel finish or of heavy gauge aluminum.

D. COMPRESSOR(S): Hermetic, 1750 RPM, scroll type designed for indicated refrigerant.
1. Tip seals to provide efficient axial sealing while preventing scroll tip to base contact.
2. Controlled Orbit Design for radial sealing to incorporate minimum flank to flank contact for long service life.
3. Refrigerant flow through the compressor with 100% suction cooled motor.
4. Large suction side free volume and oil sump to provide liquid handling capability.
5. Annular discharge check valve and reverse vent assembly to provide low pressure drop, silent shutdown and reverse rotation protection.
6. Initial Oil charge.
7. Oil Level sightglass.
8. Vibration isolator mounts for compressors.
9. Brazed-type connections for fully hermetic refrigerant circuits.

E. CONDENSER COIL: Seamless copper tubes mechanically expanded into aluminum fins; provide sub-cooling coil; provide coil guards.

F. CONDENSER FANS: Vertical discharge propeller type. Fan blades shall be statically and dynamically balanced. Provide individual motor for each fan. Fan motors shall be inherently protected and be of ball bearing construction, permanently lubricated type.

G. REFRIGERATION CIRCUIT: Copper tube with brazed joints, include shutoff valve with charging connection.

H. CONTROLS & POWER CONNECTION: Factory wired in weather proof box. Include positive timer to prevent short cycling of compressors. Include low pressurestat; field power and control circuit terminal blocks; circuit breakers; motor contactors; control relays and control circuit on-off switch.

I. HEAD PRESSURE CONTROL: Provide head pressure controls to allow unit to operate to indicated ambient temperature.

J. CAPACITY CONTROL: Provide automatic multi-step capacity control of minimum control steps indicated.

K. ACCESSORIES
1. Hot gas bypass for compressor operation to 10% of full load.
2. Control transformer.

2.27 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. ACCEPTABLE MANUFACTURERS:
1. Bell & Gossett, ITT
2. Armstrong Pump

B. DESCRIPTION: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump; designed for installation with pump and motor shafts mounted horizontally or vertically. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 250 deg F.

C. CONSTRUCTION:
1. Casing: Radially split, cast iron, with replaceable bronze wear rings**,** threaded gage tappings at inlet and outlet, and threaded companion-flange connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.
4. In subparagraph below, select first option for temperature rating of 225 deg F (107 deg C); select second option for 250 deg F (121 deg C).
5. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and EPT bellows and gasket. Include water slinger on shaft between motor and seal.
6. Select subparagraph above or first subparagraph below. Packing seal is rated for 200 deg F (93 deg C).
7. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
8. Pump Bearings: Permanently lubricated ball bearings.

D. MOTOR: Open, drip-proof, with regreaseable ball bearings, conform with NEMA specifications. 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.

2.28 BASE MOUNTED END SUCTION PUMPS

A. ACCEPTABLE MANUFACTURERS
   1. Bell & Gossett, ITT
   2. Armstrong Pump

B. GENERAL: Provide base mounted end suction pumps where indicated, and of capacities and having characteristics as schedules or indicated.

C. TYPE: Centrifugal, single stage, direct connected.

D. CASING: Cast iron, bronze fitted, split volute, single suction rated for 175 psi pressure, renewable bronze wearing rings, suction and discharge gage tappings.

E. IMPELLER: Bronze, fully enclosed, keyed to shaft, statically and dynamically balanced.

F. COUPLING GUARD: Coupling guard shall be compliant with ANSI B15.1, Section 8 and OSHA 1910.219. Provide slotted viewing windows for inspection.

G. SHAFT: High grade alloy steel with copper, bronze or stainless steel shaft sleeves.

H. BEARINGS: Regreaseable ball bearings.

I. DRIVE: Flexible coupling with coupling guard.

J. SEALS: Flushed, Mechanical seals.

K. BASEPLATE: Fabricated steel with open grouting area.

L. MOTOR: Open, drip-proof, with regreaseable ball bearings, conform with NEMA specifications. 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.

2.29 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 16 – 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 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.

F. 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: To NEMA MG 1, energy efficient for frame sizes 215T and larger.

G. Starters 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. Starters shall be sized per NEMA standards to match motor voltage and horsepower. 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. 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”.

H. Start-stop momentary pushbuttons shall be located in the covers of the starter enclosure unless other type of starting switches are required. Red and green pilot lights shall be located in the cover of the starter enclosure to indicate position of main contacts. H-O-A switches shall be included in the starter for all mechanical equipment with automatic control signals.

I. Magnetic or manual starters shall be manufactured by one of the following:
1. General Electric Company
2. Square D Company
3. Allen-Bradley Company

2.30 VARIABLE SPEED DRIVES

A. ACCEPTABLE MANUFACTURERS
1. ABB

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 -(60-11)% of drives rated current).
   b. Adjustable volts per hertz (V/HZ) +10%, -10%.
   c. Adjustable Acceleration Rate.
   d. Adjustable Deceleration Rate.
   e. Adjustable Maximum Speed 0 to 100%.
   f. Adjustable Minimum Speed 0 to 100%.
   g. Adjustable Speed Input Gain 1:1 to 10:1.
   h. Adjustable Speed Input Offset 0 - 50%.
   i. Speed Command Inverting Switch.
   j. Adjustable Analog Output of 0-1 to 0-10 VAC proportional to volts amps or hertz.
   k. Digital Output of 12 VDC.
   l. Adjustable Output Boost.
   m. Adjustable Thermal overload protection 60% to 100% of drive rating.
   n. Three sets of single pole double throw contacts indicating run, trip and current limit.
   o. Automatic restart after a fault to a maximum of 5 attempts.
   p. Set point mode of operation from a transducer input signal.
   q. 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. Options to be provided:
   a. Prewired H-O-A switch.
   b. Manual transfer to line power via contactors and including motor thermal overload and fuse protection while in bypass operation.
   c. Service switch which provides ability to service controller (electrically isolated) while in bypass operation without having to remove power to the motor.
   d. 5% line reactor

2.31 VARIABLE VOLUME TERMINAL BOXES

A. ACCEPTABLE MANUFACTURERS

1. Titus Products Div.; Philips Industries, Inc.
2. Nailor
3. Metalaire
4. JCI

B. SUBMITTALS

1. For each product indicated, include the following:
   a. Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   b. Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
   c. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
   d. Wiring Diagrams: Power, signal, and control wiring.

2. Coordination Drawings: Show all VAV terminals on Coordination drawings. Clearly indicate access and service area requirements. Refer to “COORDINATION DRAWINGS” this SECTION.

C. GENERAL
1. Provide where shown on drawings variable volume terminal boxes with hot water reheat coils and pressure independent volume controllers.

D. Terminals shall be certified under the latest edition of ARI Standard 880. Leakage shall be a maximum of 2 percent of design at 3 inches inlet static pressure.

E. The terminal casing shall be minimum 22 gauge galvanized steel. Units designed for hospital application shall have liner system with rigid insulation capped with metal nosings/corners to ensure that no insulation or sound attenuator materials come in contact with the air stream. Taped insulation shall not be allowed.

F. The terminal box shall incorporate multi point center-averaging velocity sensors. The sensor must provide control signal accuracy of +/- 5% at any inlet condition.

G. The terminal box with Hot water coils shall be provided with factor gasketed access door with cam lock for inspection of heating coil.

2.32 OUTDOOR INSTALLED AIR HANDLER

A. ACCEPTABLE MANUFACTURERS
1. York
2. Trane
3. Carrier

B. Unit must be specifically designed for outdoor installation.

C. Factory Fabricate draw-thru type air handling units with fan sections, coil sections, access sections, mixing boxes, filter sections, discharge plenums, humidifier section.

D. The unit shall be able to withstand up to 1.5 times design static pressure, or 10-inch wc whichever is less, with no more than 0.005 inch deflection per inch of panel span.

E. Base shall be welded supporting the entire length and width of the unit. Units shipped in one piece shall have at a minimum six points of lift. These lift points shall be designed to accept standard rigging devices. The unit base design shall allow unit to rest on top of roofcurb when field installed. Entire length and width under base shall be sealed in the field with curb gasketing for weather tight seal.

F. CASING
1. All panels shall be double wall construction. Interior and exterior panels shall be constructed of galvanized steel. Foam panel insulation system shall provide a minimum R value of 12. Insulation shall conform to NFPA 90 requirements. Unit casing must have thermal conductivity as specified using similar construction or superior construction as that which is specified. An R Value of 8 will not be acceptable. Four-inch wall shall be used to achieve the specified R value in lieu of a 2-inch wall construction with lower R value.
2. Panels shall be fully removable to allow for a proper way to thoroughly clean panels and to access internal parts. If panels are not removable, then manufacturer shall provide

access sections with doors between all internal components to ensure access and cleanability of the air handler.

3. Access doors shall be constructed with a double-wall of solid G90 galvanized steel interior panel. Gasketing around the full perimeter of the access door shall be used to prevent air and water leakage. Preferred door handle shall not penetrate door casing with single-handle latch.
4. To facilitate inspection of internal components, provide sealed tempered glass view windows in access doors as specified on schedule.
5. External surface of unit casing shall be prepared and factory coated with a minimum 1.5 mil enamel finish or equal. Unit casing exterior with factory coating shall be able to withstand a salt spray test in accordance with ASTM B117 for a minimum of 672 consecutive hours. Unit casing will be provided with manufacturer's standard color.
6. Unit roof shall be sloped a minimum .25 inch per foot either from one side of unit to other or from center to sides of the unit. Roof assembly shall overhang all walls of units by 2 inch minimum.
7. For units with outside air requirements, manufacturer shall provide inlet hood with high performance sine wave moisture eliminator to prevent water carryover into unit casing from outside air. Hoods shall be sized for 100% economizer cycle. If eliminator is not factory provided, contractor shall be responsible for field supplying and installing in manufacturers standard outside air inlet hood (s). If louvers are provided, then louvers shall be tested by an Independent AMCA approved laboratory for water carryover and air pressure drop in accordance with AMCA Standard 500, and testing reports shall be supplied with the submittal data.
8. Galvanized steel roof mounting curb with wood nailing strip, and neoprene gasket shall be supplied by the unit manufacturer. If unit requires external piping cabinet, a separate curb shall be supplied for support of the external cabinet.

G. DRAIN PAN CONSTRUCTION: The sealed double wall drain pan shall be constructed of Stainless steel and insulated to prevent sweating. The bottom of the drain pan shall be sloped in two planes which pitch the condensate to the drain connection. The drain pan, when the unit is installed and trapped per the manufacturer's installation manual, shall be designed to leave puddles no more than 2-inches in diameter and no more than 1/8-inch deep no longer than 3 minutes following step 4 of the following test. The test steps are:

1. Temporarily plug the drain pan.
2. Fill the drain pan with 1/2-inch of water or the maximum allowed by the drain depth, whichever is smaller.
3. Start the fan if it is a draw-thru unit. Do not operate the fan if it is a blow-thru unit.
4. Remove the temporary plug.

H. FAN SECTIONS

1. On units with standard Air Foil fans scheduled, provide supply fan section(s) with AF double width, double inlet centrifugal fan designed and suitable for class of service indicated in the unit schedule. Fan shaft to be properly sized and protectively coated with lubricating oil. Fan shafts shall be solid and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. Fans shall be statically and dynamically tested as an assembly at the required RPM to meet design specifications. Key fan wheels to fan shaft to prevent slipping.
2. Provide self-aligning, grease lubricated pillow-block ball bearings selected for L-50 200,000 hour average life per ANSI/AFBMA 9. Extend both grease lubrication fittings to drive side of unit with plastic tubes and zerk fittings rigidly attached to drive side bearing support.
3. On Plug fan units, provide supply fan sections with AF single width, single inlet centrifugal plug fans designed and suitable for class of service indicated on unit schedule. Fan shaft to be properly sized and protectively coated width lubricating oil. Fan shafts shall be solid and properly designed so that fan shaft does not pass through first critical speed as unit

comes up to rated RPM. Fans shall be statically and dynamically tested as an assembly at the required RPM to meet design specifications. key fan wheels to fan shaft to prevent slipping.

4. Equip centrifugal plug fans with self-aligning, grease lubricated pillow-block ball bearings selected for L-50 400,000 hour average life per ANSI/AFBMA 9. Extend both grease lubrication fittings to drive side of unit with plastic tubes and zerk fittings rigidly attached to drive side bearing support.
5. Mount fans on isolation bases. Internally mount motors on same isolation bases and internally isolate fans and motors with 2 inch spring seismic isolators. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A. If no isolators or flexible canvas duct is provided, then the entire unit shall be externally isolated from the supply duct work and piping by contractor in order to avoid transmission of noise and vibration through the ductwork.
6. Fan sections shall have full height, double wall, hinged doors on drive side for inspection and maintenance of internal components. Construct doors in accordance with Article 2.03 Paragraph E.
7. Weigh fan and motor assembly at AHU manufacturer's factory for isolator selection. Statically and dynamically balance fan section assemblies. Fan section assemblies include fan wheels, shafts, bearings, drives, belts, isolation bases and isolators. Allow isolators to free float when performing fan balance. Measure vibration at each fan shaft bearing in horizontal, vertical and axial directions. Balance at design RPM as scheduled on drawings.

I. MOTORS AND DRIVES
1. Factory install all motors on slide base to permit adjustment of belt tension.
2. Fan Motors shall be heavy duty, premium efficiency open drip-proof, operable at 460 Volts, 60 Hz, 3-phase.
3. V-Belt Drive shall be variable pitch rated on constant volume units and fixed pitch on fans driven by frequency inverters. The service factor shall be at 1.5 times the motor nameplate.

J. VARIABLE FEQUENCY DRIVES
1. Comply with “VARIABLE FREQUENCY DRIVES” this SECTION.

K. COILS SECTION
1. Coils shall be manufactured by the same company as the supplier of the air handling unit. Install coils such that headers and return bends are enclosed by unit casings.
2. The units insulation shall meet UL 181 requirements. The air stream surface of the insulation shall be double wall constructed such that it is not biodegradable, repels water and it can be cleaned to prevent microbial growth. The manufacturer's maintenance instructions shall describe the proper cleaning procedure for the unit.
3. Construct coils of plate fins and seamless tubes. Fins shall have collars drawn, belled and firmly bonded to tubes by means of mechanical expansion of tubes. Do not use soldering or tinning in bonding process.
4. Construct coil casings of stainless steel with formed end supports and top and bottom channels. If two or more coils are stacked in unit, install intermediate drain channels between coils to drain condensate to main drain pans without flooding lower coils or passing condensate through airstream.

L. WATER COOLING COILS
1. Clearly label supply and return headers on outside of units such that direction of coil water flow is counter to direction of unit airflow.
2. Coils shall be proof tested to 300 psig and leak tested to 200 psig air pressure under water.
3. Construct headers of round copper pipe or cast iron.

4. Construct tubes of 1/2 inch O.D. minimum .016 inch thick copper and construct fins of aluminum.

M. STEAM HEATING COILS
1. Clearly label supply and return connections on outside of units.
2. Provide non-freeze steam distributing type coils. Pitch steam coils in units for proper drainage of steam condensate from coils.
3. Proof test coils to 300 psig air under water and leak test coils to 200 psig air pressure under water.
4. Construct headers of cast iron or round copper pipe.
5. Inner tubes shall have orifices that ensure even steam distribution across coil face. Direct orifices toward return connections to ensure steam condensate is discharged from coils.

N. REFRIGERANT COOLING COILS (Alternate)
1. Clearly label suction and liquid connections on outside of units.
2. Proof test coils to 450 psig air under water and leak test coils to 300 psig air pressure under water. Dry insides of coils after testing and seal all connections.
3. Construct suction headers of copper tubing. Suction connections shall penetrate unit casings to allow for sweat connections to refrigerant lines.
4. Coils shall have equalizing type vertical distributors sized in conjunction with capacities of coils.

O. FILTERS
1. Provide factory-fabricated filter section of the same construction and finish as unit casings. Filter sections shall have filter guides and full height, double-wall, hinged doors for filter removal.
2. Filter sections shall flange to other unit components. Provide filter blockoffs as required to prevent air bypass around filters.
3. Provide 2-inch angled pre-filter sections with 30% efficient pleated filters. Filters shall be removable from one side(s) of filter sections.
4. Provide high efficiency final filter sections with 12" cartridge filters. High efficiency filters shall be 90% efficient and rated in accordance with ASHRAE 52 and UL class 1 or class 2. Filters shall be removable from one side of filter sections.

P. DAMPERS
1. Provide internally mounted ultra low leak outside air dampers as scheduled on drawings. Dampers shall be Ruskin CD60 double skin airfoil design or equivalent. Construct damper blades and damper frames of galvanized steel. Provide parallel blade action with metal compressible jamb seals and extruded vinyl blade edge seals. Blades shall rotate on stainless steel sleeve bearings. Damper blade lengths shall not exceed 60 inches. Leakage rate shall not exceed 5 CFM/square foot at one inch water gage and 9 CFM/square foot at 4 inches water gage. All Leakage testing and pressure ratings will be based on AMCA Publication 500.

2.33 RADIANT HEATING PANELS

A. ACCEPTABLE MANUFACTURERS
1. Sterling Company
2. AIRTEX Radiant Systems; a division of Engineered Air Ltd.
3. Rosemex Products.

B. GENERAL

1. Provide Hydronic ceiling radiant panels of sizes and in the locations indicated. Radiant Panels shall be of the finish, style, type, capacities, characteristics and with the accessories indicated.
2. Refer to controls paragraph of these specifications for controls requirement.
3. Refer to detail sheet for valves, vents and other hydronic components not called for by this section of the specification but required for proper installation
4. Radiant panels shall have a 5 year warranty against discoloration.

C. LINEAR RADIANT PANELS
1. Constructed of extruded aluminum planks.
2. Width and number of tubes as per design specifications.
3. Tube saddle shall be an integral part of the aluminum plank.
4. Each panel shall be factory supplied in standard white polyester powder coat
5. Circulation tubing shall be 16 mm (5/8") O.D. round tubing mechanically fastened to the plank. A non-hardening heat transfer paste is required between the tubing and the aluminum saddle.
6. Planks shall interlock using tongue and groove connection and be held together using aluminum or steel cross channels with spring clips.
7. All plank interlocking to be done at the factory with return copper coil factory installed prior to going on site. No site assembly permitted.
8. Backing Insulation: Minimum 1-inch-thick, mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB with factory-applied jacket.
9. Copper coil is to be continuous. If the manufacturer cannot supply a continuous coil, then return bends must be factory installed and a pressure test report must be submitted to the Mechanical Consultant.
10. The length of the panels shall be field measured and shall run wall to wall unless otherwise indicated on the drawings. The factory to allow for expansion before the final cut. No site cutting allowed.
11. Panel performance shall be certified in accordance with ASHRAE Std 138 Method of Testing Radiant Heating and Cooling Panels. Capacities of installed panels shall be as shown on the drawing.

D. MODULAR RADIANT PANELS:
1. Modular extruded aluminum panel with serpentine water piping, suitable for lay-in installation flush with T-bar ceiling grid, surface mounting, or recessed mounting.
2. Panels: Minimum 0.0336-inch- thick, galvanized-steel sheet.
3. Backing Insulation: Minimum 2-inch-thick, mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB with factory-applied jacket.
4. Exposed-Side Panel Finishes:
   a. Apply silk-screened finish to match appearance of Architect-selected acoustical ceiling tiles.
   b. Factory prime coated, ready for field painting.
   c. Baked-enamel finish in manufacturer's custom paint color as selected by Architect.
5. Factory Piping: ASTM B 88, Type L copper tube with ASME B16.22 wrought-copper fittings and brazed joints. Piping shall be mechanically bonded to panel.
6. Surface-Mounting Trim: Sheetmetal with baked-enamel finish in manufacturer's custom paint color as selected by Architect.

E. ACCESSORIES:
1. Panel with drape track recess.
2. Male bullnose panel.
3. Female bullnose panel.
4. Male corner panel.

5. Female corner panel.
6. Inside corner panel.
7. Filler panel.

2.34 STEAM-INJECTION HUMIDIFIERS

A. Acceptable Manufacturers:
   1. Armstrong International, Inc.
   2. Nortec Industries, Inc.

B. Description: Steam valve, separator, and dispersion tube extending across entire width of duct and equipped with mounting brackets for both ends of tube.

C. Dispersion Tube: ASTM A 666, Type 304 stainless steel, jacketed; insulated with 1/2-inch fiberglass and stainless-steel jacket.

D. Control Valve: Normally closed valve, with seat and stem matched to deliver required steam flow.
   1. Actuator: Coordinate/comply with the requirements of "AUTOMATIC TEMPERATURE CONTROLS" this SECTION.

E. Steam Separator: Integral withcontrol valve.
   1. Material: Type 304 stainless steel.

F. Steam Trap: Inverted-bucket type, sized for maximum condensate flow.

G. Optional Accessories: Include the following:
   1. Wall-mounted or return-duct-mounted humidistat.
   2. Duct-mounted, high-limit humidistat.
   3. Temperature switch to prevent cold operation.
   4. In-line on-off steam control valve for automatic and total shutdown of humidifier.
   5. In-line strainer.
   6. Airflow switch to prevent humidifier operation when there is no airflow.

2.35 SOUND ATTENUATORS

A. Provide where shown on drawings duct silencers with acoustical performance characteristics, pressure drops and dimensions shown on schedules. Basis of design for silencers shall be Industrial Acoustics Company. Substitute manufacturers must meet all acoustical and pressure drop requirements of silencers listed in schedules as well as construction and testing and certification requirements listed in this specification.

B. Outer casings of silencers shall be made of 22 gauge galvanized steel. Seams shall be lock formed and mastic filled. Interior partitions of silencers shall be made of not less than 26 gauge galvanized perforated steel. Filler material shall be of inorganic mineral or glass fiber of a density sufficient to obtain the specified acoustic performance and be packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin and moisture proof. Silencers shall not fail structurally when subjected to a differential air pressure of 8” W.C. inside to outside of casing.

C. Combustion rating of silencer when tested in accordance with ASTM E 84 shall be flame spread of 25 or less, smoke developed of 15 or less and fuel contribution of 20 or less.

D. Silencer ratings shall be determined in a duct to reverberant room test facility which provides for air flow in both directions through the test silencer in accordance with ASTM E477.

E. With submittals the manufacturer shall supply certified test data of Dynamic insertion loss, self noise power levels, and aerodynamic performance for reverse and forward flow test conditions. test data shall be for a standard product. All rating tests shall be conducted in the same facility, shall utilize the same silencer and shall be open to inspection upon request from the Engineer.

F. For silencers used in Hospital, Medical Office other health care applications packless silencers shall be used. Packless silencers shall also be used for other applications if specifically called for on the schedules. These silencers shall not use any sound absorptive material of any kind. Packless silencers shall attenuate air transmitted noise solely by virtue of controlled impedance membranes and broadly tuned resonators.

2.36 AUTOMATIC TEMPERATURE CONTROLS – FACILITIES MANAGEMENT SYSTEM

A. ACCEPTABLE MANUFACTURERS
   a. Honeywell

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. Provide new or updated graphics and operator station software as necessary to control the new components from the existing Operator workstation.
   3. Extend the existing Local Area Network as necessary.

C. GENERAL
   1. The Automatic Temperature Control (ATC) Contractor shall be the primary manufacturer-owned 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 Honeywell
   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 or Netscape.
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.
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 any Operator's console 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 operator interface points shall not require the purchase of any special software from the manufacturer in order to provide the complete user interface as described herein.
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 operator 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 any Operator PC, 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.
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. Schematics, sequences and flow diagrams.
    c. 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.]
    d. Samples of Graphic Display screen types and associated menu penetrations to show hierarchy and functional interrelationships.
    e. Detailed Bill of Material list for each Node, identifying quantity, part number, description, and optional features.
    f. 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.
    g. 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.
    h. Room Schedule including a separate line for each VAV box and terminal unit indicating minimum/maximum cfm, pickup gain, box area, and bias setting.
    i. Details of all FMS interfaces and connections to the work of other trades.
    j. Product data sheets for all products including software.

k. 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.
   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. Fully commission all aspects of the Facility Management System work.
2. 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.
3. The Engineer will use the check sheet as the basis for acceptance testing with the ATC Contractor.
4. 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.

5. 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.
6. Promptly rectify all listed deficiencies and submit to the Engineer that this has been done.

I. OPERATOR STATION

1. Utilize existing workstation. Upgrade memory, storage, and software as required to support new system points.

J. 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 operator station or other control units on network.
   d. Accept, process, and execute commands from other control unit's or devices or operator stations.
   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 operator station. 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. Each Control unit shall be equipped with the necessary un-interruptible power 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.

K. LOCAL AREA NETWORKS (LAN)

1. Provide communication between control units over local area network (LAN).
2. LAN Capacity: Extend existing BAS LAN to all new equipment and points.
3. Break in Communication Path: Alarm and automatically initiate LAN reconfiguration.
4. LAN Data Speed: Minimum 100 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.

L. OPERATING SYSTEM SOFTWARE
1. Input/Output Capability From Operator Station:
   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.
      1) Alarm printer: Print alarms, operator acknowledgements, action messages, system alarms, operator sign-on and sign-off.
      2) Data printer: Print reports, page prints, and data base prints.
   m. Select daily, weekly or monthly as scheduled frequency to synchronize time and date in digital control units. Accommodate daylight savings time adjustments.
   n. 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. Operator Station:
   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.
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. Graphical displays 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 operator device, field interface unit, point, programmable control unit.

M. TERMINAL BOX UNIT CONTROLLERS

1. The controls contractor shall furnish the terminal control unit controller, damper motor, and flow transducer for installation on each terminal unit by the terminal unit manufacturer under Division 15. These devices shall be delivered to the terminal unit manufacturer's factory in sufficient time for the terminal unit manufacturer to meet their schedule obligations. The cost of factory mounting, wiring, enclosure to meet local code and any factory testing and programming of the terminal control unit shall be included by the terminal box manufacturer.

2. The control contractor shall be responsible for installation of space sensors and communications transmission bus.
3. The terminal box manufacturer shall provide a flow cross or two (2) pipe sensor suitable for interfacing with a Microbridge flow transducer.
4. The sheetmetal contractor shall provide a minimum of three (3) duct diameters of straight duct upstream from the terminal box inlet.
5. The sheetmetal contractor shall insure all terminal box controllers are located a minimum of three (3) feet from all obstructions (walls, pipes, etc.) so as to remain accessible.
6. The sheetmetal contractor shall provide for dry storage of terminal units and mounted terminal box controllers upon receipt at jobsite.
7. The air flow balancing contractor shall check all terminal units and make any changes in the air flow parameters to ensure that the terminal box controls perform in accordance with the approved specifications and schedules.
8. Terminal Equipment Control Units (TEC's) shall be provided for direct digital control of terminal vav boxes as specified. Units shall be UL Listed (UL916 PAZX, 864 UDTZ) and CSA approved.
9. The VAV box controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 28 VAC (-25% to +17%), allowing for power source fluctuations and voltage drops. The BMCS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32-122 Deg.F. and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.
10. The controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the average differential pressure in the duct. The controller shall convert this value to actual air flow. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 4000 f.p.m. and measurement accuracy of +/- 5% at 400 to 4000 fpm , insuring primary air flow conditions shall be controlled and maintained to within +/- 32 FPM of setpoint at the specified parameters. The BMCS contractor shall provide the velocity sensor if required to meet the specified functionality.
11. Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa. Manual calibration may be accomplished by either commanding the actuator to 0% via the portable terminal or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.
12. The VAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within +/- 1.5 Deg. of setpoint at the room sensor location.
13. A damper actuator shall mount on the damper shaft and shall provide complete modulating control of the damper.
    a. The actuator motor shall de-energize when the damper has reached the operator or system determined position.
    b. Damper actuator position status shall be monitored from the central or remote operator's terminal and shall be displayed in percent open notation. Systems which provide only end switch feedback are not acceptable.
    c. The actuator shall be a removable and separate device from the Terminal Equipment Control Unit. If integral to the Terminal Equipment Control Unit, the

actuator shall be removable for servicing without removing the Terminal Equipment Control Unit.

14. The valve actuators shall mount on the valve body and provide complete modulating control of the valve.
    a. The valve actuator motor shall be of the non-stall type and shall de-energize when the valve has reached either the operator or system determined position.
    b. Valve position status shall be monitored from the central or remote operator's terminal and shall be displayed in percent open notation. Systems which provide only end switch feedback are not acceptable.
    c. Changes made during setup or normal operation to the Terminal Equipment Control Unit by the portable operator's terminal or central terminal shall not be affected by loss of communication on the LAN communication bus.
    d. It shall not be necessary to disconnect the communications bus for communication between the Portable Operator's Terminal and the Terminal Equipment Control Unit.
    e. Each controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve as required to satisfy space heating requirements. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space cooling requirements. This algorithm shall function to signal the respective Network controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint.

N. 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.; 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..
    d. Averaging Elements in Ducts: 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; 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. Room Security Sensors: Stainless-steel 304 flush mount cover plate with insulated back and security screws.
6. Room Sensor Cover Construction (non psychiatric patient areas only): Manufacturer's standard locking covers.
   a. Set-Point Adjustment: exposed, digital.
   b. Set-Point Indication: exposed, digital.
   c. Thermometer: exposed, digital.
   d. Color: Off-White
7. Room Sensor accessories include the following:
   a. Insulating Bases: For thermostats located on exterior walls.
8. 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.
9. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.
10. 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.
11. Electronic Valve/Damper Position Indication: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
12. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless-steel or bronze paddle. For chilled-water applications, provide vapor proof type.

O. 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.

P. AUTOMATIC CONTROL VALVES:
1. All automatic control valves shall be fully proportioning with modulating plug or V-port inner guides, unless otherwise specified. The valves shall be quiet in operation and fail-safe in either normally open or normally closed position in the event of power failure. All valves shall be capable of operation in sequence when required by the sequence of operation. All control valves shall be sized by the control manufacturer and shall be guaranteed to meet the heating loads as specified. All control valves shall be suitable for the pressure conditions involved. Valve operators shall be of the electronic actuating type and be fully modulating or two position type as indicated under the sequence of operation. Body pressure rating and connection type (screwed or flanged) shall conform to pipe schedule in this specification.
   a. All valves sequenced with other valves, or control devices, shall be equipped with pilot positioners.
   b. Hot water control valves shall be single-seated type with equal percentage flow characteristics. The valve discs shall be composition type with bronze trim.

Q. DAMPERS:
1. 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. All damper bearings are to be made of nylon. Bushings that turn in the bearings are to be oil-impregnated sintered metal.
   d. 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.

R. 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.

S. DDC COMPONENT INSTALLATION

1. EXAMINATION
   a. Verify that conditioned power supply is available to the control units and to the operator work station. 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. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation.
   c. Provide with 120v AC, 15 amp dedicated emergency power circuit to each programmable control unit.
   d. 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.

e. All wiring shall comply with the requirements of the DIVISION 16 – 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 for 3 day period.
   c. Provide basic operator training for 3 persons on data display, alarm and status descriptors, requesting data, execution of commands and request of logs. Include a minimum of 40 hours dedicated instructor time. Provide training on site.

T. 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 mode of operation. Names for all points and variables shall be coordinated with owner and/or Engineer.
   c. Fail-safe positions are position that devices will go to when de-energized: no = normally open, nc = normally closed. All heating coils (pre-heat, heating and reheat) shall have two way control valve arrangement with the normally open position (stay open on power failure) to the coil.
   d. Whenever a piece of HVAC equipment is off per the control system or main power is disconnected, the control devices for the unit shall go to their fail-safe position.
   e. Supply and return smoke isolation dampers (nc) for air handling shall close whenever associated unit is off. Provide end switches to verify position of dampers before unit starts.
   f. For air handling units outdoor air flow measuring stations (FMS) shall be used to monitor and display respective air volumes on attached magnehelics (calibrated in cfm) and at the control systems central computer display via transducers. The airflows shall be used by the control system to track return fan with the supply fan, and to measure and ensure that minimum outside air for ventilation is maintained.
   g. All cooling coils shall have three way control valve arrangement and shall fail in the closed position (stay closed on power failure) to the coil.
   h. Air handling units shall have outdoor air, supply air and return air flow measuring stations (AFMS) to monitor and display respective air volumes on attached magnehelics (calibrated in cfm) and at the control systems central PC display via transducers. The airflows shall be used by the control system to track return fan with the supply fan, and to measure and log the actual outdoor air coming into air handler, to pressurize the building and ensure that minimum outside air for ventilation is maintained.
   i. Dampers shall be provided by automatic temperature controls contractor including those for air handling units.
2. CRITICAL SYSTEMS
   a. Refer to drawings for equipment and systems on emergency power. All associated DDC components required to operate equipment on emergency power will be on the emergency power system. System include but are not limited to the following:
      1) Heating Plant
         a) Hot Water Pumps
         b) Heat Exchangers
         c) Controls
         d) Air Handlers

3. FIRE ALARM INTERLOCKS
   a. Air Handler Smoke Control: Smoke detector, located in supply and return air, signals alarm, stops fans, and closes smoke dampers when products of combustion are detected in airstream.
4. AIR-HANDLING UNIT CONTROL SEQUENCES – VARIABLE AIR VOLUME
   a. Supply-Fan Control: System starts fan to run continuously during occupied periods. Modulate variable-speed fan drive to maintain supply duct static pressure.
      1) Set variable-speed drive to minimum speed when fans are stopped.
      2) Demand-based Static pressure reset:
         a) 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.
         b) 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.
   b. Upon command for start associated smoke dampers shall open and shall be proven open by end switch prior to start of fans.
   c. Fans shall ramp slowly up to speed on fan start.
   d. Return-Air Fan Control: System starts fan to run continuously during occupied periods. System modulates return-air fan variable-speed fan drive to maintain differential setpoint CFM as measured at the air flow measuring stations. The differential setpoint CFM shall be the supply to return air CFM differential required to maintain a positive building pressure.
   e. On systems with return variable air volume boxes modulate variable-speed fan drive to maintain return duct static pressure.
      a) Demand-based Static pressure reset: 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. 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.
   f. Freeze Protection: Heating Coil interlaced freezestat, located before supply fan, signals alarm, stops fan, and closes outside-air dampers when temperature falls below 37 deg F.
   g. High-Temperature Protection: Duct-mounted thermostat, located in return air, signals alarm, stops fan, and closes outside-air dampers when temperature rises above 200 deg F
   h. Smoke Control: Smoke detector, located in return and supply air, signals alarm, stops fans, and closes smoke dampers when products of combustion are detected in air stream.
   i. Mixed-Air Control: During occupied periods, when fan is running, system modulates outside-air return-air, and relief-air dampers to maintain discharge supply air temperature.
      1) During occupied periods, when fan is running, open outside-air dampers to minimum position.
      2) During heating sequence, set outside-air dampers to minimum position.
      3) When outside-air temperature exceeds return-air temperature, set outside-air dampers to minimum position.
      4) When outside-air enthalpy exceeds return-air enthalpy, set outside-air dampers to minimum position.
      5) During unoccupied periods, position outside-air and relief-air dampers closed and return-air dampers open.

j. Filters: During occupied periods, when fan is running, differential air-pressure transmitter signals alarm when low- and high-pressure conditions exist.

k. Steam Preheat Coil: During occupied periods, when fan is running system modulates control valve to maintain supply-air temperature. Coil interlaced freezestat thermostat on discharge side of preheat coil stops fan when any part of coil face temperature falls below 38 deg F.

l. DX Cooling Coil (Alternate): When fan is running, system modulates valve and associated air cooled condensing unit to maintain supply-air temperature.
   1) System resets supply-air temperature in response to greatest cooling demand and outside air temperature.
   2) During unoccupied periods, when fan is off, associated air cooled condensing unit is off.
   3) During unoccupied periods, when fan is on, enable normal control.

m. Hydronic Cooling Coil: During occupied periods, when fan is running, system modulates control valve to maintain supply-air temperature.
   1) System resets supply-air temperature in response to greatest cooling demand and outside air temperature.
   2) During unoccupied periods, when fan is off, return valve to closed position.

n. Condensate pan High limit: Provide high limit float switch to alarm at DDC and shut down associated air cooled condensing unit when air handler condensate pan is near overflow condition.

o. Coordination of Air-Handling Unit Sequences: Ensure that mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.

p. Operator Station Display: Indicate the following on operator workstation display terminal:
   1) System graphic.
   2) System on-off indication.
   3) System occupied/unoccupied mode.
   4) System fan on-off indication.
   5) Return fan on-off indication.
   6) Return-fan-inlet static pressure indication.
   7) Return-fan-discharge static pressure indication.
   8) Outside-air-temperature indication.
   9) Outside-air- enthalpy
   10) Relative humidity indication.
   11) Outside-air airflow rate – Air flow measuring station.
   12) Preheat-coil air-temperature indication.
   13) Preheat-coil air-temperature set point.
   14) Preheat-coil control-valve position.
   15) Mixed-air-temperature indication.
   16) Mixed-air-temperature set point.
   17) Mixed-air damper position.
   18) Filter air-pressure-drop indication.
   19) Filter low-air-pressure set point.
   20) Filter high-air-pressure set point.
   21) Condensate pan high limit indication.
   22) Supply-fan-discharge air-temperature indication.
   23) Supply-fan-discharge air-temperature set point.
   24) Cooling-coil air-temperature indication.
   25) Cooling-coil control-valve position.
   26) Associated air cooled condensing unit indication (Alternate).
   27) Supply-fan-inlet static-pressure indication.
   28) Supply-fan-discharge static-pressure indication.
   29) Supply-fan-discharge static-pressure set point.
   30) Supply duct VAV static-pressure indication.

31) Supply duct VAV static-pressure set point: Maximum, Minimum, Optimized.
32) Supply-fan airflow rate – Air Flow measuring station.
33) Supply-fan speed.
34) Return -air-temperature indication.
35) Return -air- enthalpy indication.
36) Economizer mode indication.
37) Return-air-inlet static-pressure indication.
38) Return-fan-inlet static-pressure set point.
39) Differential cfm set point.
40) Differential cfm indication.
41) Return-fan airflow rate. – Air Flow measuring station
42) Return fan speed.
43) Building static-pressure indication.
44) Building static-pressure set point.

q. Safeties/Alarms
1) The following safeties, each with its own software manual reset, shall shut down unit and the control system shall initiate respective alarm. All safeties shall be hardwired into fan motor starter circuits with auxiliary contact to register alarm and provide software override capability at FMS central panel. Manual reset shall be accomplished by entering a command at the DDC workstation rather than going to piece of equipment involved.
a) Supply smoke detector (SD) and return smoke detectors for air handlers are activated. Smoke detectors shall be furnished and wired to the fire alarm system under the work of Division 16, ATC contractor shall mount detectors and wire to control system. All air handling units are to have smoke detectors.
b) Air handlers supply/return fan discharge static pressure high limit (SPH) indicates more than 4 1/2 " w.g. when the unit status is on (with a 5 minute delay). This will prevent overpressurizing ductwork if supply fan is on with supply smoke damper. While it is the intention to provide normally open VAV boxes for zones served by air handler number 2, if normally closed boxes are installed on the job, then this contractor shall install static pressure high limit in this air handler as well.
c) Air handlers supply/return fan inlet static pressure low limit (SPL) indicates less than -2 1/2" negative static pressure when the unit status is on (with a 5 minute delay). This will prevent duct collapse if return fan is on with return smoke damper being closed.
d) Freezestat falls to 38 F. Software manual reset of freezestat shall be required. All air handlers shall have freezestats. Length of freezestat capillary shall be minimum of 20'. Capillary shall cover the entire face area of the coil. Use more than one freezestat if required to fully cover coil face area.

r. The control system shall initiate an alarm, describing the alarm if any of the following conditions are met (all setpoints and time periods below shall be adjustable by user from the FMSs central console). Whenever a unit is shut down because of one of the safeties, the control system shall retain in memory the reading and setpoint of each device to help the operator in isolating the reason for the problem. All control system sensors shall have a high and low software alarm limit to indicate temperature problems or a faulty sensor.
1) Supply, return, or exhaust fans are commanded to run and anytime after a 15 second delay the control system senses no running status via the fans current transformer relays (ct).
2) Filter differential pressure switch, across filter section, senses greater than 1.5"w.g. for 15 minutes.

3) Discharge air temperature sensor goes 5 degrees below the minimum cooling discharge air temperature setpoint for 10 minutes when fan status is on.

5. VAV AIR TERMINAL UNIT SEQUENCES:
   a. Room sensor modulates VAV damper and coil control valve. Room sensor reports temperature.
   b. Rooms with ceiling radiant heat panels: The radiant heat panels control valve shall be controlled by the associated VAV box room sensor to ensure that heating is not called for when in cooling mode.
   c. Operator Workstation: Display the following data:
      1) Room/area served.
      2) Room occupied/unoccupied.
      3) Room temperature.
      4) Room temperature set point, occupied.
      5) Room temperature set point, occupied standby.
      6) Room temperature set point, unoccupied.
      7) Air-damper position as percent open.
      8) Control-valve position as percent open.
      9) Terminal unit discharge air temperature.
   d. Safeties/Alarms
      1) The control system shall initiate an alarm, describing the alarm if any of the following conditions are met (all setpoints and time periods below shall be adjustable by user from the FMSs central console). Whenever a unit is shut down because of one of the safeties, the control system shall retain in memory the reading and setpoint of each device to help the operator in isolating the reason for the problem. All control system sensors shall have a high and low software alarm limit to indicate temperature problems or a faulty sensor.
         a) Any space temperature is more than five degrees from setpoint as sensed by the terminal boxes DDC box controller for five minutes.
6. CHILLER PLANT CONTROLS
   a. Operator Workstation: Display the following data: Add data requirements in coordination with chiller manufacturers. Provide all required system points (and associated sensors and equipment) to display the following (at a minimum).
      1) Outside air temperature.
      2) Chillers' on-off status.
      3) Compressors' VFD power demand and speed.
      4) Entering chilled-water temperature.
      5) Entering chilled-water temperature set point.
      6) Leaving chilled-water temperature.
      7) Chilled water flow rate through chiller
      8) Chilled-water pressure drop through chiller.
      9) Operating status of primary chilled-water pumps (including drive speed).
      10) Power draw of primary chilled water pumps.
   b. Chiller shall not start until flow is proved by water flow switch wired to chiller control panel. Flow switch shall be furnished and wired by this contractor.
   c. Chilled water primary pumps shall be interlocked with chiller and shall not be energized unless chiller is energized. Standby pump shall run upon failure of any of the above.
   d. The ATC contractor shall install any temperature controls supplied by chiller manufacturer including but not limited to discharge and return chilled water temperature sensors, flow switches, alarm points, etc.
   e. This contractor shall wire from a common alarm contact in the chiller control panel to the FMS to alarm if any chiller alarms are activated.
   f. Safeties

1) The control system shall initiate an alarm, describing the alarm if any of the following conditions are met (all setpoints and time periods below shall be adjustable by user from the FMSs central console). Whenever a unit is shut down because of one of the safeties, the control system shall retain in memory the reading and setpoint of each device to help the operator in isolating the reason for the problem. All control system sensors shall have a high and low software alarm limit to indicate temperature problems or a faulty sensor.
   a) Any alarm from the chiller control panel is initiated.
   b) The chilled water supply or return temperature goes 5 degrees F below or above its setpoint for five minutes.
   c) The chiller is commanded to run and anytime after a fifteen second delay the control system senses no running status via the chiller control panel.
   d) Any pump is commanded to run and anytime after a 15 second delay the control system senses no running status via the pumps current transformer relays (ct).

7. HOT WATER PUMPS AND STEAM CONVERTER SEQUENCES
   a. Hot water temperature sensor in hot water supply line shall modulate 1/3rd- 2/3rd control valves as required to maintain set point.
   b. Start lead pump if the temperature is below 60 F or if there is any call for heat at any air handler control valves or if there is a call for heat at any of the DDC monitoring sensors.
   c. Pumps shall have variable frequency drive to maintain differential pressure in system.
   d. On the failure of one pump the stand-by pump will be started automatically.
   e. A differential pressure by-pass valve will be provided to ensure that the heat exchanger always has required minimum flow.
   f. Pumps shall have lead lag operation to equalize run time of each pump.
   g. Operator Workstation: Display the following data:
      1) System Graphic
      2) Outside temperature.
      3) Heating-water supply temperature.
      4) Heating-water supply temperature set point.
      5) Operating status of primary circulating pumps.
      6) Differential pressure indication
      7) Differential pressure set-point
      8) Pump speed set-point
      9) Pump speed indication
      10) Differential pressure bypass control-valve position.
   h. Safeties/Alarms
      1) The control system shall initiate an alarm, describing the alarm if any of the following conditions are met (all setpoints and time periods below shall be adjustable by user from the FMSs central console). Whenever a unit is shut down because of one of the safeties, the control system shall retain in memory the reading and setpoint of each device to help the operator in isolating the reason for the problem. All control system sensors shall have a high and low software alarm limit to indicate temperature problems or a faulty sensor.
         a) Any pump is commanded to run and anytime after a 15 second delay the control system senses no running status via the pumps current transformer relays (ct).
         b) Temperature of hot water discharge at HX or return to HX varies more than five degrees from set point for more than five minutes.

8. EXHAUST FAN SEQUENCES

a. All fans shall be controlled by the FMS. See the schedules for fan numbers and the areas which they serve.
b. Exhaust fans shall be started and stopped by a time based schedule in the DDC panel.
c. Provide motorized control dampers interlocked to exhaust fans. Dampers shall open when fans are energized.
d. Operator Workstation: Display the following data:
    1) Room/area or System served.
    2) Operating status of fan
    3) Fan failure indication
e. Safeties/Alarms
    1) The control system shall initiate an alarm, describing the alarm if any of the following conditions are met (all setpoints and time periods below shall be adjustable by user from the FMSs central console). Whenever a unit is shut down because of one of the safeties, the control system shall retain in memory the reading and setpoint of each device to help the operator in isolating the reason for the problem. All control system sensors shall have a high and low software alarm limit to indicate temperature problems or a faulty sensor.
        a) Exhaust fans are commanded to run and anytime after a 15 second delay the control system senses no running status via the fans current transformer relays (ct).

9. RADIATION SEQUENCES
    a. Occupied Cycle
        1) DDC thermostats shall modulate the radiation control valve to maintain space temperature at 68 degrees (adj).
    b. Operator Workstation: Display the following data:
        1) Room/area served.
        2) Room temperature.
        3) Room temperature set point.
        4) Control-valve position as percent open.
    c. Safeties/Alarms
        1) The control system shall initiate an alarm, describing the alarm if any of the following conditions are met (all setpoints and time periods below shall be adjustable by user from the FMSs central console). Whenever a unit is shut down because of one of the safeties, the control system shall retain in memory the reading and setpoint of each device to help the operator in isolating the reason for the problem. All control system sensors shall have a high and low software alarm limit to indicate temperature problems or a faulty sensor.
            a) Any space temperature is more than five degrees from setpoint as sensed by the terminal boxes DDC box controller for five minutes.

10. CHEMICAL TREATMENT SYSTEM SEQUENCES
    a. Controls for water treatment system shall be by water treatment system manufacturer. FMS shall start stop and monitor the systems. Provide alarms on equipment failures back to the main building EMS system.
    b. Safeties/Alarms
        1) The control system shall initiate an alarm, describing the alarm if any of the following conditions are met (all setpoints and time periods below shall be adjustable by user from the FMSs central console). Whenever a unit is shut down because of one of the safeties, the control system shall retain in memory the reading and setpoint of each device to help the operator in isolating the reason for the problem. All control system sensors shall have a high and low software alarm limit to indicate temperature problems or a faulty sensor.

a) Any alarm for system control panel.

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. 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 16.

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

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

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

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

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

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 THERMOMETERS AND GAUGES

A. Install one pressure gage per pump, with taps before strainers and on suction and discharge of pump; pipe to gage.

B. GENERAL

1. Install gage taps in piping.
2. Install pressure gages with pulsation dampers. Provide needle valve or ball valve to isolate each gage. Extend nipples and siphons to allow clearance from insulation.
3. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inches for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
4. Install thermometers in air duct systems on flanges.
5. Locate duct mounted thermometers minimum 10 feet downstream of mixing dampers, coils, or other devices causing air turbulence.
6. Coil and conceal excess capillary on remote element instruments.
7. Install static pressure gages to measure across filters and filter banks, (inlet to outlet). On multiple banks, provide manifold and single gage.
8. Provide instruments with scale ranges selected according to service with largest appropriate scale.
9. Install gages and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
10. Adjust gages and thermometers to final angle, clean windows and lenses, and calibrate to zero.

C. SCHEDULES
   1. Pressure Gages.
      a. Pumps.
         1) Location: Install one compound pressure gage per pump, with taps before suction diffuser or strainer and on suction and discharge of pump; pipe to gage with pet cock at each tap. Use pump body taps when available.
         2) Scale range: 0 - 100 psi.
      b. Expansion tanks.
         1) Location: Inlet and Outlet
         2) Scale range: 0 - 100 psi
      c. Chillers.
         1) Location: Chilled Water Inlet and Outlet, Condenser Water Inlet and Outlet
         2) Scale range: 0 - 100 psi
      d. Shot Feeders.
         1) Location: Shot Feeder
         2) Scale range: 0 - 100 psi
      e. Air Handler Coils.
         1) Location: Inlet and Outlet
         2) Scale range: 0 - 100 psi
      f. Make-up Water.
         1) Location: Regulator valve inlet and outlet
         2) Scale range: 0 - 100 psi
      g. Steam pressure reducing stations.
         1) Location: Inlet and outlet
         2) Scale range: To match system pressures
      h. Heat Exchangers.
         1) Location: Steam Inlet, Hot water inlet and Outlet
         2) Scale range: 0 - 100 psi
   2. Stem Type Thermometers:
      a. Chilled water Headers to central equipment.
         1) Location: Inlet and Outlet
         2) Scale range: 0 - 100 F
      b. Hot water Headers to central equipment.
         1) Location: Inlet and Outlet
         2) Scale range: 0 - 212 F
      c. Air Handler Chilled Water Coils

1) Location: Inlet and Outlet
2) Scale range: 0 - 100 F

d. Air Handler Hot Water Coils
1) Location: Inlet and Outlet
2) Scale range: 0 - 212 F

e. Heat Exchangers.
1) Location: Inlet and Outlet
2) Scale range: 0 - 212 F

f. Chillers - Chilled Water Inlet and Outlet, Condenser Water Inlet and Outlet
1) Location: Inlet and Outlet
2) Scale range: 0 - 100 F

3. Test Plug Location:
a. Control valves 3/4 inch & larger - inlets and outlets.
b. Coil - inlets and outlets.
c. Heat exchangers - inlets and outlets.
d. Chiller - inlets and outlets.
e. Reheat coils - inlets and outlets.
f. Cabinet heaters - inlets and outlets.

4. Dial Thermometer Location:
a. Each supply air zone.
b. Each return air zone.
c. Outside air.
d. Return air.
e. Mixed air.

5. Static Pressure and Filter Gages.
a. Built up filter banks.
1) Location: Across Filters
2) Scale range: 0 - 8” W.C.

b. Static pressure controllers
1) Location: At static pressure controller
2) Scale range: 0 - 8” W.C.

c. Packaged unit filter sections.
1) Location: Across Filters
2) Scale range: 0 - 8” W.C.

3.11 INSTALLATION OF PIPE AND PIPE FITTINGS

A. GENERAL

1. Hold piping close to walls, overhead construction, columns and other structural and permanent enclosure elements of building. Limit clearance to 2" where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any. Where possible, locate insulated piping for 1" clearance outside insulation.
2. Install each run with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment.
3. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
4. Anchor piping for proper direction of expansion and contraction.
5. Align piping accurately at connections, within 1/16" misalignment tolerance.
6. ASME Compliance: Comply with ASME B31.9, “Building Services Piping,” for materials, products, and installation.
7. Fire and/or Smoke Barrier Penetrations: Maintain indicated fire/smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

8. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
9. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
10. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
11. Install piping at indicated slopes.
12. Install piping free of sags and bends.
13. Install fittings for changes in direction and branch connections.
14. Install escutcheons for penetrations of walls, ceilings, and floors.

B. THREADED JOINTS: Thread pipe in accordance with ANSI B2.1; cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint compound, or pipe joint tape (Teflon) on male threads at each joint and tighten joint to leave not less than 3 threads exposed.

C. SOLDERED JOINTS: Solder copper tube and fitting joints where indicated, in accordance with recognized industry practice. Cut tube ends squarely, ream to full diameter, and clean outside of tube ends and inside of fittings. Apply solder flux to joint areas of both tubes and fittings. Insert tube full depth into fitting, and solder in manner which will draw solder full depth and circumference of joint. Wipe excess solder from joint before it hardens.

D. WELDED JOINTS: Weld joints in accordance with recognized industry standards as follows:
1. Weld only when ambient temperature is above 0 deg. F.
2. Bevel pipe ends at a 37.5 deg. angle where possible, smooth rough cuts, and clean to remove slag, metal particles and dirt.
3. Use pipe clamps or tack weld joints with 1" long welds; 4 welds for pipe sizes to 10", 8 welds for pipe sizes 12" to 20".
4. Build up welds with stringer bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedure which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes and nonmetallic inclusions.
5. Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, “Welding and Brazing Qualifications.”

E. FLANGED JOINTS: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

F. CLEANING, FLUSHING, INSPECTING
1. Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coating (if any). Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items.

G. PIPING TESTS
1. Test pressure piping in accordance with ASME B 31.
2. Fill system with water. Provide temporary equipment for testing, including pump and gages. Test piping systems before insulation is installed and remove control devices before testing. Test each natural section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating.
3. Required test period is 2 hours.
4. Test each piping system at 150% of operating pressure indicated, but not less than 25 psi test pressure.

5. Observe each test section for leakage at end of test period. Test fails if leakage is observed or if pressure drops exceeds 5% of test pressure.
6. Repair piping systems sections that fail required test, by disassembly and reinstallation, using new materials to the extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.
7. Drain test water from systems after testing and repair work has been completed.

3.12 INSTALLATION OF VALVES

A. Locate valves so as to be accessible and so that separate support can be provided when necessary.

B. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane unless unavoidable. Install valve drains with hose-end adapter for each valve that must be installed with stem below horizontal plane.

C. Where insulation is indicated, install extended stem valves, arranged to receive insulation.

D. Mechanical Actuators: Install mechanical actuators with chain operators where indicated. Extend chains to about 5' above floor and hook to clips to clear aisle passage.

E. Install swing check valves in horizontal position with hinge pin horizontally perpendicular to center line of pipe.

F. Install wafer check valves between 2 flanges in horizontal or vertical position.

G. Install lift check valves in piping line with stem vertically upward.

H. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks, replace valve if leak persists.

I. Cleaning: Clean factory finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.13 INSTALLATION OF PIPING SPECIALTIES

A. PIPE ESCUTCHEONS: Install on each pipe penetration through floors, walls partitions and ceilings where penetration is exposed to view.

B. Y-TYPE STRAINERS: Install full size of pipe line, install pipe nipple and blow-down valve except for strainers 2" and smaller ahead of control valves feeding individual terminals.

C. DIELECTRIC UNIONS: Install at each piping joint between ferrous and non-ferrous piping.

D. MECHANICAL SLEEVE SEALS: Loosely assembly rubber links around pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form watertight seal.

E. FIRE BARRIER PENETRATION SEALS: Fill entire opening with sealing compound.

F. PIPE SLEEVES: Install of type indicated where piping passes through walls, floors, ceilings, and roofs. Install sleeves accurately centered on pipe runs. Size sleeves so that piping and insulation (if any) will have free movement. Install length of sleeve equal to thickness of construction penetrated, and finish flush to surface; except for floor sleeves. Extend floor sleeves 1/4" above level finish floor or as indicated.
1. Install sheetmetal sleeves at interior partitions and ceilings other than suspended ceilings.
2. Install steel pipe iron pipe sleeves at exterior penetrations; both above and below grade.
3. Install steel or plastic sleeves except as otherwise indicated.

G. SLEEVES SEALS
1. Lead and Oakum: Fill and pack annular space between sleeve and pipe with oakum, caulk with lead on both sides.

3.14 INSTALLATION OF HANGERS AND SUPPORTS

A. INSERTS
1. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
2. Where concrete forms finished ceiling, provide inserts to be flush with slab surface.
3. Where inserts are omitted, drill through from below and provide through bolts with recessed steel plate and nut flush with slab.

B. PIPE HANGERS AND SUPPORTS
1. Support horizontal piping as follows:

	PIPE SIZE	MAX. SPACING	ROD DIA.
a.			
b.	2 to 1-1/4"	6'-6"	3/8"
c.	1-1/2 to 2"	10'-0"	3/8"
d.	2-1/2 to 3"	10'-0"	2"
e.	4 to 6"	10'-0"	5/8"

2. Install hangers to provide minimum 2 inch space between finished covering and adjacent work.
3. Place hanger within 12 inches of each horizontal elbow.
4. Support vertical piping at every floor.
5. Where several pipes can be installed in parallel and at same elevation, provide trapeze or multiple hangers.

3.15 INSTALLATION OF PIPE INSULATION

A. GENERAL
1. Install materials after piping has been tested and approved.
2. Install materials in accordance with manufacturer's instructions.
3. Continue insulation with vapor barrier through penetrations.
4. On insulated piping systems with vapor barrier, insulate fittings, valves, unions, flanges, strainers, PT plugs, drains, flexible connections and expansion joints. All cold piping surfaces shall be insulated. Balancing valves and PT plugs shall have insulation which is removable and reattachable.
5. On insulated piping systems without vapor barriers and piping conveying fluids 140 deg. F. or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation at such locations.
6. Provide an insert, not less than 6 inches long, of same thickness and contour as adjoining insulation, between support shield and piping, but under the finish jacket, on piping 2 inch diameter and larger, to prevent insulation from sagging at support points.

Inserts shall be cork or other heavy density insulating material suitable for the planned temperature range. Factory fabricated inserts may be used.

7. Neatly finish insulation at supports, protrusions, and interruptions.
8. Exterior Applications: Provide indicated jacket with seams located on the bottom of horizontal piping. Insulate fitting, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement.
9. INSULATION OMITTED: Omit insulation on hot piping within radiation enclosures or unit cabinets; on cold piping within unit cabinets providing piping is located over drain pan; on condensate piping between steam trap and union; and on unions, flanges, strainers flexible connections, and expansion joints.

B. PIPE INSULATION APPLICATION

1. Insulate the following piping systems with the type and thickness of insulation indicated as follows:
   1) F.G.=FIBERGLASS

PIPING SYSTEM	INSUL TYPE	RUNOUT TO 2”	1” AND LESS	1.25” TO 2”	2.5” TO 4”	5” TO 6”	8” AND LARGER
HOT/CH WATER SUP/RET	F.G	1.0	1.5	1.5	1.5	1.5	1.5
LP STEAM	F.G.	1.0	1.5	2.0	2.0	2.0	2.0
MP STEAM	F.G.	1.5	1.5	2.5	3.0	3.0	3.0
STEAM CONDENSATE	F.G.	1.0	1.0	1.0	1.5	1.5	2.0
MAKEUP WATER	F.G.	0.5	0.5	1.0	1.0	1.0	1.0
REFRIGERANT SUCTION	F.G.	0.5	0.5	0.5	0.5	0.5	0.5
REFRIGERANT HOT GAS	F.G.	0.5	0.5	0.5	0.5	0.5	0.5

C. INDOOR, PIPE INSULATION JACKET APPLICATION

1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. Piping, Concealed:
   a. None.
3. Piping, Exposed:
   a. PVC, Color-Coded by System.

D. OUTDOOR, PIPE INSULATION APPLICATION

1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. Piping, Exposed:
   a. Aluminum

3.16 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.

C. APPLICATION

1. EQUIPMENT NAMEPLATES: Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:
   a. Pumps, compressors, chillers, condensers, and similar motor-driven units.
   b. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
   c. Fans, blowers, primary balancing dampers, and mixing boxes.
   d. Packaged HVAC central-station and zone-type units.
   e. Control components
2. EQUIPMENT MARKERS: Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.
   a. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   b. Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
   c. Include markers for the following general categories of equipment:
      1) Meters, gages, thermometers, and similar units.
      2) Pumps, compressors, chillers, condensers, and similar motor-driven units.
      3) Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
3. EQUIPMENT SIGNS: Install equipment signs with screws or permanent adhesive on or near each major item of mechanical equipment. Locate signs where accessible and visible.
   a. Identify mechanical equipment with equipment markers in the following color codes:
   b. Green: For cooling equipment and components.
   c. Yellow: For heating equipment and components.
   d. Green and Yellow: For combination cooling and heating equipment and components.
   e. Brown: For energy-reclamation equipment and components.
   f. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   g. Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
   h. Include signs for the following general categories of equipment:
      1) Pumps, compressors, chillers, condensers, and similar motor-driven units.
      2) Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
      3) Fans, blowers, primary balancing dampers, filters, mixing boxes.
      4) Packaged HVAC central-station and zone-type units.
      5) Tanks and pressure vessels.
      6) Strainers, filters, humidifiers, water-treatment systems, and similar equipment.
      7) Control Components

4. WARNING-TAG INSTALLATION: Print required message on, and attach warning tags to, equipment and other items where required.
5. ACCESS PANELS: Identify all access doors and panels.
6. VALVES: Identify valves, except valves within heating or cooling terminals, with metal tags.
7. VALVE CHART AND SCHEDULE: Provide valve chart and schedule in aluminum frame with clear plastic shield. Install at location as directed.
8. CONCEALED EQUIPMENT LOCATION INDICATORS: Provide markings for all concealed equipment and systems requiring routine maintenance to indicate location of access. Equipment to be indicated includes but is not limited to terminal boxes, terminal equipment, reheat coils, filters, control dampers, etc. Coordinate marking system methods and products with Owner and Architect.

D. Locate Piping identification and flow arrows as follows:
1. Identify piping, concealed or exposed, with plastic pipe markers. Identify service and flow direction. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and "T", at each side of penetration of structure or enclosure, and at each obstruction.
2. On vertical pipes approximately seven feet above floor.
3. Behind each access door and panel.
4. At each change of direction of piping.
5. On each piping branch close to point of connection to main piping.
6. At valves.
7. At no greater than intervals of 50 feet on straight runs of piping, and on both sides of walls.

E. Locate Ductwork identification and flow arrows as follows:
1. 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.
2. On vertical ductwork approximately seven feet above floor.
3. Behind each access door and panel.
4. At each change of direction of ductwork.
5. On each ductwork branch close to point of connection to main ductwork.
6. At no greater than intervals of 25 feet on straight runs of ductwork, and on both sides of walls.

F. Do color coding of pipes with two (2) inch wide bands according to color schedule to be issued by the Owner during the progress of the work.

G. Labeling on all exposed piping in finished spaces shall be on top of the piping out of line of sight.

H. Labeling on all exposed ductwork in finished spaces shall be on top of the ductwork out of line of sight.

I. Identify all pumps, controls, remote switches, starters, disconnects, pushbuttons and similar equipment as to service with white lamacoid engraved name-plates with black letters. Firmly secure with self-tapping screws. Submit sample plates and lettering for review.

J. Identify all fans (including air handler systems) with a label which shall be dated and be a minimum of 6” x 4”. The label shall be made of (minimum) heavy-duty plastic laminate securely attached to the air handling devices. Submit a sample and a list of all equipment tags to be provided complete with all information included within the tag to Engineer for (shop drawing) approval. The label shall be provided with the following information:

1. Tag number.
2. Design airflows (CFM).
3. Design external static pressures (in. H_20).
4. Motor horsepowers.
5. Areas served by unit.

K. Install valve tags at each valve. Attach to valves with four (4) inch brass chains.

3.17 INSTALLATION OF DUCTWORK INSULATION

A. GENERAL
1. Install materials after ductwork has been 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: Seal jacket joints with vapor barrier tape to match jacket. Staple seams 6" O.C. with outward cinching staples, then seal with pressure sensitive tape matching jacket. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier tape. Stop and point insulation

around access doors and damper operators to allow operation without disturbing wrapping.

2. RIGID FIBERGLASS: Secure insulation to ductwork using mechanical fasteners with pin spacing no greater than 12 inch on center. 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. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping. Duct Liner Not acceptable on Healthcare Projects. Duct Liner is not F&T standard delete unless specifically used on the project.

C. APPLICATION

1. Insulate all exposed fresh air intake, and hot and/or cold supply air ducts within finished spaces with 2 inch thick rigid fiberglass ductwork insulation or other such thickness that the installed R value accounting for compression is minimum R5. Cover with PVC jacket for field painting.
2. Insulate all concealed fresh air intake, and concealed hot and/or cold supply air ducts with 2 inch thick Flexible Fiberglass ductwork insulation or other such thickness that the installed R value accounting for compression is minimum R5.
3. Insulate all exposed exhaust air ductwork within 10 feet of exterior opening with 1 inch thick Rigid Fiberglass ductwork insulation. All rectangular exposed ductwork is to be covered by an aluminum jacket. All round exposed ductwork is to be covered by PVC jacket.
4. Insulate supply and return ductwork located out of doors with 2" rigid fiberglass insulation. Cover insulation with a Exterior Rubber Jacket System. Jacket system shall be installed using manufacturers adhesives and in strict accordance with manufacturer’s instructions.

3.18 INSTALLATION OF EQUIPMENT INSULATION

A. GENERAL

1. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of equipment.
2. Do not insulate factory insulated equipment.
3. Apply insulation as close as possible to equipment by grooving, scoring, beveling insulation, if necessary. Secure insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
4. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.
5. Cover Rigid Fiberglass and Calcium Silicate insulation with metal mesh finish and finish with heavy coat of insulating cement.
6. Do not insulate over nameplates or testing agency labels and stamps. Bevel and seal insulation around such.
7. When equipment with insulation requires periodical opening for maintenance, repair, or cleaning, install insulation in such a manner that it can be easily removed and replaced without damage.
8. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either the wet or dry state.
9. Apply multiple layers of insulation with longitudinal and end seams staggered.
10. Keep insulation materials dry during application and finishing.
11. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
12. Apply insulation with the least number of joints practical.

13. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
14. 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.
15. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
16. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.
17. Install vapor-retarder mastic on equipment scheduled to receive vapor retarders. Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.

B. APPLICATION
1. Insulate the following equipment:
2. Insulate heat exchangers with 2" thick Rigid Fiberglass equipment insulation.
3. Insulate chilled water pump bodies with 1" thick Rubber Sheet equipment insulation.
4. Insulate Chilled-water compression and buffer tanks with 2" thick Rigid Fiberglass equipment insulation. Jacket all exterior systems.
5. Insulate air separators with 2" thick Rigid Fiberglass equipment insulation. Jacket all exterior systems.
6. Insulate steam flash tanks with 2" thick Rigid Fiberglass equipment insulation.

C. Omit insulation from the following:
1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.19 INSTALLATION OF DUCTWORK

A. GENERAL
1. Align ductwork accurately at connections, within 1/8 inch misalignment tolerance and internal surfaces smooth.
2. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true to shape and to prevent buckling.
3. Limit clearance to 2 inch where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.
4. Locate insulated ductwork for 1 inch clearance outside of insulation.
5. Coordinate layout with suspended ceiling and lighting layouts and similar finish work.
6. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.
7. Fire-Rated Partition Penetrations: Where ducts pass through walls, partitions, ceilings and floors, install appropriately rated fire dampers, sleeves, and fire-stopping materials.
8. Smoke Barrier Penetrations: Where ducts pass through walls, partitions, ceilings and floors, install appropriately rated smoke dampers, sleeves, and fire-stopping materials.

9. Maintain indicated fire/smoke rating of walls, partitions, ceilings, and floors at duct penetrations. Seal with fire-stop materials.
10. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
11. Coordinate duct installation with installation of accessories, dampers, coils frames, equipment, controls and other associated work of the ductwork system.
12. Install in the ductwork system control dampers furnished by the Automatic Temperature Control Contractor, assemble such multiple section dampers and provide required blank off plates where dampers are smaller than the duct.
13. Provide openings in ductwork where required to accommodate thermometers, sensors, and controllers. Provide pilot tube openings where required for testing of systems.
14. Set plenum doors 6 to 12 inches above floor. Arrange door swing so that fan static pressure holds door in closed position.
15. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork.
16. Where allowed Install flexible supply ductwork so that full cross sectional area is maintained, take care not to crush collapse or crimp duct.
17. Flexible ductwork not allowed on return or exhaust air systems.
18. Install double wall insulated flexible ductwork so that full cross sectional area is maintained, take care not to crush, collapse or crimp duct.

B. CLASS 2 DUCTWORK
1. Assemble and install to achieve maximum leakage rate of 5 percent.
2. Seal ductwork, after installation, to seal class recommended, and method prescribed in SMACNA "Duct Standards".
3. Support ductwork in manner complying with SMACNA "Duct Standards", hanger and support section.
4. Connect register, grilles and diffusers or troffers (where connection is concealed) to ducts with 5 foot maximum length of flexible or insulated flexible duct as required by the application. Hold in place with strap or clamp. Connect to air terminal with 22 gauge draw bands.

C. CLASS 3, 4, AND 6 DUCTWORK
1. Assemble and install to achieve maximum leakage rate of 1 percent.
2. Seal ductwork, after installation, to seal class recommended, and method prescribed in SMACNA "Duct Standards".
3. Support ductwork in manner complying with SMACNA "Duct Standards", hanger and support section.
4. Connect Variable Air Volume Terminal inlets with 2 foot maximum length of double wall flexible insulated duct if required by the application. Hold in place with strap or clamp. Attach to duct and variable air volume air terminal inlet with 22 gauge metal draw band and sheet metal screws.
5. Provide duct leak testing.

D. LEAK TESTING
1. Perform tests and inspections.
2. Leakage Tests:
3. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual."
4. Test all Class 3, 4, 6 and 10 supply, return, and exhaust systems.
5. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
6. Test for leaks before insulation application.
7. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum

system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.

E. CLEANING
1. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances.
2. Duct System Cleanliness Tests:
   a. Visually inspect duct system to ensure that no visible contaminants are present.
   b. Test sections of metal duct system, chosen randomly by Owner/Engineer, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
      1) Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
3. Duct system will be considered defective if it does not pass tests and inspections. Clean entire system
4. Prepare test and inspection reports.

F. DUCTWORK APPLICATION SCHEDULE

	System	Class	Material
1.	Supply from fan to VAV terminal	6	Steel
2.	Supply from VAV terminal/Duct Coil to Diffusers	2	Steel
3.	Return & Relief – VAV systems	3	Steel
4.	General Exhaust	2	Steel

3.20 INSTALLATION OF DUCTWORK ACCESSORIES

A. Install accessories in accordance with manufacturer's instructions and as indicated.

B. Fire Dampers, Smoke Dampers and combination fire/smoke dampers
1. Install fire dampers, smoke dampers and combination fire/smoke dampers with required with perimeter mounting angles, sleeves, and breakaway duct connections. Install dampers in accordance with manufacturer's UL Installation Instructions, labeling, and NFPA 90A at locations indicated on the drawings. Any damper installation that is not in accordance with the manufacturer's UL Installation Instructions must be approved prior to installation.
2. Dampers must be accessible to allow inspection, adjustment, and replacement of components. Provide duct access doors in ductwork or plenums required to provide this access. Provide access doors required in walls, ceilings, or other general building construction.
3. Install dampers square and free from racking. Do not compress or stretch the damper frame into the duct or opening. Handle dampers using the frame or sleeve. Do not lift or move dampers using blades, actuator or jackshaft.
4. Fire Damper Application:
   a. Provide Curtain type Dynamic fire dampers on any system part of a smoke evacuation system with velocities less than or equal to 2000 fpm.
   b. Provide Multi-blade type Dynamic fire dampers on any system part of a smoke evacuation system with velocities greater than 2000 fpm.
   c. Provide Static Curtain type fire dampers on all systems that are not part of the smoke evacuation system.

C. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment. Cover connections to medium and high pressure fans with leaded vinyl sheet, held in place with metal straps.

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

3.21 INSTALLATION OF HYDRONIC PIPING SYSTEMS

A. GENERAL: Unless otherwise indicated install hydronic piping as follows:
1. Install eccentric reducers where pipe is reduced in size in direction of flow, with tops of both pipes and reducer flush.
2. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
3. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.
4. Install drains, consisting of a tee fitting, NPS ¾ ball valve, and short NPS 3/4threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
5. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
6. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4nipple and ball valve in blow-down connection of strainers NPS 2and larger. Match size of strainer blow-off connection for strainers smaller than NPS 2.
7. Install manual air vents at the system high points to allow bleeding off air.

B. VALVES: Unless otherwise indicated install valves as listed below and elsewhere as indicated.
1. Isolation: ball and butterfly valves.
2. Throttling: ball and butterfly valves
3. Combination balancing and shut-off: Refer to “HYDRONIC SPECIALTIES” elsewhere in these specifications.
4. Provide isolation valves at each hydronic terminal, coil and equipment and elsewhere as indicated.
5. Provide combination balancing and shut-off valves at each hydronic terminal, coil and equipment and elsewhere as indicated.
6. Provide balance cock at the by-pass port of each 3-way control.
7. Provide drain valves on each mechanical equipment item located to completely drain equipment; at base of each isolated riser and elsewhere as indicated or required to completely drain hydronic piping system.

C. EQUIPMENT CONNECTIONS:
1. Connect hydronic terminal, coil and equipment to the hydronic piping system in accordance to equipment manufacturer's instructions. Installation shall allow easy repair, cleaning, removal and replacement of hydronic terminal, coil and equipment.
2. Size for supply and return piping connections shall be same as for equipment connections.
3. Install control valves in accessible locations close to connected equipment.
4. For control valve 1 1/4” and greater install bypass piping with globe valve around control valve. If multiple, parallel control valves are installed, only one bypass is required.
5. Install ports for pressure and temperature gages at terminal, coil and equipment inlet and outlet connections.

D. CHEMICAL TREATMENT:
1. After cleaning and flushing, refill hydronic piping system, adding caustic soda to maintain pH of 8.0 to 8.5 and sodium sulfate in amount of 1/3 caustic soda or to maintain residual of 30 to 40 PPM in system. Add trisodium phosphate to make hardness of 0 PPM and residual of approximately 30 PPM in system. Repeat measurements daily with system

under full circulation and apply chemicals to adjust levels until no apparent change is apparent.

3.22 INSTALLATION OF HYDRONIC SPECIALTIES

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

B. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

C. Install only automatic air vents in mechanical equipment rooms only. Install at high points of system piping, at heat-transfer equipment and coils, and elsewhere as required for system air venting. Provide vent tubing to nearest drain. Where large air quantities can accumulate, provide enlarged air collection standpipes.

D. Install in-line air separators in pump suction lines. Install piping to compression tank with a 2 percent upward slope toward tank. Install drain valve on units NPS 2 and larger.

E. Install bypass chemical shot feeders in each hydronic system, in upright position with top of funnel not more than 36 inches above floor. Install feeder in bypass line, off main, using globe valves on each side of feeder and in the main between bypass connections. Pipe drain, with ball valve, to nearest equipment drain.

F. Install diaphragm-type compression tanks on floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system design requirements.

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

H. Remove temporary strainers after cleaning systems.

I. Support pump fittings with floor mounted pipe and flange supports.

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

K. Pipe relief valve outlet to nearest floor drain.

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

3.23 INSTALLATION OF STEAM AND CONDENSATE SYSTEMS

A. GENERAL: Unless otherwise indicated install steam and condensate piping as follows:
   1. Install steam and condensate piping with 1/4" per 10 foot downward slope in the direction of flow.
   2. Install branch piping and riser offsets with 1/8" per foot downward slope in the direction of condensate flow.
   3. Install branch and run-outs at top of main, either in the vertical or at 45 deg. from the vertical and perpendicular to main.
   4. Install run-out piping to terminals with 1/4" per foot downward slope in direction of condensate return.
   5. Install eccentric reducers where pipe is reduced in size, with bottoms of both pipes and reducer flush. Locate reducers 18" min. distance from branch connection.

6. Install condensate riser drips on all steam piping risers.
7. Provide end of main drip at the end of each steam run.

B. VALVES: Unless otherwise indicated install valves as listed below and elsewhere as indicated.
1. Provide isolation valves at each steam terminal each piece of mechanical equipment and elsewhere as indicated.
2. Provide drain valves on each mechanical equipment item located to completely drain equipment; at base of each isolated riser and elsewhere as indicated or required to completely drain steam and condensate piping system.

C. EQUIPMENT CONNECTIONS: Connect steam and condensate equipment to piping system in accordance to equipment manufacturer's instructions.

D. LEAK TESTS
1. Prepare steam and condensate piping according to ASME B31.9, "Building Services Piping" and as follows
   a. Leave joints, including welds, uninsulated and exposed for examination during test.
   b. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
   c. Flush system with clean water. Clean strainers.
   d. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
2. Perform the following tests on steam and condensate piping:
   a. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
   b. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
   c. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components and repeat hydrostatic test until there are no leaks.
3. Prepare written report of testing.

3.24 INSTALLATION OF REFRIGERANT PIPING SYSTEMS

A. GENERAL
1. Size refrigerant pipe and install valves and accessories as required and/or recommended by refrigerant equipment manufacturer.
2. Install refrigerant piping, valves and equipment per the refrigerant equipment manufacturer's requirements.
3. Connect refrigerant equipment to piping system in accordance to equipment manufacture's requirements.
4. Size refrigerant pipe and install valves and accessories as required and/or recommended by refrigerant equipment manufacturer.

B. PIPING

1. Install refrigerant piping with 1/16" per foot downward slope in direction of oil return to the compressor. Provide oil traps and double risers where indicated, and where required to provide oil return

C. VALVES AND SPECIALTIES
1. Install refrigerant valves and specialties in accordance with manufacturer's instructions.

D. LEAK TESTS
1. Prior to initial operation perform leak test on piping system. Perform initial test with dry nitrogen, using soap solution to test all joints. Perform final test with 27" vacuum, and then 200 psi using halide torch. System must be entirely leak-free.

E. DEHYDRATION AND CHARGING
1. Install core in filter drier after leak test but before evacuation.
2. Evacuate with vacuum pump, until temperature of 35 deg. F. is indicated on vacuum dehydration indicator.
3. During evacuation, apply heat to pockets, elbows, and low spots in piping.
4. Maintain vacuum for 5 hours after closing valve between vacuum pump and system.
5. Break vacuum with refrigerant gas, allow pressure to build up to 2 psi.
6. Complete charging system, using new filter drier core in charging line. Provide full operating charge.

3.25 INSTALLATION OF ROOF FANS

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

B. Furnish roof curbs to roofing installer or general contractor for installation. Provide locations of penetrations to installer.

C. Secure with corrosion resistant lag screws to roof mounting curbs

3.26 INSTALLATION OF RADIANT HEATING PANELS

A. The mechanical contractor shall cooperate with other trades working in the ceiling area to achieve a neat and well coordinated installation.

B. All support molding shall be the responsibility of Division 9 unless specialized application is required. All wall moldings shall be mitred with cross tees installed flush. Perimeter molding to be extruded aluminum - minimum 25 gauge. Ensure ceiling openings and wall moldings are installed as per radiant panel shop drawings.

C. Radiant panels installed in psychiatric patient areas shall be secured to ceiling using backing angles and tamperproof hardware.

D. Installed Manufacturer supplied fluted inter-connectors to connect panels installed in series. Soft copper or pigtail type connectors are not be acceptable.

E. Connection to supply, return piping with 16 mm (5/8") O.D. soft copper.

F. System piping shall be thoroughly cleaned and flushed before connecting to radiant panels.

G. Wire employed to suspend the radiant ceiling panel from the existing structure. The standard material is 2.64 mm (12 gauge) galvanized, soft annealed steel wire, conforming to ASTM A

641M or A 641. Vertical suspension of 1 (one) wire per cross-brace for panels of a width equal to or less than 600mm (24”). Panels over 600mm (24”) require a minimum of 2 wire hangers per cross-brace. Minimum of 2 wire hangers per panel. Wire hangers are to be suspended to a maximum of 1200mm (4’) on centre. Refer to VIBRATION ISOLATION AND SEISMIC RESTRAINT paragraph of these specifications for additional requirements.

3.27 INSTALLATION OF PUMPS

A. Install in accordance with manufacturer's instructions.

B. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches and over

D. Provide line sized shut-off valve and strainer pump suction fitting on pump suction, and line sized soft seat check valve and balancing valve or combination pump discharge valve] on pump discharge.

E. Provide air cock and drain connection on horizontal pump casings.

F. Provide drains for bases and seals, piped to and discharging into floor drains.

G. Check, align, and certify alignment of base mounted pumps prior to start-up.

H. Install base mounted pumps on concrete housekeeping base, with anchor bolts, set and level, and grout in place. Refer to CONCRETE portions of these specifications.

I. Lubricate pumps before start-up.

J. Provide Type FC-1 flexible connectors.

3.28 INSTALLATION OF CHILLERS

A. Install in accordance with manufacturer's instructions.

B. Provide for connection to electrical service. Refer to DIVISION 26 – ELECTRICAL.

C. Provide for connection of electrical wiring between starter and chiller control panel, oil pump, and purge unit. Refer to DIVISION 26 – ELECTRICAL.

D. Align chiller on concrete foundations, sole plates, and sub-bases. Level, grout, and bolt in place.

E. Install units on vibration isolation. Refer to VIBRATION ISOLATION AND SEISMIC RESTRAINT paragraph of these specifications.

F. Provide evaporator connections to chilled water piping.
   1. On inlet, provide:

a. Thermometer well for temperature controller.
b. Thermometer well and thermometer.
c. Strainer.
d. Nipple and flow switch.
e. Flexible pipe connector.
f. Pressure gage.
g. Shut-off valve.

2. On outlet, provide:
a. Thermometer well and thermometer.
b. Flexible pipe connector.
c. Pressure gage.
d. Shut-off and Balancing valve.

G. Furnish and install necessary auxiliary water piping for oil cooling units and purge condensers.

H. Insulate evaporator and cold surfaces.

I. Provide condenser connection to condenser water piping.
1. On inlet, provide:
a. Thermometer well for temperature controller.
b. Thermometer well and thermometer.
c. Strainer.
d. Nipple and flow switch.
e. Flexible pipe connector.
f. Pressure gage.
g. Shut-off valve.

2. On outlet, provide:
a. Thermometer well and thermometer.
b. Flexible pipe connector.
c. Pressure gage.
d. Shut-off and Balancing valve.

J. Arrange piping for easy dismantling to permit tube cleaning.

K. Provide piping from chiller rupture disc to outdoors. Size as recommended by manufacturer.

L. Manufacturer's Field Services
1. Prepare and start systems.
2. Provide services of factory trained representative for minimum one day to leak test, refrigerant pressure test, evacuate, dehydrate, charge, start-up, calibrate controls, and instruct Owner on operation and maintenance.
3. Supply initial charge of refrigerant and oil.

3.29 INSTALLATION OF HUMIDIFIERS

A. Install in accordance with manufacturer's instructions.

B. Install to ARI 630.

3.30 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.

3.31 INSTALLATION OF VARIABLE SPEED DRIVES

A. Install in accordance with NEMA ICS 3.1.

B. Tighten accessible connections and mechanical fasteners after placing controller.

C. Provide fuses in fusible switches; refer to DIVISION 16 – ELECTRICAL for product requirements.

D. Select and install overload heater elements in motor controllers to match installed motor characteristics.

E. Provide engraved plastic nameplates

F. Neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place in clear plastic holder.

G. Prepare and start systems.

H. Make final adjustments to installed controller to assure proper operation of load system. Obtain performance requirements from installer of driven loads.

I. Manufacturer's Field Services
   1. Prepare, calibrate and start systems.

2. Start-up Variable Frequency Drive in presence of and instruct Owners operating personnel.

3.32 INSTALLATION OF REGISTERS, GRILLES AND DIFFUSERS

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated on architectural ceiling grids, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

D. Adjusting: After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

E. Install safety chains on all diffusers, registers, and grilles install more than 15’ above the floor. Refer to VIBRATION ISOLATION AND SEISMIC RESTRAINT paragraph of these specifications for additional requirements.

3.33 INSTALLATION OF VARIABLE AIR VOLUME TERMINAL BOXES

A. Install in accordance with manufacturer's instructions.

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

C. Support units individually from structure. Do not support from adjacent ductwork.

D. Connect to ductwork.

E. Install heating coils.

3.34 WATER TREATMENT INITIALIZATION

A. PREPARATION
1. Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.
2. Place terminal control valves in open position during cleaning.
3. Verify that electric power is available and of the correct characteristics.

B. CLEANING SEQUENCE
1. Concentration:
   a. As recommended by manufacturer.
   b. One pound per 100 gallons of water contained in the system.
   c. One pound per 100 gallons of water for hot systems and one pound per 50 gallons of water for cold systems.
2. Hot Water Heating Systems:

a. Apply heat while circulating, slowly raising temperature to 160 degrees F and maintain for 12 hours minimum.
b. Remove heat and circulate to 100 degrees F or less; drain systems as quickly as possible and refill with clean water.
c. Circulate for 6 hours at design temperatures, then drain.
d. Refill with clean water and repeat until system cleaner is removed.

3. Chilled Water Systems:
   a. Circulate for 48 hours, then drain systems as quickly as possible.
   b. Refill with clean water, circulate for 24 hours, then drain.
   c. Refill with clean water and repeat until system cleaner is removed.
4. Use neutralizer agents on recommendation of system cleaner supplier and approval of Architect/Engineer.
5. Flush open systems with clean water for one hour minimum. Drain completely and refill.
6. Remove, clean, and replace strainer screens.
7. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

C. INSTALLATION
1. Install in accordance with manufacturer's instructions.

D. CLOSED SYSTEM TREATMENT
1. Provide one bypass feeder on each system. Install isolating and drain valves and necessary piping. Install around balancing valve downstream of circulating pumps unless indicated otherwise.
2. Introduce closed system treatment through bypass feeder when required or indicated by test.
3. Provide 3/4 inch water coupon rack around circulating pumps with space for 12 test specimens.

E. Extra Materials: Furnish sufficient chemicals for initial system start-up and for preventative maintenance for one year from date of substantial completion.

F. Manufacturer's Field Services
1. Prepare, calibrate and start systems.
2. Start-up system in presence of and instruct Owners operating personnel.
3. Retest System at the completion of 1 year period. Submit test report.

3.35 INSTALLATION OF PIPE EXPANSION FITTINGS AND LOOPS

A. Install in accordance with manufacturer's instructions.

B. Construct spool pieces to exact size of flexible connection for future insertion.

C. Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Provide line size flexible connectors.

D. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.

E. Rigidly anchor pipe to building structure where necessary. Provide pipe guides so movement is directed along axis of pipe only. Erect piping such that strain and weight is not on cast connections or apparatus.

F. Provide support and equipment required to control expansion and contraction of piping. Provide loops, pipe offsets, and swing joints, or expansion joints where required or indicated.

G. Provide expansion loops as indicated on drawings.

H. EXPANSION-JOINT INSTALLATION
1. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
2. Install expansion joints of sizes matching size of piping in which they are installed.
3. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

I. PIPE BEND AND LOOP INSTALLATION
1. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
2. Attach pipe bends and loops to anchors.
   a. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   b. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

J. SWING CONNECTIONS
1. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.
2. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.
3. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

K. ALIGNMENT-GUIDE INSTALLATION
1. Install guides on piping adjoining pipe expansion joints and bends and loops.
2. Coordinate below with structural Sections and Drawings if welding is included in structural work.
3. Attach guides to pipe and secure to building structure.

L. ANCHOR INSTALLATION
1. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
2. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.
3. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.
4. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints or compensators are indicated.
5. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

3.36 INSTALLATION OF VIBRATION ISOLATION AND SEISMIC RESTRAINT

A. GENERAL
1. Isolation 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 and vacuum 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.

2. Exclusions from seismic requirements on non life safety equipment:
   a. Curb mounted mushroom, exhaust and vent fans with curb area less than nine square feet are excluded unless specifically detailed in the schedules or drawings.
   b. Duct exemptions
      1) Rectangular, Square and Oval ducts less than six square feet in cross sectional area.
      2) Round duct less than 33 inches in diameter.
      3) Individual ducts suspended by hangers positively attached to the structure that are less than 12 inches in length as measured to top of the duct to the point of attachment to the structure. Hangers must be attached within 2 inches of the top of the duct with a minimum of two #10 sheet metal screws. If any hanger in the run exceeds the 12” limit, seismic bracing is required for the run.
   c. Piping exemptions
      1) All piping less than 2-1/2" diameter except in mechanical rooms where piping less than 1-1/4" is exempted.
      2) All clevis or single level trapeze supported piping suspended by hangers with positive attachment to the structure that are less than 12 inches in length as measured from the top of the pipe to the point of attachment to the structure. If any hanger in the run exceeds the 12” limit, seismic bracing is required for the run.
3. Exclusions from seismic requirements on life safety equipment.
   a. Duct exemptions
      1) Smoke evacuation duct or fresh air make-up air that has a cross sectional area less than 3 square feet.

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**
AIR HANDLING UNITS AIR CONDITIONING UNITS CABINET TYPE FANS HEAT RECOVERY UNITS		TO 10 H.P.	FLOOR	D	0.3	(1)	B	0.75	(1)	- -	- -	- -
			CEILING	- -	- -	- -	F			- -	- -	- -
		OVER 10 H.P.	FLOOR	D	0.3	(1)	B	(2)		- -	- -	- -
			CEILING	- -	- -	(1)	F	(2)		- -	- -	- -
AIR OR REFRIGERANT COMPRESSORS	TANK	TO 10 H.P.	FLOOR	D	0.3	- -	B	0.75	- -	- -	- -	- -
		OVER 10 H.P.		B	0.75	- -		1.5	B-2	- -	- -	- -
	UNITARY	TO 10 H.P.		D	0.3	- -		0.75	B-2 (3)	- -	- -	- -
		OVER 10 H.P.		B	0.75	- -		1.5		- -	- -	- -
AIR COOLED CONDENSERS & DRY COOLERS		TO 1 H.P.	ROOF	- -	- -	- -	- -	- -	- -	- -	.75	B-4
		OVER 1 H.P.		- -	- -	- -	- -	- -	- -	- -	1.5	B-4
AXIAL FANS		TO 15 H.P.	FLOOR/ ROOF	D	0.3	B-1	B	(2)	B-1	- -	(2)	B-3 OR 4
			CEILING	- -	- -	- -	F		- -	- -		- -
		OVER 15 H.P.	FLOOR/ ROOF	B	0.75	B-1	B		B-1	- -		B-3 OR 4
			CEILING	- -	- -	- -	F		- -	- -		- -
BOILERS & STEAM GENERATORS		OIL OR GAS	FLOOR	- -	- -	- -	B	0.75 (1)	- -	- -	- -	- -
		ELECTRIC		- -	- -	- -	G	0.1	- -	- -	- -	- -
CENTRIFUGAL FANS	ARRG'T 1 & 3	ALL	FLOOR/ ROOF	B	0.75	B-1	B	(2)(6)	B-1 (4)	B	(2) (6)	B-1 (4)
			CEILING	- -	- -	- -	F			- -		- -
	ARRG'T 4,9 & 10		FLOOR/ ROOF	D	0.3	- -	B		- -	- -		B-4
			CEILING	- -	- -	- -	F		- -	- -		- -
CHILLERS & CONDENSING UNITS	ABSORB. & CENTRIF.	ALL	FLOOR	G	0.1	- -	B	0.75	- -	- -	1.5	B-4
	RECIPR. & ROTARY	To 5 TONS	FLOOR / ROOF	D	0.25	- -	D	.25	- -	- -	.75	B-4
		6-20 TONS		B	1.0	- -	B	1.5	- -	- -	1.5	B-4
		OVER 20 TONS						2.5	- -	- -	2.5	
COMPUTER ROOM UNITS		ALL	CEILING	- -	- -	- -	F	0.75	- -	- -	- -	- -
			FLOOR	- -	- -	B-9	B	0.75	B-9	- -	- -	- -
COOLING TOWERS		TO 200 TONS	FLOOR OR ROOF	G	0.10	- -	B	1.5	- -	B	1.5	B-1
		OVER 200				- -		2.5	- -		2.5	
CURB MOUNTED ROOF EXHAUSTERS		ALL (7)	ROOF	- -	- -	- -	- -	- -	- -	- -	- -	B-5
FAN COIL UNITS FAN POWERED BOXES CABINET UNIT HEATERS UNIT VENTILATORS HEAT PUMPS		ALL	CEILING	- -	- -	- -	F	0.75	- -	- -	- -	- -
PUMPS	BASE MOUNTED	TO 15 H.P.	FLOOR	D	0.3	B-2	B	0.75	B-2	- -	- -	- -
		15-30 H.P.		B	0.75					- -	- -	- -
		OVER 30 H.P.						1.5		- -	- -	- -
	INLINE	ALL	FLOOR	- -	- -	- -	D	0.3	- -	- -	- -	- -
			CEILING	- -	- -	- -	F	0.75	- -	- -	- -	- -
	CONDEN-SATE		FLOOR	D	0.3	- -	D	0.3	- -	- -	- -	- -
	BOILER FEED					- -			- -	- -	- -	- -
DX ROOF TOP UNITS AIR HANDLING UNITS		TO 3,000 CFM	CURB MOUNT-	- -	- -	- -	- -	- -	- -	- -	0.75	B-3

TABLE A VIBRATION ISOLATION & SEISMIC RESTRAINT REQUIREMENTS FOR **HVAC** EQUIPMENT			**EQUIPMENT INSTALLATION ATTACHMENT POINT**								
AIR CONDITIONING UNITS MAKE UP AIR UNITS HEAT RECOVERY UNITS H&V UNITS (10)	3,001 TO 10,000 CFM	ED	- -	- -	- -	- -	- -	- -	- -	1.50	B-3
	OVER 10,000 CFM		- -	- -	- -	- -	- -	- -	- -	2.50	B-3
	TO 6000 CFM	POINT SUPPORT -ED	- -	- -	- -	- -	- -	- -	B	0.75	(1)
	OVER 6000 CFM		- -	- -	- -	- -	- -	- -		2.5	(1)
UNIT HEATERS	ALL	CEILING	- -	- -	- -	E	0.3	- -	- -	- -	- -

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.

3.37 TESTING, ADJUSTING AND BALANCING

A. ACCEPTABLE BALANCERS
1. Provide the services of an independent AABC or NEBC certified air balancing contractor. Submit contractor qualifications for approval prior to commencement of testing, adjusting, and balancing.

B. 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.
   o. Service and balance valves are open.

C. Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.

D. Beginning of work means acceptance of existing conditions.

E. PREPARATION
1. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect/Engineer to facilitate spot checks during testing.
2. Provide additional balancing devices as required.

F. 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.

G. 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.

H. RENOVATION PRE-CONSTRUCTION TESTING
1. Measure and prepare a balancing report prior to demolition and/or new construction.
2. 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. Test all associated heating and cooling generation and transfer equipment serving the renovated spaces.
3. Testing technician shall record the physical condition of all equipment being tested. Note condition, maintenance or repairs required.
4. Prior to commencing testing coordinate with owner to ensure the all equipment is operational and spaces are accessible.
5. Submit pre-construction testing report for review and approval prior to commencement of demolition.
6. Record sound and vibration within spaces being renovated.
7. Measure and record all main supply, return and exhaust air ducts at limit of demolition.

I. 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.

J. AIR SYSTEM PROCEDURE
1. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities [at site altitude].
2. Make air quantity measurements in ducts by Pivot tube traverse of entire cross sectional area of duct.
3. Measure air quantities at registers, grilles and diffusers.
4. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
5. 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%.
6. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
7. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
8. 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.
9. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
10. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

11. 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.
12. Variable Volume Systems. Work with ATC contractor to determine optimal duct static pressure sensor setpoint: Demand-based Static pressure reset:
    a. 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.
    b. 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.

K. WATER SYSTEM PROCEDURE
1. Adjust water systems to provide required or design quantities.
2. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
3. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
4. Effect system balance with automatic control valves fully open to heat transfer elements.
5. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
6. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

L. SCHEDULES
1. Equipment requiring sound level, Air, Water, and vibration - testing, Adjusting, and Balancing:
    a. HVAC Pumps
    b. Water Chillers
    c. Air Coils
    d. Terminal Heat Transfer Units
    e. Air Handling Units
    f. Fans
    g. Air Filters
    h. Air Terminal Units
    i. Registers, Grilles and Diffusers
    j. Duct Mains
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: 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. Instrument List:
   a. Instrument
   b. Manufacturer
   c. Model number
   d. Serial number
   e. Range
   f. Calibration date
4. Electric Motors:
   a. Manufacturer
   b. Model/Frame
   c. HP/BHP
   d. Phase, voltage, amperage; nameplate, actual, no load
   e. RPM
   f. Service factor
   g. Starter size, rating, heater elements
   h. Sheave Make/Size/Bore
5. V-Belt Drive:
   a. Identification/location
   b. Required driven RPM
   c. Driven sheave, diameter and RPM
   d. Belt, size and quantity
   e. Motor sheave diameter and RPM
   f. Center to center distance, maximum, minimum, and actual
6. Pump Data:
   a. Identification/number
   b. Manufacturer
   c. Size/model
   d. Impeller
   e. Service
   f. Design flow rate, pressure drop, BHP
   g. Actual flow rate, pressure drop, BHP
   h. Discharge pressure
   i. Suction pressure
   j. Total operating head pressure
   k. Shut off, discharge and suction pressures
   l. Shut off, total head pressure
7. Chillers:
   a. Identification/number
   b. Manufacturer
   c. Capacity
   d. Model number
   e. Serial number
   f. Evaporator entering water temperature, design and actual
   g. Evaporator leaving water temperature, design and actual

h. Evaporator pressure drop, design and actual
i. Evaporator water flow rate, design and actual
j. Condenser entering water temperature, design and actual
k. Condenser pressure drop, design and actual
l. Condenser water flow rate, design and actual

8. Cooling Coil Data:
   a. Identification/number
   b. Location
   c. Service
   d. Manufacturer
   e. Air flow, design and actual
   f. Entering air DB temperature, design and actual
   g. Entering air WB temperature, design and actual
   h. Leaving air DB temperature, design and actual
   i. Leaving air WB temperature, design and actual
   j. Water flow, design and actual
   k. Water pressure drop, design and actual
   l. Entering water temperature, design and actual
   m. Leaving water temperature, design and actual
   n. Saturated suction temperature, design and actual
   o. Air pressure drop, design and actual
9. Heating Coil Data:
   a. Identification/number
   b. Location
   c. Service
   d. Manufacturer
   e. Air flow, design and actual
   f. Water flow, design and actual
   g. Water pressure drop, design and actual
   h. Entering water temperature, design and actual
   i. Leaving water temperature, design and actual
   j. Entering air temperature, design and actual
   k. Leaving air temperature, design and actual
   l. Air pressure drop, design and actual
10. Air Moving Equipment
   a. Location
   b. Manufacturer
   c. Model number
   d. Serial number
   e. Arrangement/Class/Discharge
   f. Air flow, specified and actual
   g. Return air flow, specified and actual
   h. Outside air flow, specified and actual
   i. Total static pressure (total external), specified and actual
   j. Inlet pressure
   k. Discharge pressure
   l. Duct static pressure setpoint: Max, Minimum and Optimized.
   m. Sheave Make/Size/Bore
   n. Number of Belts/Make/Size
   o. Fan RPM
11. Return Air/Outside Air Data:
   a. Identification/location
   b. Design air flow
   c. Actual air flow
   d. Design return air flow

e. Actual return air flow
f. Design outside air flow
g. Actual outside air flow
h. Return air temperature
i. Outside air temperature
j. Required mixed air temperature
k. Actual mixed air temperature
l. Design outside/return air ratio
m. Actual outside/return air ratio

12. Exhaust Fan Data:
    a. Location
    b. Manufacturer
    c. Model number
    d. Serial number
    e. Air flow, specified and actual
    f. Total static pressure (total external), specified and actual
    g. Inlet pressure
    h. Discharge pressure
    i. Sheave Make/Size/Bore
    j. Number of Belts/Make/Size
    k. Fan RPM
13. 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
14. Duct Leak Test:
    a. Description of ductwork under test
    b. Duct design operating pressure
    c. Duct design test static pressure
    d. Duct capacity, air flow
    e. Maximum allowable leakage duct capacity times leak factor
    f. Test apparatus
    g. Blower
    h. Orifice, tube size
    i. Orifice size
    j. Calibrated
    k. Test static pressure
    l. Test orifice differential pressure
    m. Leakage
15. Air Monitoring Station Data:
    a. Identification/location
    b. System
    c. Size
    d. Area
    e. Design velocity
    f. Design air flow
    g. Test velocity
    h. Test air flow

16. Flow Measuring Station:
    a. Identification/number
    b. Location
    c. Size
    d. Manufacturer
    e. Model number
    f. Serial number
    g. Design Flow rate
    h. Design pressure drop
    i. Actual/final pressure drop
    j. Actual/final flow rate
    k. Station calibrated setting
17. Terminal Unit Data:
    a. Manufacturer
    b. Type, constant, variable, single, dual duct
    c. Identification/number
    d. Location
    e. Model number
    f. Size
    g. Minimum static pressure
    h. Minimum design air flow
    i. Maximum design air flow
    j. Maximum actual air flow
    k. Inlet static pressure
18. 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
19. Sound Level Report:
    a. Location
    b. Octave bands - equipment off
    c. Octave bands - equipment on
20. 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)

3.38 AIR DUCT AND SYSTEM CLEANING

A. Engage a certified Air system cleaning specialist (ASCS) to clean the following systems:
   1. Supply system.
   2. Return system.
   3. Exhaust system.

B. 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

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

D. 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.

E. Perform cleaning and testing before air balancing. Upon completion of air cleaning and prior to air balancing replace Air filters.

F. 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.

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

H. 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.

I. 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.

J. 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.

K. 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.

L. 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. On both sides of duct coils.
   b. Downstream from volume dampers, turning vanes, and equipment.
   c. Adjacent to fire or smoke dampers; reset or install new fusible links.
   d. Before and after each change in direction, at maximum 50-footspacing.
   e. On sides of ducts where adequate clearance is available.

M. 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.

N. Testing/Reporting
   1. Gravimetric Analysis: 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. If analysis determines that levels of debris are equal to or lower than suitable levels, system shall have passed cleanliness verification.
      b. 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.

3.39 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.

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.

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.

3.40 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.

3.41 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 videoed 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 2 hours of instruction in the operation of the water treatment system, and 8 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