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SECTION 15300 - FIRE PROTECTION

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. Include GENERAL CONDITIONS and applicable parts of Division 1 as part of this Section.

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

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

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

E. Where referred to, Standard Specifications or Technical Societies, Manufacturer's Associations, and Federal Agencies shall include all amendments current as of the date of issue of these Specifications.

F. Performance Criteria:

1. The Fire Protection Engineer has developed the performance and design criteria for the fire protection systems. The Fire Protection work shall be done on the basis of a "shared design" responsibility. The Fire Protection Sub-Contractor is responsible for engaging a qualified Registered Fire Protection Engineer (FPE) or NICET Level IV layout technician (Designer), certified in automatic sprinkler system layout to prepare the "Installation" drawings, and hydraulic calculations.

2. The "Installation" Drawings shall be prepared in accordance with the requirements of the latest editions of NFPA-13, along with the requirements indicated in the Contract Documents. It is the responsibility of this Subcontractor to fully coordinate all aspects of the system layout with the building construction features and all installing trades, and to confirm the preliminary design and design criteria.

3. The final system "Installation" Drawings and all supporting information including hydraulic calculations, material and equipment submittals, etc. as required, shall be submitted through the Architect for review and approval prior to fabrication and installation.

4. The submittal review process may require system modifications or alterations, additional or revised hydraulic calculations, material changes, etc., if in the opinion or interpretation of the Fire Protection Engineer, the intent of the design criteria or standards are not being met.

5. Following approval of the submittal by the specifying Fire Protection Engineer, the Fire Protection Sub-Contractor may proceed with submittal to appropriate authorities as indicated in the Specifications and may apply for the permit to install.; upon which time

fabrication and installation are then authorized, in accordance with the Project Schedule

6. The Fire Protection Subcontractor is required to maintain current: (1) Sprinkler Contractor's license and, (2) Errors and Omissions Insurance.

G. Where an item is referred to in singular number in Contract Documents, provide as many such items as are necessary to complete work.

H. Before submitting bid, visit and carefully examine site to identify existing conditions and difficulties that will affect work of this Section. No extra payment will be allowed for additional work caused by unfamiliarity with site conditions that are visible or readily construed by experienced observer.

I. Before starting work of this Section, visit site and examine conditions under which work must be performed including preparatory work done under other Sections or Contracts or by Owner. Report conditions that might affect work adversely in writing through the General Contractor to Architect. Do not proceed with work until defects have been corrected and conditions are satisfactory. Commencement of work shall constitute complete acceptance of existing conditions and preparatory work.

J. All work shall be performed in accordance with the State Building Code, NFPA, the Local Fire Prevention Department, the State Fire Marshall, the Insurance Underwriter and all Local Codes and Ordinances.

K. The Fire Protection Subcontractor shall work out the "means and methods" of performing the work with the General Contractor.

L. Refer to the Alternates Section for all Alternates which may affect the work of this Section.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide all labor, materials and equipment necessary to do all Fire Protection work as shown on the Drawings and as specified herein, including but not limited to:

1. Exterior water service beginning outside of the building wall as shown on the drawings, including connection.

2. Complete wet and dry sprinkler systems.

3. Gate valves, check valves, drain valves.

4. Sprinkler heads, piping, fittings and valves.

5. Preparation of complete "Fire Protection Working Drawings" and calculations.

6. Tests of all piping, systems, devices and alarms.

7. Sleeves, escutcheons, hangers and supports.

8. Flow tests.

9. Fire Department connection.
10. Pressure gauges.
11. Miscellaneous steel supports.
12. Flow and tamper switches.
13. Sprinkler drains.
14. Backflow preventer on fire water service.
15. Identification of systems, equipment and valves.
16. Shop Drawings and Submittals.
17. Permits, fees and inspections.
18. System and equipment start-ups; Owner instructions.
19. Operation and Maintenance Manuals.
20. Drilling for installation of inserts.
21. Thrust blocks and related supports and restraints.
22. All hoisting and rigging required for the Fire Protection work.
23. All scaffolding and staging required for the Fire Protection work.
24. Cutting through non-masonry construction.
25. Core drilling.
26. Record Drawings.
27. Coordination Drawings.
28. Firestopping.

B. Furnish the following materials to be installed under other Sections.

1. Flashing.
2. Access panels to be installed under Applicable Sections.

1.3 RELATED WORK UNDER OTHER SECTIONS

A. The following related items are included under other Sections:

1. Pads, concrete bases and form work.

2. Excavation and backfilling.

3. Sawcutting.

4. Dewatering.

5. Cutting and patching (except drilling for hangers and providing openings in metal decks). However, this work shall be paid for by the Fire Protection Sub-Contractor where due to his omissions or negligence.

6. Exterior water service piping beyond points indicated on the drawings, installed by a Licensed Sprinkler Contractor.

7. Painting of all exposed sprinkler equipment not having enameled surfaces, stainless steel or chromed finishes.

8. All power and alarm wiring of every description shall be provided under ELECTRICAL Section.

9. Fire extinguishers and cabinets.

10. Testing of sprinkler water service to the street or main.

1.4 INTENT

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

B. Consider the Specifications as 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. 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. Provide fully qualified personnel to fulfill this requirement. Be responsible for prompt replacement of defective materials, equipment and parts of equipment and related damage.

1.5 STANDARD OF MATERIAL AND WORKMANSHIP

A. Workmanship and installation methods shall conform to the best standard practice. Work shall be performed by skilled tradesmen under the direct supervision of fully qualified personnel.

B. Install equipment in strict accordance with manufacturer's written recommendations.

C. When requested, submit samples of materials proposed for review before proceeding with the work.

D. Install equipment and materials to present a neat appearance. Run piping parallel with or perpendicular to building planes.

E. Conceal piping in finished areas. Install work so as to require a minimum amount of furring.

F. All heads, piping, equipment and devices shall comply with FM.

G. Make provisions for neat insulation finish where required. Do not mount piping or equipment within insulation depth.

H. Equipment, materials and work shall comply with the requirements of listed agencies, and shall conform to and be installed in strict accordance with Federal, State and City requirements and shall meet all of the requirements of all authorities having jurisdiction.

1.6 ABBREVIATIONS AND DEFINITIONS

A. "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.

B. "Concealed" shall be defined as areas where piping is located in chases, shafts, and furred ceilings.

C. All other piping shall be considered "exposed".

D. "Fire Protection" and "Sprinkler" as used herein are generally interchangeable.

E. "NFPA" is interpreted to mean "NFPA and all HPR/Underwriter interpretations and data sheets".

F. "This Subcontractor" means specifically the Fire Protection Subcontractor working under this Section of the Specifications.

G. "Equipment" as mentioned and intended herein shall mean any and all valves, controls and equipment.

H. "Exposed" shall mean within sight in closets, in finished rooms, under counters, behind and/or under equipment and/or otherwise visible.

I. "Underground" shall mean pipe, conduit or equipment that is buried exterior to or within the building.

J. "Finish grade" as used herein means the final grade elevations indicated on the drawings.

K. Piping shall mean and include pipe, fittings, hangers and valves.

L. "DATE OF ACCEPTANCE", as it is used herein in reference to the guarantee, shall mean that date (after substantial completion), upon which the system or equipment is turned over to and accepted by the Owner complete with initial start-up and the Owner's instructions.

M. "Service Entry Room" as used herein means, and is interchangeable with "Mechanical Room", "Pump Room", "Valve Room", etc.

N. "General Contractor" and "Construction Manager" as used herein, are interchangeable.

O. "Calculations" shall mean hydraulic type calculations, as required by Code, the Underwriter, the Owner and/or Local Authorities, as required for the Project.

1.7 EXAMINATION

A. Examine the Specifications and Drawings, including the Specifications and Drawings of other Sections.

B. Report in writing, any discrepancies or deficiencies which may adversely affect the work.

C. 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 STANDARDS

A. The latest published issue of the standards, recommendations and requirements of the following listed Societies, Associations or Institutes in effect at the date of Contract are part of this Section. These shall be considered as minimum requirements. Specific requirements of this Section and/or associated Drawings shall have precedence. In case of conflict between published requirements, the stricter requirement shall be followed.

1.	AGA	-	American Gas Association
2.	ANSI	-	American National Standards Institute
3.	ASME	-	American Society of Mechanical Engineers
4.	ASTM	-	American Society for Testing and Materials
5.	DEP	-	Department of Environmental Protection (formerly DEQE)
6.	FM	-	Factory Mutual
7.	IEEE	-	Institute of Electrical and Electronic Engineers
8.	MCAA	-	Mechanical Contractors Associations of America
9.	NEMA	-	National Electrical Manufacturers Association
10.	UL	-	Underwriters' Laboratories, Inc.
11.	NFPA	-	National Fire Protection Association
12.	OSHA	-	Occupational Safety and Health Act
13.	N.E.C.	-	National Electric Code
14.	I.S.O.	-	Insurance Services Office of Mass.
15.		-	Owner's Insurance Underwriter
16.		-	Maine State Building Code

1.9 FIRE PROTECTION WORKING DRAWINGS

A. After visit to site, the Fire Protection Subcontractor shall study building Architectural, Structural, Mechanical, reflected ceiling and Electrical plans and prepare "Fire Protection Working Drawings" in conformance with NFPA, the Owner's Insurance Underwriter and the Underwriter's Interpretation of NFPA.

B. Working Drawings shall show sections, pipe hangers, heating units, ductwork, electric lighting fixtures, diffusers and indicate a coordinated layout of heads and mains with these components. This is critical since the available space is restricted, and coordination is critical. For this reason, the timing of (the Final Approval of) these drawings is critical, and shall be done during the first stages of the Project.

C. Submit the appropriate number of sets of finished Working Drawings, with the Fire Protection Subcontractor's License Number and stamped by a qualified Fire Protection Engineer, Registered in the State, or NICET Level IV Designer, and all the necessary and required calculations (including flow tests) to the Architect and, if applicable, the Insurance Underwriter, for review and approval.

D. Working Drawings shall be subject to Architect's final review, and drawn to scale no less than 1/8-inch = 1 ft. on sheets of uniform size. Plans shall show all design data required by the appropriate NFPA pamphlets and the Underwriter.

E. Prior to performing the Fire Protection Working Drawings, obtain an approved copy of the "Coordination Drawings", and incorporate all pertinent information. However, poor timing of the receipt of these drawings shall not delay production of the Fire Protection Working Drawings.

F. Fire Protection Working Drawings and calculations shall have been reviewed by the Architect and approved by the Insurance Underwriter and the Fire Department (Local Authority) prior to fabrication/installation. Any deviation from this process shall be entirely at the Fire Protection Subcontractor's risk.

G. Prior to preparing the Fire Protection Working Drawings and Calculations, obtain Underwriter flow test data or conduct proper independent flow tests to verify conditions and the preliminary design herein. Coordinate flow tests with the Local Water Authority's requirements. If the Local Authority will not allow the flow tests the Fire Protection Subcontractor shall notify the Architect through the G.C.

H. Approvals provided by the Owner's Insurance Underwriter shall be considered as preliminary and are subject to final approval, by the Architect.

I. The Fire Protection Subcontractor shall assume that modifications to the calculations and Fire Protection Working Drawings will be required, and shall have made such allowance in his Project cost.

J. ISO review is required. The Fire Protection Subcontractor shall pay all costs of the reviews and shall obtain the ISO embossed seal on the Drawings.

K. As an aid in the bidding process, and to assist in the coordination of the building systems, the Fire Protection Design Drawings may indicate a piping layout with pipe sizes and sprinkler heads indicated. This Subcontractor is cautioned that this is a "Design" set of documents, for the above-stated purposes, and that all of the flow test, sizing and related requirements indicated herein apply to the Fire Protection Subcontractor's final design requirements for the "Installation" set of documents. All piping, heads and offsets may not be indicated. The Fire Protection Subcontractor is fully responsible for the final complete installation. However, where mains and branch mains are sized, this shall be the minimum size that is required.

1.10 COORDINATION

A. It shall be the responsibility of the Fire Protection Subcontractor to participate in coordination with all other trades and parties to avoid conflicts. No additional charges will be approved due to lack of coordination. Comply with DIVISION 1.

B. Fully coordinate with other trades to ensure that work is carried out in a timely manner and in proper sequence to conserve headroom and space.

C. Coordinate work with other trades to provide maximum accessibility for maintenance and operation.

D. Give notice of requirements for holes, recessed openings, pits and chases before structure is erected.

E. Set all necessary sleeves and inserts before concrete is poured.

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

G. Prior to performing any digging, "DIG-SAFE," the utility underground plant damage prevention authority shall be contacted. Notification shall be made at least 72 hours prior to the work: 1-888-DIG-SAFE.

1.11 DRAWINGS

A. The Contract Drawings are approximately correct to scale, but figured dimensions and detailed drawings are to be followed in every case. The Drawings shall be taken as diagrammatic. General method of running piping is shown, but it is not intended to show every offset and fitting nor every structural difficulty that may be encountered.

B. Locations shown on the Fire Protection Plans shall be checked against the general and detailed drawings of the construction proper as the basis for developing the "Fire Protection Working Drawings". All measurements shall be taken at the building.

C. Do not scale drawings. Obtain all information requiring dimensions from Architectural and Structural Drawings and from site measurements. Check locations and elevations before proceeding with work.

D. At no additional cost to the Owner, make all reasonable changes and additions to location of materials and equipment and coordination issues, necessary to accommodate the structural and architectural conditions and the systems.

E. Refer to Architectural Drawings for fire ratings of walls and slabs. This Subcontractor shall be fully responsible for sealing all sprinkler penetrations to maintain the required fire ratings, and acoustic seals.

F. Some sprinkler heads have been indicated as a general and preliminary guide for ceiling system coordination and all heads may not be indicated. It shall be the responsibility of this Subcontractor to provide the correct number of heads and to fully coordinate the number, type and location of all heads with the ceiling and ceiling sandwich conditions.

G. Whether shown on Drawings or not, leave adequate space and provision for servicing of equipment and removal and reinstallation of replaceable items such as motors, controls, panels, etc.

1.12 FABRICATION OF MATERIALS

A. Before ordering of materials and prefabricating piping for installation, the "Fire Protection Working Drawings" shall be fully reviewed and approved by all pertinent parties. Make certain that such items can be installed as intended on the Drawings without interfering with the structure and the work of other trades.

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

1.13 PERMITS, FEES, INSPECTIONS AND CERTIFICATES

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

B. Obtain permit for the work from the local Fire Department.

C. Be fully acquainted with and obey all Federal, State and Municipal Laws, Bylaws, Codes and Regulations, and all Authorities having jurisdiction.

D. Before starting any work, submit the required Specifications and Drawings to the Governing Authorities. Comply with any requested changes as part of the Contract, and give any notification immediately of such changes.

E. 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.

F. If any work is covered up without inspection, it shall, if required, be uncovered for examination and made good at no extra cost to the Owner.

G. Furnish all certificates necessary as evidence that the sprinkler work conforms to the requirements of all Authorities having jurisdiction.

1.14 RECORD DRAWINGS

A. Refer to and coordinate with the GENERAL REQUIREMENTS, DIVISION 1 and SECTION 01700.

B. Refer to Section 01300 for requirements regarding the use of Contract Drawing AutoCAD files. Contract Drawing files will be provided at a cost of $50.00 (fifty dollars) per drawing, with a minimum cost of $500.00 (five hundred dollars).

C. Maintain at the job site at all times a complete set of blackline prints of the approved "Fire Protection Working Drawings". As the Work progresses, mark all changes made, whether resulting from addenda, formal change orders and other instructions issued by the Architect. Color in the various 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, and 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 Fire Protection Subcontractor.

F. When this procedure has been accomplished to the satisfaction of the Owner, the Fire Protection Subcontractor shall furnish to the Owner the following:

1. The marked up job record blackline prints.

2. The reproducible revised transparencies entitled "Record Drawings" marked with the date when printed and signed by the Fire Protection Subcontractor's Engineer who made them.

3. Three complete sets of blackline prints of the "Record Drawings".

4. Record Drawings on AutoCAD 2000.

5. Distribution by the Architect shall be:

a. One set blackline prints to the Fire Protection Engineer.

b. One set blackline prints retained by the Architect.

1.15 OPERATION AND MAINTENANCE DATA

A. Refer to and coordinate with the GENERAL REQUIREMENTS, DIVISION 1 and SECTION 01700, for submittal procedures pertaining to operating and maintenance manuals.

B. Assemble indexed hard cover manuals entitled "Operating and Maintenance Instructions for Fire Protection Systems".

C. Submit for review before instructions to Owner are commenced. Instruct the Owner as to the operation-maintenance of the system.

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 page-size equipment Shop Drawings including any 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. A copy of the applicable NFPA pamphlets (as applicable to design).

8. Names, addresses and phone numbers of all suppliers and service personnel for all equipment.

9. Copies of all product equipment and system guarantees from manufacturers, including signed written guarantee of systems from this Subcontractor.

10. Copy of NFPA (HPR Underwriter) system maintenance manuals including, as applicable (NFPA-1, 13, 25).

11. A schedule of system maintenance and testing (such as BFP, ZCV's, ACV's, DV's, Alarms, drains, etc.).

1.16 SHOP DRAWINGS

A. Refer to and coordinate with Division 1 and, as applicable, the other Sections for Shop Drawing requirements. Refer to Section 01300 for policies regarding the use of Contract Drawing AutoCAD files. The Fire Protection Subcontractor shall also submit the additional information noted herein.

B. Present immediately, after award of the Contract, a list of Shop Drawings to be submitted with the name of each manufacturer and supplier.

C. Shop Drawings shall be submitted for all items and equipment furnished under this Section.

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

E. Submit for review, one sepia and the proper number of copies of the "Fire Protection Working Drawings" and shop drawings of all equipment, materials, equipment wiring diagrams, motors, starters, controls, and schedules. Ensure that sepias have adequate clear space for all stamps. When requested, resubmit drawings promptly.

F. Be responsible for processing of Shop Drawings to suit manufacturing schedule of equipment and construction schedule of building. Allow for reasonable engineering review and resubmittal time.

G. Be responsible for 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.

H. Each Shop Drawing shall indicate clearly the correct name and address of the Project, the intended use and location of the equipment, and the Specification paragraph number.

I. Upon receipt of reviewed Shop Drawings, distribute prints to all trades and manufacturers affected.

J. Keep one set of the reviewed Shop Drawings and "Fire Protection Working Drawings" on the site at all times.

K. Prior to submission of Shop Drawings, the Fire Protection 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 Shop Drawings. Stamp each submittal with firm name, date and approval, thereby representing that the above has been complied with. Shop Drawings not so checked and stamped will be returned without being examined by the Architect. Review of the Shop Drawings shall not relieve this Subcontractor from the responsibility for departures from the Contract Documents. Errors in Shop Drawings shall be the sole responsibility of the Fire Protection Subcontractor whether the drawings are reviewed or not.

L. Submit to the General Contractor, all samples requested by the Architect. Submittal, review, and approval of samples shall be in accordance with DIVISION 1.

M. Bind one set of the corrected "Reviewed" Shop Drawings in each Operation and Maintenance Instructions Manual.

1.17 COORDINATION DRAWINGS

A. Refer to SECTION 01300 - Coordination for General Requirements for the preparation and submittal of Coordination Drawings.

B. Before work progresses, coordinate with and obtain approved copies of the HVAC Contractor's "Coordination Drawings" and, in addition to the Shop Drawings listed herein, Coordination Drawings shall be prepared by the Fire Protection Subcontractor at a suitable scale not less than 1/4 inch equals one foot.

C. Coordination Drawings shall be done on AutoCAD 2000 and shall show how Fire Protection systems are to be installed and where conflicts with the work of other trades may occur. The General Contractor, before transmittal of the Coordination Drawings to the Architect for approval, may require the Fire Protection Subcontractor to revise the Coordination Drawings and to make reasonable modifications in the layout of the Fire Protection work, so that the work may be properly accommodated without the interference with work of other trades. Make such revisions to Coordination Shop Drawings, when requested, without extra charge.

D. Coordination Shop Drawings shall also be done for changes in the Fire Protection and adjoining work where an approved substitution of the Fire Protection equipment requires such changes in the Fire Protection work or in the adjoining work of any other trade.

E. Coordination Drawings shall also be done for concrete equipment bases and for any other work to be performed by other trades as required for the installation of the fire protection work.

F. On renovation projects, Coordination Drawings shall show all existing piping, equipment and items that are to remain in use.

1.18 PROTECTION

A. Protect all Fire Protection work from damage. Keep all items and 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. Make good any damage caused by improper storage, handling, or installation of equipment and materials.

D. Protect equipment, piping and temporary services from weather damage.

1.19 WARRANTY

A. Conform to Division 1 - General Requirements.

B. All equipment, material and workmanship shall be warranteed, as set forth in the Contract, or for longer periods when stated in the Specifications. At a minimum, all equipment and systems shall be warranteed for a period of not less than one year from the Date of Acceptance by the Owner.

C. If any equipment or material does not match the manufacturer's published data or specially supplied rating schedules during performance tests, replace without delay the defective equipment and materials. Bear all associated costs to eliminate all charges to the Owner and adjust all components to achieve the proper rating.

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

E. Written warranty shall be included in the operation and maintenance manuals as discussed elsewhere in this Section.

1.20 LICENSE

A. All work shall be performed by Fire Protection Subcontractor licensed to install such systems in the State of Maine.

1.21 VERIFICATION OF CONDITIONS

A. Before performing any new work and running any new lines, this Subcontractor shall uncover, locate and determine the invert, routing, size and material of all existing lines, and of all prep and utility work done, including buried lines.

B. These verifications shall be done in coordination with the phasing and timing of the project and in coordination with all other trades involved.

C. Slab and wall cutting shall be minimized until proper verifications are made.

D. Inform the General Contractor if other than non-destructive means are required to verify existing conditions.

1.22 HYDRAULIC CALCULATIONS AND SIZING

A. The Fire Protection Subcontractor shall perform hydraulic calculations to size all portions of all systems. "Installation" hydraulics shall be performed even if "design" hydraulics have been done by TMP.

B. Hydraulics and sizing shall have been reviewed by the Architect prior to fabrication.

C. All hydraulics indicated on the documents are for "Design" purposes only and are to be revised and completed as required, by the Fire Protection Subcontractor for "Installation" purposes.

D. Note: Sizes indicated for service entry, service entry equipment, mains, and risers are not to be reduced in size.

E. Hydraulic calculations shall be performed for:

1. Each zone of the sprinkler system.

2. From the Fire Department inlet to the most remote sprinkler zone, to verify pressures and flows based on the local fire department equipment.

F. Hydraulic sizing has been performed for the hydraulically most remote areas of certain zones. Sizing for other zones which are not the hydraulically most remote shall be similar. All sizing which is proposed to vary from that indicated shall be fully supported with complete hydraulic calculations.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. The piping systems and all fittings and components shall be rated for the working pressures involved.

B. All piping shall conform to ASTM Standards and shall be UL listed and FM approved for fire service; piping shall be marked accordingly.

C. The project shall be completed using only one (1) manufacturer of fittings and couplings.

D. All fittings and couplings shall be 100% manufactured in the U.S. Foreign fittings and couplings are not allowed.

E. Galvanized pipe shall be used in all dry systems. The inside of pipe shall also be galvanized. Fittings need not be galvanized.

F. "Victaulic" fittings and couplings are used throughout to establish a specific criteria and level of quality.

G. Pipe sizes shall change only with one-piece reducing fittings. Bushings shall not be allowed.

H. Service: Buried fire service.

1. Pipe Material: Ductile iron, standard thickness cement mortar lining, Class 52.

2. Fitting Material: Cast or ductile iron 250 psi rating, standard thickness cement mortar lining.

3. Pipe Joint: Push-on. Install flexible couplings on exterior side of foundation wall. All changes in direction to have tie rods and clamps anchored to thrust blocks in accordance with NFPA 24.

I. Service: Fire Service lines in service entry room, exclusive of sprinkler piping, and generally to the discharge of ACV's/DCV's. Also, to meet all required seismic requirements.

1. Material: Schedule 40 black steel, roll grooved ends (cut grooving shall not be allowed).

2. Fittings: Victaulic full flow malleable iron, ductile iron, steel.

3. Couplings: Victaulic Style 07 "Zero-Flex" couplings in equipment rooms; Style 005 for standpipes and risers; Style 77 standard flexible couplings at pumps and vibration-producing equipment; Style 741 "Vic-Flange" adapters at all valves and equipment connections.

J. Service: Sprinkler and fire service piping 6 inches and larger (unless otherwise noted).

1. Material: 6 inch pipe: 0.134 inch (Schedule 10) wall thickness, roll grooved ends (cut grooving shall not be allowed). 8 and 10 inch pipe: 0.188 inch (Schedule 10) wall thickness, roll grooved ends (cut grooving shall not be allowed).

2. Fittings: Victaulic full flow malleable iron, ductile iron, steel.

3. Couplings: Victaulic Style 005 rigid couplings; Style 72 outlet couplings; Style 920 Mechanical T's; Style 920 Mechanical T's; Style 741 "Vic-Flange" at valves and equipment.

K. Service: Sprinkler and fire service piping 2-1/2 inch through 5 inch.

1. Material: ASTM-135, Schedule 10 steel, roll grooved ends (cut grooving shall not be allowed).

2. Fittings: Victaulic full flow malleable iron, ductile iron, steel.

3. Couplings: Victaulic Style 005 rigid couplings; Style 72 outlet couplings; Style 920 mechanical tee's; Style 741 "Vic-Flange" at equipment and valves 2-1/2 inches and larger.

L. Service: Sprinkler piping 2 inch and below, all piping (all sizes) exposed to view in occupiable/habitable areas, and all threaded lines.

1. Material: Schedule 40 steel with threaded ends.

2. Fittings: Full flow malleable iron, cast iron or steel; screwed.

3. All exposed lines in habitable areas which use couplings, shall use style 005 rigid couplings.

M. Service: Sprinkler drains, inspector's test connection lines.

1. Material: Connections to sprinkler lines, valves and test stations: Schedule 40 steel, threaded. Drain and test risers: ASTM-135 Schedule 10 steel, roll grooved ends (cut grooving shall not be allowed).

2. Fittings: Full flow malleable iron, ductile iron, steel; screwed fittings as applicable; Victaulic fittings with grooved or shouldered ends as applicable.

3. Couplings: Victaulic Style 07 "Zero-Flex" couplings for risers; Style 005 rigid couplings for horizontal runs; Style 72 outlet couplings for connections to sprinkler lines and test or drain risers. (Style 920/925 "Mechanical-T" threaded U-bolted branch outlets may be utilized in lieu of Style 72 outlet couplings in this application.)

N. Service: Piping for the dry system.

1. Material: Schedule 40 galvanized steel; threaded.

2. Fittings: Iron or brass, as applicable; screwed.

O. Gaskets: Victaulic couplings shall be provided with Grade "E", EPDM gaskets. For dry systems, "Flush Seal" gaskets shall be used.

P. Reducers: Reducing fittings shall be used throughout; Style 750 reducing coupling.

Q. Expansion: When crossing building expansion joints, expansion loops, as required, shall be installed with the appropriate couplings to allow for expansion in agreement with that as provided for by the building joint. Piping shall be securely anchored to the building structure on both sides of the expansion loop.

R. Threading: Threaded joints may be substituted for grooved ends and Victaulic couplings; however, threading shall be limited to Schedule 40 piping. NOTE: Threading of piping less than Schedule 40 shall not be allowed.

2.2 VALVES

A. Valves shall be of standard weight and materials as required by NFPA; UL listed, FM approved. Victaulic, Jenkins, Mueller, Stockholm or approved equal.

B. Initial control valve inside the building shall be OS&Y type, 175 psi; no substitution allowed.

C. Check Valves: Approved pattern placed in the horizontal and of a 175 PSI WWP. Wafer type check valves, installed in the vertical, shall be used at dry pipe valves. Victaulic Style 717 Firelok check valves (250 psi).

D. Gate Valves 2-1/2 inch and Larger: Gate valves shall have iron body, bronze mounted, straightway pattern, OS&Y, flanged ends, 175 PSI WWP; Jenkins Brothers Figure No. 825-C. Victaulic No. 708-W UL/FM butterfly valves may be substituted except where NFPA/Underwriter Specifically requires an OS&Y valve.

E. Gate Valves 2 inch and Smaller: Gate valve shall have bronze body, OS&Y, screwed ends, 175 PSI WWP; Jenkins Brothers Figure No. 275-U. Victaulic No. 727 UL/FM "Fireball" valve may be substituted.

F. Globe Valves: Globe valves shall be bronze body with screwed ends, suitable for 300 lbs. non-shock cold water, similar to Jenkins Brothers Figure No. 106-A.

G. Check Valves 2-1/2 inch and larger: Check valves shall be swing type with cast iron body, bronze mounted, flanged ends, suitable for 175 lbs. working water pressure, similar to Jenkins Brothers Figure No. 729-C, tapped for automatic ball drip as required. Grooved Victaulic Style 717 Firelok check valves (250 psi).

H. Check Valves 2 inch and Smaller: Check valves shall be of the silent type, No. 203-A-T as manufactured by Mueller Steam Specialty.

I. Tamper switches shall be provided on all normally open valves, DPDT, self-restoring type.

2.3 FIRE DEPARTMENT CONNECTIONS

A. Provide a check and ball drip assembly for each inlet and outlet connection.

B. Fire Department Connections:

1. Fire Department inlet connection shall be similar to Potter Roemer free standing, 4 inch Storz Connection Model 5795-01 with 5799-01 cap, escutcheon ID plate, 4 inch X 8 inch brass sleeve and brass ID plate. Plate shall read "AUTO SPKLR STNDP" on the top and "MAX 175 PSI" on the bottom. Connection, cap and escutcheon plate shall be polished chrome plated. This type of fire department connection is a

requirement of the Fire Department. Install in minimum 20 inch X 20 inch X 6 inch concrete pad with 4 X 4 wire mesh, flush with grade. Ensure General Contractor provides bollards to protect inlet.

2.4 SPRINKLER HEADS

A. Sprinkler heads shall be UL listed and FM approved and of the automatic, closed type. Reliable, Viking, Grinnell, Gem, Star, Victaulic, or approved equal. Heads using "O-Ring" type seals are not allowed.

B. Sprinkler heads shall have a minimum temperature rating of 155 degrees F with 1/2 inch orifice. Areas subject to higher temperatures shall be provided with heads of higher temperature rating, in accordance with NFPA #13.

C. Sprinkler heads located in uninhabited areas without ceilings (mechanical rooms, storage rooms, etc.) shall be of conventional design, upright style, and shall have a rough brass finish and protective cages.

D. Sprinkler heads located in unheated spaces with ceilings shall be dry pendent style.

E. Sprinkler heads located in inhabited areas without ceilings shall be of conventional design upright style and shall have a polished chrome finish.

F. Sprinkler heads located in areas with ceilings shall be of conventional design, concealed pendent style, low profile and shall have white cover plates.

G. Heads for dry system shall be listed dry pendent heads.

H. Quick response heads shall be provided in all "light hazard" type occupancies and when otherwise required.

I. Sprinkler heads located in Mechanical Rooms, Storage Rooms, Service Areas, and where otherwise subjected to susceptible damage, shall be provided with guards.

J. Refer to Architectural Plans and Schedules to verify ceiling types and heights for areas of construction and for final locations of all sprinkler heads. If additional heads are required, beyond what is shown on the reflected ceiling plans, provide the required heads and coordinate their final locations with the Architect.

K. All recessed and concealed sprinkler heads shall be of the adjustable type.

L. All heads shall be centered in tiles, and with other ceiling objects, unless specifically denoted otherwise.

M. Sprinkler head locations shall be coordinated with all surface mounted items, such as cornices, low soffits and lighting fixtures and shall be located accordingly. Extended escutcheons may be utilized where heads cannot be moved, if acceptable to the Architect.

N. Heads in locations subject to chemicals, moisture or corrosive vapors shall be corrosion resistant listed types.

O. Heads in locations subject to chemicals, moisture or corrosive vapors shall be corrosion resistant listed types.

P. Extended coverage heads may be utilized, provided they are installed in accordance with their listing and performance is verified through hydraulic calculations.

2.5 SPARE HEADS

A. Furnish spare heads equal to one (1) percent of the total number installed of each type, but not less than ten (10).

B. Two (2) sprinkler head wrenches for each type of head installed shall also be furnished.

C. All spare heads and wrenches shall be packed in an enameled steel cabinet and mounted on a wall where directed by the Architect.

2.6 ALARM CHECK VALVE

A. The alarm check valves shall be approved types for a wet sprinkler system. Complete with electric alarm pressure switch and bell, drain valve, pressure gauges, supervisory switches, and all other required trimmings.

B. Where the ACV's and/or piping is sized on the drawings, the ACV's shall be installed full size.

2.7 DRY PIPE VALVE

A. The dry pipe valves shall be approved types for dry sprinkler systems. Complete with electric alarm pressure switch, drain valve, pressure gauges, supervisory switches, accelerators, exhausters and all other required trimmings, including air compressor.

B. Where the DPV's and/or piping is sized on the drawings, the DPV's shall be installed full size.

C. Dry pipe system to be provided with low/high air supervisory alarm signal switches and water flow alarm switch similar to Gamewell, Model M-2701.

D. Air compressors shall be provided with a starter as required. (Air compressors will be on emergency power.)

2.8 FLOW SWITCHES

A. Furnish and install vane-type waterflow detectors as required for the proper zoning of the system. Waterflow detectors shall be UL listed and FM approved with two single-pole, double-throw switches, adjustable retard (0 to 70 seconds), equal to Potter-Roemer, Inc., VSR-F Series, with plastic paddle. They shall be adjustable for time and pressure.

B. Flow switches shall be sized for the piping in which installed, to insure proper fit.

C. Potter Electric, Gem, Reliable, Autocall or approved equal.

2.9 SUPERVISORY (TAMPER) SWITCHES

A. Furnish and install supervisory switches UL and FM approved, equal to Potter-Roemer, Inc. 6220 (OS&Y), 6221 (rising stem globe valves) and 6223 as required.

B. Supervisory switches shall be provided on all normally open control valves.

C. Potter Electric, Gem, Reliable, Autocall or approved equal.

2.10 PRESSURE SWITCHES

A. Furnish and install pressure switches at all alarm check valves and dry pipe valves, UL listed and FM approved, two double pole, double throw switches, adjustable; Reliable Model #J54A 8295.

B. Potter Electric, Gem, Reliable, Autocall or approved equal.

C. Pressure switches at air compressors shall be double pole, double throw.

2.11 PRESSURE GAUGES

A. Furnish and install a pressure gauge at the top of the riser in the penthouse, and installed in such a manner so as to be readable from the floor.

B. Pressure gauges shall be at least four and one-half inches, bronze bourdon tube and steel case, with retard.

2.12 MISCELLANEOUS

A. Furnish all other accessories required, as per NFPA #13, including:

1. Electric Alarm Bells: Reliable Model KMS-10-24, 24 VDC with guard. For all wet and dry systems.

2. Sprinkler Guards: Reliable Model C1 (on all heads in basement, stairs, storage rooms and in plenum spaces).

3. Sight Drains: Reliable Model B, one inch, to suit.

4. Signs shall be as per NFPA 13.

2.13 BACKFLOW PREVENTER

A. Provide an FM approved, backflow preventer on the sprinkler water service where indicated on the drawings. The BFP shall be full line size. Where the service entry is specifically sized, the BFP shall be the same size.

B. The unit shall comply with all State and Local Water Authority requirements.

C. Unit shall be Watts, Hersey, Beeco, Febco, or approved equal, and be acceptable to the Local Water Authority and the Fire Department.

D. The inlet and outlet gate valves shall be equipped with tamper switches.

E. Spare Parts Kit: Furnish one (1) spare parts kit for each unit.

F. Double check valve assembly shall be Watts Model #709, bronze body construction through 2 inch in size and epoxy coated cast iron for 2-1/2 inch to 10 inch, removable bronze seats, stainless steel internal parts, bronze-bodied ball valve test cocks, OS&Y stem gate valves with union or flanged connections between the valves and the device itself. Size as indicated on the Drawings. Approved equals may be accepted with proof of state approval.

G. Inlet strainers shall not be provided.

H. A low pressure switch shall be provided upstream of the device.

2.14 INSULATION

A. Insulation shall not be applied until piping has been tested and accepted and until heat tracing has been installed, tested and accepted.

B. All wet system sprinkler piping, valves and accessories that are in unheated spaces and/or that are subject to freezing shall be heat traced and insulated.

C. The Sprinkler Contractor is responsible for the full compliance and coordination of this effort.

D. All fittings shall be insulted with fiberglass wrapping and Zeston covers or with nonchecking insulating cement troweled to a one inch thickness and covered with six ounce canvas jacket.

E. Pipe hangers shall be installed outside of insulation and provided with protection shields.

F. Insulation thickness shall be 2 inch. Staples are not allowed.

2.15 FIRESTOP SYSTEMS

A. Provide firestop system components at all fire rated construction where penetrated by the work of this section.

B. Refer to SECTION 07840 - Through-Penetration Firestop Systems, for all product requirements for maintaining integrity of fire rated construction at penetrations.

C. Firesafing and smoke seal is required where all pipes and conduit leave or enter all vertical shafts, at all floors and through all walls above or below all Class "A" acoustical tile ceilings, and all spaces without any type of finish ceiling.

D. Firesafing and smoke seal is required for all penetrations through rated walls and partitions and at partitions separating smoke zones.

E. Firesafing and smoke seal of pipe and duct penetrations through non-rated secondary walls within a rated larger area need not require firesafing and smoke seal until they penetrate the rated walls.

F. Firesafing and smoke seal materials shall be in accordance with Section 07840, if listed, or as follows:

1. "Poke-through" fire containment, USG "THERMAFIBER", fire test CEG 4-11-78; USG 6-2-76; CEG 8-7-85.

2. USG "THERMAFIBER" Rigid-type, various thickness.

3. USG "THERMAFIBER SMOKE SEAL COMPOUND" - UL No. R11327-L; UL No. R11327-R.

4. Dow Corning fire stop sealant and Dow Corning fire stop foam "A" and "B" classified for 1, 2 and 3 hours.

G. All firesafing material shall be noncombustible as defined by NFPA Standard 220 when tested in accordance with ASTME136; melt point – 2000°F; when in contact with metal, be non-corrosive meeting FS-HH-1-558 B; "k" value of 0.25 or less per ASTM C 518; the material shall be moisture-resistant, mildew, vermin-proof and non-deteriorating. The firesafing insulation shall meet fire containment tests per ASTM E119.

H. All sealants and compounds shall be neatly applied to each end of opening of ceiling, floor or wall penetrations and in accordance with Code requirements. All penetrations shall be minimum size possible.

2.16 ELECTRICAL MOTOR CHARACTERISTICS

A. Electrical motors shall conform to the requirements of IEEE, NEMA, U.L. N.E.C., F.M. and NFPA suitable for load conditions, squirrel cage, 1.15 service factor, drip proof, 1750 rpm unless otherwise noted, with inherent overload protection and pressure lubricated bearings with grease fittings. Refer to Electrical Characteristics Requirements in the Electrical Section of the Specifications.

B. Motors below 1/2 HP shall be 120V - l phase. All motors shall be designed for use with across-the-line starters. Motors shall be provided with overload protection. Phase protection shall be provided on motors 1/2 HP and larger.

C. Motor leads shall be permanently identified and supplied with connectors.

D. The minimum requirement for three phase motors shall be NEMA Design B, Class B, insulated for a maximum 40 degree C (104 degrees F.) ambient.

E. Select motors for quiet, continuous operation to suit loads which may be imposed by equipment. Recognize that motor horsepowers specified and scheduled are minimum sizes. If larger motors, starters, power wiring and additional control wiring are included in bid.

2.17 STARTERS AND CONTROLLERS

A. Motor driven equipment supplied under this Section shall be operated by starters furnished and installed under the Electrical Section of the Specifications, except for starters integral with Sprinkler equipment which shall be provided by the Fire Protection Contractor.

B. The Fire Protection Contractor shall provide nameplates on all starters.

C. All motor controls shall conform to NEMA Standards and be the product of a single manufacturer; Arrow-Hart and Hagemen, Allen-Brady, or Square D.

D. Auxiliary contacts shall be included in all starters provided under the Electrical Section and by this Section, for integrally mounted starters. Auxiliary contacts shall be provided for all interlocking wiring.

E. Starters shall normally be provided with two sets of contactors; one set normally open and one set normally closed. Interface shall be provided for all starters and other devices as noted herein.

F. Starters and contactors factory-built into the control panel of packaged equipment will be considered as an integral part of the package.

G. All starters, disconnects and control devices shall be clearly labeled with black lamacoid plates with engraved white letters, to indicate Owner's identification number, function and the equipment which they control. Submit list of labels for review.

2.18 ZONE CONTROL AND INSPECTOR'S TEST STATIONS

A. Furnish and install Inspector's test stations at all zone control valve stations and flow switch locations to permit testing of each individual flow switch.

B. Stations shall be as indicated on the drawings and in accordance with NFPA #13. Stations shall consist of OS&Y gate valve with supervisory switch, a check valve, waterflow switch with delay switch, inspector's test valve, auxiliary drain valve, two (one inch) sightglasses and a one inch union with brass orifice disk with hole equal to the orifice size of the smallest sprinkler head in that zone. Victaulic Style 718 "Test Master" with threaded ends, UL listed and FM approved, or approved equal, may be substituted.

C. Piping in and out of test stations shall be Schedule 40 black steel, threaded. A union connection shall be installed on the discharge side of the station.

D. Stations shall be located at all zone assemblies. Maintain the recommended minimum distance beyond flow switch devices.

E. Stations shall be located as low as possible for ease of testing and maintenance, yet high enough to avoid all conflicts including lights, egress, ducts, pipes, etc.

2.19 ACCESS PANELS

A. All work shall be installed so that all parts requiring inspection, operation, maintenance and repair are readily accessible. Minor deviations from the drawings may be made to accomplish this, but changes of magnitude shall not be made prior to written approval from the Architect.

B. Furnish access panels and doors for installation in walls and ceilings at locations indicated on drawings and as required to permit access for adjustment, removal or replacement and servicing of all valves and equipment.

C. Access panels and doors shall be installed under other appropriate Sections for the surface or construction upon which the panels are located.

D. All access panels and doors shall be located in closets, storage rooms and/or other non-public areas, in a workmanlike manner, positioned so that the junction can be easily reached and the size shall be sufficient for this purpose (minimum 12 inches by 16 inches). When the access panels and doors are required in corridors, lobbies or other occupied areas, they shall be located as directed by the Architect.

E. Access panels and doors shall be prime painted and furnished with cylinder lock and two keys as manufactured by Inland Steel Products Company "Milcor", Wash-Hannon, Inc. or "Way-Loctor" or equal. Type shall be as follows:

1.	Acoustical Tile Ceiling	"Milcor" Type A
2.	Drywall	"Milcor" Type DW
3.	Plastered Surfaces	"Milcor" Type K
4.	Masonry Construction	"Milcor" Type M
5.	1-1/2 Hour, 3-Hour or 4 Hour Rated	"Milcor" rated to equal ratings of surface doors installed in.

F. Access panels and doors in structural or glazed tile walls shall be equal to Continental metal products no. 1212MF, 14 gauge Type 304 satin finish stainless steel, minimum 12 inches by 12 inches.

G. Access panels shall be in accordance with the manufacturers and model numbers indicated in the Miscellaneous Specialties Section of the specification.

H. Access panels and doors Shop Drawings shall be submitted to the Architect for review.

I. Inform the Applicable Section Subcontractor where access is required through ceilings in order that special clips for access can be provided.

J. Access panels and doors shall be rated as required to maintain rating of surface they are installed in.

2.20 DRAIN CONNECTIONS

A. Drain connections shall be provided in the systems as required to comply with the Standards of NFPA #13 and #14. Drains shall be provided at all low points in the piping and wherever necessary to insure that all portions of the sprinkler piping may be completely drained. Drain valves shall be provided with caps and chains.

B. Drip legs with less than 5 gallon capacity shall be provided where required on all dry systems.

2.21 HANGERS AND SUPPORTS

A. Furnish and install hangers and supports to attach all pipes securely to the structure in correct alignment and pitch, to prevent vibration and to effectively care for expansion and contraction. Parts in contact with copper pipe or tubing shall be copper plated, and chrome plated for chrome plated piping, etc.

B. Spacing for horizontal piping shall be as follows:

1. Copper Tubing: 6 feet on centers for 1-1/4 inch and smaller, 10 feet on centers for 1-1/2 inch and larger and as per NFPA 13 and 14.

2. Steel Pipe: 6 feet on center for 1-1/4 inch and smaller, 10 feet on center for 1-1/2 inch and larger and as per NFPA 13 and 14.

C. Vertical lines shall be adequately supported at their bases by a suitable hanger placed in the horizontal line near the riser and clamped at every 10 foot interval vertically.

D. Vertical lines shall be supported at each floor level if the floor-to-floor dimension is greater than 10 feet, and if this is approved by the pipe manufacturer's guidelines for that type of pipe joint system.

E. Piping supported from structural steel shall have beam clamps and hangers consisting of threaded rod and hangers. Carpenter-Patterson No. 1-A steel band hanger for piping 2 inch and smaller and No. 100 steel clevis hanger for piping 2-1/2 inch and larger, sized to suit for continuous insulation, with pipe shields.

F. Where piping is required to be hung from other than stone concrete slabs, such as precast or metal decking, submit proposed method of support to the structural engineer for approval prior to installation.

G. All hangers and devices for buried piping shall be hot dipped galvanized.

H. Seismic Pipe Hanging Requirements:

1. Seismic protection of all fire protection piping systems and equipment shall comply with the requirements of NFPA 13 and the State Building Code.

2. This Subcontractor shall have the option of substituting alternate seismic supports and anchors; provided his submittals are accompanied by calculations and shop drawings signed and sealed by a Licensed Professional Engineer in the State.

3. All mechanical materials and equipment including all pipes shall be supported and anchored to resist the external seismic forces for seismic hazard exposure Group and seismic performance category, per the code. Force shall be resisted without failure or permanent displacement when it is applied in any direction.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide materials and equipment as shown and specified as required to provide complete and satisfactory operating systems, omitting only those items specifically excluded. Make connections to equipment, devices, etc. provided or installed under this Section as shown and specified.

3.2 MATERIALS AND WORKMANSHIP

A. Work shall be executed in a workmanlike manner and shall present neat and mechanical appearance when completed. Piping shall run concealed except in mechanical rooms and areas where no ceiling exists.

B. Work and workmen shall be fully insured as required.

C. Material and equipment shall be furnished new.

D. Owner will not be responsible for material and equipment prior to testing and acceptance.

3.3 BULLETINS, MANUALS AND INSTRUCTIONS

A. Furnish three (3) copies of Operation, Lubrication and Maintenance Manuals for each piece of equipment.

3.4 INSTALLATION OF EQUIPMENT

A. Equipment shall be installed to avoid interference with structure and with work of other trades.

B. Equipment shall be installed so as to properly distribute equipment loads.

C. All steel supports and hardware for proper installation of anchors, guides and hangers shall be provided.

D. Provide hangers, brackets and shelves for the proper installation of equipment.

3.5 PROVISION FOR PIPE EXPANSION

A. Make provisions for pipe expansion and contraction with suitable anchors and offsets.

B. Install piping to allow freedom of movement in all planes without imposing undue stress on any Section of the main piping, branch piping, equipment and structure.

3.6 CUTTING AND PATCHING

A. Refer to the General and Supplementary Conditions and DIVISION 1.

B. Give notification in time to other trades of openings required for Sprinkler Work, Supply accurate details of location and size. When this requirement is not met, bear the cost of cutting and patching.

C. The General Contractor will do all cutting and patching required for the installation of the Fire Protection Work.

D. Obtain written approval of the Architect before cutting any openings through structural members.

3.7 PIPE GUIDES AND ANCHORS

A. Provide pipe guides for expansion joints and loops according to expansion joint manufacturer's published recommendations. Use at least two guides each side of expansion joint or loops.

B. Install manufacturer or field fabricated alignment guides to allow movement in axial direction only. Install vertical risers properly anchored and guided to maintain accurate vertical position of piping. At time of start-up, clean and lubricate guides, and adjust to allow free sliding at operating conditions.

C. Fabricate anchors from structural steel channels, plates or angles secured to the structure.

D. Take care to avoid introduction of excessive reactive forces and operating weights into the structure and onto equipment and piping.

E. Prepare and submit for review, prior to installation, drawings showing the location of expansion joints and anchors. Show details of proposed connection to structure.

3.8 INSERTS

A. Properly locate and firmly secure inserts to form before any new concrete is poured, for new construction.

B. For support of light equipment and materials, approved self-drilled expansion shields may be used.

C. Where inserts must be placed after concrete has been poured, use self-drilling (Red Head) expansion shield inserts as approved by the Architect.

D. Place inserts only within main structure and not in any finishing material.

E. When inserts are required in precast concrete, supply inserts and location drawings to the precast concrete supplier for casting into the material. Otherwise, include the cost of having the precast concrete supplier install inserts at the site.

F. Use wedge type concrete inserts, similar to Grinnell Fig. 281, for pipe and equipment hangers, supports and anchors, adequately sized for loads to be carried.

G. All inserts shall be in accordance with NFPA.

3.9 HANGERS

A. All hangers and supports shall be in accordance with NFPA.

B. All hangers shall be suspended directly from beams and the top chord of joists. Hangers shall not be suspended from the bottom chord of joists, or from standard gauge metal decking. Hanging from all other items, such as structural metal decking, etc., shall require the approval of the Architect.

C. Suspend piping and equipment with all necessary hangers and supports required for a safe and workmanlike installation. Ensure that pipes are free to expand and contract and are graded properly, and that each hanger is adjusted to take its full share of the weight.

D. Suspend hanger rods directly from the structure. Do not suspend from pipes, ducts, equipment, metal work, or ceilings.

E. Supply and install auxiliary structural steel angles, channels and beams where piping and equipment must be suspended between joists or beams.

F. Hangers shall be spaced to ensure that structural steel members are not overstressed. In no case shall pipe hangers be further apart than indicated in the tables. Where appropriate, include details on the "Fire Protection Working Drawings" of hangers as well as showing locations and magnitude of piping and equipment loads on the structure.

G. Support of the sprinkler systems at the skylights and cupolas shall be subject to the approval of the skylight manufacturer. Close coordination and attention shall be given to the type of and placement of hangers at these locations to ensure that skylight structure is not overstressed.

H. The use of trapeze-type hangers for support of piping shall be subject to prior acceptance. Where permitted, fabricate from angle or channel frames and space hangers to suit the smallest pipe size.

I. Do not use hooks, chains, or straps to support equipment and materials.

J. For precast concrete work, if inserts cannot be cast into members, pass hanger rods between the members and weld to steel plates resting on the upper surface of the precast interval. To prevent raising of the hanger rod, apply a lock nut and two (2) inches minimum diameter slot washer tight against the upper surface of the precast material.

K. Ensure that copper materials are completely isolated from ferrous materials. Use either plastic coated hangers and clamps, or use inserts between copper piping and ferrous materials, and between copper piping and copper coated ferrous materials.

L. All hangers shall have provision for adjustment. Hangers and rods in equipment rooms shall have a prime coat of rust inhibitive paint or cadmium coating.

M. Use round steel threaded rods, which shall conform to ASTM Spec. A-36, diameters as required by NFPA.

3.10 SYSTEM IDENTIFICATION

A. Provide color-coded pipe identification markers on all piping installed under this Section.

B. Pipe markers shall be snap-on laminated plastic equal to "Setmark" by Seton Name Plate Corp.

C. Provide an arrow marker with each pipe service marker.

D. Piping shall be labeled at 40 foot intervals and at the entrance and exit of the fire pump room.

E. In general, 1-1/2 inch high legend shall be used for pipes 4 inch diameter and larger; 3/4 inch high legend shall be used for pipe lines 3 inch diameter and smaller. All identification shall be in accordance with NFPA and ANSI standards.

F. Identify all drains and drain points (by zone), zone control assemblies, equipment, pumps, controls, remote switches, starters, disconnects, pushbuttons and similar equipment as to service with white lamacoid engraved nameplates with black letters. Permanently secure with self-tapping screws. Submit plate description for review.

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

H. Supply and install 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.

I. Prepare a small-scale sprinkler system flow diagram of the piping systems to identify equipment control valves, drains, Inspector's tests and valves. Mount a chart framed under glass where directed. Include these diagrams in Record Drawings.

J. Insert page-size copies of diagrams into each Operating and Maintenance Manual.

K. Install a diagram, framed under glass, on the mechanical equipment room wall. Final location shall be as directed by Architect.

3.11 ACCESS AND ACCESS PANELS

A. Provide proper access to material and equipment which may need inspection, replacement or services. Coordinate locations with General Contractor.

B. Where shut-off valves or other items requiring access occur, furnish access panels for installation under other Sections.

3.12 ESCUTCHEONS

A. Escutcheons shall be installed around exposed pipe passing through finished floors, walls and ceilings. Escutcheons shall be IPS chrome-plated steel or heavy, cast brass, chromium plated, depending upon pipe material, adjustable to fit snugly around pipe with set screw.

3.13 SLEEVES, WALL PLATES, FLOOR PLATES

A. Set sleeves for piping in conjunction with erection of floors and walls, for new construction. Locate sleeves accurately and in accordance with Shop Drawings.

B. Size sleeves to provide for the proper clearance around piping and to allow continuous runs of insulation where specified. Ensure that piping does not touch sleeves. For seismic restrained installations, clearances shall be as per NFPA standards. Where proper clearances cannot be obtained or are not provided, flexible couplings shall be installed on both sides of the sleeve.

C. Pack clearance spaces with Thermafiber Firestopping. Caulk with fire-resistant, resilient waterproof compound, Flintguard 120-13 or equal. Ensure that fire ratings of floors and walls are maintained.

D. Piping sleeves shall be according to the following:

1. Through interior walls, use 18 gauge rolled and tack welded galvanized steel sleeves, set flush with finished surfaces on both sides. Refer to Room Finish schedule.

2. Through exterior walls above grade and roofs, use machine cut and reamed standard weight steel piping, set flush with finished surfaces on inside and to suit flashing on outside.

3. For floors, a water dam is required, use machine cut and reamed standard weight steel piping, 18 gauge rolled and tack welded galvanized steel, or machine cut and reamed plastic pipe set flush to underside of structure and extending 1-1/2 inches above finished floor.

4. Refer to drawing details for sleeving through below grade walls.

5. Cover pipe sleeves in walls and ceilings of finished areas other than equipment rooms with satin finish stainless steel, or satin finish chrome or nickel plated brass escutcheons, with non-ferrous set screws. Do not use stamped steel split plates. Split cast plates with screw locks may be used.

3.14 PAINTING

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

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

C. Furnish items with one (1) coat of anti-rust paint and one (1) coat of flat black enamel to all support steel, hangers and other steel or iron elements of the Fire Protection System, except piping, which will be enclosed or above ceilings when the project is completed.

D. Paint shall be omitted from all items with a galvanized finish.

E. All surfaces to be painted shall be free of dirt, scale, rust, grease and oil. Rust spots are to be wire brushed. Ambient temperature shall be in accordance with paint manufacturer's requirements when painting is being performed.

F. This Subcontractor shall touch up, with spray paint, all scratched or damaged surfaces of equipment with factory finish. Spray paint shall be the same color and type as factory finish.

G. Work under Related Sections shall include the painting of all equipment enclosures, covers, panels, insulation, conduit and other equipment exposed to view, except factory finished items and sprinkler heads. This Subcontractor shall leave surfaces to be painted ready to receive paint. Colors shall be selected by the Architect.

H. This Subcontractor shall furnish and install approved protective "bags" neatly and tightly secured over each sprinkler head, for protection during painting and other finish work. Remove bags when painting is complete.

I. Prime coat materials shall conform to the "PAINTING" Section of the Specification.

J. All finish painting will be done under the Painting Section of the Specifications.

3.15 INSULATION

A. General: All insulation shall be installed in strict accordance with the manufacturer's recommendations and shall be applied by a qualified insulation contractor. Covering shall not be applied on any apparatus or piping until the apparatus and piping have been thoroughly cleaned, tested and accepted as tight.

B. Piping: Pipe Insulation where vapor barrier jacket is required shall be installed with vapor barrier jackets drawn tight and firmly sealed to assure a positive vapor seal. End joints shall be covered with 4-inch wide butt strips of material identical to vapor barrier jackets, and they shall be drawn tight and securely sealed. The use of staples, bands, etc., to secure insulation where vapor barrier jackets is required will not be accepted. Pipe insulation where no vapor barrier is required may be secured with flare type staples.

C. Fittings and Valves: Cement or molded insulation on fittings and valve bodies shall be same thickness as adjacent covering and finished neatly to match the adjacent pipe insulation. Insulation at hangers, anchors and supports shall be neatly cut and fitted.

3.16 CONNECTIONS TO EQUIPMENT

A. Provide unions or flanges at all connections to equipment. Ensure that piping adjacent to equipment is readily removable for servicing and/or removal of equipment, without shutting down the entire system.

B. Install unions in piping up to and including 2-inch pipe size. Install flanges in piping 2-1/2 inch pipe size and larger.

C. Prevent galvanic corrosion by isolating copper and steel. Use red brass adapters, or completely isolate flanges using full face gaskets with bolts installed through phenolic sleeves with insulating fiber washers.

3.17 BACKFLOW PREVENTER PERMIT AND INSTALLATION

A. All backflow prevention devices shall be approved, permitted, installed, maintained and tested in accordance with the requirements of the State and the Local Water Authority. A full size brass discharge line shall be extended to the nearest floor drain.

B. Prior to installation, submit through the Architect, a design data sheet, with plans showing the method of protecting the water system, and secure approval from the Local Water Authority, or its designee. This shall not be done until Shop Drawings have been approved.

C. Immediately upon installation, have the backflow preventer tested by a "Certified Backflow Prevention Device Tester", and the results recorded on the Local Water Authority's Inspection and Maintenance Report Forms. Within 14 days after the installation, through the Architect, the reviewing authority to arrange inspection of the installation.

D. The Approved Tester shall perform the testing utilizing (his own) properly maintained and calibrated, compatible test kit.

E. Three (3) copies of each application and all subsequent correspondence, including the final permit, shall be forwarded to the Architect for record. Availability of final approvals or permits shall be prerequisite to scheduling a final inspection of the Fire Protection work.

3.18 WATER SERVICE ENTRANCE

A. The exterior water service will be brought to the point indicated on the drawings under another Section. This Subcontractor's work shall begin from that point.

B. The water service shall be provided with flexible couplings outside of the foundation wall. Couplings shall be U.S. Pipe, American Ductile Iron Pipe or approved equal.

C. The water service shall be appropriately restrained with thrust blocks, where soil conditions are considered suitable for their use or with Restrained Joint Type Systems. Restrained joints shall include locking mechanical or push-on joints, mechanical joints utilizing setscrew retainer glands, bolted flange joints, heat fused or welded joints, pipe clamps and tie rods, or other approved methods or devices.

3.19 MAIN BUILDING SYSTEM

A. The building Fire Protection systems shall begin as denoted herein and where indicated. Immediately inside the building, provide an OS&Y gate valve with tamper switch.

B. The system shall be designed to handle the design flow with a pressure requirement at the top as required for proper system operation.

C. All connections to alarm valves, dry pipe valves, and equipment shall be provided with OS&Y valves, sized to handle the system they are serving.

D. All normally open valves shall be provided with supervisory switches. In the portions of the system discussed above, this includes, but may not be limited to, the following:

1. Main incoming service OS&Y valve;

2. Isolation valves;

3. Backflow preventer isolation valves;

4. Alarm check valve isolation valves;

5. Dry pipe valve isolation valves.

E. All components of the system described above shall be furnished and installed under this portion of the work.

F. All equipment in the service entry room shall be full size of the service entry or full line size of the line sizes noted on the plans.

3.20 WET BUILDING SYSTEM

A. Furnish and install a complete wet sprinkler system to cover all areas of the building. The system shall commence where indicated on the drawings outside of the building wall, extending into and throughout the building to include all piping, alarm check valves, backflow preventer, zone control valves, fire department connection, alarm bells, heads, flow switches, tamper switches, and any appurtenances and incidentals required to make a complete and operable system. Immediately inside the building, provide an OS&Y gate valve with tamper switch (no exceptions allowed).

B. Piping for the sprinkler systems is not completely shown. Some piping/heads may be indicated to suggest methods of avoiding interferences, etc. It is the intent of the Specification that the Subcontractor complete the hydraulic design of the systems and lay out the piping the most effective way. All piping shall be run concealed where ceilings will be installed. Piping shall be integrated within the structure as structure is presently designed. Sprinkler piping intent is shown in some cases to input specific location requirements. This shall not relieve this Subcontractor from coordinating all exposed and concealed items.

C. Install drain valves, vents and Section valves where required for venting and draining systems and to facilitate repairs to any Section of the systems without shutting down the entire system. Section valves shall be installed for each riser in multiple riser installations. All valves shall be provided with tamper switches.

D. Install pressure gauge connections with valve and cap at top of each riser.

E. Piping shall be designed and laid out to allow flexibility in final head locations relative to other ceiling components and for future alterations. This requires a system of tees facing up with adequate swing elbows and arm-overs to allow for exact final positioning and height of heads.

F. Dry pendent heads shall be installed into "tees" only, not elbows, etc.

G. Each zone shall be provided with a zone control valve assembly complete with OS&Y valve, tamper switch, flow switch, inspector's test station and drain.

H. Water curtain demands shall be added to the full sprinkler demand of each zone as required by NFPA Pamphlet No. 13.

3.21 DRY BUILDING SYSTEM

A. The attic dry system shall begin where indicated and shall include all wafer check valves, dry pipe valves, air compressors, accelerators, pressure switches, alarm bells, Sectionalizing check valves, dry sprinkler heads, pipe, fittings, hangers, and all appurtenances and accessories required to make a complete and operable system. It is a requirement of the Fire Department that an exhauster be provided, to minimize the air evacuation/delay time.

B. Piping for the sprinkler systems is generally not entirely shown. It is the intent of the Specification that this Subcontractor hydraulically design the systems and lay out the pitched piping system in the most effective way. All piping shall be run concealed where ceilings will be installed. Piping shall be integrated within the structure as structure is presently designed.

Sprinkler piping intent is shown in some cases to input specific location requirements. This shall not relieve this Contractor from coordinating all exposed and concealed items.

C. Install drain valves, vents and section valves where required for draining and venting systems and to facilitate repairs to any section of the systems without shutting down the entire system. Section valves shall be installed for each riser in multiple riser installations. All valves shall be provided with tamper switches.

D. Piping systems shall be installed in accordance with NFPA 13 including: pitching/branch lines a minimum of 1/2 inch every ten (10) feet and cross/feed mains 1/2 inch every ten (10) feet. Low point drainage shall be: a one inch nipple and cap for areas of less than 5 gallons and a heat traced drip drum for areas with capacities greater than 5 gallons.

E. Maximum volume of each System/Zone shall not exceed 500 gallons.

F. Accelerators and exhausters shall be provided, to meet all system requirements and water flow delivery time requirements.

3.22 TESTING

A. Testing and flushing of the sprinkler systems shall be done at the expense of this Subcontractor and with equipment furnished by him. Testing shall be done in the presence of duly authorized inspectors and representatives of the Architect and Owner within forty- eight (48) hour notice given those authorities. Prior to testing, the system shall be thoroughly flushed with clean water.

B. The system shall be repaired and retested until made perfect, without additional expense to the Owner.

C. To test piping, subject it to a two-hour hydraulic test of 200 psi, and as required by NFPA and the Owner's Insurance Underwriter. Piping shall be repaired until such tests show no leaks. Where required, and depending on the building timing and schedule, the system may be required to be tested without final swing elbows and heads installed. In this case, a second test will be required upon installation of swing elbows and heads.

D. Material and test certificates must be signed by the Owner's Field Representative prior to and upon completion of testing. Final test reports must be approved in writing by local authorities.

E. Results of tests shall be recorded and submitted using the forms in NFPA #13 and #20, for review by the Architect. The Material and Test Certificate shall also be sent to the Owner and Owner's Insurance Underwriter.

F. This Subcontractor shall test all underground piping installed under this Section as well as ensure that the underground piping from the street main to the start of the work under this Section has been tested to 200 psig in accordance with NFPA 24 requirements, prior to the system being connected, and at a rate equal to the maximum system demand, or a rate producing a velocity of 10 fps, whichever is greater. This shall be recorded separately from the interior piping. Coordinate this with the water piping installer beyond the limit of work of this Section.

G. Provide all necessary and appropriate personnel to participate in and coordinate sprinkler systems with all fire alarm testing, or other systems testing which may interface with sprinkler system. Participation shall include all preliminary testing, walk-through testing prior to official walk-through testing and any re-testing if required.

H. Where Insurance Service Office (ISO) review is required, the Fire Protection Subcontractor shall be sure that:

1. Plans and calculations are sent for review to ISO, 100 Newport Avenue, CS1700, Quincy, MA 02269, and that all required changes are made.

2. The certificate covering materials and tests is filed with ISO.

3. That ISO has been given the proper notification, and that they are present for the 2 inch main drain test.

4. That the underground test certificate is filed with ISO. Coordinate with the Site Contractor.

3.23 COMPLETION

A. Remove oil and dirt from equipment surfaces and bases.

B. Clean all items and equipment.

C. Leave sprinkler work in a new, working order.

3.24 INSTRUCTIONS TO OWNER

A. After completion of assembly and installation of all systems, equipment and piping required under this Section of the Specifications, the Owner's supervisory and operating personnel shall be instructed regarding the operation and maintenance of the systems. The instruction shall be given by the Fire Protection Subcontractor and other qualified personnel who are thoroughly familiar with all systems and shall be furnished for a time period as directed by the Architect.

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

C. Thoroughly instruct the Owner's authorized representative in the safe operation of the systems and equipment.

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 or persons giving instructions.

5. Names persons of being instructed.

6. Other people present.

3.25 INSPECTION

A. Periodic inspections of the work in progress may be made to check general conformity of the work to the Drawings and Specifications.

B. Correct all deficiencies immediately upon notification.

3.26 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 Fire Protection Subcontractor, who shall not waive any responsibility because of trial usage.

3.27 SPECIAL DESIGN CONSIDERATIONS

A. Perform hydrant flow tests, satisfactory to NFPA and the Underwriter's requirements, and in conformance with the timing and requirements of the Local Water Department/Authority.

B. Sprinklers shall be provided in all areas including electric rooms, electric closets, etc.

C. Maximum head spacing shall be:

1. 225 SF for Ordinary Hazard.

2. 375 SF for Light Hazard, Standard Coverage.

3. 196 SF for Light Hazard, extended coverage.

D. The systems shall be hydraulically designed and supported by hydraulic calculations. Fire Protection Working Drawings and complete hydraulic calculations shall be provided for approval showing the proposed layout of piping based on hydraulic calculations.

E. The pressure cushion available from the supply source shall be a minimum of 10% above or 10 psig greater than the required demand pressure, whichever is greater. In addition, the available supply flow shall be a minimum of 10% greater than the required demand flow, at the required demand pressure.

F. Galvanized pipe (including the inside of the pipe) shall be used in all dry pipe, sprinkler systems. A Hazen-William's "C" value of 120 shall be used in wet system hydraulic calculations; C = 100 in dry systems.

G. All sprinkler heads shall be either 155°F rated or 212°F rated, with an orifice size of 1/2 inch.

H. Minimum and maximum sprinkler head capacity pressures shall be in accordance with UL listings and FM approvals for the heads being installed.

I. Flushing connections shall be provided at the most hydraulically remote ends of the crossmains. All branch lines on gridded sprinkler systems shall be arranged to facilitate flushing; this requires that one end of each branch line be detachable.

J. The systems shall be designed in complete accordance with and as defined in NFPA and as required by the Insurance Underwriter and the Fire Department. Systems shall be designed to provide for the minimum required water densities over the hydraulically most demanding rectangular areas as follows. (Note: The NFPA 40% reduction in the most remote area for light and ordinary hazard designs is not allowed. The minimum design area for any system shall be 1,500 SF.):

1. Provide for the proper hose allowance and cushion.

2. Where concealed type heads are utilized, Ordinary Hazard Group I occupancy shall be used.

3. Ordinary Hazard, Group 1: 0.15 GPM over 1,500 SF for storage rooms, mechanical rooms and similar type areas.

4. Light Hazard: 0.10 GPM over 1,500 SF for all other areas.

K. Velocities shall not exceed 20 fps for piping above grade and 16 fps for buried lines.

L. The dry sprinkler system shall further be designed and laid out as follows:

1. Each system branch shall be limited to a maximum water volume of 500 gallons (from the check valve).

2. Gridded dry pipe systems shall not be allowed.

3. Maximum trip (response) time shall be 30 seconds, with the exhauster; this time being defined as the time required to deliver water to the most remote sprinkler head, starting with the normal air pressure on the system and at the time of opening of the sprinkler head.

4. Areas shall be increased by 30%.

5. All design shall comply with NFPA.

6. Maximum velocity in the systems shall be limited to 20 feet per second.

3.28 WELDING

A. All welding shall be done in accordance with the welding procedures of the National Certified Pipe Welding Bureau, only by certified welders with certification provided prior to the start of work. Long radius welding fittings shall be installed on all weld lines. Branches from main piping shall utilize welding tees where branch size is main size or two (2) nominal sizes smaller except, where main is two and one-half (2-1/2) inches or larger and branch size is two (2) inches or smaller utilize Thread-o-let. Weld-o-lets shall be utilized where branch size is two and one-half (2-1/2) inches or larger and main is three (3) sizes larger than branch. Mitering of pipe to form elbows, tees, or similar construction will not be permitted. All pipe to be welded shall be cut off clean in pipe machine and beveled.

1. The Fire Protection Subcontractor is required to have a Qualified Welding Procedure, approved by a testing laboratory. Welders are required to be certified to this procedure by a testing laboratory. If welders cannot present documentation or certification and continuous employment, recertification is required.

3.29 FLOW TESTS

A. This Subcontractor shall perform flow tests satisfactory to the Engineer of Record, the Owner and the Owner's Insurance Underwriter, as the basis for the installation of the Fire Protection Working Drawings and for hydraulically calculating the systems and verifying service size. This Subcontractor shall review the test data with the Engineer of Record and the Underwriter, as appropriate, to settle on which data to use, prior to performing the final hydraulic calculations. It shall be pointed out that the "Default Selection" is to use the most conservative data (between the spec and the new flow tests). The flow test results shall be forwarded to the Architect with the Fire Protection Working Drawings. Both the Engineer of Record and, as applicable, the Insurance Underwriter, shall be given proper notice and the opportunity to participate in and to witness the tests. Tests done without the involvement of the Engineer of Record are subject to being rescheduled and redone.

B. Note: The 'design' hydraulics are based on a 'clean' 6 inch line from Congress Street. Upon the General Contractor opening the existing 6 inch line in Brown Street, pictures and an assessment shall be made of the condition of the existing 6 inch line. Rodding and/or cleaning, or replacement, may be required to insure a properly hydraulically functional system.

C. Flow tests shall not be performed until all new site water system work has been installed and approved, but prior to the design of the interior distribution systems. Therefore, the final hydraulics and system sizing depend upon the timing of this work. It is incumbent upon this Subcontractor to help coordinate and expedite this work as well as to be prepared to work within the schedule.

D. Coordinate the timing of the flow tests with the approved project timing/phasing.

E. CAUTION: The water flow data provided herein was used strictly for preliminary design purposes and shall not be construed as final design data for the sizing of the systems.

F. Flow test timing shall be coordinated with the General Contractor and the Local Water Authority so as to occur after the completion of installation of new street mains and prior to commencement of installation of interior distribution systems.

G. All tests shall be done at times which are most representative of the usual demands which would be placed on the system; preferably at 9:00 a.m., Monday to Friday.

H. Provide local paid advertisements of the flow tests, if required by the Water Authority, and coordinate with the Local Authority's requirements and timing of performing the tests. Obtain water maps and understand the water system in the area and the directions of flow. Ensure that no valves in the system are faulty or closed. Select the hydrants for testing which will provide for the best and most comprehensive results. Locations for flow tests and hydrants for testing shall be reviewed with the Engineer of Record prior to performing the tests. Perform as many tests as are required to obtain accurate results which are representative of the system. Obtain tank level readings for tank fed systems, and the status of all system pumps, at the time of testing.

I. The following hydrant flow test data was obtained and used as the basis for the "design" documents. This Contractor shall perform new tests as a basis for the "installation" documents.

1.	Date/Time:	7/31/2003
2.	Location/Street:	Congress Street, Hyd. 081/460
3.	Main Size:	8 inch
4.	Direction of flow:	Unknown
5.	Butt elevation/size:	Unknown
6.	Static:	78 psig
7.	Residual:	76 psig
8.	Flow:	1,321 gpm

3.30 RUBBISH REMOVAL

A. Remove from the site and legally dispose of all cartons of rubbish and debris resulting from work under this Section not less than once per week.

3.31 CORE DRILLING

A. All core drilling required for the installation of the Fire Protection systems shall be done by this Subcontractor. This Subcontractor shall carry all costs for core drilling. The General Contractor will not be responsible for any circular penetrations required for the proper installation of the sprinkler systems. Locate all required openings and prior to coring, coordinate the opening with the General Contractor and all other trades. Do not disturb existing systems. Thoroughly investigate the existing conditions in the vicinity of the required opening prior to coring. This Subcontractor shall be responsible for damages to the building and its systems from the coring operations. Disturbances from coring shall be kept to a minimum.

3.32 PHASING

A. Work may be performed in phases and this Subcontractor shall provide all necessary temporary valves, fittings, piping, shutdowns, labor, tools, etc., to comply with the approved phasing schedule. Piping and devices installed in one phase, to serve future phases, shall be valved and capped to allow systems to remain clean and operational and to facilitate extensions in future phases without shutdown of the previous phases.

3.33 SHUTDOWNS AND CONTINUITY OF SERVICE

A. The Fire Protection Subcontractor shall work with the building owner in maintaining integrity of all fire protection systems in adjacent buildings as well as floors not under renovation. Coordinate and minimize any and all shutdowns of the fire protection system as follows:

1. Give proper notice to building manager and proper notice to all other authorities having jurisdiction when making shutdowns and pay all fees required.

2. Perform all duties required by owner when making a shutdown.

3. Fill out a shutdown notice form answering all items requested such as time and location of shutdown, systems affected, areas affected, etc., when requesting a shutdown.

4. Fire watch may be required during a shutdown.

5. Duration of shutdowns shall be kept to a minimum.

6. In no case shall the sprinkler system be shut down during off hours of work day without a fire watch.

7. System shall be returned to normal operating conditions at end of each work day.

8. Do not interrupt existing services without Owner's approval and notification of all authorities having jurisdiction.

9. Schedule interruptions in advance, according to Owner's instructions. Submit, request for interruption with methods proposed to minimize length of interruption, in writing.

END OF SECTION 15300

SECTION 15400 - PLUMBING - INDEX

PART 1 - GENERAL

PART 2 - PRODUCTS

SECTION 15400 - PLUMBING INDEX (CONT'D)

PART 2 - PRODUCTS(CONT'D)

PART 3 - EXECUTION

SECTION 15400 - PLUMBING INDEX (CONT'D)

PART 3 - EXECUTION, CONT'D

SECTION 15400 - PLUMBING

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. Include GENERAL CONDITIONS and applicable parts of Division 1 as part of this Section.

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

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

D. Cooperate and coordinate with all trades in execution of the work described in this Section.

E. Where referred to, Standard Specifications of Technical Societies, Manufacturer's Associations, and Federal Agencies shall include all amendments current as of the date of receipt of bids.

F. It is intended that the Manufacturer's name used first throughout this Section of the Specification, is that used in the design of the PLUMBING systems. All material submitted shall be equal in all respects to that used in the design.

G. Fully coordinate all work under this Contract with the proper and approved project phasing.

H. All work shall be performed in strict accordance with the State Building, Plumbing and Fuel Gas Codes, all Local Codes and requirements and with the standards mentioned herein.

I. Before starting work of this Section, visit site and examine conditions under which work must be performed including preparatory work done under other Sections or Contracts or by Owner. Report conditions that might affect work adversely in writing through Contractor to Architect. Do not proceed with work until defects have been corrected and conditions are satisfactory. Commencement of work shall constitute acceptance of existing conditions and preparatory work.

J. This Subcontractor shall work out the "means and methods" of performing the work with the General Contractor.

K. Refer to the Alternates Section, for Alternates which may affect work of this Section.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide all labor, equipment, material, implements and materials required to furnish and install all Plumbing work, complete as shown on the Drawings and noted herein, including but not limited to:

1. Domestic water service from a point indicated on the Drawings outside the building wall, to all fixtures and outlets.

2. Building sanitary sewers extending to points indicated on the Drawings outside building wall.

3. Building storm sewers extending to points indicated on the Drawings outside the building wall.

4. Complete interior sanitary, waste and vent system serving all fixtures, outlets and waste points.

5. Complete interior roof storm drainage system.

6. Complete interior domestic hot and cold water piping systems.

7. Plumbing fixtures and trim.

8. Pumped domestic hot water recirculation water systems.

9. Complete natural gas piping system extending from the house side of all meters and connecting to all equipment and outlets, including venting of all gas line devices.

10. Backflow preventers.

11. Water meter and accessories.

12. Insulation.

13. Sump pump.

14. Domestic water heaters.

15. Hose bibbs and wall hydrants.

16. Piping, valves, fittings, unions, flanges, couplings and pipeline accessories.

17. Hangers, supports, plates and inserts.

18. Cleaning, testing and disinfection.

19. All supplementary steel for piping and equipment.

20. Guarantees.

21. Drilling for installation of inserts.

22. Drains.

23. System and equipment identification.

24. Shop Drawings and Submittals.

25. Permits, fees and inspections.

26. System and equipment start-up and Owner instructions.

27. Operating and Maintenance Manuals.

28. Receptors for condensate drainage.

29. All work herein specified and shown on the Drawings.

30. Thrust blocks and related supports and restraints.

31. All hoisting and rigging required for the Plumbing work.

32. All scaffolding and staging required for the Plumbing work.

33. Cutting through non-masonry construction.

34. Core drilling.

35. Final connections to all utility lines.

36. Record Drawings.

37. Coordination Drawings.

38. Firestopping.

1.3 RELATED WORK UNDER OTHER SECTIONS

A. The following related items of work are included under other Sections:

1. Pads, concrete bases and form work.

2. Saw cutting, trenching, excavation and backfilling.

3. Dewatering.

4. Cutting and patching (except drilling for hangers and providing openings in metal decks). However, this work shall be paid for by the Plumbing Subcontractor where this is due to his omissions or negligence.

5. Demolition and Removal: The Plumbing Subcontractor shall drain, disconnect, cap components and make safe for removal by the General Contractor. All existing fixtures, fittings, piping and components shall be removed. Verify scope in the field.

6. Toilet room accessories.

7. Utilities (such as storm, sanitary and water) beyond points indicated on the drawings from the building walls.

8. Site drainage.

9. Flashing of roof penetrations and setting sump receivers.

10. Painting of all exposed plumbing equipment not having enameled surfaces, stainless steel or chromed finishes.

11. Extension of city water piping and fittings including insulation, connecting to HVAC equipment.

12. All power wiring of every description. All starters and controllers for mechanical equipment, except where provided as integral with mechanical equipment, shall be provided under Electrical Section.

13. Utility structures, including foundation drain pumping system.

14. Irrigation systems.

15. Gas service and meters (by Gas Company).

16. Structural supports necessary to distribute loading from equipment to roof or floor.

17. Fire service piping.

18. Sub-soil, foundation and underslab drainage systems.

19. Sprinkler drains.

20. Wood blocking and grounds.

21. Gutters, downspouts and boots.

B. Furnish the following materials to be installed under other Sections:

1. Drain sump receivers.

2. Flashing.

3. Access panels to be installed under applicable Sections.

1.4 INTENT

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

B. Consider the Specifications as 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. 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.

Provide fully qualified personnel to fulfill this requirement. Be responsible for prompt replacement of defective materials, equipment and parts of equipment and related damages.

1.5 STANDARD OF MATERIALS AND WORKMANSHIP

A. Refer to Division 1 for general instructions and, in addition, adhere to the following:

1. Workmanship and installation methods shall conform to the best 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 written 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. Run piping parallel with or perpendicular to building planes.

5. Conceal piping 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, and shall conform to and be installed in strict accordance with Federal, State and City or Town requirements and shall meet all of the requirements of all Authorities having jurisdiction.

8. All products shall be Massachusetts State Plumbing Board approved, as required.

1.6 ABBREVIATIONS AND DEFINITIONS

A. "This Subcontractor", and "This Contractor" mean specifically the Plumbing Subcontractor working under this respective Section of the Specifications.

B. "Equipment" as mentioned and intended herein shall mean any and all plumbing fixtures and equipment.

C. The terms "storm drainage" and "rainwater drainage" are synonymous and are used interchangeably.

D. "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 and equipment referred to, unless otherwise specified.

E. "Concealed" shall be defined as areas where piping is located in chases, shafts, and furred ceilings. All other piping shall be considered "exposed".

F. "Exposed" shall mean within sight in closets, in finished rooms, under counters, behind and/or under equipment and/or otherwise visible.

G. "Underground" shall mean pipe, conduit or equipment that is buried exterior to or within the building.

H. "Finish grade" as used herein means the final grade elevations indicated on the Drawings.

I. "Piping" shall mean and include pipe, fittings, hangers and valves.

J. "Tempered water" shall be considered the same as hot water.

K. "Date of acceptance", as it is used in reference to the guarantee, shall mean that date upon which the system or equipment is turned over and accepted by the Owner complete with initial start-up and the Owner's instruction period.

L. The terms "General Contractor" and "Construction Manager", as used herein, are intended to be interchangeable depending on the type of Contract that the Owner has entered into.

M. "FFEC" shall mean the "Food Facilities Equipment Subcontractor".

1.7 EXAMINATION

A. Examine the Specifications and Drawings of all other Sections before bid.

B. Report in writing, any discrepancies and deficiencies which may adversely affect the work, prior to close of bid.

C. 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 STANDARDS

A. The latest published issue of the standards, recommendations and requirements of the following listed Societies, Associations and Institutes in effect at the date of Contract are part of this Section. These shall be considered as minimum requirements. Specific requirements of this Specification and/or associated Drawings shall have precedence. In case of conflict between published requirements, the most stringent is to be followed.

1. ADA - Americans with Disabilities Act
2. AGA - American Gas Association
3. ANSI - American National Standards Institute
4. ASME - American Society of Mechanical Engineers
5. ASTM - American Society for Testing and Materials
6. AWWA - American Water Works Association
7. FM - Factory Mutual
8. IEEE - Institute of Electrical and Electronic Engineers
9. MCAA - Mechanical Contractors Associations of America
10. NEMA - National Electrical Manufacturers Association
11. UL - Underwriters' Laboratories, Inc.
12. OSHA - Occupational Safety and Health Act
13. N.E.C. - National Electric Code

14.	CISPI	-	Cast Iron Soil Pipe Institute
15.	PDI	-	Plumbing and Draining Institute
16.	CDA	-	Copper Development Association
17.	DPW	-	The Local Water and Public Utility Departments
18.		-	Maine Plumbing and Fuel Gas Codes

1.9 DRAWINGS

A. The Plumbing Drawings are intended to show approximate locations of apparatus, fixtures and piping in diagrammatic form. The Plumbing 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 and from site measurements. Check locations and elevations before proceeding with work.

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

D. Leave areas clean where space is indicated as reserved for future equipment.

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

F. Where "roughing-in" only for equipment, which is not part of this Section, obtain accurate information before proceeding with the work.

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

H. Refer to Architectural Drawings for fire ratings of walls and slabs. This Subcontractor shall be fully responsible for sealing all penetrations to maintain the required fire ratings.

1.10 FABRICATION OF MATERIALS

A. Before prefabricating piping for installation, make certain that such items can be installed as intended on the 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 piping is prefabricated prior to the investigation and reaching of a solution to possible interference problems, necessary changes in such prefabricated items shall be made at no extra cost to the Owner.

C. In case of any difference between the Specifications and Drawings, or where the Specifications or Drawings require clarification, the subject shall be referred to and decided by the Architect whose decision shall be final. Otherwise, any adjustments shall be made at no expense to the Owner.

1.11 PERMITS, FEES, INSPECTIONS & CERTIFICATES

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

B. A copy of the Plumbing and Fuel Gas Codes shall be on hand when an inspection is conducted.

C. Be fully acquainted with and obey all Federal, State, and Municipal Laws, Bylaws, Codes and Regulations, and all Authorities having jurisdiction.

D. 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.

E. 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.

F. If any work is covered up without inspection, it shall, if required, be uncovered for examination and made good at no extra cost to the Owner.

G. Furnish all certificates necessary as evidence that the Plumbing work conforms to the requirements of all Authorities having jurisdiction.

H. Make changes, if required, to make the Plumbing work conform to all laws, bylaws, codes, and regulations.

1.12 RECORD DRAWINGS

A. Refer to and coordinate with the GENERAL REQUIREMENTS, DIVISION 1, and SECTION 01700.

B. Refer to Section 01300 for requirements regarding the use of Contract Drawing AutoCAD files.

C. Maintain at the job site at all times a complete set of blackline prints of the Plumbing 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 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 when reviewing the monthly applications for payment submitted by the Plumbing Subcontractor.

F. When the Plumbing Subcontractor has completed his work, he shall submit for preliminary review through the Contractor two (2) sets of job record prints for review and approval.

G. When this procedure has been accomplished to the satisfaction of the Owner, the Plumbing Subcontractor shall furnish to the Architect the following:

1. The marked up job record blackline prints.
2. The reproducible revised transparencies entitled "Record Drawings" marked with the date when printed and signed by the Plumbing Subcontractor.
3. Three (3) complete sets of blackline prints of the "Record Drawings".
4. Record Drawings on AutoCAD Release 14, or higher.

   NOTE: Distribution will be by the Architect.

1.13 OPERATION AND MAINTENANCE DATA

A. Refer to and coordinate with DIVISION 1 and SECTION 01700, for submittal procedures pertaining to operating and maintenance manuals.

B. Assemble indexed hard cover manuals entitled "Operating and Maintenance Instructions for Plumbing System".

C. Submit for review before instructions to Owner are commenced. Instruct the Owner as to the operation-maintenance of the system.

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 page-size fixture and equipment Shop Drawings including any Control Drawings.
3. A lubrication schedule of all specified equipment.
4. Exploded views of equipment showing names of parts and parts numbers.
5. Fixture and equipment identification list with serial numbers.
6. Page-size valve tag schedule and flow diagrams.
7. Final water balancing report of fixtures and equipment.
8. Water sterilization procedure and tests.
9. Names, addresses and phone numbers of all suppliers and service personnel for all equipment.
10. Copies of all product equipment and system guarantees from manufacturers, including signed written guarantee of system from this Subcontractor.

1.14 SHOP DRAWINGS

A. Refer to and coordinate with DIVISION 1 and SECTION 01300, and as applicable, the other Sections for Shop Drawing requirements. The Plumbing Subcontractor shall also submit the additional information noted herein.

B. Refer to and coordinate with Division 1 and, as applicable, the other Sections for Shop Drawing requirements. Refer to Section 01300 for policies regarding the use of Contract Drawing AutoCAD files.

C. It is the responsibility of the contractor, to ensure that all materials that are submitted, and used on the project, are approved by the State.

D. Shop Drawings shall be submitted for all items and equipment furnished under this Section.

E. Present, immediately after award of the Contract, a list of Shop Drawings to be submitted with the name of the intended manufacturer and supplier.

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

G. Submit for review, the required number of copies of certified Shop Drawings of all equipment, materials, equipment wiring diagrams, motors, starters, controls, and schedules. Ensure that Shop Drawings have adequate clear space for all stamps. When requested, resubmit Shop Drawings promptly.

H. Include for each pump, a performance curve showing duty and horsepower with design operating point indicated clearly.

I. Submit sound power levels of all pumps and equipment.

J. Be responsible for the processing of Shop Drawings 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 proposed alternative equipment and materials, and that which is specified.

L. Each Shop Drawing shall indicate clearly the correct name and address of the project, the intended use and location of the equipment, and the Specification paragraph number.

M. Upon receipt of reviewed Shop Drawings, distribute prints to all trades and manufacturers affected.

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

O. Bind one set of the corrected "Reviewed" Shop Drawings in each Operation and Maintenance Instructions Manual.

P. Prior to submission of Shop Drawings, the Plumbing 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 Shop Drawings. The Plumbing Contractor 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 by the Architect. Review of the Shop Drawings shall not relieve the Plumbing Subcontractor from the responsibility for departures from the Contract Documents. Errors in Shop Drawings shall be the sole responsibility of the Plumbing Subcontractor whether the Drawings are reviewed or not.

Q. The Plumbing Subcontractor shall submit to the General Contractor, for transmittal to the Architect, any samples requested by the Architect. Submittal, review, and approval of samples shall be in accordance with DIVISION 1.

1.15 PROJECT COORDINATION

A. Refer to SECTION 01300 - Coordination for General Requirements for the preparation and submittal of Coordination Drawings.

B. Before work progresses, coordinate with and obtain approved copies of the HVAC Contractor's "Coordination Drawings" and, in addition to the Shop Drawings listed herein, Coordination Drawings shall be prepared by the Plumbing Subcontractor at a suitable scale not less than 1/4 inch equals one foot.

C. Coordination Drawings shall be done on AutoCAD Release 14 and shall show how Plumbing systems are to be installed and where conflicts with the work of other trades may occur. The Contractor, before transmittal of the Coordination Drawings to the Architect for approval, may require the Plumbing Subcontractor to revise the Coordination Drawings and to make reasonable modifications in the layout of the Plumbing work, so that the Plumbing may be properly accommodated without interference with work of other trades. The PLUMBING Subcontractor shall make such revisions to Coordination Drawings, when requested, without extra charge.

D. Coordination Drawings shall also be done for changes in the Plumbing and adjoining work where an approved substitution of Plumbing equipment requires such changes in the Plumbing work or in the adjoining work of any other trade.

E. Coordination Drawings shall include concrete equipment bases and any other work to be performed by other trades as required for the installation of Plumbing work.

F. On renovation projects, Coordination Drawings shall show all existing piping, equipment and items that are to remain in use.

1.16 PROTECTION

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

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

C. Make good any damage caused by improper storage, handling, or installation of equipment and materials.

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

1.17 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. Conform to requirements of Project Coordination Section.

B. Coordinate work with other trades to provide maximum accessibility for maintenance and operation.

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

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

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

F. Prior to performing any digging, "DIG-SAFE," the utility underground plant damage prevention authority shall be contacted. Notification shall be made at least 72 hours prior to the work: 1-888-DIG-SAFE.

1.18 WARRANTY

A. Conform to and coordinate with DIVISION 1 - GENERAL REQUIREMENTS.

B. All equipment, material and workmanship shall be warranteed, as set forth in the Contract, or for longer periods when stated in the Specifications. At a minimum, all equipment and systems shall be warranteed for a period not less than one (1) year from the DATE OF ACCEPTANCE by the Owner.

C. If any equipment or material does not match the manufacturer's published data or specially supplied rating schedules during performance tests, replace without delay the defective equipment or materials. Bear all associated costs to eliminate any charges to the Owner and adjust all components to achieve the proper rating.

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

E. Written warranty shall be included in the operation and maintenance manuals.

1.19 DEMOLITION AND REMOVAL

A. Be responsible for the draining, disconnection, capping and making safe of all items to be removed. Drop all "unsafe" materials to the floor. All removals will be done by the General Contractor.

B. Coordinate the timing of disconnections and removals, and all related utility and system shut downs with the General Contractor and the approved phasing schedule.

C. Identify and mark all system components scheduled to be removed and coordinate the timing with the Project Superintendent.

D. Demolition shall consist of service shut downs, draining, disconnections, capping of abandoned utilities behind the new surface construction points and disconnecting all items, piping, materials and accessories.

1.20 CROSS AND INTERCONNECTIONS

A. No plumbing fixtures, equipment, connection, device or pipe shall be installed which would provide a cross or interconnection between a distributing supply and a non-potable system, a drainage system or a soil or waste pipe, which would permit or make possible the backflow of sewage, polluted water, pollutants or waste into the domestic water supply system, unless such connections are protected with approved cross connection devices.

1.21 VERIFICATION OF CONDITIONS

A. Before performing any new work and running any new lines, this Subcontractor shall uncover, locate and determine the invert, routing, size and material of all existing lines, and of all prep and utility work done, including buried lines.

B. These verifications shall be done in coordination with the phasing and timing of the project and in coordination with all other trades involved.

C. Slab and wall cutting shall be minimized until proper verifications are made.

D. Inform the Architect if other than non-destructive means are required to verify existing conditions.

PART 2 - PRODUCTS

2.1 PLUMBING FIXTURES

A. Provide plumbing fixtures as indicated on Architectural and Plumbing Drawings.

B. All exposed trim, traps, escutcheons and waste piping shall be chrome plated (or stainless steel). This includes connections to equipment furnished under other Sections, such as the Kitchen, casework, etc.

C. All fixtures shall have manufacturer's guarantee label or trademark indicating first quality.

D. The Architect shall be the final judge as to whether fixtures fulfill the requirements of the Specifications and as to whether they are of suitable quality.

E. All materials specified to be chromium plated shall be thoroughly cleaned and polished before plating and plate shall be heavily, thoroughly and evenly applied, guaranteed not to strip or peel.

F. Where escutcheons are not furnished with plumbing fixtures, and equipment, this Subcontractor shall supply them.

G. Each fixture, outlet and piece of equipment shall be separately trapped, using type and size of trap required by the Plumbing Code, except as specified otherwise. All traps shall have cleanouts.

H. All wall-mounted devices shall have concealed chair carriers which shall be securely bolted to floor slabs in accordance with the manufacturer's recommendations.

I. Flush valves shall meet the requirements of Federal Spec. QQ-C-390B2 and ASTM-B584 for copper alloy castings and shall be coordinated with the height of grab bars and adjusted, as necessary. Controls for flush valves shall be mounted on the wide side of fixtures, at the required height.

J. Dimensions locating plumbing fixtures shall be as shown on the Architectural Drawings.

K. All soldered joints in fixtures and fittings shall be made up with 95/5 solder where in contact with potable water. This includes, but is not limited to, supplies, faucets and water coolers. Documentation shall be provided with submittals.

L. All supply pipes to flush and quick closing valves shall be securely anchored within the walls to ensure no movement.

M. All metering and/or temperature limiting type faucets shall be adjusted to deliver the proper temperature and flow/duration.

N. Fixtures and Trim:

1. Acceptable Manufacturers: Submit manufacturers not listed below for review and approval as specified for substitutions in Article 1.22 - Quality Assurance.

a. Vitreous China: American Standard, Crane or Kohler.

b. Faucets: Chicago Faucet Co., Kohler or T & S Brass.

c. Self Closing Faucets: Chicago Faucet Co., Kohler or Symmons.

d. Sensor Faucets: Chicago, Sloan, Zurn.

e. Stainless Steel Sinks: Elkay, Just Manufacturing or Metcraft Inc.

f. Mop Service Basins: Crane, Fiat or Stern Williams.

g. Carriers and Supports: Jay R. Smith, Wade, or Zurn.

h. Thermostatic Mixing Valves: Leonard Valve Co., Powers Process Controls or Symmons.

i. Electric Water Coolers: Filtrine, Halsey Taylor or Haws.

j. Flush Valves: Sloan, or Delany.

k. Stops and Supplies: Chicago Faucet Co., Kohler or McGuire.

l. P-Traps: McGuire, Sanitary-Dash, or Jameco.

m. Handicap Lavatory Insulators: McGuire, TCI Products or Truebro.

2. Fixture Trim and Accessories: Provide fixtures complete with floor mounted fixture carrier supports; faucets, flushometers; drain outlets, tailpieces, P-traps, seats, stops and supplies.

   a. Color and Finish: All trim exposed to view shall be polished chrome plated, and all fixtures and toilet seats shall be white unless specified otherwise.

   b. Drain Outlets: Provide drain outlet of the same manufacturer as the fixture or faucet trim with chrome plated 17 gauge minimum weight tailpiece.

      1) Provide 1-1/4 inch tailpiece on lavatories.

      2) Provide 1-1/2 inch tailpiece on sinks.

      3) Provide offset drain outlets on handicapped use lavatories and sinks.

3. P-Traps: Cast brass adjustable P-trap with cleanout plug, ground joint and 17 gage minimum weight extension with escutcheon.

   a. Provide McGuire No. 8090 1-1/4 inch by 1-1/2 inch on lavatories.

   b. Provide McGuire No. 8089 1-1/2 inch by 1-1/2 inch on sinks.

4. Stops and Supplies: Provide stops and supplies of the same manufacturer as the fixture or faucet trim, or provide McGuire Model 170-LK loose key angle stop with 5

inch long 2 inch nominal copper sweat extension, bell escutcheon, and 3/8 inch O.D. by 12 inch flexible riser.

5. Sinks: Seamlessly drawn, self-rimming minimum 18 gauge, type 302 (18-8) nickel bearing stainless steel with 1-3/4 inch minimum rounded corners, satin finish, and fully undercoated.

6. Faucets: Chrome plated cast brass with stainless steel seats and monel stems. Gooseneck spouts shall be interchangeable and convertible rigid/swing type. Handles shall be interchangeable with square handle broachings.

7. Flushometers: Diaphragm operated, cast-brass body, brass or copper pipe or tubing inlet with wall flange and tailpiece with spud, screwdriver check stop, vacuum breaker, and brass lever handle actuation except where other variations are specified.

8. Water Conservation: Provide water conserving fixtures and trim in compliance with the following maximum water use requirements. Provide Omni or approved equal variable pressure flow controls on showers, sinks, and lavatory faucets.

   a. Public lavatories: 0.5 gpm

   b. Sinks: 1.5 gpm

   c. Water Closets: Dual flush, 0.8/1.6 gallons per flush.

   d. Urinals: 0.5 gallons per flush.

9. Fixture Supports: Provide floor mounted fixture support carriers for wall mounted fixtures including but not limited to: water closets, lavatories, scrub sinks, urinals, and clinical sinks.

10. Fixture carriers shall support at least 250 pounds on the front rim of the fixture for five (5) minutes.

   a. Water Closets: Jay R. Smith Series 200-Y

   b. Urinals: Jay R. Smith 637.

   c. Lavatories: Jay R. Smith 700-M31.

11. Toilet Seats: Provide extra heavy-duty, commercial/industrial type, elongated, open front, solid white injection molded plastic with integral bumpers; and self sustaining stainless steel check hinges, without cover.

   a. Acceptable Manufacturers: Bemis, Beneke, or Church.

12. Hot Water Dispensers: ASSE 1023, instant on-off control on chrome-plated dispenser faucet with removable strainer; steel tank housing with insulated stainless steel inner tank; adjustable thermostat control for water temperature from 140 degrees F to 190 degrees F with thermal overload protection; 120 volt, and 2-gallon minimum tank capacity.

   a. Acceptable Manufacturers: Elkay, or Insinkerator.

13. Handicap Lavatory and Sink Insulators: Shall be provided on water supplies and waste piping below handicapped lavatories and sinks.

O. Fixture List:

1. P-1 Water Closet

Fixture: American Standard #2257.103 "Afwall Aquameter" toilet, wall hung, vitreous china, elongated bowl, siphon jet action with 1-1/2 inch top spud (30 psi required).

Valve: Sloan Royal #WES-111 dual flush valve with screwdriver stop and integral vacuum breaker. Maximum 0.8/1.6 gpf.

Misc.: Provide fittings and J.R. Smith, Josam or Zurn floor mounted chair carrier to suit building conditions.

2. P-1A Water Closet (Accessible)

Fixture: American Standard #2257.103 "Afwall" toilet, wall hung, vitreous china, elongated bowl, siphon jet action with 1-1/2 inch top spud (30 psi required).

Valve: Sloan Royal #WES-111 dual flush valve with screwdriver stop and integral vacuum breaker. Maximum 0.8/1.6 gpf.

Misc.: Provide fittings and J.R. Smith, Josam or Zurn floor mounted chair carrier to suit building conditions. Fixture shall be mounted to meet access requirements.

3. P-2 Urinal

Fixture: American Standard #6501.010 "Washbrook" water saver urinal, wall hung, vitreous china, extended sides, washout action, with 3/4 inch top spud.

Valve: Water saving Sloan Royal "Optima Plus" model #8186-0.5 sensor-operated flush valve with screwdriver stop and integral vacuum breaker. Maximum 0.5 gallons per flush. Battery operated.

Misc.: Provide fittings and J.R. Smith, Josam or Zurn fixture carrier to suit building conditions.

4. P-2A Urinal (Accessible)

Fixture: American Standard #6501.010 "Washbrook" water saver urinal, wall hung, vitreous china, extended sides, washout action, with 3/4 inch top spud.

Valve: Water saving Sloan Royal "Optima Plus" model #8186-0.5 sensor-operated flush valve with screwdriver stop and integral vacuum breaker. Maximum 0.5 gallons per flush. Battery operated.

Misc.: Provide fittings and J.R. Smith, Josam or Zurn fixture carrier to suit building conditions. Fixture shall be mounted to meet access requirements.

5. P-3 Lavatory

Fixture: American Standard #0476.028 "Aqualyn" 20 inch X 17 inch oval self-rimming counter-top lavatory, vitreous china, fitting ledge, front overflow, punched for 4 inch faucet centers.

Faucet: Sloan "Optima Plus" battery-powered, sensor-operated electronic faucet for hot/cold application, model EBF-85. Sloan MIX-60-A mixing valve.

6. P-3A Lavatory (Accessible)

Fixture: American Standard #0476.028 "Aqualyn" 20 inch X 17 inch oval self-rimming counter-top lavatory, vitreous china, fitting ledge, front overflow, punched for 4 inch faucet centers.

Faucet: Sloan "Optima Plus" battery-powered, sensor-operated electronic faucet for hot/cold application, model EBF-85. Sloan MIX-60-A mixing valve.

NOTE: Roughing height of under-counter trim shall meet access requirements. Drain, trap and supplies shall be insulated.

7. P-4 Mop Receptor

Fixture: Stern Williams #SB-902-BP Terrazzo "Serviceptor", 24 inch X 24 inch X 12 inch, integral 3 inch cast brass drain with nickel-bronze strainer, continuous 20 gauge Type 302 stainless steel cap with tiling flanges and splash catcher panels to suit.

Faucet: Kohler #K-8904 service sink faucet, 3/4 inch hose thread, vacuum breaker, pail hook, wall brace and integral loose key stops.

Trap: 3 inch cast iron P-trap.

8. P-5A Water Cooler (Accessible)

Fixture: Halsey Taylor Model #OVL-II ER-Q, energy efficient, barrier free cooler, surface mounted. 19-3/4 inch wide X 40-7/8 inch face panel with 18 inch projection, 7.5 gph of 50°F water at 90°F ambient and 80°F inlet water. ARI Std 1010-94. 120V/1 PH, 4.0 FLA, 370 watts/ hour.

Trap: 1-1/4 inch cast brass P-trap to suit.

Misc.: Service stop. Unit shall be constructed of "Lead-Free" solder (maximum 0.2% lead). Submit manufacturer's certified affidavit with Shop Drawings. Adjust stream height for existing water pressure.

9. P-6 Sink (Kitchen)

Fixture: Elkay #LR-2522, 18 gauge type 302 stainless steel, 23 inch X 22 inch X 8 inch deep, self-rimming with coved corners, recessed ledge, satin finish (LK-6K-H), underside fully undercoated.

Faucet: Chicago #200-GN8A-E3-317 rigid/swing field convertible gooseneck, 8 inch centers, 4 inch wrist blade handles, E-3 aerator, spray with hose.

Supplies: Pair of Chicago #1017 flexible supplies, to suit, 1/2 inch loose key lock shield angle valves, flexible riser, cast brass escutcheons with set screws, polished chromium plated.

Drain: Elkay #LK-35 3-1/2 inch strainer with basket and neoprene stopper. CP brass 1-1/2 inch OD tailpiece. P-trap to suit.

10. P-7 Sink (Tech Services)

Fixture: Elkay #LR-2522, 18 gauge type 302 stainless steel, 23 inch X 22 inch X 8 inch deep, self-rimming with coved corners, recessed ledge, satin finish (LK-6K-H), underside fully undercoated.

Faucet: Chicago #200-GN8A-E3-317 rigid/swing field convertible gooseneck, 8 inch centers, 4 inch wrist blade handles, E-3 aerator.

Supplies: Pair of Chicago #1017 flexible supplies, to suit, 1/2 inch loose key lock shield angle valves, flexible riser, cast brass escutcheons with set screws, polished chromium plated.

Drain: Elkay #LK-35 3-1/2 inch strainer with basket and neoprene stopper. CP brass 1-1/2 inch OD tailpiece. P-trap to suit.

2.2 PIPE MATERIALS

A. Service: Above ground hot and cold water (4 inches and smaller).

Pipe Material: Copper tubing Type L, hard temper, ASTM B88/B75, except exposed at fixtures and equipment (CPCB).

Fitting Material: Wrought copper and bronze solder joint. Pressure fittings.

Pipe Joints: Joint shall be soldered using 95/5 (lead-free) solder.

NOTE: As an option for above grade water piping, the contractor may substitute "The Copper Connection" by Victaulic, or approved equal, for sizes 2 inch to 8 inch. Roll grooved to manufacturer's current standards only, cut grooving not allowed. All items and accessories as per Victaulic's recommendations including couplings, gaskets, installation, etc.

Couplings: Style 606 rigid. Ductile iron conforming to ASTM A-536, Grade 65-45-12, coated with copper colored alkyd enamel. Housings cast with offsetting, angle-pattern bolt pads to provide rigidity.

Grooved Fittings: Fittings shall be manufactured to copper tubing sizes, with grooves designed to accept grooved end couplings of the same manufacturer. Fittings shall be wrought copper, conforming to ASTM B-75 alloy C12200 or ASTM B-152 alloy C11000 and ANSI B16.22.

Gaskets: Synthetic rubber in a Flush Seal configuration conforming to the copper tube size (CTS) outside diameter and coupling housing of elastomers having properties as designated in

ASTM D-2000. Reference shall always be made to the latest published Selection Guide for Victaulic Gaskets for proper gasket selection for the intended service.

Flange adapters: 2 inch to 6 inch (DN50-DN150) for copper tubing consisting of ade 65-45-12, ductile iron housing, coated with copper colored alkyd enamel. Flange adapters shall be manufactured for engaging directly into copper tubing sized roll grooved copper tube and fittings and bolting directly to ANSI Class 125 cast iron and Class 150 steel flanged components. Victaulic Style 641.

Valves: 2-1/2 inch to 6 inch (DN65-DN150), 300 psi (2065 kPa) maximum pressure rating, with copper tubing sized grooved ends. Cast bronze body to CDA-836 (85-5-5-). Elastomer encapsulated ductile iron disc, ASTM A-536, Grade 65-45-12, with integrally cast stem. Bubble tight, dead-end or bi-directional service, with memory stop for throttling, metering or balancing service. Victaulic Series 608

Assembly:

1. Pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing.

2. All grooved components (couplings, fittings, valves, gaskets, bolts and nuts) shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

3. Victaulic shall provide on-site training for contractor's field personnel by a factory-trained representative in the proper use of grooving tools, application of groove, and product installation. Victaulic's representative shall periodically visit the job site and inspect installation. Contractor shall remove and replace all improperly installed products.

B. Service: Above ground hot and cold water (1-1/2 inches and smaller).

Pipe Material: Copper tubing Type L, hard temper.

Fitting Material: Wrought copper and cast copper alloy push-to-connect PermaLynx™ fittings.

OPTION #1: As an option for above grade water piping 1/2 inch and smaller, the contractor may substitute push-to-connect fittings as manufactured by Victaulic. ASME B16.22 wrought copper alloy or ASME B16.18 cast copper alloy fittings with push-to-connect ends designed for direct insertion of copper tube. Push-to-connect ends shall be complete with EPDM engineered seal and 301 stainless steel internal components. EPDM engineered seal shall be suitable for water operating temperatures of -30°F to +230°F. Seal shall be ANSI/NSF 61 certified for potable water service.

OPTION #2: As an option for above grade water piping 1/2 inch to 2 inch, the contractor may substitute a copper "press fit" system, Pro Press by Viega, or approved equal, using hydraulic crimping tools and high performance EPDM sealing elements.

C. Service: Below ground water (3 inch and smaller).

Pipe Material: Type K copper tubing, soft temper, with bituminous coating. ASTM B42, seamless.

Fitting Material: Jointless where possible otherwise, brazed.

D. Service: Below ground cold water (4 inch and larger).

Pipe Material: Ductile iron, standard thickness cement mortar lining, Class 52.

Fitting Material: Cast or ductile iron 250 psi rating, standard thickness cement mortar lining.

Pipe Joint: Push-on. Install flexible coupling 5 feet from foundation wall. All changes in direction to have tie rods and clamps anchored to thrust blocks.

E. Service: Sanitary, waste, vent and rainwater piping above ground.

Pipe Material: ASTM A-74, service weight cast iron no-hub soil pipe conforming to latest standards, or DWV copper tube (up to 2 inch), CISPI trademark, or approved equal.

Fitting Material: Cast iron, cast brass, wrought copper drainage fittings.

Pipe Joint: Gasket or soldered using silver lead-free solder, ASTM B813. No hub double clamps shall be Anaheim "Huskey" Series 4000, "Clamp All 125" or Tyler "wide body", CISP 301.

F. Service: Sanitary, waste, vent and rainwater piping below ground.

Pipe Material: ASTM A-74, service weight cast iron hub-end soil pipe, asphalt or coal-tar pitch coated, CISPI trademark, or approved equal.

Pipe Joint: Caulked with lead and oakum or neoprene. (Must be caulked through building wall.)

Fitting Material: Cast iron hub-end drainage fittings.

G. Service: Force main (pump discharge).

Pipe Material: Schedule 40 galvanized steel, threaded or roll grooved (cut grooving shall not be allowed).

Fitting Material: Cast iron drainage fittings or Victaulic.

Pipe Joint: For clear water waste (sump pumps only): screwed fittings or Victaulic "Zero-Flex". For Sanitary waste: screwed fittings or Victaulic "Zero-Flex" with EPDM E/T Grade gasket.

H. Service: Natural gas (2 inch and smaller) and gas vents.

Pipe Material: Schedule 40 black steel.

Fitting Material: 125# malleable iron.

Pipe Joint: Screwed.

As an option for gas piping 2 inch and smaller, and less than 5 psig, the contractor may submit for approval, after securing Owner approval, flexible gas piping, as follows:

Pipe Material: Corrugated semi-rigid stainless steel tubing (CSST) with a yellow polyethylene jacket. (Tape, plug or cap all ends until jointed.)

Fitting/Joint: Manufacturer approved and supplied, brass self-piloting and self-flaring, threaded fittings with flared inserts.

Note: Manufacturer's published installation methods and materials must be utilized, and every installer must undertake, pass and provide a manufacturer's "Training Test" Certificate.

I. Service: Natural Gas (2-1/2 inch and larger).

Pipe Material: Schedule 40 black steel. (All buried piping shall have a continuous bituminous coating, or an extruded plastic polyethylene pipe coating.)

Fitting Material: Standard weight carbon steel.

Pipe Joint: Welded, flanged.

J. Service: Buried Natural Gas (below grade only).

Pipe Material: Polyethylene plastic tubing conforming to "Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings, ASTM D2513." Pipe to be marked "gas" and "ASTM D2513".

Fitting Material: (same).

Pipe Joint: Heat fusion (marked "ASTM D2513").

Note: As an option for buried gas piping 2 inch and smaller, and less than 5 psig, the contractor may submit for approval, after securing Owner approval, flexible CSST tubing installed in a watertight conduit, as follows:

Pipe Material: Corrugated semi-rigid stainless steel tubing (CSST) with a yellow polyethylene jacket. (Tape, plug or cap all ends until jointed.)

Conduit: Black, polyethylene water tight conduit, jointless, pre-sleeved.

Sealing: Heat shrink polyolefin cuffs (using a heat gun).

Vent: Vent tees, per code.

Note: Manufacturer's published installation methods and materials must be utilized, and every installer must undertake, pass and provide a manufacturer's "Training Test" Certificate.

K. Urinal Wastes: Urinal branch and fixture wastes shall be of service weight cast iron soil pipe and fittings with caulked joints, threaded cast iron pipe with cast iron drainage fittings, or iron size brass with cast brass drainage fittings. Resilient gaskets shall not be used on urinal wastes.

2.3 VALVES

A. The entire plumbing installation shall be provided with valves located to permit easy operation, replacement and repair. Each type shall be the product of a single manufacturer. Valves shall be provided where required by Code and as shown on the drawings. Valves shall be Jenkins, Hammond, Crane, or equal.

B. Gate Valves/Service Entry:

1. Acceptable Manufacturers: Watts, Jenkins, Crane, Hammond.

2. Gate valves 4 inch and larger shall be iron body bronze mounted OS&Y flanged end 200 psi cold working pressure. Watts SF-503, Jenkins Model 454A.

3. Gate valves 1/2 inch to 3 inch shall be all bronze, solder end, non-rising stem 200 psi cold working pressure. Watts B-3101, Jenkins Model 1240.

C. Ball Valves:

1. Acceptable Manufacturers: Apollo, Watts, Jenkins.

2. 2-1/2 inches and Smaller: Two-piece full port bronze body with fiberglass reinforced TFE seats with chrome plated ball and stem extension. Apollo 77-100/77-200, or Watts B-6080/B-6081-SS.

3. 3 and 4 inch: Three-piece full port bronze body with fiberglass reinforced TFE seats, chrome plated ball and stem extension. Apollo 82-100/82-200, Watts B-6800/6801.

D. Check Valves:

1. Two inch and smaller shall be horizontal, all bronze swing check regrinding type, solder end, 200 psi working pressure. Watts B-5001, Jenkins Model 1222.

2. Two and one-half inch and larger shall be iron body flanged swing type. Watts F-511, Jenkins Model 295.

E. Pressure and temperature relief valves shall be ASME, Watts or approved equal, sized to suit the inlet size and to exceed the ASME, AGA and Manufacturer's pressure rating of the device.

F. Pressure Reducing Valves (PRV):

1. Up to 3 inch and for heating system make-up shall be all bronze with separate strainer, threaded end and adjustment range of 25-75 psi equal to Watts 223SB, with pressure range to suit.

G. Gas Valves: Shutoff valves shall be Watts Series B6000-UL-Massachusetts or Boston Key bronze body and plug cock with tee head and check for 2 inch and smaller in size. For 2-1/2 inch and larger valves shall be lubricated plug cock having Boston Key and square head with shoulder stops, or full port ball valves, Massachusetts gas approved. Check valves shall be Eclipse aluminum disc type check valves Series 1000.

H. Balancing Valves:

1. Balancing valves 3 inch and smaller shall be "circuitsetter" type bronze ball valve, bronze ball, TFE seat, two piece body, thread end, or soldered, 400 psi working pressure, with memory stop:

   Watts CSM 61 Series, Bell & Gossett, Taco circuit setter or approved equal.

2. Provide shutoff valves on both sides of the balancing valve.

I. Drain Valves: It shall be possible to drain water from all sections of the cold, hot and hot water return piping. This Contractor shall furnish and install 1/2 inch bronze ball valves with 3/4 inch hose outlets to drain each section and branch. The 3/4 inch hose ends shall be provided with bronze caps and chains. Chains shall be secured to drain valve. Watts Series B-6000/01-CC.

2.4 HOSE BIBBS AND WALL HYDRANTS

A. Hose bibbs shall be as follows or approved equal:

1. For toilet, mechanical and trash type rooms, Chicago #952 where piping is to be concealed in walls and Chicago #998 where piping is exposed.

B. Wall Hydrants:

1. Exterior use, non-freeze wall hydrants, Woodford model B65, inlet style to suit, 3/4 inch, "WATER" cast on cover, loose key lock, adjustable wall clamp. Polished brass face, stainless steel box.

2.5 DRAINS

A. Drains shall be Watts Drainage Products, J.R. Smith, Zurn, or approved equal.

B. Floor Drains: Shall be as follows or approved equal:

1. Type "A" - For toilet rooms, and finished areas, Watts FD-100-A5-5, J.R. Smith, Figure 2005-B-PB-U-P, round top, sediment bucket, polished bronze strainer, vandalproof, trap primer connection (plug as required).

2. Type "B" - For mechanical areas, Watts FD-34D-5-6-7-13, J.R. Smith, Figure 2230-YUG, sediment bucket, galvanized CI, vandalproof, trap primer connection.

3. Type "C" - Mechanical room - same as Type "B" except modify with funnel, Watts F-4, .R. Smith, Figure 3580.

C. Roof Drains shall be as follows or approved equal:

1. Primary roof drains shall be Watts RD-300-F-B-K, J.R. Smith Figure #1010-ERCY with secured cast iron dome, extension, sump receiver, underdeck clamp, No-Hub adapter.

2. Roof drains which are directly connected to vertical leaders or are within five (5) feet of the offset shall be threaded and shall utilize Smith #1710 expansion joint.

2.6 WATER HEATERS

A. General:

1. Furnish and install storage type heaters as indicated on drawings. Heaters shall be tested according to Code and rated for 150 psi working pressure.

2. Heaters shall be provided with (AGA rated and ASME constructed) pressure and temperature relief valves, vacuum relief valves and drain valves.

3. Heaters shall be complete with controls and anode rods.

4. Heaters shall have a minimum standby heat loss, in accordance with requirements of the State Energy Code.

5. Heaters shall be set to maintain water at 145 degrees F.

B. Electric:

1. EWH-1: Ruud electric water heater, Model #EGSP30, 30 gallons, 208 volt, 1 phase, 60 cycles, with single 4500 Watt element meeting the energy efficiency requirements of ASHRAE Standard 90, 21.6 FLA, 23 GPH recovery at 80°F temperature rise.

2. EWH-2: In-Sink-Erator, Model #W-152, point-of-use electric water heater, 2-1/2 gallon, bronze, adjustable temperature range, 1500 watts, 120V., 3-1/2 foot grounded plug.

2.7 INSULATION

A. Insulation shall not be applied until pipes have been tested and accepted by all parties making inspection.

B. All hot and cold water pipes, rainwater pipe (horizontal and vertical), roof drain bodies, handicapped lavatory piping, heat traced piping, condensate drain receptor and associated piping up to rainwater pipe, and water cooler drain piping shall be insulated. Distribution piping shall be covered with fiberglass with flame safe U.L. approved A.S.J. jacket and vapor barrier lap cement and manufacturer's printed instructions. Owens Corning, Schuller, Pittsburgh Corning or approved equal. Insulation thickness shall be per Code, and as follows:

1. Domestic and service hot water greater than 105°F:

a. 1/2 inch thick up through 1-1/4 inch pipe size.

b. 1 inch thick for 1-1/2 inch and larger pipe size.

2. Cold water, non-potable water, and storm - same as for hot water.

C. All fittings and valves shall be insulated with fiberglass wrapping and preformed PVC covers by Zeston, Speedline or approved equal.

D. Pipe hangers shall be installed outside of insulation and provided with protection shields.

E. Provide insulation on all exposed hot, cold and waste piping beneath handicapped fixtures. Insulation shall be "Truebro" Handi Lav-Guard fully molded closed cell vinyl with nylon fasteners. Truebro, Brocar "Trap Wrap", Prowrap or approved equal.

F. Staples shall not be used on any part of the installation.

G. Cold Water Meter:

1. Shall be insulated with Fiberglass Aerocor with foil facings 1-1/2 inch sealed and tied with jute twine or wire, a smooth coat of cement with an open weave glass cloth jacket applied with BF 30-35 adhesive.

H. Provide "Childers" or approved equal, 0.016 corrugated aluminum seamless jacket joined with rivets on exposed pipe within 9 feet-0 inch above finished floor and where susceptible to damage in finished occupied spaces, not mechanical rooms. Bracket pipe every four feet off of wall. Jacket to be joined at lap seam by rivets every three (3) inches on center.

I. All piping subject to freezing that is installed in outside wall construction shall be installed on the warm side of the building's insulation system. In addition, the piping shall be double - insulated. Approval is required for all piping to be installed in cold walls.

J. Buried piping insulation shall be Owens Corning or approved equal, urethane insulation, type 24, 1-1/2 inch thick, tightly butted and taped, in accordance with manufacturer's spec sheets and insulation recommendations. Insulation shall be continuous. Fill all holes with mastic. Provide a continuous vapor barrier system (installed the same day), perm rating <0.05, of Benjamin Foster #60-65 Butyl mastic reinforced with glass fabric, to 1/8 inch, continuing past insulation onto abutting pipe surfaces and seal. Use adhesive of #81-33 and sealer of BF #30-45. All surfaces shall be dry and shall be prime coated prior to installation.

2.8 HANGERS AND SUPPORTS

A. Furnish and install hangers and supports to attach all pipes securely to the structure in correct alignment and pitch, to prevent vibration and to effectively care for expansion and contraction. Parts in contact with copper pipe or tubing shall be copper plated, and chrome plated for chrome plated piping, etc.

B. Spacing for horizontal piping shall be as follows:

1. Cast Iron Soil Pipe: For 5 foot lengths, 5 feet at the hubs; for 10 foot lengths use one hanger at the connection and one at midpoint of each length (provide metal straps or 2 X 4 blocking to control swaying on No Hub systems).

2. Copper Tubing: 6 feet on centers for 1-1/4 inch and smaller, 10 feet on centers for 1-1/2 inch and larger.

3. Steel Pipe: 6 feet on center for 1-1/4 inch and smaller, 10 feet on center for 1-1/2 inch and larger.

4. Plastic Pipe (PVC, PP): three (3) feet on centers for 1-1/2 inch and smaller, four (4) feet on centers for 2 inch and larger.

C. Vertical lines shall be adequately supported at their bases by a suitable hanger placed in the horizontal line near the riser and clamped at every 10 foot interval vertically.

D. Vertical lines may be supported at each floor level if the floor-to-floor dimension is greater than 10 feet, and if this is approved by the pipe manufacturer's guidelines for that type of pipe joint system.

E. Piping supported from structural steel shall have beam clamps and hangers consisting of threaded rod and hangers. Band hanger for piping 2 inch and smaller, clevis hanger for piping 2-1/2 inch and larger, sized to suit for continuous insulation, with pipe shields at all insulated piping locations.

F. Where piping is required to be hung from other than structural concrete slabs, such as precast or metal decking, submit proposed method of support to the structural engineer for approval prior to installation.

G. Piping shall not be hung from hangers of other trades.

H. All piping within pipe space and at plumbing fixtures shall be supported using the prefabricated pipe support and alignment system as manufactured by B-Line, Snap-n-strut, Unistrut, Sumner Corporation or approved equal. Horizontal and vertical piping shall be supported in a workmanlike manner, securely holding pipe, preventing vibration. Compensate for all static and operational conditions. The proper alignment fitting shall be used at each and every fixture or equipment. Each flush valve supply shall be secured to structure. These supports shall be constructed of cycloid plastic and stainless steel bands. The plastic shall meet appropriate requirements on flamespread and toxicity. Wood blocking and wire straps shall not be permitted. All loose flush valve supply pipes, lavatory supports, etc., shall require reopening of the walls and resupporting, at the Plumber's expense and timing.

I. All hangers and devices for buried piping and in crawl spaces shall be hot dipped galvanized.

J. Seismic Pipe Hanging Requirements:

1. Seismic protection of plumbing systems shall comply with the requirements of the State Building Code.

2. The Plumbing Subcontractor shall have the option of substituting alternate seismic supports and anchors; provided his submittals are accompanied by calculations and shop drawings signed and sealed by a licensed professional engineer in the state.

3. All mechanical materials and equipment including all pipes shall be supported and anchored to resist the external seismic forces for the required seismic hazard exposure Group and seismic performance category. Force shall be resisted without failure or permanent displacement when it is applied in any direction, and shall conform to the State Building Code.

4. General

a. Anchor bolt calculations, signed and stamped by a Massachusetts Registered Professional Engineer, shall be submitted showing adequacy of the bolt sizing and type. Calculations shall include anchor embedment minimum edge distance and minimum center distance and minimum center distance. The design lateral forces shall be distributed in proportion to the mass distribution of the equipment. Calculations shall be furnished for anchors on restraint devices, cables, isolators and on rigidly mounted equipment. The seismic designer must perform final jobsite inspection to verify anchor installation.

b. Restraint of rigidly mounted piping may conform to "National Uniform Seismic Installation Guidelines", NUSIG or Guidelines for Seismic of Mechanical Systems and Plumbing Piping Systems", SMACNA. Calculations need not be submitted for restraint systems conforming to these guidelines.

5. Piping

a. All gas piping and all other piping 2-1/2 inch and over shall be protected in all planes by cable restraints, designed to accommodate thermal movement as well as restrain seismic motion. Locations shall be:

1) At all drops to equipment connections.

2) At changes in direction of pipe.

3) At horizontal runs of pipe, not to exceed the spacing requirements of the Seismic Designer.

b. Seismic requirements are not required on the following (except for gas piping):

1) Pipes under 2-1/2 inch size outside of mechanical rooms.

2) Piping in mechanical rooms less than 1-1/4 inch size.

3) All devices hung pipe suspended by individual hangers 12 inch in length (or less) as measured from the top if the pipe to the bottom of the support for the hanger.

6. Rigidly Mounted Equipment

a. Floor mounted and suspended equipment and vessels and all suspended or wall mounted equipment shall be protected by properly sized anchor bolts or hangers rode and bracing and if required by additional seismic restraints such as cable restraints. The need for additional restraints shall be determined by and, if required, furnished by the supplier of the seismic restraints.

7. Installation

a. All seismic restraints are to be securely anchored or fastened to the equipment and supporting structure in accordance with the approved submittal data.

b. Operating clearances are to be adjusted so that restraints do not interfere during normal operation of the equipment.

c. Upon completion of the installation, the supplier of the seismic restraints shall inspect and certify in writing to the Architect that restraints have been installed properly and in accordance with his recommendations.

8. Submittals

a. The Seismic and Vibration Control manufacturer shall determine the number, size and type of anchor bolts, cable restraints, seismic snubbing, etc. for each piece of equipment and groups of pipes.

b. Complete engineering calculations and drawings for all vibration and seismic requirements for all equipment and piping.

c. The State professional stamp of the Engineer who is responsible for the design and operation of the Vibration and Seismic System.

d. Details for all the seismic bracing with snubbers proposed for items in this specification and on the drawings.

e. Details for steel frames and concrete inertia bases to be used in conjunction with the seismic restraint of the items in this specification and drawings.

f. Clearly outlined procedures for installing and adjusting the seismic bracing and snubber.

9. Seismic Restraints

a. Cable Restraints: A restraint assembly for suspended equipment or piping consisting of plow steel cable attached to steel thimbles with neoprene sleeve all specifically designed for cable service and securely fastened to the equipment, or the equipment base and the building structure with A/B type SRB steel angle brackets. Cables shall be installed to prevent excessive seismic motion and so arranged that they do not engage during normal operation, starting or stopping.

2.9 UNIONS, FLANGES AND DIELECTRIC SEPARATION

A. Unions: Provide union connections to fixtures and equipment such as water heaters. Union connections on domestic water piping shall be bronze with minimum cold working pressure of 200 psi.

B. Flanges: Provide flanges in accordance with ANSI standards for construction and working pressure.

C. Dielectric Separation: Whenever the water piping system comes in contact with ferrous pipe, fittings, valves and other equipment which make up the domestic water system, connections shall be separated to prevent galvanic action and shall be made with valves, flanges or dielectric nipples. Dielectric couplings are not allowed. Contact between ferrous bolts and non-ferrous bronze flanges shall be insulated with non-metallic washers.

D. All piping within metal stud walls shall be isolated from the studs and related materials with fitted plastic inserts properly installed.

2.10 THERMOMETERS AND PRESSURE GAUGES

A. Provide separable-well dial thermometers and pressure gauges where indicated on drawings.

B. Thermometers shall have a five inch diameter hermetically sealed bi-metal dial with stainless steel case.

C. Pressure gauges shall be at least four and one-half inches, bronze bourdon tube and steel case.

2.11 CLEANOUTS

A. Cleanouts shall be Watts, Jay R. Smith, Zurn, Josam or approved equal.

B. Cleanouts shall be provided in all sanitary and storm drain piping at changes in direction, at the base of stacks and as required by the Local Authorities.

C. Cleanouts shall be located within 50 feet of each other for pipe sizes 4 inches and smaller and not more than 100 feet apart for larger pipe sizes.

D. Cleanouts shall be of the same size as the pipe installed up to 4 inches in diameter. For pipe sizes larger, a cleanout of 4 inches minimum shall be provided.

E. Cleanouts shall be installed so that they open in the direction of flow or at right angles.

F. In finished/habitable areas, cleanouts shall be Watts CO-200-R Series, J.R. Smith 4020 series, outlet to suit, round nickel bronze top, vandalproof screws, flashing flange to suit.

G. In finished/habitable areas receiving vinyl floor tile, cleanouts shall be Watts CO-200-T, J.R. Smith 4140 series, outlet to suit, round nickel bronze top with tile recess to receive inlay (by others), vandalproof screws, flashing flange to suit.

H. In all areas that are carpeted with carpet tiles, Watts CO-200-RC, J.R. Smith 4020-Y series with stamped stainless steel carpet marker, 1-1/2 inch diameter. In all continuous carpet areas, 4020-X with carpet clamping frame.

I. In all mechanical, storage and other areas subject to heavy load traffic, Watts CO-200-RX, J.R. Smith 4100 series, outlet to suit, round nickel bronze top, vandalproof screws, flashing flange to suit.

J. Wall cleanouts shall be Watts CO-380 with CO-300-R or S, J.R. Smith 4432 or 4433 for hub type or 4436 or 4437 for threaded plug, to suit wall types. Round frame and secured cover, chrome plated bronze, vandalproof screws, 4 inch size, 6 inch opening.

K. Final locations of all cleanouts in occupiable and egress spaces shall be approved prior to installation of cleanouts and related sanitary, waste and storm piping.

2.12 WATER HAMMER ARRESTERS

A. Provide water hammer arresters for fixtures with automatic flush valves, pressure assisted flush tanks and quick-closing valves. (This includes laundry valves, dishwashers, etc.)

B. Provide proper access to water hammer arresters and locate as close as possible to the last designated fixture, in accordance with manufacturer's recommendations.

C. Water hammer arresters shall be J.R. Smith, Zurn, Josam, Watts Drainage Products, or approved equal, equal to Watts SS Series, J.R. Smith Series 5000.

2.13 TRAPS

A. All equipment and fixtures requiring connections to the sanitary system shall be provided with individual traps with integral cleanouts.

B. Traps exposed to view, including drain lines, shall be chrome plated. The smallest size trap shall be one and one-half inch.

C. All accessible traps shall have cleanout plugs.

2.14 VACUUM BREAKERS

A. For water heaters, Watts, Zurn, Conbraco or approved equal, equal to Watts #N36, sized to suit.

B. Atmospheric type shall be Watts No. 288A series, plain brass with bronze internal trim, high heat resistant and durable silicone disc. Rated 210 degrees F at 125 psi. Tested and approved in accordance with ASSE Std. 1001 and ANSI A112.1.1. Provide as many as is required to exceed rating.

C. Vacuum relief for water heaters and other pressure vessels, shall be sized such that the total cross-sectional area (at the valve seat), is not less than one pipe size less than the cold water feed size; 1/2 inch CW (1 at 1/2 inch), 3/4 inch CW (1 at 1/2 inch), 1 inch CW (1 at 3/4 inch), 1-1/4 inch CW (2 at 3/4 inch), 1-1/2 inch CW (3 at 3/4 inch), 2 inch CW (4 at 3/4 inch).

2.15 WATER TEMPERING VALVES

A. TYPE - Domestic Hot Water - Thermostatic water mixing valve shall be Leonard Type TM, Model TM-20, or approved equal, as noted on the drawings, with Duratrol thermostat, color coded scale cold to hot, safety stops set for maximum temperature, union angle check stops with removable strainers on inlets, volume control and shutoff and lockable temperature regulator. 3/4 inch inlets, 3/4 inch outlet.

2.16 BACKFLOW PREVENTION DEVICES

A. Reduced pressure backflow preventers shall have bronze inlet strainer, bronze body construction, removable bronze seats, stainless steel internal parts, bronze-bodied ball valve test cocks, non-rising stem gate valves with union or flanged connections between the valves and the device itself. Size as indicated on the drawings. Approved equals may be accepted with proof of State approval.

B. Units shall be Watts, or approved equal, Model #009 for 3/4 inch through 3 inch size or Model #909 for 4 inch and larger. All units shall meet the approval of the local Water Authority.

C. Spare Parts Kit: Furnish one (1) spare parts kits for each size of device to be installed.

D. Units shall be Watts, Conbraco, Febco or approved equal, and be Massachusetts State Board and USC approved.

2.17 ACCESS PANELS

A. All work shall be installed so that all parts requiring inspection, operation, maintenance and repair are readily accessible. Minor deviations from the drawings may be made to accomplish this, but changes of magnitude shall not be made prior to written approval from the Architect.

B. Furnish access panels and doors for installation in walls and ceilings at locations indicated on drawings and as required to permit access for adjustment, removal or replacement and servicing of all valves and equipment.

C. Access panels and doors shall be installed under other appropriate Sections for the surface or construction upon which the panels are located.

D. All access panels and doors shall be located in closets, storage rooms and/or other non-public areas, in a workmanlike manner, positioned so that the junction can be easily reached and the size shall be sufficient for this purpose (minimum 12 inches by 16 inches). When the access panels and doors are required in corridors, lobbies or other areas, they shall be located as directed by the Architect.

E. Access panels and doors shall be prime painted and furnished with cylinder lock and two keys as manufactured by Inland Steel Products Company "Milcor", Wash-Hannon, Inc. or "Way-Loctor" or equal. Type shall be as follows:

1.	Acoustical Tile Ceiling	"Milcor" Type A
2.	Drywall	"Milcor" Type DW
3.	Plastered Surfaces	"Milcor" Type K
4.	Masonry Construction	"Milcor" Type M
5.	1-1/2 Hour, 3-Hour or 4 Hour Rated	"Milcor" rated to equal ratings of surface doors installed in.

F. Access panels and doors in structural or glazed tile walls shall be equal to Continental metal products no. 1212MF, 14 gauge Type 304 satin finish stainless steel, minimum 12 inches by 12 inches.

G. Access panels shall be in accordance with the manufacturers and model numbers indicated in the Miscellaneous Specialties Section of the specifications.

H. Access panel and door Shop Drawings shall be submitted to the Architect for review.

I. Inform the other Subcontractors where access is required through ceilings in order that special clips for access can be provided.

J. Access panels and doors shall be 2, 3 or 4 hour rated as required to maintain rating of surface they are installed in.

2.18 WATER METER

A. The main house domestic water meter shall be provided in accordance with the requirements of the Local Water Authority.

B. The meter shall be the remote reading type with the remote read device mounted in a location acceptable to the Owner, the Architect and the Local Water Authority. Furnish and install all devices including meter interface unit, as required.

C. Shut-off valves shall be installed on both sides of the meter and a strainer shall be installed on the inlet side of the meter after the inlet shut-off valve. Provide bypass only if required by the Water Authority.

2.19 TRAP PRIMERS/PROTECTION

A. Trap seals shall be maintained using either trap primer units or, when approved by the Owner and Plumber Inspector, trap seals may be maintained using "Trap Guard" inserts by Proset Systems, Inc.

B. NOTE: it should be noted that in Massachusetts, there is a condition of approval on the Trap Guard™. It may not be used in rooms with only one drain. Also, in rooms with multiple drains, at least one drain must be fed by a trap primer.

C. Trap primer units to serve one or multiple drains, shall be:

D. Pressure Drop Activated Units:

1. Units shall be Precision Plumbing Products, Inc., or approved equal, Model P1-500 or P2-500, 1/2 inch connections, automatic brass trap primer units which shall be activated by a drop in water pressure (minimum 3 psi) in the active cold water line in which attached. Units shall meet Code and ASSE Standard #1018. Units shall be adjustable to line pressure and desired delivery amount.

2. Units shall deliver a maximum of two ounces of water on a 15 second pressure drop and have corrosion resistant brass fittings with a copper reservoir with clear plastic inspection cover, and mounting brackets, "O" ring seals.

E. Solenoid/Timer Units:

1. Units shall be Precision or approved equal model "Mini-Prime" Series MP-500, 115 volts, with solenoid valve, air gap and electronic controller.

F. Install units one foot above the flood level of the device served for every 20 feet of primer line. Pipe according to manufacturer's instructions, off top of supply line, and 15-1/4 inch down to bottom of distribution units.

G. Units serving multiple devices shall be furnished with #SS-8 straight supply tube and #DV-2, 3 or 4 distribution unit.

H. Adjust all units and cycle all primers at least six times to insure proper activity.

I. A shut off valve shall be installed prior to every trap primer unit.

2.20 CIRCULATOR

A. System circulators shall be Taco or approved equal, as follows:

1. 120° System - Taco Model 006-B6 in-line circulator, 1/40 HP, 115V, 1 phase, 60 hertz, 3250 rpm, capable of 2 GPM at 7 FT TDH, 1/2 inch. Set aquastat to start pump when temperature drops below 120 degrees and stop pump at 124 degrees F.

B. Pump shall be in-line, horizontal, oil-lubricated type designed for quiet operation, 125 #WP, all bronze construction, sleeve bearing, built-in overload protection, resilient mounted, dynamically balanced, open drip-proof motor, stainless steel shaft, carbon or ceramic seal.

C. Furnish and install an aquastat controller with remote bulb and immersion well for each circulator. Include proper length of capillary. Calibrate the units and adjust the set points so that indicated temperature is attained at the furthest fixture/outlet.

D. Balance the DW recirculation system, and provide all gauges, thermometers and flow devices, to accomplish the balancing, to ensure the required flow and temperature at all fixtures and outlets and at the pumps.

2.21 EXPANSION TANK

A. Provide thermal expansion tank for the domestic water heating system. Amtrol, Bell & Gossett, Taco or approved equal.

B. Tank shall be equal to Amtrol "Therm-X-trol" thermal expansion absorbers, ST series, diaphragm type, pre-pressurized thermal expansion tank specifically designed for potable hot water systems.

C. Tank shall be equal to Amtrol Model # ST-12 and rated for a maximum working pressure of 150 psig and a working temperature of 200 degrees F.

D. Tank shall be (NSF) National Sanitation Foundation listed.

2.22 ELECTRICAL MOTOR CHARACTERISTICS

A. Electrical motors shall conform to the requirements of IEEE, NEMA, U.L., N.E.C., F.M. and NFPA suitable for load conditions, squirrel cage, 1.15 service factor, drip proof, 1750 rpm unless otherwise noted, with inherent overload protection and pressure lubricated bearings with grease fittings. Refer to ELECTRICAL CHARACTERISTICS REQUIREMENTS of the Electrical Section of the Specifications.

B. Motors below 1/2 HP shall be 120V - 1 phase. Motors that are 1/2 HP and greater shall be in accordance with the electrical requirements. (Verify with Elec.) All motors shall be designed for use with across-the-line starters. Motors shall be provided with overload protection. Phase protection shall be provided on motors 1/2 HP and larger.

C. Motor leads shall be permanently identified and supplied with connectors.

D. The minimum requirement for three phase motors shall be NEMA Design B, Class B, insulated for a maximum 40 degree C (104 degrees F.) ambient.

E. Select motors for quiet, continuous operation to suit loads which may be imposed by equipment. Recognize that motor horsepowers specified and scheduled are minimum sizes. If larger motors, starters, power wiring and additional control wiring are included in bid.

F. Submit an accurate schedule of all motors. Include for each motor, the HP, RPM, nameplate, current, equipment served, location, electrical characteristics and identification number.

2.23 STARTERS AND CONTROLLERS

A. Motor driven equipment supplied under this Section shall be operated by starters furnished and installed under the Electrical Section, except for starters integral with Plumbing equipment which shall be provided by the Plumbing Subcontractor. Starters provided by the Plumbing Subcontractor shall meet all requirements of the Electrical Section of the Specifications.

B. The Plumbing Contractor shall provide nameplates on all starters furnished under DIVISION 16000 and SECTION 15400 for use on equipment provided under SECTION 15400.

C. All motor controls shall conform to NEMA Standards and be the product of a single manufacturer; Arrow-Hart and Hageman, Allen-Brady, or Square D.

D. Auxiliary contacts shall be included in all starters provided under DIVISION 16000, Electrical, and by Section 15400, for integrally mounted starters. Auxiliary contacts shall be provided for all interlocking wiring.

E. Starters shall normally be provided with two sets of contactors; one set normally open and one set normally closed. Interface shall be provided for all starters and other devices as noted herein.

F. Starters and contactors factory-built into the control panel of packaged equipment will be considered as an integral part of the package.

G. All starters, disconnects and control devices shall be clearly labeled with black lamacoid plates with engraved white letters, to indicate Owner's identification number, function and the equipment which they control. Submit list of labels for review.

2.24 VENTING GAS TRAIN DEVICES

A. All gas train devices shall be properly vented to unobjectionable locations to atmosphere.

B. Low pressure gas switches may be manifolded together.

C. High pressure gas switches may be manifolded together.

D. Main gas pressure regulators shall not be manifolded but shall be extended individually.

E. A vent line for each bleed valve/pilot regulator, for each gas train.

F. Lines shall terminate where shown, or 30 inch above horizontal surfaces with 90 degree goosenecks and tack welded stainless insect screens.

G. All piping and support assemblies exposed or located above roofs shall be cleaned and painted with a rust inhibitive paint.

H. Vent lines shall pitch back to the devices they are venting.

2.25 FIRESTOP SYSTEMS

A. Provide firestop system components at all fire rated construction where penetrated by the work of this section.

B. Refer to SECTION 07840 - Through-Penetration Firestop Systems, for all product requirements for maintaining integrity of fire rated construction at penetrations.

C. Firesafing and smoke seal is required where pipes and conduit leave or enter vertical shafts, at all floors and through all walls above or below all Class "A" acoustical tile ceilings, and all spaces without any type of finish ceiling.

D. Firesafing and smoke seal is required for all penetrations through rated walls and partitions and at partitions separating smoke zones.

E. Firesafing and smoke seal of pipe and duct penetrations through non-rated secondary walls within a rated larger area need not require firesafing and smoke seal until they penetrate the rated walls.

F. Firesafing and smoke seal materials shall be in accordance with Section 07840, if listed, or as follows:

1. "Poke-through" fire containment, USG "THERMAFIBER", fire test CEG 4-11-78; USG 6-2-76; CEG 8-7-85.

2. USG "THERMAFIBER" Rigid-type, various thickness.

3. USG "THERMAFIBER SMOKE SEAL COMPOUND" - UL No. R11327-L; UL No. R11327-R.

4. Dow Corning fire stop sealant and Dow Corning fire stop foam "A" and "B" classified for 1, 2 and 3 hours.

G. All firesafing material shall be noncombustible as defined by NFPA Standard 220 when tested in accordance with ASTME 136; melt point - 2000°F; when in contact with metal, be non-corrosive meeting FS-HH-1-558 B; "k" value of 0.25 or less per ASTM C 518; the material shall be moisture-resistant, mildew, vermin-proof and non-deteriorating. The firesafing insulation shall meet fire containment tests per ASTM E119.

H. All sealants and compounds shall be neatly applied to each end of opening of ceiling, floor or wall penetrations and in accordance with Code requirements. All penetrations shall be minimum size possible.

2.26 CYST/LEAD REDUCTION FILTERS

A. Furnish and install a "Cyst and Lead Reduction Filter" for every drinking water outlet. This shall include drinking fountains, coffee stations, lounge drinking water outlets and whenever else indicated on the drawings.

B. Filters shall be Halsey Taylor model "HWF172 Water Sentry VII", or approved equal. (Note, where space in the unit does not allow the HWF172, the HWF142 Aqua Sentry shall be utilized.)

C. Cap and housing shall be made of rust and corrosion free plastic, quick disconnect 1/4 turn installation, automatic inlet shutoff valve that closes when filter is removed, spun polypropylene prefilter mesh. Filter shall be made of activated carbon and "ATS" lead removable media. Unit shall be rated for 1,500 gallons, .75 gpm flow rate, 40-120 degrees F, 20-105 psig, 3/8 inch O.D. inlet, 1/4 inch O.D. outlet. Use 3/8 inch piping to fountain, Provide valves on inlet and outlet.

D. Performance Criteria:

1. ANSI/NSF 42, Chlorine-Class 1, Particulate - Class 1, taste and odor.

2. ANSI/NSF 53 for reduction of lead and cyst through 3000 gallons.

E. Each filter shall be flushed for three (3) minutes to remove any residue of carbon fines.

F. Note: For some models of coolers and fountains, the units will need to be mounted remote from the fountains. Provide access and all piping.

2.27 DUPLEX EJECTOR

A. Furnish and install Weil, Gorman Rupp, Zoeller, or approved equal, equal to two (2) Weil Series 2400, model 2427, submersible, pumps. Each pump will be rated to deliver 75 GPM at 24 feet TDH.

B. The motors will be not less than 1-1/2 HP, 60 hertz, 1750 RPM, 208 volt, three phase, AC, airfilled, NEMA 6 submersible design. Motors shall be furnished with sufficient length of neoprene jacketed power cable to reach control cabinet.

C. The motors shall be housed in an air filled watertight cast iron motor shell with the windings having Class 'F' insulation and pre-lubricated double seal bearings. The motor shaft shall be 300 stainless steel with keyway for positive positioning and securing of the impeller. Motor end bell shall be designed as a terminal box.

D. Impeller shall be bronze, accurately machined to the proper diameter and statically and dynamically balanced.

E. The pumps shall have a double mechanical seal. The entire seal shall be housed in an oil filled chamber with no portion of the seal face coming in contact with the pumping media.

F. Controls: 4-Weil Series 8234 mercury float switches, hermetically sealed, mounted on galvanized rod with cover plate mounting. Controls shall be pumps off, pumps on (alternates pumps), high water alarm, pump on (alternates pumps), high water alarm, pump on (second, stand-by pump). Each switch shall have sufficient length of cable to reach control cabinet.

G. Duplex control panel shall be NEMA 3R rated for outdoor installation containing the following:

2 - magnetic starters with three-coil OL protection
2 - fusible disconnect switches
1 - automatic alternator
2 - T.O.A. selector switches
2 - pump running lights
2 - moisture sensor warning lights
2 - test station for moisture sensor
2 - sets of moisture sensor relay with test station
2 - control circuit transformers
1 - 4 inch alarm bell, 115 volt, mounted on panel door with on-off silencing switch mounted inside of cabinet
1 - alarm light with flasher mounted on panel door
2 - overload reset buttons
2 - sets of temperature limiter relays with indicating lights and resets
1 - set of dry contacts for wiring to remote audio/visual alarm panel
1 - numbered and wired terminal strip

H. 42 inch diameter x 60 inch deep cast iron basin.

I. One (1) 48 inch diameter steel cover with all necessary openings including vent connection and matching angle iron curb frame.

J. Each pump to have Weil 2613 quick removal system allowing pumps to be removed without entering pump chamber.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide materials and equipment as shown and specified and as required to provide complete and satisfactory operating systems. Make connections to equipment, devices, etc., provided or installed under this Section as shown and specified.

B. All equipment, fixtures, outlets and devices shown on the Plumbing and Architectural Drawings shall be connected with all of the proper utilities and properly tied into the building plumbing systems.

3.2 MATERIALS AND WORKMANSHIP

A. Work shall be executed in a workmanlike manner and shall present neat and mechanical appearance when completed. Piping shall run concealed except in mechanical rooms and areas where no ceiling exists.

B. Work and workmen shall be fully insured as required.

C. Material and equipment shall be furnished new.

D. Owner shall not be responsible for material and equipment prior to testing and acceptance.

3.3 BULLETINS, MANUALS, AND INSTRUCTIONS

A. Furnish operation, lubrication and maintenance manuals for each piece of equipment.

3.4 INSTALLATION OF EQUIPMENT

A. Equipment shall be installed to avoid interference with structure and with work of other trades.

B. Equipment shall be installed so as to properly distribute equipment loads.

C. All steel supports and hardware for proper installation of anchors, guides and hangers shall be provided.

D. Provide hangers, brackets and shelves for the proper installation of equipment.

3.5 EXPANSION

A. All piping shall be installed to allow for expansion using offsets, loops or expansion joints.

B. Provide alignment guides and anchors as required.

C. Install piping to allow freedom of movement in all planes without imposing undue stress on any section of the main piping, branch piping, equipment and structure.

3.6 PIPE GUIDES AND ANCHORS

A. Provide pipe guides for expansion joints according to expansion joint manufacturer's published recommendations. Use at least two guides each side of expansion joint or loops.

B. Install manufacturer or field fabricated alignment guides to allow movement in axial direction only. Install vertical risers properly anchored and guided to maintain accurate vertical position of piping. At time of start-up, clean and lubricate guides and adjust to allow free sliding at operating conditions.

C. Fabricate anchors from structural steel channels, plates or angles secured to the structure.

D. Take care to avoid introduction of excessive reactive forces and operating weights into the structure and onto equipment and piping.

E. Prepare and submit for review, prior to installation, drawings showing the location of expansion joints and anchors. Show details of proposed connection to structure.

3.7 INSERTS

A. Properly locate and firmly secure inserts to form before concrete is poured, for new construction.

B. For support of light equipment and materials, approved self-drilling expansion shields may be used.

C. Where inserts must be placed after concrete has been poured, use self-drilling expansion shield inserts as approved by the Structural Engineer.

D. Place inserts only within main structure and not in any finishing materials.

E. When inserts are required in precast concrete, supply inserts and location drawings to the precast concrete supplier for casting into the material. Otherwise, include the cost of having the precast concrete supplier install inserts at the site.

F. Use wedge type concrete inserts, similar to Grinnell Fig. 281, for pipe and equipment hangers, supports and anchors, adequately sized for loads to be carried.

G. The use of "explosive" type inserts shall be prohibited.

3.8 HANGERS

A. Suspend piping and equipment with all necessary hangers and supports required for a safe and workmanlike installation. Ensure that pipes are free to expand and contract and are graded properly and that each hanger is adjusted to take its full share of the weight.

B. Suspend hanger rods directly from the structure. Do not suspend from pipes, ducts, equipment, metal work, ceilings, or hangers of other trades.

C. Supply and install auxiliary structural steel angles, channels and beams where piping and equipment must be suspended between joists or beams.

D. Hangers shall be spaced to ensure that structural steel members are not overstressed. In no case shall pipe hangers be further apart than indicated in this Specification.

E. The use of trapeze-type hangers for support of piping shall be subject to prior acceptance. Where permitted, fabricate from angle or channel frames and space hangers to suit the smallest pipe size.

F. Do not use hooks, chains or straps to support equipment and materials.

G. All hangers shall be suspended directly from beams and the top chord of joists. Hangers shall not be suspended from the bottom chord of joists, or from standard gauge metal decking. Hanging from all other items, such as structural metal decking, etc., shall require the approval of the Architect.

H. Copper piping shall utilize copper plated supports or copper plated rockers sized for insulation thickness to hanger ring on underside (to prevent electrolysis).

3.9 PIPE IDENTIFICATION

A. Provide color-coded pipe identification markers on all piping installed under this Section.

B. Pipe markers shall be snap-on laminated plastic equal to "Setmark" by Seton Name Plate Corp.

C. Provide an arrow marker with each pipe service marker.

D. Piping shall be labeled at twenty feet intervals and at the entrance and exit of all mechanical areas.

E. In general, one and one-half inch high legend shall be used for pipes four inch diameter and larger; 3/4 inch high legend shall be used for pipe lines three inch diameter and smaller.

F. Color coding shall be in accordance with industry standards and with ANSI A13.1, latest edition.

G. Locate identification and flow arrows as follows:

1. On vertical pipes approximately seven feet above floor.

2. Behind each access door and panel.

3. At each change of direction of piping.

4. On each piping branch closest to point of connection to main piping.

5. At all valves.

6. At intervals not greater than 40 feet on straight runs of exposed piping and on both sides of walls.

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

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

3.10 VALVE TAGS AND CHART

A. At the completion of work, attach to each valve on the hot and cold water system, a valve tag of at least 1-1/2 inch in diameter with designating numbers corresponding to a chart for identification purposes.

B. Provide a chart framed under glass and mount where directed.

3.11 ACCESS AND ACCESS PANELS

A. Provide proper access to all valves, traps, strainers, controls and material and equipment which may need inspection, replacement or service. Coordinate locations with General Contractor.

B. Where shut-off valves or other items requiring access occur, furnish access panels for installation under other Sections.

3.12 ESCUTCHEONS

A. Escutcheons shall be installed around exposed pipe passing through finished floors, walls and ceilings. Escutcheons shall be heavy, cast brass, chromium plated and adjustable to fit snugly around pipe, with set screw.

3.13 SLEEVES

A. Provide sleeves for all services for all penetrations to floors, roofs, masonry and below grade walls and for all other penetrations above grade for all services.

B. Set sleeves for piping in conjunction with erection of floors and walls, for new construction. Locate sleeves accurately and in accordance with Shop Drawings.

C. Size sleeves to provide 1 inch clearance around piping and to allow continuous runs of insulation where specified. Ensure that piping does not touch sleeves.

D. Pack clearance spaces with Thermafiber Firestopping. Caulk with fire-resistant, resilient waterproof compound, Flintguard 120-13 or equal. Ensure that fire ratings of floors and walls are maintained.

E. Piping sleeves shall be according to the following:

1. Through interior walls, use 18 gauge rolled and tack welded galvanized steel sleeves, set flush with finished surfaces on both sides. Refer to Room Finish Schedule.

2. Through exterior walls above grade and roofs, use machine cut and reamed standard weight steel piping, set flush with finished surfaces on inside and to suit flashing on outside.

3. For floors, a water dam is required. Use machine cut and reamed standard weight steel piping 18 gauge rolled and tack welded galvanized steel, or machine cut and reamed plastic pipe, set flush to underside of structure and extending 1-1/2 inches above finished floor.

4. Refer to drawing details for sleeving through below grade walls.

5. Cover pipe sleeves in walls and ceilings of finished areas other than equipment rooms with satin finish stainless steel, or satin finish chrome or nickel plated brass escutcheons, with non-ferrous set screws. Do not use stamped steel split plates. Split cast plates with screw locks may be used.

F. Prepare and submit detailed drawings showing accurate size and spacing of sleeves. Submit for review at least four weeks before installation.

3.14 FLASHING

A. Floor drains shall be flashed watertight. Order floor drains with suitable flashing and collar and provide additional flashing as required for flooring system.

B. Provide counter flashing for all roof penetrations.

3.15 INTERIOR WATER DISTRIBUTION

A. Furnish and install a properly sized water meter and all valving and accessories, as approved by the Water Authority. Provide meter support, inlet and outlet shutoff valves, inlet strainer and system drain valve.

B. All interior water piping shall be run parallel with the lines of the building unless otherwise shown or noted on the drawings and shall be concealed or run in the least conspicuous locations.

C. All interior service pipes, valves and fittings shall be kept a sufficient distance from other work to permit finish covering not less than 1/2 inch from such other work.

D. Furnish and install valves or stops on each connection to fixtures. Hot and cold water branches shall be valved with access panels provided as required.

E. Complete provisions shall be made for expansion, contraction and draining of all supply piping. Install drain valves with chains and caps at all low points.

F. All lines of water piping shall be protected from water hammer with approved shock absorbers at the ends of all branches and risers. Shock absorbers shall be used for all flush and quick closing valves. Shock absorbers shall be used at all other fixtures and fixture groups which do not have a quick-closing valve. Shock absorbers shall be installed in accordance with the Copper Development Association guidelines.

G. Hot water pipe takeoffs shall have a minimum of three elbow swing.

H. Mechanical make-up water shall be provided with a reduced pressure backflow preventer and capped for extension under separate Section.

I. Provide a balancing valve and a check valve on every recirculation branch line at connections to mains. Provide a shutoff valve at each balancing valve.

J. For each irrigation system, provide a reduced pressure backflow preventer with inlet and outlet shut-off valves, valved and capped for extension to exterior irrigation systems under separate Section.

3.16 INTERIOR SANITARY, WASTE, STORM DRAINAGE AND VENT PIPING

A. Piping shall be installed as shown on drawings.

B. Piping shall be installed without undue strains and stresses, allowing for expansion and contraction.

C. A three inch air gap shall be provided on all equipment and drains discharging to floor drains.

D. Piping shall be installed in uniform alignment at uniform slopes as follows:

Pipe 1-1/2 inch and less:	1/2 inch per foot
Pipe 2 inch and 2-1/2 inch:	1/4 inch per foot
Pipe 3 inch and above:	1/8 inch per foot

E. Horizontal vent piping shall be graded and connected so as to drain back to the sanitary or waste pipe by gravity.

F. Piping shall be tested and approved prior to backfilling or concealing.

G. All open pipe ends, including grates of all drains, shall be temporarily sealed during construction to prevent the entrance of foreign debris.

H. Buried piping shall be a minimum of three inch size for sanitary and two inch for vents and be uniformly supported along its entire length. The minimum vent through the roof size shall be three inch.

I. The locations shown for buried piping are approximate only. Run the lines such that they are not installed within the "zone of influence" of the footings and below grade structures. In general, this means not below a 45 degree plane down and away from the lower edges of the footings.

J. The Plumbing Subcontractor shall be responsible for the quality of all excavation, trenching and backfill and for monitoring that work sufficiently to ensure a quality installation.

K. Piping through the building wall and at the building cleanout shall be caulked with lead and oakum. Offsets (caulked) in the sewer lines shall be provided in order to install the building cleanout in a direct line with the leaving sewer, in accordance with the Code.

L. All connections to combined sewers shall be trapped and separately vented to atmosphere.

M. Proper and compatible drain sump receivers shall be furnished to the roofer for cutting and installation under the Roofing Section.

N. All in-slab and underground work must be complete and tested prior to scheduled slab work. Any such work omitted or found defective after pouring of slabs will be the responsibility of this Subcontractor to correct, including but not limited to plumbing, excavation, backfill, compaction, and concrete. This Subcontractor is responsible for the inspection of underground piping installed under this Subcontract and proper coordination of inspecting agencies and pour schedule.

3.17 WATER SERVICE ENTRANCE

A. The exterior water piping shall begin at the points indicated outside the building wall and run as indicated on drawings.

B. Excavation for underground water piping shall be kept open until system is tested and approved.

C. The water service entry shall be appropriately restrained with thrust blocks and/or rods and clamps and be provided with flexible couplings outside of the foundation wall. Couplings shall be U.S. Pipe, American Ductile Iron Pipe or approved equal.

3.18 EXTERIOR SANITARY SEWER AND STORM DRAINAGE

A. The sewer drains shall run by gravity and extend to the points indicated outside the exterior building wall.

B. Piping shall be tested and approved prior to backfilling.

C. Provide a proper building cleanout for each service, just prior to the exit point, with proper access.

3.19 GAS SYSTEM

A. Provide a complete natural gas system beginning from the discharge of the Gas Company's meter. Initiate the Owner's request for Service with the Gas Company and coordinate the installation and timing of their work.

B. All horizontal lines shall be graded not less than one-forth (1/4) inch in fifteen (15) feet to drip pockets, which shall be readily accessible to permit cleaning and emptying. A suitable drip or condensation pocket shall be installed at service entrance, bottom of risers, and where required where condensate may collect. Furnish access panels for hidden drips.

C. Each outlet, including a valve or cock outlet, shall be securely closed gas-tight with a threaded iron plug or cap immediately after installation and shall be left closed until this equipment or appliance is connected thereto.

D. All branch outlet pipes shall be taken from the top or sides of horizontal mains and not from the bottom.

E. Every regulator and gas device requiring venting shall be vented to the outside. Low and high pressure vents shall be kept separate.

F. Emergency power generator shall be served by a dedicated gas line, tapped immediately downstream off the meter assembly, with a labeled shutoff valve. The fuel line at the shutoff valve, and every ten feet shall be labeled as follows:

"WARNING: Fuel for Emergency Power Generator. Do not shut off without the approval of the appropriate Authorities."

G. Buried Plastic Gas Piping:

1. Fill material shall be free of all solid and sharp objects.

2. A layer of sand, approximately 4 inch deep, shall be laid at the bottom of the trench prior to the installation of the gas pipe.

3. Install piping with "slack" so that external loading or thermal contraction will not place unnecessary stress on the piping or joints.

4. A tracer wire shall be installed 2 to 6 inch from the pipe, along the full length of the pipe, for locating #12 AWG copper wire with yellow insulating jacket.

5. Pipe shall be installed with 36 inch of cover.

6. A layer of sand shall be installed to 6 inch above the pipe.

7. A warning tape shall be installed not more than one foot below grade. The tape shall be 6 inch wide, yellow, non-detectable.

8. Clean backfill material shall properly fill the rest of the trench, properly compacted.

3.20 PIPE JOINTS

A. All welding shall be done in accordance with the welding procedures of the National Certified Pipe Welding Bureau, only by certified welders with certification provided prior to the start of work. Long radius welding fittings shall be installed on all weld lines. Branches from main piping shall utilize welding tees where branch size is main size or two (2) nominal sizes smaller except, where main is two and one-half (2-1/2) inches or larger and branch size is two (2) inches or smaller utilize Thread-o-let. Weld-o-lets shall be utilized where branch size is two and one-half (2-1/2) inches or larger and main is three (3) sizes larger than branch. Mitering of pipe to form elbows, tees, or similar construction will not be permitted. All pipe to be welded shall be cut off clean in pipe machine and beveled.

1. The Plumbing Subcontractor is required to have a Qualified Welding Procedure, approved by a testing laboratory. Welders are required to be certified to this procedure by a testing laboratory. If welders cannot present documentation of certification and continuous employment, recertification is required.

B. All screwed pipe joints shall have IPS threads. All thread on pipe shall be full and cleaned out. Gas piping shall be made up with compound suitable for gas, similar to Rectorseal.

C. Joints for buried hub-and-spigot cast iron soil pipe that are not gasketed shall be packed with picked oakum and caulked with molten pig lead. Twelve (12) ounces of fine soft lead shall be used for each joint for each inch in diameter of the pipe.

D. Soldered joints on water and waste piping shall be made up using lead free solder, conforming to Federal Spec. QQ-S-571c, and joint shall be filled the full length of the socket. The flux shall be applied evenly and tubing centered in socket of fitting. The fitting shall be heated evenly to the proper temperature to run the solder. The ends of the tubing and the inside of the fitting shall be thoroughly cleaned to a bright shining finish before applying flux. Flux shall be non-corrosive type conforming to Federal Spec. O-F-506.

E. Flanged water pipe joints shall be made with compressed rubber gaskets, full face for flanges, minimum thickness one-sixteenth (1/16) inch.

F. Press fit type connections for small diameter copper joining, shall be done in accordance with the approved manufacturer's instructions, using hydraulic crimping tools as obtained and calibrated from the manufacturer, specifically for these joints. All installers shall be certified to have been trained/instructed by manufacturer's representatives.

G. The Plumbing Subcontractor, if directed by the Architect, shall cut joints as directed to demonstrate how joint is filled.

H. PVC pipe joints shall be made with unions and mechanical joints where required for maintenance and removal, or solvent welded in accordance with manufacturer's published instruments.

3.21 PLUMBING SYSTEM TESTS

A. All systems shall be tested by the Plumbing Subcontractor in the presence of the Architect or his representative and the Plumbing Inspector after completion of "ROUGHING IN" and before concealing any section from view. This shall include all new systems and all existing systems and portions thereof that are scheduled to remain.

B. Furnish labor, tools, and all materials and do all testing as described herein.

C. No piping shall be insulated until it has been pressure tested and proven tight. All new systems that can be isolated with valves shall be pressure tested and proven tight as described herein.

D. Each system shall be pressure tested at pressures described herein and in a manner as described herein. Test pressures for each system shall be maintained as long as required by the Architect to determine the tightness of the system and/or as long as required to inspect the joints visually or with painted soap solutions. Wherever testing indicates leaks, the leaks shall be repaired in a manner prescribed by the Architect, and the test shall be repeated until the system is proven tight.

E. Storm, soil, waste and vent piping shall have openings plugged and the system above filled with water to the top of vent pipes. Water shall be allowed to stand a minimum of sixty (60) minutes or as long thereafter as is required for the complete inspection. Each vertical stack with its branches may be tested separately. If the lines prove tight, the water shall be drawn off and the fixtures connected.

F. Water piping shall be tested to a hydrostatic pressure of one hundred twenty-five (125) pounds per square inch or 50 psig above the incoming water pressure, whichever is greater, and proven tight at this pressure. Test pressures shall be held for at least eight (8) hours minimum, or as long thereafter as is required to make the complete test.

Water piping to be concealed by structural work or put below grade shall be tested to the above pressure and proven tight before pipes are concealed.

G. All domestic water recirculation systems shall be balanced for adequate flows in all loops that are shown/required to have a bona file "Circuit Setter" TM type balancing device.

H. Furnish and make temporary installations of all pumps, compressors and instruments for the testing. Test pressures shall be held for at least the minimum time periods noted above, or long enough thereafter to prove the system shall be repaired or replaced as directed, and the expense shall be borne by the Plumbing Subcontractor. All soap tested joints shall be washed clean after testing, and test water properly drawn off.

I. All gas piping shall be tested in accordance with the Fuel Gas Code, and the local Inspector, and in the Inspector's presence. (For systems up to 1/2 lb. or 14 inch w.c., with air or inert gas, to 6 inch hg (85 inch w.c. or 3 psig), with a mercury manometer or slope gauge, with no loss in pressure, for ten minutes.)

J. The Plumbing Subcontractor shall ensure that the Gas Supplier tests all piping, regulators and devices that are installed by the Supplier, up through the meters and/or regulators.

3.22 CLEANING AND ADJUSTING

A. At the completion of the work, all fixtures, equipment apparatus and exposed trim for this Section shall be cleaned and, where required, polished ready for use. Faucet washers which have been damaged during construction shall be replaced. Drains and traps shall be thoroughly cleaned. At the completion of the work, all valves, faucets and automatic control devices shall be adjusted for proper and quiet operation.

3.23 DISINFECTION OF THE POTABLE WATER SYSTEM

A. All new and repaired water systems, site and in-plant fabricated, shall be purged of all deleterious matter and disinfected prior to use. The method to be used shall be one of the following, depending on the local Plumbing Inspector:

1. The methods prescribed by the local Health Authority having jurisdiction.

2. The procedure described in AWWA C652 or AWWA C5186 (in accordance with the International Plumbing Code) in the absence of a prescribed method, or.

3. The method listed below:

a. The pipe system shall be flushed with clean, potable water until dirty water does not appear at the points of outlet.

b. The system or part thereof shall be filled with a water/chlorine solution containing at least 50 parts per million (50 mg/l) of chlorine, and the system or part thereof shall be valved off and allowed to stand for 24 hours.

c. The system or part thereof shall be filled with a water/chlorine solution containing at least 200 parts per million (200 mg/l) of chlorine and allowed to stand for 3 hours.

d. Following the allowed standing time, the system shall be flushed with clean potable water until chlorine does not remain in the water coming from the system.

e. The procedure shall be repeated if it is shown by a bacteriological examination made by the authority that contamination is still present in the system.

3.24 COMMISSIONING

A. Fill water systems. Check compression tanks to determine that they are not air bound and that system is completely full of water.

B. Before operating systems, perform these steps:

1. Close drain valves, hydrants and hose bibbs.

2. Open shutoff valves to full open position.

3. Open throttling valves to proper setting.

4. Remove plugs used during testing of piping systems and plugs used for temporary sealing of piping during installation.

5. Remove and clean strainer screens. Close drain valves and replace drain plugs.

6. Remove filter cartridges from housings and verify that cartridges are as specified for application where used, clean and ready for use.

7. Ensure that all traps are primed.

8. Balance all hot water recirculation systems to ensure minimum flow in all legs, and 120 degrees F to all fixtures.

C. Check plumbing equipment and verify proper settings, adjustments and operation. Do not operate water heaters before filling with water.

D. Check plumbing specialties and verify proper settings, adjustments and operation.

E. Energize pumps and verify proper operation.

3.25 INSTRUCTIONS

A. After completion of assembly and installation of all systems, equipment and piping required under this Section of the Specifications, the Owner's supervisory and operating personnel shall be instructed regarding the operation and maintenance of the systems. The instructions shall be given by the Plumbing Subcontractor and other qualified personnel who are thoroughly familiar with all systems and shall be furnished for a time period as directed by the Architect.

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

C. Thoroughly instruct the Owner's authorized representative in the safe operation of the systems and equipment.

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. Names of persons being instructed.
6. Other people present.

3.26 INSPECTION

A. Periodic inspections of the work in progress will be made to check general conformity of the work to the Drawings and Specifications.

B. Correct all deficiencies immediately upon notification.

3.27 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 Plumbing Subcontractor, who shall not waive any responsibility because of trial usage.

3.28 CUTTING AND PATCHING

A. Refer to the General and Supplementary Conditions and DIVISION 1.

B. Give notification in time to other trades of openings required for Plumbing Work. Supply accurate details of location and size. When this requirement is not met, bear the cost of cutting and patching.

C. The General Contractor shall do all cutting and patching required for the installation of the Plumbing work.

D. Obtain written approval of the Architect before cutting any openings through structural members.

3.29 PAINTING

A. Supply ferrous metal work, except piping, with at least one factory prime coat, or paint one prime coat on 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 and installation and leave ready for finish painting.

E. Prime coat material shall conform to SECTION 09900 - PAINTING.

3.30 BACKFLOW PREVENTER PERMIT AND INSTALLATION

A. All backflow prevention devices shall be approved, permitted, installed, maintained and tested in accordance with the local Water Authority and all State and local requirements. A full size brass discharge line shall be extended to the nearest floor drain.

B. Prior to installation, submit a design data sheet, with plans showing the method of protecting the water system, and secure approval from the (cross connection control division of the) local water authority, or its designee. This shall not be done until Shop Drawings have been reviewed.

C. Immediately upon installation, the Plumbing Subcontractor shall have the backflow preventer tested by a "Certified Backflow Prevention Device Tester", and the results recorded on the Water Authority's forms. Within 14 days after the installation, the Plumbing Subcontractor shall notify, the reviewing authority to arrange inspection of the installation. Submit copies of all paperwork to the water authority and the Engineer, through the Architect.

D. The approved Tester shall perform the testing utilizing (his own) properly maintained and calibrated compatible test kit.

E. Three (3) copies of each application and all subsequent correspondence, including the final permit, shall be forwarded to the Architect for record. Availability of final approvals or permits shall be prerequisite to scheduling a final inspection of the plumbing work.

3.31 INSULATION

A. General: All insulation shall be installed in strict accordance with the manufacturer's recommendations and shall be applied by a qualified insulation contractor. Covering shall not be applied on any apparatus or piping until the apparatus and piping have been thoroughly cleaned, tested and accepted as tight.

B. Piping: Pipe Insulation where vapor barrier jacket is required shall be installed with vapor barrier jackets drawn tight and firmly sealed to assure a positive vapor seal. End joints shall be covered with 4-inch wide butt strips of material identical to vapor barrier jackets, and they shall be drawn tight and securely sealed. The use of staples to secure insulation where vapor barrier jacket is required will not be accepted.

C. Fittings and Valves: Cement or molded insulation on fittings and valve bodies shall be same thickness as adjacent covering and finished neatly to match the adjacent pipe insulation. Insulation at anchors and supports shall be neatly cut and fitted.

3.32 SYSTEM START-UP AND OPERATION

A. The Plumbing Subcontractor shall provide all labor and materials and services necessary for the initial start-up and operation of all systems and equipment furnished and installed under this Section of the Specifications.

B. This Subcontractor shall provide the services of a qualified representative for all major equipment pre-start set-up, start-up and initial operation. Such periods shall be sufficient to insure proper operation of systems and equipment.

C. This Subcontractor shall check all equipment during initial start-up to insure correct rotation, proper lubrication, adequate fluid flows, non-overloading electrical characteristics, proper alignment and minimal vibration. Systems shall be checked for water flows throughout without blockages.

D. During operation of the systems qualified licensed personnel shall be provided and designated for maintenance of equipment and systems in good running order. Items such as strainer cleanouts, bearing lubrication, packing replacement and other consumables shall be provided without additional cost to the Owner. Failure of equipment during this period due to lack of proper supervision is the responsibility of the Plumbing Subcontractor, and continued failures shall be grounds for the Owner to provide such services with back-charges to the Plumbing Subcontractor.

3.33 EXCAVATION AND BACKFILL

A. All excavation and backfilling and related work, will be performed under DIVISION 2. The Plumbing Subcontractor shall be responsible for coordination and denoting the proper locations for buried work within the plumbing limits and for monitoring the work to ensure proper trenching, tunneling and backfilling.

B. All work shall be done in accordance with the proper phasing and timing of the work and in accordance with the Plumbing Code.

C. The Plumbing Subcontractor shall be responsible for the final preparation and final grading of all trenches.

3.34 RUBBISH REMOVAL

A. Remove from the site and legally dispose of all cartons of rubbish and debris resulting from work under this Section not less than once per week.

3.35 CORE DRILLING

A. All core drilling required for the installation of the plumbing systems shall be done by this Plumbing Subcontractor. This Subcontractor shall carry all costs for core drilling. The General Contractor will not be responsible for any circular penetrations required for the proper installation of the plumbing systems. Locate all required openings and prior to coring, coordinate the opening with the General Contractor and all other trades. Do not disturb existing systems. Thoroughly investigate the existing conditions in the vicinity of the required opening prior to coring. This Subcontractor shall be responsible for damage to the building and its systems from the coring operations. Disturbances from coring shall be kept to a minimum.

3.36 PHASING

A. Work may be performed in phases and the Plumbing Subcontractor shall provide necessary temporary valves, fittings, piping, shutdowns, labor, tools, etc., to comply with the approved phasing schedule. Piping and devices installed in one phase, to serve future phases, shall be valved and capped to allow systems to remain clean and operational and to facilitate extensions in future phases without shut down of the previous phases.

3.37 SHUTDOWNS AND CONTINUITY OF SERVICE

A. The Plumbing Subcontractor shall work with the building owner in maintaining integrity of all plumbing systems in all areas of work, as well as floors not under renovation. Coordinate and minimize any and all shutdowns of the plumbing system as follows:

1. Give proper notice to building manager and proper notice to all other authorities having jurisdiction when making shutdowns and pay all fees required.

2. Perform all duties required by owner when making a shutdown.

3. Fill out a shutdown notice form answering all items requested such as time and location of shutdown, systems affected, areas affected, etc., when requesting a shutdown.

4. Duration of shutdowns shall be kept to a minimum.

5. System shall be returned to normal operating conditions at end of each work day.

6. Do not interrupt existing services without Owner's approval and notification of all authorities having jurisdiction.

7. Schedule interruptions in advance, according to Owner's instructions. Submit, request for interruption with methods proposed to minimize length of interruption, in writing.

END OF SECTION 15400

SECTION 15500 - HEATING, VENTILATING AND AIR CONDITIONING - INDEX

PART 1 - GENERAL

PART 2 - PRODUCTS

SECTION 15500 - HEATING, VENTILATING AND AIR CONDITIONING INDEX, CONT'D

PART 2 - PRODUCTS, CONT'D

PART 3 - EXECUTION

SECTION 15500 - HEATING, VENTILATING AND AIR CONDITIONING INDEX, CONT'D

PART 3 - EXECUTION, CONT'D

PART 4 - AUTOMATIC TEMPERATURE CONTROL SYSTEM

SECTION 15500 - HEATING, VENTILATING and AIR CONDITIONING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Requirements of General Conditions of the Contract, Supplementary General Conditions and Division 1 (or Part A and Division 1 of Part B) are hereby made a part of this SECTION as fully as if repeated herein. (Attention is called to Division 1 General Requirements which may affect the work of this Section.)

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

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

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

E. The following sentence is intended for the guidance of the bidders. Wherever it occurs in this Section; when a group of Manufacturers is being referred to, it is the first Manufacturer listed whose equipment has been 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 thereunder which affects the work of this trade, whether or not such work is specifically mentioned in this Section.

G. Refer to Applicable Sections, including Section 01030 Alternates, for alternates which may affect work of this Section.

H. All computer equipment hardware and software provided under this Section which has microprocessor based control or monitoring functions which utilize date information shall operate without any error of any nature relating to date data, and without limiting the generality of the foregoing, such hardware, software and systems will not terminate ordinary operations nor produce invalid or incorrect data or information as a result of the input of date data that includes the year 2000 or earlier and later years.

Any problems arising because of non-compliance with the above shall be corrected by the Contractor without cost to the Owner.

1.2 WORK INCLUDED

A. Systems to be designed according to 2003 International Building Code, International Mechanical Code (as adopted by the State of Maine), and local codes that govern.

B. Special temperature, humidity, and filtration requirements are limited to the Collections/ Storage Rooms in the addition. Refer to drawings for specifics.

C. Furnish and install the following items required to complete the work of this Section. All equipment sizes indicated are approximate. Actual loads are not calculated until Design Development Documents are approved and Construction Document Phase begins. This consists of furnishing all fees, permits, insurance, materials, equipment, labor, transportation facilities, and all operations and adjustments required for the complete and operating installation of the Heating, Ventilating and Air Conditioning work and all items incidental thereto, including testing adjusting and balancing. This includes the following:

1. Two (2) gas-fired condensing boilers with Class IV vent system, safety and operating controls, condensate drainage, neutralization, and disposal system.

2. Dual temperature and hot water pumps and specialties. (Pumps on VSD's.)

3. Toilet room, electric closet, main electric room, mechanical room, Kitchenette/lounge, and miscellaneous exhaust duct systems, fans, curbs and relief vents.

4. Hot water unit heaters, cabinet unit heaters, convectors and finned tube radiation and enclosures, including custom enclosures in addition at full height glass.

5. Supply, return and exhaust ductwork. Low (2.0 inch) and medium (6.0 inch) pressure class.

6. Dual temperature, chilled water and hot water piping, valves and fittings.

7. Steam and condensate piping, valves, and accessories to cut back existing steam system.

8. Air cooled liquid chiller, low ambient operation.

9. Condensing unit, refrigerant piping and fan coil unit for 24/7 operation. Low ambient operation to -20°F.

10. Insulation and jacketing for piping, ductwork and equipment.

11. Grilles, registers and diffusers.

12. Two-pipe fan coil units, horizontal ducted, console types, and custom built-in units.

13. Condensate piping and traps for all cooling coils.

14. Sheetmetal covering and insulation for unused portions of louvers and unused louvers (blanking off).

15. Destratification fans. (Installation by DIVISION 16, ELECTRICAL.)

16. Direct Digital Control (DDC) Automatic Temperature Control System.

17. Variable air volume (VAV) and fan powered (FP) terminal boxes with sound attenuators and hot water and/or electric reheat coils.

18. In-duct sound attenuators.

19. Expansion tank (Diaphragm type) and air separator for piping system.

20. Interior air handlers with hot and chilled water coils, supply and return fans (constant volume and variable volume), economizer, and 100% outdoor air units providing ventilation air to existing building. Unit shall have hydronic heating and cooling. This unit shall include heat recovery wheel section.

21. Variable frequency drives for air system(s), and dual temperature pumps.

22. Electric duct mounted water to steam humidifiers for special collections areas.

23. Chemical treatment and glycol for freeze protection.

24. Testing and balancing of all air and water systems.

25. Vibration isolation and seismic restraint.

26. Operation and Maintenance (O&M) Manuals.

27. Electric duct mounted heating coils for high occupancy areas such as conference rooms and also rooms with strict temperature requirements such as the Collection/Storage Areas. "SCR" infinitely variable output is required for all.

D. Abbreviations:

1. HVAC - Heating, Ventilating and Air Conditioning.

2. H&V - Heating and Ventilating.

3. VAV - Variable Air Volume.

4. ATC - Automatic Temperature Control.

5. AHU - Air Handling Units.

6. DDC - Direct Digital Controls.

7. DX - Direct Expansion.

8. FCU - Fan Coil Unit.

9. ACCU - Air Cooled Condensing Unit.

E. Design Conditions:

Outside: Winter -3°F; Summer 86°DB/71°WB

Inside: Refer to Part III Special Temperature and Humidity Requirements.

Outside air will be provided at the rate of 20 cfm/person.

Outside air system serving fan coil systems is constant volume type system, therefore minimum air quantities are increased to allow for duct leakage, filter build-up and system efficiency decrease over time. Refer to Schedules.

The existing building as a whole will not be humidified or have any special filtration. However, the new addition Collection/Storage Rooms will have special filtration and humidification from a dedicated AHU.

F. Primary Systems:

1. Hot Water Heating System

a. Heating will be provided by low temperature, hot water (140°F) which will be generated in two (2) gas-fired condensing, modulating, packaged boilers.

1) The plant will be sized at an approximate net output for each boiler to provide a minimum of 2/3 of full capacity upon a failure of one of the boilers and to promote low load efficiency.

b. The boiler plant will have low fire start with modulating burner operation. (4:1 minimum turn down peak burner and staged for optimum plant efficiency.)

c. The heating plant will generate hot water for the entire facility. The hot water will be circulated through the dual temperature pumps in the heating season where these pumps shall each be rated for 100% flow at full head. (Two pumps total - one primary pump and one standby pump shall be automatically energized upon notification of loss of flow by the primary pump via DDC control system.)

d. Individual spaces will be heated with a combination of multi-row fin tube radiation; fan coil units; convectors; cabinet unit heaters; unit heaters; fan powered or VAV terminal reheat coils.

1) Fan powered boxes will be used in areas where fin tube is not desired or where constant air delivery is required.

e. A dedicated hot water piping system designed to serve the heating only equipment shall be included. This piping system will be designed with dedicated in-line pumps (two sized at 100% of the design water flow rate). Electric heating coils shall also be used in areas of high occupancy such as conference rooms (that would otherwise require summer operation of boiler), and two Collections/Storage area.

2. Air Conditioning System - Building is completely air conditioned, except Basement and Penthouse Mechanical Rooms.

a. Chilled water will be generated in a high efficiency type rooftop packaged air cooled chiller as scheduled. The single-piece chiller shall be factory assembled and fully run tested, be complete with (multiple) compressors as specified, motors, evaporator, condenser, refrigerant and oil operating charges, microprocessor control system and single point electrical power connection. There is no back-up for chiller system.

b. The dual temperature pumps with VSD's shall each be rated for 100% flow at full head. (Two pumps total, one primary pump and one standby as previously described.) Chilled water is pumped to air handlers and fan coil units.

c. Central station air handling unit will be utilized for the new addition and two-pipe fan coils for the existing building. All common building systems to be chilled water.

d. Provide hot gas bypass for low load conditions at chiller.

e. Collection/Storage Rooms will be served by dedicated AHU with chilled water first stage cooling followed by a second stage DX evaporative coil and ACCU. This unit shall be set up to operate continuously on demand, 24/7.

G. Ventilation Systems:

1. The addition will be ventilated and conditioned by central station, air handling units located in penthouse. The existing building will be ventilated by 100% outdoor air handler located in basement, providing a fixed amount of outside air. Energy recovery will be implemented for this unit.

2. All toilet rooms will be exhausted per code.

3. The Kitchen/lounge will be served by a dedicated exhaust fan.

H. Humidification Control:

1. Both buildings will be dehumidified via the air conditioning systems.

2. The addition will have humidification added to the collections areas only, utilizing electric type humidifier at dedicated unit. All Collections/Storage areas will have same level of humidification averaged across all spaces within that function.

a. Area being humidified must be separated by normally closed doors with gaskets from areas not being humidified. Partitions, floors, and ceilings shall be vapor retardant with perm ratings of 0.80 or less, all by ASC per the Architect.

I. Automatic Temperature Controls:

1. DDC ATC system shall be utilized. Main DDC panels shall control all HVAC systems and shall perform day/night scheduling for all unitary equipment. Provide occupied/unoccupied set back controls and morning warm-up controls.

2. All thermostats (sensors) will be protected with lockable "non-see-through" covers and guards. Thermostats will be non-readable and non-adjustable from the space by occupants.

3. Radiators and convectors in ancillary areas which are not generally occupied will receive self-contained, temperature regulating valves (corridors, toilets, storage rooms, etc.). Thermostats in non-supervised area will have heavy duty wire guards.

4. 100% outside unit will deliver three general temperatures: Cooling 55° +/-; Heating 74° +/-; Spring/Fall 65° +/- each to be controlled variables.

5. The existing building system will have normal occupied/unoccupied cycle with fan coils cycling at night to maintain reduced night temperature.

6. The AHU serving the Collection/Storage areas will run 24/7 to ensure proper environmental conditions for the collections area are maintained.

7. The AHU serving the remainder of the new addition will have normal occupied/unoccupied cycle. Unit will be off at night and weekends (as scheduled by Owner) and set back temperatures will be maintained by fin tube and FPB. Unit shall have automatic reset capability to increase discharge air temperature to minimize reheat use.

J. Demolition/Renovation:

1. Disconnection or breaking of connections, and the cutting of connections of piping or ductwork to existing HVAC apparatus that is to be removed, shall be provided by the HVAC Contractor. The HVAC Contractor shall place ductwork, piping, associated hangers and apparatus on the floor for removal by the Applicable Section Contractor. The HVAC Contractor shall cap piping and ductwork which is to remain.

2. It is intended that all piping and hangers, as indicated on the drawings be removed.

3. All piping that is not shown as being removed shall be retained and shall remain functional.

4. It is required that the HVAC Subcontractor fully coordinate the removal of all items with all other trades and the General Contractor. It is required that the piping shown to be removed not be removed until all other demolition and removal has occurred.

5. The HVAC Subcontractor shall modify the "Existing Conditions" as shown on the Demolition HVAC drawing(s) by adding, to a "reproducible wash-off mylar" all piping not shown on this drawing. All existing riser pipes, and steam and condensate return pipes, shall be tagged and identified in the field and on this drawing.

6. The HVAC Engineer shall review the above noted drawing, and shall advise as to any revisions to be made to the pipes to be removed or saved, and the removal of existing ductwork, etc.

7. After review by the HVAC Engineer pipe removal shall proceed.

8. Unless shown as remaining, all existing unit ventilators, radiation, ductwork, fans, heating and ventilating units, air conditioning units, thermostats, controls, associated piping and pipe runouts, boilers and all appurtenances of the above shall be removed.

K. ATC Demolition/Renovation:

1. The ATC Subcontractor shall survey the existing pneumatic system which is to be reused to determine appropriate cut back point. This Contractor shall clean all reused piping of oil and water. Any piping which has deteriorated due to corrosion, or which is kinked, shall be replaced, to keep existing areas in operation.

L. Emergency fuel shutoff switch, mounted outside of the boiler room, connected to every fossil fuel fire appliance in the boiler room to automatically suspend fuel flow to these devices. Provide all wiring and fuel valves. This shall be in addition to other series safety circuit controls (high limit, heat detectors, low water cut-offs, draft proving switches, CO detectors, service disconnects).

1.3 INTENT

A. Descriptions in the Specifications, or indications on the Drawings, of equipment, materials, operations and methods, requires that such items, operations and methods shall be of the quantities required, and that the systems shall be complete in every respect.

B. The Specifications shall be considered an integral part of the accompanying Drawings. Any item or subject which is not mentioned in one but is either mentioned or reasonably implied in the other shall be considered as properly and sufficiently specified. In the case of a conflict, where an item is described and specified differently in the specifications than on the drawings, the more stringent shall apply.

C. The HVAC Subcontractor 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 the installation. The HVAC Subcontractor shall provide fully qualified personnel to fulfill this requirement. The HVAC Subcontractor shall be responsible for the prompt replacement of defective materials, equipment and parts of equipment, and the repair of related damages.

1.4 RELATED WORK

A. Examine all other Sections of the Specifications and all other drawings and determine the relationship of the work under this Section to the work of other trades. Cooperate with all trades, and coordinate all work under this Section with all trades.

B. The following related items are included under sections listed below:

1. Concrete bases and thrust blocks for HVAC equipment. SECTION 03300.

2. Excavation and backfilling. DIVISION 2.

3. Cutting and patching of masonry, concrete, tile and other parts of the structure shall be under and by the APPLICABLE SECTIONS. Refer to SECTION 01045.

4. Fuel, water and electricity for all tests and the temporary operation of HVAC equipment. SECTION 01500.

5. Temporary heat. SECTION 01500.

6. Demolition and Removal: SECTION 01732. The HVAC Subcontractor shall cut, break connections, or disconnect HVAC components from ductwork and piping for dismantling and removal of all ductwork, piping and HVAC components (including hangers), that are to be removed. The HVAC contractor shall place these items on the floor for removal by the Applicable Section Contractor. The HVAC Contractor shall cap at disconnections, all piping and ductwork which is to remain.

7. Openings for Air Intake Devices (Louvers): In APPLICABLE SECTIONS, in which they occur.

8. Undercut doors and door louvers. DIVISION 8.

9. Woodgrounds for fastening air devices and radiation. Refer to Architectural drawings and DIVISION 6 to determine if woodgrounds are provided. Secure air devices and radiation to woodgrounds, if provided. Secure air devices and radiation directly to wall or ceiling surface if woodgrounds are not provided. Provide expansion bolts for masonry, concrete and block wall mounting.

10. Flashing of ductwork and roof curbs for HVAC equipment. DIVISION 7.

11. Painting of all exposed ductwork and piping and other mechanical equipment not having enameled surfaces, or stainless steel or chromed finishes. SECTION 09901.

12. The General Contractor shall provide all scaffolding and staging above six (6) feet in height, for all materials specified under this Section of the specifications.

13. City water piping and fittings, including insulation and backflow prevention, on plumbing piping systems connecting to HVAC equipment. SECTION 15400. All extensions of domestic water systems, to points of connection, shall be installed by licensed plumbers.

14. Refer to DIVISION 16 ELECTRICAL and to SECTION 15500 HVAC, for division of responsibility of Electrical work. All power wiring of every description shall be provided under DIVISION 16 Electrical, including power to ATC panels. All starters and controllers for mechanical equipment, except where provided as integral with mechanical equipment, shall be provided under DIVISION 16 Electrical. Power wiring does not include any A.T.C. wiring interlocks. Refer to SECTION 15500 PART 4 - AUTOMATIC TEMPERATURE CONTROLS.

15. In general, all wiring required for equipment provided by the HVAC Contractor and all controls and interlock wiring for this HVAC equipment, which is not shown or indicated on the Electrical Drawings of DIVISION 16 ELECTRICAL, shall be provided under Section 15500 HVAC.

16. Exterior wall louvers: DIVISIONS 5, 7 and 8.

17. Equipment: DIVISION 11.

18. Asbestos removal: The removal of any materials containing asbestos is hereby specifically excluded under the scope of this Contract. The HVAC Contractor shall be responsible, however, for the reinsulation of any existing piping designated to remain, from which asbestos cover has been removed. It shall be understood that the removal

of existing asbestos shall have been accomplished by others. The HVAC Contractor shall advise the architect where he believes that asbestos has not been fully removed before proceeding with any work.

19. This HVAC Subcontractor shall refer to Applicable Sections for phasing and shall apply the aspects of those sections to this HVAC Specifications.

20. This HVAC Subcontractor shall refer to Applicable Sections for Alternates and shall apply the aspects of those Sections to this HVAC Specification.

C. Furnish the following materials to be installed under other SECTIONS.

1. Prefabricated roof curbs and flashing to be installed under DIVISION 7 ROOFING AND FLASHING.

2. Access panels to be installed under applicable sections.

3. Destratification fans installed under DIVISION 16.

4. The ATC Sub-subcontractor shall provide relays, installed under DIVISION 16, to enable the BMS system to remote start all fractional horsepower HVAC motors. All power wiring to and from the relay shall be by DIVISION 16; all low voltage wiring shall be by the ATC Subcontractor.

D. Install the following materials to be furnished under other SECTIONS.

1. Duct installed smoke detectors furnished and wired under DIVISION 16 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 (or SECTION 01400-QUALITY CONTROL) 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 guideline, recommendations and instructions.

3. When requested, submit for review samples of materials proposed for installation 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 (as appropriate) 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, ductwork, or equipment within the insulation of other piping, ductwork or equipment.

7. Equipment, materials and work shall comply with the requirements of governing agencies, including, but not limited to those agencies listed under SECTION 15500 Paragraph 1.8 STANDARDS. Equipment, materials and work shall conform to, and be installed in strict accordance with, Federal, State and City or Town requirements and shall meet all of the requirements of all authorities having jurisdiction.

8. HVAC Subcontractor shall be responsible for cleaning up related debris to central locations for rubbish removal by the Applicable Section Contractor.

9. Install all HVAC equipment with the minimum code clearance from all 120 volt (or greater) electrical panel locations. A minimum of 36 inch clearance shall be maintained as required. Provide a minimum of 24 inch clearance for all low voltage panels.

1.6 ABBREVIATIONS AND DEFINITIONS

A. "HVAC", "HV" and "AC" as mentioned herein means specifically "Heating, Ventilating and Air Conditioning", "Heating and Ventilating", and "Air Conditioning" respectively, when used in this specification.

B. A.T.C. as mentioned herein means specifically "Automatic Temperature Control".

C. BMS as mentioned herein means specifically an Automatic Temperature Control provided Building Management System.

D. "Provide" may be used in place of "furnish and install". Where used, "provide" shall mean to deliver, furnish, erect, and connect-up, complete in readiness for regular operation, the particular work or equipment referred to.

E. "Concealed" shall be defined as: where piping or ducts are located in chases, shafts, and furred ceilings.

F. All ductwork and piping which is not concealed shall be considered "exposed".

G. 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.

H. The term "snapshot" shall be understood to refer to a computer printout of all the ATC points at a given instant in time. This shall include the status of all the DDC points and schedules for all control systems under this scope of work.

I. The term "or approved equal" shall be understood to refer to equipment manufacturers that the contractors of the 15500 Scope of Work shall be allowed to suggest for use in lieu of the manufacturer names listed herein. Any or approved equal or alternate manufacturers that the contractors wish to suggest shall be submitted within fifteen (15) days of awarding of a contract to the contractor, for review and comment by the engineer, architect and owner/user. It is understood that these alternate manufacturer names may or may not be accepted by the engineer, architect or owner/user with no resultant change to the contract price.

J. The Contractor shall submit based upon the manufacturer(s) that are scheduled and shall advise as to the cost reduction to include one of the other named or any "or approved equal" manufacturers. The scheduled manufacturer(s) shall be the basis of the bid.

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. Refer to SECTION 01005 - ADMINISTRATIVE PROVISIONS.

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

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

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 STANDARDS

A. The latest published issue of the standards, recommendations and requirements of the following listed Societies, Associations and Institutes, in effect at the date of Contract, are part of this Section. These standards shall be considered as minimum requirements; specific requirements of this Section and/or associated Drawings shall have precedence. In case of conflict between published requirements, the Engineer shall determine which is to be followed. Refer to SECTION 01090 - REFERENCE STANDARDS.

1. AABC - Associated Air Balance Council
2. AFI - Air Filter Institute
3. AMCA - Air Moving and Conditioning Association
4. ANSI - American National Standards Institute
5. ARI - Air Conditioning and Refrigeration Institute
6. ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers
7. ASME - American Society of Mechanical Engineers
8. ASTM - American Society for Testing and Materials
9. FIA - Factory Insurance Association
10. FMEC - Factory Mutual Engineering Corporation
11. IEEE - Institute of Electrical and Electronic Engineers
12. MCAA - Mechanical Contractors Associations of America
13. NEMA - National Electrical Manufacturers Association
14. NFPA - National Fire Protection Association
15. SMACNA - Sheet Metal and Air Conditioning Contractors National Association
16. UL - Underwriters' Laboratories, Inc.
17. OSHA - Occupational Safety and Health Act
18. N.E.C. - National Electric Code

1.9 DRAWINGS

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

B. Do not scale Drawings. Obtain accurate dimensions from Architectural and Structural Drawings or from direct 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 encountered.

D. Leave areas clear and unobstructed where such areas are indicated as reserved for future equipment.

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

F. Provide all ceiling mounted components, including air terminals, access doors and panels, in strict accordance with Architectural 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 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 to the Contractor and Architect for decision.

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

C. In case of any discrepancies between the Specifications and Drawings, or where the Specifications or Drawings are not clear or definite, the subject Contractor conflicts shall be referred to the Architect, whose decision shall be final. Adjustments arising from Contractor conflicts shall be made at no expense to the Owner.

1.11 PERMITS, FEES, INSPECTION, CERTIFICATES

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

B. Be fully acquainted with and obey all Federal, State, and Municipal laws, bylaws, codes and regulations, and all authorities having jurisdiction. Provide fire dampers and smoke dampers in air handling systems where required.

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. If any Work is covered up without consent, it shall, if required, be uncovered for examination and the required corrections made at no 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 SECTION 15500 work.

1.12 RECORD DRAWINGS

A. Refer to GENERAL CONDITIONS AND SUPPLEMENTAL GENERAL CONDITIONS (or SECTION 01700 - CONTRACT CLOSE-OUT).

B. All costs for Record Drawings shall be borne by the HVAC Subcontractor. Drawing files to be provided in AutoCAD Release 14 format or 2000 format, whichever is required by the Owner, to the HVAC Contractor by TMP at a charge of $40.00 (forty dollars) per drawing ($500 minimum) to TMP by the Contractor. The drawing files provided by TMP to consist of the bid document drawing files with any RFI's, addenda and revisions incorporated by TMP included.

C. Purchase and maintain at the job site at all times a complete set of prints of the HVAC Drawings. As the work progresses mark all changes made, whether resulting from addenda, resolution of conflicts, 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 locations of future access doors and panels. Show pipe invert or centerline elevations, and pipe sizes, of all services at key points within the building, where buried, and where entering and leaving the building. Show location dimensions from building grid lines.

E. The Record Drawings will be reviewed at regular intervals by the Architect, and will be considered when reviewing the monthly applications for payment submitted by the HVAC Subcontractor.

F. When the Record Drawings have been completed to the satisfaction of the Architect, the Contractor shall furnish to the Architect the following:

1. The marked-up job record blackline prints.

2. The reproducible revised transparencies entitled "Record Drawings" marked with the date when printed and signed by the HVAC Subcontractor's Engineer who made them.

3. Three (3) complete sets of blackline prints of the "Record Drawings" and two (2) sets of CD-R disks in AutoCAD 2002 format.

G. Distribution by the Architect of the Record Drawings shall be:

1. One set blackline prints to the HVAC Engineer.

2. One set blackline prints retained by the Owner.

3. Two (2) Record Drawing CD-R disks in AutoCAD 2002 format to be retained by the Owner.

1.13 OPERATION AND MAINTENANCE DATA

A. Refer to SECTION 01700 - CONTRACT CLOSE-OUT (or General Conditions and Supplemental General Conditions) for submittal procedures pertaining to operating and maintenance manuals.

B. Assemble three (3) copies of indexed, hard cover manuals entitled: "Operating and Maintenance Instructions for Mechanical System". Submit one copy for review at least two (2) weeks before instructions to Owner are commenced.

C. Instruct the Owner for one week as to the operation and maintenance of the system. This and all instructional sessions shall be video taped and three (3) hard copies made. Submit one (1) copy to the Architect as part of the Project close-out process, the other two (2) copies shall be turned over to the Owner.

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 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. Two (2) "snapshots" of the DDC points of the Automatic Temperature Control system. This data shall be compiled and recorded when the system is in the "occupied" and "unoccupied" modes of each zone. Also include the schedule for these modes as established by the Owner.

11. Start-up reports for all major equipment.

1.14 SHOP DRAWINGS

A. Refer to GENERAL CONDITIONS and SUPPLEMENTAL GENERAL CONDITIONS (or SECTION 01300 - SUBMITTALS) and specifications for shop drawing requirements. The HVAC Subcontractor shall submit the additional information indicated herein.

B. Present, not later than three (3) weeks (or as noted under General Conditions) after award of the Contract, a list of Shop Drawings to be submitted with the name of each manufacturer and supplier intended to be supplied. Failure to provide this list will result in all alternative manufacturers not scheduled or listed in the Contract Documents to be disallowed.

C. Shop drawings of equipment furnished under this Section shall include, but not be limited to, all items listed under 15500 - 1.2 and all items listed within this Section. This shall include piping, pipe fittings, and method of pipe joining (piping standards).

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

E. Submit for review, one reproducible and seven (7) copies of certified Shop Drawings of all equipment, materials, equipment wiring, diagrams, motors, starters, controls, and schedules. Ensure that all submitted Drawings have adequate clear space for all stamps. When requested, resubmit Drawings promptly.

F. Include for each fan, air handling unit and pump, a performance curve showing duty and horsepower with design operating point indicated clearly.

G. Submit sound power levels of air terminal units, fans, and air handling units, and pumps.

H. Be responsible for the timely submission of Shop Drawings to suit manufacturing schedules of equipment and construction schedules of the building.

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

J. Each Shop Drawing shall indicate clearly the correct name and address of the project, the intended use and location of the equipment, and the specified designated number.

K. Upon receipt of approved Shop Drawings, distribute prints to all trades and manufacturers affected.

L. Submit certified Shop Drawings to manufacturer of sound and vibration control equipment and components.

M. Submit Shop Drawings to authorities having jurisdiction.

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

O. Bind one set of the corrected "Reviewed" Shop Drawings in each Operation and Maintenance Instructions Manual. Refer to DIVISION 1 and Item 15500 - 1.13.

P. Provide information to other Contractors as required of concrete equipment bases and for any other work to be performed by other trades.

Q. Prior to submission of Shop Drawings, 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 Shop Drawings. The HVAC Subcontractor will 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 will be returned without being examined by the Architect. 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.

R. 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 Division 1.

S. The contractors may purchase design drawing CAD files if the procedures and payments outlined in Section 01330 and in Section 15500, paragraph 1.15, subparagraph A. are provided and agreed to by the contractors.

1.15 COORDINATION DRAWINGS

A. Conform to the requirements of Division 1 Section 01040 - COORDINATION. Before work progresses, and in addition to the shop drawings listed herein, submit Coordination Drawings prepared by the HVAC and Sheetmetal Subcontractors at a suitable scale not less than 3/8 inch equals one foot in an AutoCAD 2002 format or AutoCAD 2000 format, whichever is preferred by Owner. Provide one reproducible and one blue print of the 3/8 inch sheetmetal HVAC-Coordination Drawings showing the following:

1. Systems layout Coordination Drawings of all ductwork, piping and equipment installed under this SECTION showing the adjoining work of other trades at all floors, Mechanical Rooms and duct shafts.

2. Composite systems Coordination Drawings showing how HVAC systems are to be installed where conflicts with the work of other trades may occur. The Contractor, before transmittal of the Shop Drawings to the Owner for approval, may require the HVAC and Sheet Metal Subcontractors to revise the composite systems 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 Sheet Metal Subcontractors shall make such revisions to composite systems coordination drawings, when requested, without extra charge.

3. The HVAC Subcontractor shall be responsible for the cost of 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.

4. Where ductwork is installed above suspended ceilings the Ceiling Contractor and the Sheet Metal Contractor shall coordinate the method of support for the ceiling. In no case shall the ductwork be used to support the ceiling construction.

5. Access Panel Coordination: Show locations of all access panels for all trades on Coordination Drawings The Testing and Balancing (TAB) Sub-Subcontractor shall review the Coordination Drawings and verify that all balancing devices are shown and all required access had been addressed. This Sub-Subcontractor shall be required to sign-off on the Coordination Drawings prior to submittal.

6. The HVAC Subcontractor shall survey the existing building(s) and measure existing steel structure to show existing steel on the Sheetmetal and Coordination Drawings.

7. The HVAC Subcontractor shall produce a set of Rooftop Equipment Coordination Drawings; complete with air intakes, stacks, emergency generator exhaust and air systems exhausts shown.

8. The contractors may purchase design drawing CAD files if the procedures and payments outlined in Section 01330 are provided and agreed to by the contractors.

1.16 TEMPORARY SERVICES

A. Refer to SECTION 1A SPECIAL CONDITIONS (or SECTION 01500 - CONSTRUCTION FACILITIES and TEMPORARY CONTROLS).

B. Operations necessary for checking, testing and balancing shall be done after written approval is given to start up the 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 to prevent construction debris from entering.

C. Permanent heating or air conditioning systems shall not be used for temporary heating or air conditioning, 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, chillers or any permanent equipment be operated without feed water, chemical treatment, and air filters.

1.17 IDENTIFICATION OF MECHANICAL SERVICES

A. After finish painting is completed, 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. Use Brady, Seton, MSI, Atlantic Engraving labels or approved equal.

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

D. For pipe and ductwork identification provide the following:

1. On ductwork and piping three (3) inches diameter (including insulation) and larger, lettering shall be two (2) inch high capitals. On smaller diameter piping, use 3/4 inch high capital letters.

E. Locate identification and flow arrows as follows:

1. On vertical pipes and ducts approximately seven feet above floor.

2. Behind each access door and panel.

3. At each change of direction of piping and ductwork.

4. On each piping and duct branch close to point of connection to main piping and ductwork.

5. At valves.

6. At intervals not greater than 50 feet on straight runs of exposed piping and ductwork. On ducts and pipes penetrating walls and floors (two labels required at each penetration).

7. 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.

8. Identify heat traced piping.

9. 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.

10. Label colors per ANSI Standards.

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

G. Identify each fan (including air handler systems) with a label which shall be dated and be a minimum of 6 inch X 4 inch. The label shall be made of heavy-duty plastic laminate securely attached to the air handling device. Submit a sample and a list of all equipment tags to be provided complete with all information included on the tags to the Engineer for shop drawing approval. Each label shall be provided with the following information:

1. Tag number.

2. Design airflow (CFM).

3. Design external static pressure (in. H_2O).

4. Motor horsepower.

5. Area served by unit.

H. Provide typewritten master lists of Mechanical Services Identifications in Operating and Maintenance Instruction Manuals.

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

J. Supply and install 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 long brass chains. Brass tags may be omitted on small valves which isolate a single piece of equipment such as a unit heater, fan coil unit, or section of radiation.

K. Prepare flow diagrams (same size as record documents) of piping systems to identify equipment and valves. Include these diagrams in record drawings.

L. Insert page-size copies of diagrams into each Operating and Maintenance Manual.

M. 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. Provide 1/16 inch = 1 foot-0 inch scale drawings with all valves (complete with tag number) indicated on the drawings. When valves are located above lay-in ceilings, the HVAC Subcontractor shall install a blue sheetmetal screw in the ceiling grid near the valve for quick valve location identification.

N. A line item in the schedule of values shall be dedicated to flow diagrams of mechanical services.

O. All rooftop HVAC motor driven equipment, including exhaust and supply fans, shall be labeled with reflective unit tags, labeling each piece of equipment with 1 inch high letters identifying the equipment with the tag number used in the Contract Documents. Unit tags shall be of a material which maintains it's adhesion qualities in exposed (outdoor) applications. This criteria shall be in addition to all other requirements of this section. These unit tags shall be located on the east side of the equipment at 5 feet-0 inch ± above the roof.

1.18 PROTECTION

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

B. Until final connections are made, cover openings in equipment, pipes, and ducts with caps or heavy gauge plastic sheeting.

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 SECTION 15500 from weather damage.

E. Provide temporary sheetmetal caps on all ductwork delivered, stored or partially installed at the site.

1.19 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. Install work to conserve headroom and space. Conform to requirements of SECTION 01040 - COORDINATION.

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 scheduled progress of work.

1.20 GUARANTEE

A. Conform to the requirements of GENERAL CONDITIONS. (or SECTION 01700 CONTRACT 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, which shall be not less than one year, shall be arranged by the HVAC Subcontractor to enable the period to commence upon beneficial use by the Owner.

C. Any equipment or material which does not match the manufacturer's published data or specifically supplied rating schedules during performance tests, shall be replaced without delay. Bear all associated costs, and adjust all components, at no additional cost to the Owner, and adjust all components to achieve the proper rating.

D. Correct defects and deficiencies. Pay for resulting damage to Mechanical or other work, and to property and persons, which appear or originate during the guarantee period.

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

F. Written guarantees shall be included in the Operation and Maintenance Manuals.

1.21 DEMOLITION AND MAINTENANCE OF EXISTING SERVICES

A. During the execution of the work, all required rerouting, capping, valving, deactivating and relocating of existing equipment and systems shall be performed by the HVAC Contractor as indicated on the drawings and as determined by the Architect and as required by job and phasing conditions. The above work shall be done in close cooperation with the Construction Manager's (or General Contractor's) representative to facilitate the installation and interface of new systems with existing systems, and the completion of this Contract. The Owner will require the continuous operation of all existing systems, while demolition, relocation work, and new connections to systems will be performed. Outages required for construction purposes shall be scheduled for the shortest possible periods of time with the Owner's designated representative for specific, mutually agreeable periods of time, after each of which the interruption shall cease and service shall be restored. This procedure shall be repeated to suit the Owner's working schedule as many times as required, until all work is completed.

B. Prior to any deactivation, relocation, rerouting, refeeding, etc., consult the drawings and arrange a conference with the Owner's representative in the field to inspect each of the items to be deactivated, removed, relocated or demolished. Care shall be taken to protect all equipment designated to be relocated and reused.

C. Give notice to all parties, with a minimum of forty-eight (48) hours in advance.

D. All draining of existing systems, and all filling and venting required, to remove and relocate existing piping systems or make new connections to existing systems, shall be provided under this Contract. This shall include providing adequate water treatment chemicals, etc.

E. All deactivated systems designated to be demolished, shall be demolished, removed and legally disposed of by the Construction Manager, including disposal of oil, refrigerant and or other types of waste. Refer to Paragraph 1.2, subparagraph K, for further information regarding HVAC Contractors responsibility.

F. Refer to Division 1.

G. Owner's "right of first refusal" is affirmed for all equipment and material slated to be removed, including all salvage value. The Owner shall accept or waive this right in writing. All material so waived shall be disposed of, off-site and in a lawful manner. All material with rights so retained shall be delivered to a location on campus as directed by the Owner.

1.22 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 indicated on the Contract Documents and as herein specified, including final connections to equipment to result in a complete system, fully operational. Coordinate the location of all equipment with the Architect. Obtain installation diagrams and methods of installation of all equipment from manufacturers. Follow instructions strictly. If additional information is required, obtain same from the Architect.

1.23 PROTECTION OF ELECTRONIC DEVICES

A. Provide electrical current surge protection and current conditioning for all electrical power externally supplied to HVAC equipment and supporting devices using or dependent upon circuit boards and other electronic devices. This shall not be limited to automatic temperature control panels and devices outlined under 15500 Part 4, but shall include any HVAC equipment with circuit boards where not internally protected by the host equipment. This shall include but not be limited to boilers, external control panels, VFD's, air handling units with on-board controls.

B. Circuit surge suppression shall be provided to a standard of U.S. Government Mode 1 (1,000 surges of 6,000 volts, 3,000 amperes, SRV <400 volts, no failures, L-N (ground wire protection) mode endurance test) and shall be listed under UL standard 1449.

1. Type shall be a series surge reactor current limiter; cascaded, auto-tracking dual polarity voltage; dual pulse inverters. Parameters optimized for switch-mode power supply protection. Clamping voltage onset shall be 172 volts nominal; 2 volts above peak line voltage (auto-tracking).

2. MOV's (Metal Oxide Varistors) or other sacrificial devices will not be an acceptable means of surge protection and will be rejected.

3. EMI/RFI filter response shall be bi-directional, wave tracking with 50 ohm Rg load: 3db at 5kHz; 26dB at 100kHz; 38dB at 300kHz.

4. Let-through slew rate shall be 5,000 volt/microsecond disturbance reduced to 28v/microsecond within AC power wave envelope, and less than 10v/microsecond outside the power wave envelope.

5. Maximum Applied Surge Pulse Joule Rating Unlimited rating (due to surge current limiting) (8x20 microsecond).

6. Maximum Applied Surge Pulse Voltage 6,000 volts (1.2 x 50 microseconds) (Industry Standard rating).

7. Maximum Applied Surge Pulse Current >100,000 amperes (unlimited due to current limiting) (8 x 20 microseconds).

8. Endurance, C62.41-1991 (formerly IEEE 587) Category B3 (C1) pulses 2kv>100,000; 4kv>10,000; 6kv>1,000 (NRTL verified).

C. The selection of surge suppressor devices shall be made with listed connected loads and shall be sized to serve the entire connected load with at least a 25 percent reserve capacity (80 percent maximum loading exclusive of service factors).

D. Voltage output shall be, unless otherwise noted, 120 volts single phase, plus or minus two (2) percent. Units shall be hard-wired unless otherwise noted. The surge suppressor shall be furnished to the Electrical Sub-contractor for installation in the power train. A disconnect switch shall be provided with each installation in a junction box furnished and installed under Division 16100.

E. The use of uninterruptible power supplies (UPS) shall be limited to only those devices reliant upon volatile memory. UPS devices will not be acceptable in any circuit dedicated to safety and shut-down limit functions. Power and surge conditioning only shall be acceptable in these cases.

F. Products meeting this specification shall be equal to Price Wheeler Corporation Brick Wall Division, San Diego CA.

PART 2 - PRODUCTS

2.1 ELECTRICAL MOTOR CHARACTERISTICS

A. Electrical motors shall conform to the requirements of IEEE, NEMA, U.L., N.E.C., F.M., and NFPA suitable for load conditions, squirrel cage, 1.15 service factor, drip proof, 1750 rpm unless otherwise noted, with inherent overload protection and pressure lubricated bearings with grease fittings. Provide totally enclosed fan cooled motors as noted within the specifications. Refer to DIVISION 16 ELECTRICAL for ELECTRICAL CHARACTERISTICS REQUIREMENTS.

B. Motors below 1/2 HP shall be 120V - 1 phase. Provide "ECM" motors for all fractional fan coil units, including speed control. Motors that are 1/2 HP and greater shall be 460V - 3 phase (or 208V - 3 - Phase or 240V - 1 - Phase). All motors shall be designed for use with across-the-line starters or VSD's as per Section 15500 and Division 16. Motors to be provided with overload protection. Provide two speed motors with two windings where two speed motors are noted on the drawings or in this specification including in 15500 - 2.1. Motors 20 HP and above (208V-3 phase) shall have reduced voltage starter. Motors 40 HP and above (480V-3 phase) shall have reduced voltage "soft start" type starter where the motor is not VSD controlled. Bypass starters packaged with the VSD shall be a reduced voltage type for all motors 40 HP or larger.

C. Belt driven equipment. Motors shall be mounted on adjustable sliding bases, except fractional motors shall be mounted on slotted bases.

D. Greater than 1 HP: cast construction, roller or ball bearings. Fractional: sleeve or ball bearings capable of end thrust equal to weight of motor, rolled or case and shield.

E. Motor leads shall be permanently identified and supplied with connectors.

F. The minimum requirement for three phase motors shall be NEMA Design B, Class B, insulated for a maximum 40 degrees C (104 degrees F.) ambient.

G. Select motors for quiet, continuous operation to suit loads which may be imposed by equipment. Recognize that motor horsepowers specified and scheduled are minimum sizes. If larger motors are required, ensure that extra costs of larger motors, starters, power wiring and additional control wiring are included in bid. Provide inverter compatible motors when being provided for a variable frequency drive controlled application.

H. Motors located within the air streams shall be selected to operate satisfactorily at maximum temperature and moisture levels of surrounding air.

I. Submit an accurate schedule (shop drawing) of all motors. Include for each motor the HP, RPM, nameplate, current, equipment served, location, electrical characteristics, and identification number.

J. All 1800 RPM, ODP motors 1 HP and above shall be premium efficiency. Premium efficiency motors shall meet or exceed the following minimum nominal efficiencies: 1HP = 85.5%, 1-1/2HP = 86.5%, 2HP = 86.5%, 3HP = 89.5%, 5HP = 89.5%, 7-1/2HP = 91.7%, 10HP = 91.7%, 15HP = 93.0%, 20HP = 93.0%, 25HP = 93.6%, 30HP = 94.1%, 40HP = 94.1%, 50HP = 94.5%, 60HP = 95.0%,, 75HP = 95.4%, 100HP = 95.4%, 125HP = 95.4%, 150HP = 95.8% and 200 HP and above = 96.2%. Provide premium efficiency motors for 1200 and 3600 RPM ODP motors as well as for 1200, 1800 and 3600 RPM TEFC/TEAO motors.

K. Motors used with variable frequency drives shall be specifically designed for that usage.

L. The minimum power factor for all motors shall be 85% in accordance with the State Energy Code. Equipment motors which have a lower power factor shall be corrected to attain a minimum of 90% power factor in the as-built, final balancing arrangement (under actual load conditions) by the use of capacitors provided by the equipment manufacturer.

2.2 STARTERS AND CONTROLLERS

A. Motor driven equipment supplied under Section 15500 shall be operated by starters furnished and installed under DIVISION 16 ELECTRICAL, except for starters integral with HVAC equipment or variable frequency drives/starter combinations which shall be provided by the HVAC Subcontractor.

B. The HVAC Subcontractor shall provide nameplates on all starters furnished under DIVISION 16 and Section 15500 for use on motor driven equipment provided under Section 15500.

C. All motor controls shall conform to NEMA Standards and be the product of a single manufacturer; Arrow-Hart and Hagemen, Allen-Bradley, or Square D.

D. Auxiliary contacts shall be included on all starters provided under DIVISION 16, ELECTRICAL and by Section 15500, for integrally mounted starters. Auxiliary contacts shall be provided for all interlocking wiring as per A.T.C. requirements, and for Automation Interface.

E. Starters shall normally be provided with four sets of contactors; two sets normally open and two sets normally closed. Where additional contactors are required for Automation Interface or Temperature Control, it shall be the A.T.C. Sub-Subcontractor's responsibility. Interface shall be provided for all starters and other devices as noted herein.

F. Starters and contactors factory-built into the control panel of packaged equipment will be considered as an integral part of the package.

G. All starters, disconnects and control devices provided by the HVAC Subcontractor or his Sub-subcontractors shall be clearly labeled with black lamacoid plates with engraved white letters, to indicate Owner's identification number, function and the equipment which they control. Submit list of labels (shop drawing) for review.

H. Provide self-powered, ambient insensitive, adjustable solid state overload relays (selectable for motor running overload protection), selected to protect the motor against phase unbalance and phase loss.

2.3 THERMOMETERS AND THERMOMETER WELLS

A. Install wells for sensing elements and thermometers where indicated on the Drawings and in the Specifications and where directed by the Automatic Controls Sub-subcontractor and as listed under Section 15500, PART 4 - AUTOMATIC TEMPERATURE CONTROLS SYSTEM.

B. Provide thermometers and suitable separable chrome plated forged brass thermometer wells, complete with caps and chains in the following locations:

1. Where shown on Detail Drawings, flow diagrams and as noted in items 2 through 5 below.

2. On downstream side of mixing valves.

3. On suction piping to all water pumps between isolation valves and pumps.

4. On individual supply and return lines at the heat exchangers, boilers, cooling towers, evaporative cooler, dry coolers and chillers between isolation valves and each connection to apparatus.

5. At supply and return piping to water coils located in air handling units, between isolation valve and coil. Not required, unless otherwise shown on drawings, at fan coil units or VAV boxes and VAV fan powered boxes.

C. Provide temperature and pressure ports at all piping 2 inch and smaller for 150 psi or lower system pressures. Ports to be Pete's Plugs, Muessco, Sysco or approved equal. Provide at unit heaters, cabinet unit heaters, hot water reheat or heating coils in ductwork, terminal box hot water coils, fan coils and individual piping feeds less than 2-1/2 inch to multiple heating or cooling coils in air handling units.

D. Provide extension necks where required to locate sockets outside of insulation.

E. For air thermometers, refer to Automatic Temperature Controls.

F. Liquid thermometers shall be Trerice BX9 Series adjustable angle separable well type, calibrated in C and F, Webster, Weiss, or equal. All thermometers shall be non-mercury (spirit filled) type to conform to local codes.

G. Thermometers shall be furnished complete with fully adjustable angle hinge assembly, 9 inch aluminum case, unbreakable window, lens front, red appearing mercury tubing and brass stem. Locate so that thermometers may be easily read from 5-foot level.

H. Select thermometers to suit full temperature range of liquid. Operating temperature shall indicate at approximate mid point of scale.

I. Thermometers shall have a reserve void at top to allow not less than 25 percent temperature over scale without damage.

J. Submit schedule, in the form of Shop Drawings, to show for each thermometer's duty, location and scale range.

K. Supply to the Owner, for his use, two additional thermometers per temperature range.

L. Select pipe thermometer wells and thermometers to match pressure rating of shutoff valves at the apparatus the thermometer serves; 150 psig, 200 psig, or 300 psig.

2.4 GAUGES AND GAUGE CONNECTIONS

A. Pressure Gauges - Fluids:

1. Provide gauges, gauge connections and gauge cocks for piping in the following locations:

a. Where shown on Detail Drawings, flow diagrams and as noted in items b through f below.

b. On entering domestic cold water service to HVAC equipment.

c. On suction and discharge sides of pumps and circulators between isolation valves and pumps.

d. On individual supply and return lines at heat exchangers and chillers, boilers, cooling towers and dry coolers between isolation valves and each connection to apparatus. Provide on the water (wet) side of all bladder type expansion tanks.

e. At supply and return piping to water coils located in air handling units, between isolation valve and coil. Not required unless otherwise shown on drawings at fan coil units or VAV boxes and VAV fan powered boxes.

f. Upstream and downstream of all pump strainers. Provide gauge connections with capped pet cocks upstream and downstream of all other strainers.

2. Where gauges are not connected, cap gauge connections after balancing of system.

3. Locate gauge connections to ensure that gauges can be read easily from a level five feet above floor.

4. Gauge cocks shall be Trerice No. 735, Weiss, Weksler or equal, 1/4 inch brass needle, valves, Webster, Weiss or equal.

5. Gauges shall be Trerice 4-1/2 inch size No. 600 Series, Weiss, Weksler or equal with black finished cast aluminum case, phosphor bronze bushed rotary movement, silver brazed tip and socket joints, adjustable type pointer, stationary red hands, and calibrated in psi.

6. Each gauge shall be installed with Trerice, Weiss, Weksler or equal brass impulse dampener.

7. Select gauges to suit an overpressure of 25 percent without damage to movement. Normal operating pressure shall indicate approximately at mid point of dial.

8. Submit a schedule in the form of a Shop Drawing, to show for each gauge, the duty, location and dial range.

9. Supply two additional gauges to the Owner for his use per gauge type.

10. Select gauge with pressure rating based on rating of shutoff valve at the apparatus the gauge serves.

11. Provide compound gauges on suction side of all pumps.

12. Provide gauges for in-duct heating coils, cooling coils, and at each header for units with multiple coils.

B. Provide temperature and pressure ports at all piping 2 inch and smaller. Ports to be Pete's Plugs, Muessco or approved equal. Provide at unit heaters, cabinet unit heaters, hot water reheat and terminal box hot water coils, fan coil units.

C. Pressure Gauges - Air:

1. Provide differential pressure gauges and associated connections to the following locations:

   a. Where shown on Detail Drawings, flow diagrams and as noted below.

   b. Across all filter banks in air handling units except the Computer Room air conditioning units which are installed exposed in the space.

   c. Across all in-duct filter banks (i.e. final filters, etc.).

   d. Install gauges as per manufacturer's recommendations on the most accessible side of the equipment. Indicate on scale the "clean filter" pressure drop and the manufacturer's recommended "change filter" pressure drop.

   e. Gauge shall be Dwyer Series 250, Weksler, Weiss or equal air filter gauge with a range to suit the service.

   f. Final calibration of gauge shall be by the Testing and Balancing Contractor.

2. Provide pressure gauge on the air (dry) side of all bladder type expansion tanks. Gauge shall be 3-1/2 inch Trerice No. 600 or approved equal.

2.5 STRAINERS

A. Water Systems:

1. Strainers shall be Armstrong, Sarco, Mueller, or equal pipeline strainer with stainless steel screens according to the following schedule:

Pipe Schedule	Pipe Size	Type	Screen Perforation
Copper	All sizes	Y - Bronze	1/32 inch
Steel	2 inch and smaller	Y - C.I.	1/32 inch
Steel	2-1/2 inch to 10 inch	Y - C.I.	1/8 inch
Steel	12 inch and above	Basket-C.I.	1/4 inch

2. Provide threaded body in sizes through 2 inch and rated at 400 psi WOG; flanged body in sizes over 2 inch and rated at 200 psi WOG at 150°F.

3. Basket type strainers shall include a bolted cover, body tapped for a blow-off valve and a 125 psig (minimum) flanged body.

B. Steam Systems:

1. Strainers shall be Armstrong, Keckley, Sarco or equal pipeline strainer with stainless steel screens according to the following schedule:

Pipe Schedule	Pipe Size	Type	Screen Perforation
Steel	2 inch and under	Y - C.I.	20 mesh
Steel	2-1/2 inch to 10 inch	Y - C.I.	.045 inch
Steel	12 inch and up	Basket-C.I.	1/8 inch

2. Provide threaded body in sizes through 2 inch and under, rated at 250 psi; flanged body in sizes 2-1/2 inch and greater, rated at 250 psi at 450°F.

3. Basket type strainers shall include a bolted cover, body tapped for a blow-off valve and a 250 psi (minimum) flanged body.

C. All strainers shall be pressure rated for intended service and so marked.

D. Equip each strainer 1-1/2 inches and smaller in size, with hose end valve, cap and chain.

E. Equip each strainer 2 inches and larger in size with blow-off tapping. Provide blow-off piping complete with shutoff valve and capped and terminated in downward vertical position. Blow-off piping and valve shall be the same size as the blow-off tapping.

F. Ensure that each strainer can be isolated from piping systems with isolating valves on each side of strainer, and which are not more than ten feet away from strainer.

G. Provide 150, 300 or 400 psig strainers as per the system requirement.

H. Provide strainers in the following locations:

1. At the suction of each pump, as shown on Drawings.

2. Immediately upstream of each pressure reducing valve.

3. Upstream from each control valve, except control valves which serve individual coils such as a unit heater, convector, terminal re-heating coil or radiation, unless indicated otherwise on drawings.

4. Where indicated in drawing details and flow diagrams.

2.6 DRAINS

A. Provide 3/4 inch minimum size drains from overflow, condensate pans, and pump bases to nearest equipment room floor drain or as shown on plans. Drains shall be copper. Pitch drain lines 1/8 inch per foot in the direction of flow. Provide a minimum of 1-1/4 inch drain piping size for all horizontal drain piping with clean-outs at every change of direction.

B. Drains (all with hose ends) for larger piping shall conform to the following:

Up to 2-1/2 inch	-	3/4 inch (minimum drain size)
3 inch to 5 inch	-	1 inch
6 inch to 10 inch	-	1-1/2 inch
10 inch to 14 inch	-	2 inch
Over 14 inch	-	2-1/2 inch

Provide hose end.

C. Provide at all low points of all systems and the base of all risers. Provide a minimum 3/4 inch hose end valve, metal cap and chain. Locate valve assembly to allow easy connection of hose. Refer to Item 15500 - 2.7. Provide valve and capped drains in ceiling cavity below all rooftop unit for the individual supply and return piping for all hydronic services serving the rooftop unit(s).

D. Provide at all rooftop units for condensate drainage from unit cooling coil - etc. - drain connection(s) to nearest roof drain. Provide necessary traps at unit.

E. Where the intended design of pitching the bottom connection of plenums to the louver is not feasible; provide 1-1/2 inch minimum size drains from ductwork connected to intake hoods and wall louver. Equip drains with deep seal traps and locate traps in heated areas.

2.7 PIPE AND FITTINGS

A. Legend:

C.I. - Cast Iron	R.F. - Raised Face
C.S. - Cast Steel	F.F. - Flat Face
F.S. - Forged Steel	W.N. - Weld Neck
S.S. - Stainless Steel	SCRD - Screwed
S.W. - Socket Weld	FLGD - Flanged
B.W. - Butt Weld	M.I. - Malleable Iron
C.P. - Chromium Plated	C.W. - Continuous Weld
W.P. - Working Pressure	ERW-Electric Resistance Weld

B. All heated water (also including a heated mixture of glycol/water), steam, relief, drain, chilled water (also including a chilled mixture of glycol/water), glycol, condenser water, closed circuit evaporative cooler, closed circuit condenser water, vent, gas vent, exhaust, water treatment, and oil piping shall conform to the following unless noted otherwise herein. All piping, pipe fittings, and jointing methods shall be submitted as a shop drawing called "Piping Standards".

Piping: 3/4 inch through 2 inch: A-120/A-53 steel/C.W. Schedule 40

2-1/2 inch through 10 inch - ASTM A-53 ERW Grade B Schedule 40 steel

12 inch and above - 0.375 thick wall ASTM A-53 ERW

Line Joints: 2 inches and under - SCRD, (except as per 15500-2.7-C.) 150 psi beaded C.I. malleable couplings.

2-1/2 inch and larger welded.

Elbows shall be long radius.

No field fabricated fittings of any type for welded pipe sizes.

For welded pipe use Tubeturn type welded tees and fittings. Thread-o-lets to be used for threaded pipe 2 inch and less.

All glycol, water/glycol mixture, and oil piping shall have either welded (or if copper piping is used, sweated) or screwed (with proper sealant for use with a water/glycol mixture) line joints. Note Section 15500, Paragraph 2.7 D.

Flanges:	All sizes 150 psi steel welding neck type Tubeturn or as required by the system operating pressure.
Gaskets:	Water piping gaskets on flanges are to be ring type 1/16 inch thick red rubber for service and temperature pressures involved, equal to Garlock.
Bolting:	A107 commercial steel bolts hexagon head units.
High Pressure Steam:	Fittings 2 inch and Larger: Butt welded or flanged as required.
	Fittings 1-1/2 inch and Smaller: ANSI 300 pound forged steel socket weld type per ASTM A-105.
	Flange - All Sizes: ANSI 300 pound forged steel weld neck, slip on or blind flange per ASTM A-105.
	Gasket - All Sizes: Style 10 Anklon Plus 1/16 inch thick or Style 9800 HTC by Garlock or equal.

C. At the Contractor's discretion and where code permits, Mechanical Grooved Piping Products as manufactured by Victaulic or Grinnell (Gruvlok) may be used on all heated water, drain, chilled water, glycol, glycol/water mixtures, condenser water, closed circuit evaporative cooler, closed circuit condenser water, vent and water treatment piping which shall be products of one (1) manufacturer and shall conform to the following unless noted otherwise herein:

Piping:	3/4 inch through 2 inch: A-120/A-53 steel/C.W. Schedule 40
	2-1/2 inch through 10 inch - ASTM A-53 ERW Grade B Schedule 40 steel roll grooved piping to accept Grooved Mechanical joint fittings. 12 inch and above shall be .375 inch thick wall ASTM A-53 ERW (standard wall). 14 inch and above shall be roll grooved only with AGS wedge-shaped groove. Prepare pipe using standard Victaulic grooving tools equipped with AGS roll sets.
Coupling Housing:	Coupling segments on all Grooved Piping Joint piping shall be primarily rigid style 07 ("Zero-flex") heavy duty couplings and shall be cast of ductile iron conforming to ASTM A-536. The coupling shall be of the grooved, mechanical type that engages the pipe ends to create the seal. The coupling shall be cast in two parts secured together during assembly by nuts and bolts as specified. Flexible style couplings shall permit a degree of angular pipe deflection, as well as thermal contraction and expansion. These couplings shall be used as required when piping expansion/ contraction is accomplished in a linear path. Rigid style 07 (zero flex) couplings complete with angular bolt pads shall be used in all other cases. Note: Flexible couplings shall not take the place of vibration isolation equipment.
	AGS "W" Series couplings for steel pipe sizes 14 inch and larger shall be cast of ductile iron conforming to ASTM A536. The coupling shall be cast in two parts with a wedge-shaped key profile, lead in chamfer and flat bolt pads for metal-to-metal contact, secured together during assembly by nuts and bolts as specified. Only bona-fide vibration, expansion couplings equal to "Metraflex" shall be used to allow linear and angular movement,

vibration attenuation, and stress relief. The use of flexible or resilient grooved couplings will not be acceptable. Rigid type style W07 provides a rigid joint that corresponds with support spacings as defined by ASME B31.1. AGS "W" series couplings shall be installed with metal-to-metal contact at the required torque (as published by the manufacturer).

Line Joints: 2 inches and under - threaded, (except for glycol piping service and as per 15500-2.7-C.) 150 psi beaded C.I. malleable couplings.

2-1/2 inch and larger - Grooved Mechanical Joint - Standard fittings shall be cast ductile iron (ASTM A-536) Grade 65-45-12, forged steel (ASTM A-234) Grade WPB, or fabricated from carbon steel (ASTM A-53) Grade B, supplied with factory grooved ends designed for installation with mechanical couplings.

Elbows shall be long radius.

No field fabricated fittings of any type.

Thread-o-lets to be used for threaded pipe 2 inch and less.

Flanges: All sizes 150 psi steel welding neck type Tubeturn or as required by the system operating pressure.

Flange Adapters: 2-1/2 inch or larger: ASTM A-536 ductile iron flat face, for direct connection to flanges with ANSI Class 125 and 150 bolt hole patterns. Victaulic style 741 or equal.

Gaskets: Water piping gaskets on flanges are to be ring type 1/16 inch thick red rubber for service and temperature-pressures involved, equal to Garlock. Grooved Mechanical Joint gaskets shall be made of elastomers which shall have properties as designed by ASTM D-2000. Gaskets shall be of the mechanical grooved coupling design, pressure responsive so that internal pressure responsive so that internal pressure serves to increase the seal's tightness. Gasket shall be "flush seal" type EPDM Grade "E" conforming to ASTM D-200 Designation 2CA615A15B44F17Z for water and propylene glycol services from -30°F to 230°F.

Bolting: ASTM A183 and A449 Grade 2 heat treated carbon steel bolts hexagon head with minimum tensile strength of 110,000 psi. Zinc electroplated as standard.

D. No screwed connections of any kind will be permitted in vertical concealed spaces, or behind furrings for water, water/glycol mixtures, steam and condensate risers and runouts. All of this piping shall be welded steel or copper with sweat fittings.

E. Condensate return and pumped condensate of steam systems shall be ASTM A-53 Schedule 80 steel C.W.

F. All piping shall be new, free from rust or dirt and in first class condition both when installed and when the project is completed.

G. Provide all piping required to connect apparatus complete and ready for operation, in accordance with manufacturer's standard details as approved, unless otherwise noted. The minimum size pipe shall be 3/4 inch for hot water, chilled water, condensate return and condensate piping, 1-1/4 inch for steam supply piping. The minimum pipe size serving two (2) pieces of equipment shall be 1 inch for hot water systems.

H. Flow Meters:

1. Provide Macon Controls, Armstrong, Victaulic or Tour and Andersson, or equal variable Venturi or Orifice type Y-pattern globe balancing valves for water piping in return water connections for all chilled water, dual temperature, and hot water coils. Provide at all unitary HVAC equipment (unit ventilators, fan coil units, cabinet unit heaters, fin tube radiation, etc.). Install in strict accordance with manufacturer's guidelines for accurate flow measuring results. Furnish a chained tag showing size, location, GPM and differential pressure reading on all devices. Y-pattern globe valves shall have a minimum of 4 turns (360 degrees) of handwheel rotation and be provided with a digital readout handwheel that incorporates a hidden, tamperproof locking device.

2. Also provide flow meters at all water and glycol pumps, in mains, and where indicated on plans and diagrams to measure total pump and/or main flow.

3. Provide a portable 6 inch dial, 270° ARC, readout meter with +/- 1.75% accuracy. The range of the meter shall be as required to balance all units with readings near the mid-range of the meter. Provide multiple meters, if necessary.

I. Provide accessory piping, such as vent, drain and relief piping, wherever equipment is provided with connections for such piping, and run to atmosphere or indirect waste, as required or as shown on the drawings.

J. Provide unions or flange connections for each control valve, where shown on drawings and manufacturer's details, and where necessary to permit easy dismantling of piping. Mating flange shall be same service as companion flange of equipment.

K. Piping and appurtenances shall be arranged so as to avoid interference with tube cleaning or removal for various apparatus.

L. Pipe nipples shall be of the same quality as piping on which used, and all short space nipples shall be extra heavy; no standard weight close or shoulder nipples shall be permitted.

M. Refrigerant piping, glycol piping (sized at 2-1/2 inch or smaller), and condensate drain piping for cooling coils shall be Type L (ACR) copper (washed nitrogen purged and capped). Install refrigerant piping utilizing non-corrosive flux silver solder (15% silver content) joints. The refrigerant piping shall be installed using a "nitrogen purge" method to insure systems free of contamination. Install glycol, glycol/ water mixtures, and drain piping using 95/5 solder joints.

[The HVAC Contractor shall have the option of providing Type L copper piping for 2-1/2 inch or smaller hot water, hot or glycol/water mixture piping using 95/5 or silver solder joints. Use bronze bodied valves at all steel - copper interfaces, dielectric unions are not acceptable.]

N. All valves and fittings shall have the manufacturer's identification thereon in accordance with the ANSI or ASTM requirements.

O. All piping, other than PVC piping, shall be air tested initially then water tested each to 1-1/2 times the psi working pressure of the systems for 24 hours without leakage. Remove or valve-off specialties and equipment to protect them from damage during pressure test. Do not exceed pressure of tanks or other connected apparatus during test. Test to be witnessed by the "Owner's Representative".

P. All piping shall be concealed in finished areas. Notification shall be given to the Structural Engineer of any holes required in beams for piping.

Q. Slope steam, gravity steam condensate return, cooling coil condensate drain, drain, gravity oil return and gravity water return piping a minimum of 1/8 inch per linear foot down in direction of flow unless otherwise noted on the drawings or approved by the engineer.

R. Use bronze bodied valve where steel pipe and copper pipe are joined. Provide isolation/balancing valves at all piping branch connections off the main piping risers (at each floor).

S. All welders shall be certified per ASME standards.

T. All interior oil piping within the building, including fill and vent piping, shall be either installed inside a separate Schedule 40 steel pipe conduit or shall be provided as RICWIL Fuel Guard.

U. The HVAC Subcontractor shall install all piping below the ductwork unless clearance condition requires piping to be above.

V. Swing joints with a minimum of three (3) 90 degree piping elbows shall be furnished and installed for all piping take-offs from horizontal to vertical piping.

W. Air Separator (Hot, Dual Temperature, Chilled and Closed Circuit Water Systems):

1. Furnish and install as shown on plans, an microbubble resorber type air separation unit consisting of welded steel painted with red oxide. The unit shall have flanged inlet and outlet connections, a stainless steel screen (strainer) and internal stainless steel brush and mesh or Pall ring air collector designed to direct released air to a vent. Unit shall be constructed in accordance with ASME boiler and pressure vessel code and stamped 125 psig working pressure. A blowdown connection shall be provided to facilitate routine cleaning of the unit of separated dirt. Taco 4900 Series, Spirovent high velocity dirt/air separator or equal.

X. Replace all existing traps that are being reused at and related to points of steam system disconnection. Provide a 3/4 inch F&TT at the base of all risers and at all changes in elevation of steam mains. Provide thermostatic traps at steam radiation, float and thermostatic type (F&TT) traps for all low and medium steam pressure using equipment and drips and inverted bucket traps for all high pressure steam-using equipment and drips, as manufactured by Barnes and Jones, Armstrong 15B Series, Sarco, or equal and as rated by SHEMA.

1. F&TT shall be heavy duty, semi-steel body with S.S. valve plug and seats suitable for low and medium pressure steam service. Thermostatic element shall have a capacity factor of not less than two times the equipment it serves with a pressure drop not to exceed 1/2 psig.

2. Provide inverted bucket traps for all high pressure using equipment as manufactured by Armstrong, Sarco, Barnes and Jones, or equal.

a. Bucket traps shall be stainless steel or cast iron body side inlet, with all stainless steel working parts and shall be complete with continuous air venting and internal check valve. Valve and seat to be chrome heat treated steel.

b. Trap to have 125 lb. rating.

3. Traps shall have a capacity factor of not less than two times the equipment it serves with a pressure drop not to exceed 1/2 psig.

4. All condensate shall be automatically drained from all piping free of noise and hammer.

5. All trap assemblies shall consist (in direction of flow) of a gate valve, strainer, union, trap, union and gate valve with a gate valve bypass around the trap. Where condensate is lifted, provide a check valve downstream of the trap.

Y. The HVAC Contractor shall submit all refrigerant piping isometric piping diagrams to the Engineer complete with the equipment manufacturers review. Provide all necessary piping specialties and pipe sizes to enable manufactured warranties to remain enforced. Approval of equipment using refrigerant piping systems shall be contingent on these piping schematics. Include, also, any hot gas bypass or similar system piping to conform to the intent of the specification.

Z. Condensate Cooler:

1. Provide a welded, polished 304 or 316 stainless steel condensate cooler designed to receive blow down from the humidifier to cool the steam condensate going down the drain. The blow down condensate cooler shall be ASME code constructed and stamped for 150 psi working pressure as based on Dri-Steem "Drane Kooler" or equal. Discharge shall enter the tangential inlet where it meets a 90° type 316 stainless steel wear plate. The temperature of the condensate will activate the thermal control valve which will feed cold water into the drain body resulting in a drained liquid temperature which is acceptable for municipal sewage.

AA. All piping exposed and routed along (on top of) roof shall be seismically supported off roof steel as per the requirements of Paragraph 2.28 of this specification.

2.8 VALVES

A. Provide valves on all piping where shutoff or balancing, throttling or isolation is required or as shown on the drawings. All valves shall be compatible with a 100% solution of propylene glycol. All valves in a glycol service shall be flange or welded or sweated type. Screwed (threaded) valves shall not be allowed unless the proper sealant is used, one compatible with glycol. All valves shall be operable where located by the HVAC Subcontractor. Provide valve stem extensions where applicable to achieve complete shutoff operation without the use of additional tools or devices.

B. Valves shall be as follows:

1. 2-inches and smaller for refrigerant, steam and condensate return shutoff shall be gate valves. Valves shall be for 150 psi service. Provide cap and chain with drain valves.

a. Valves to be rated for 150 S.W.P., bronze body and trim, non-rising stem, union bonnet, solid bronze wedge. Provide with cap and chain for drain valves. Provide Milwaukee valve #1141 (threaded) or #1169 (sweated) or an approved equal.

b. Refrigerant shutoff valves may also be ball valves, Mueller "Cyclemaster" or equal by Sporlan (EBV) Alco.

2. 2-inches and smaller for refrigerant, steam and condensate return, balancing and shutoff shall be globe valves. Valves shall be for 150 psi service.

a. Provide 150 S.W.P., bronze body, bronze seat with replaceable Teflon disc., union bonnet, threaded, internal rising stem. Provide Milwaukee valve #590T (threaded) or #1590T (sweated) or an approved equal. Do not provide on pipe where an integral ball valve type flow measuring device is used.

3. 2-inch and smaller for water shutoff.

a. Ball valves up to 2-inches shall have 150 lb. S.W.P., 600 lbs. WOG bronze bodies, brass stem, hardened chrome-plated brass ball - tunnel bore design, glass reinforced teflon seats and seals, single reduction bore, adapter loaded 2 piece design. Provide with tee handle where located inside radiation enclosures. Provide Milwaukee valve #BA-100 (threaded) or #BA-150 (sweated) or an approved equal.

4. 2-1/2 inch and larger for water shutoff shall be butterfly valves, rated for 200 psi.

a. Valves shall be capable of conversion to an actuated operation or chainwheel operation. Provide with chainwheel and chain for valves located higher than six (6) feet above floor.

b. Valves 6 inch and under shall be complete with ten position lever operator with adjustable memory stop plate and totally enclosed weatherproof screw gear operator with handwheel on valves 8 inch and larger with position indicator.

1) Rated for 200 PSI Service: butterfly valves shall be installed between ANSI B 16.1 cast iron 125 lb. or ANSI B 16.5 forged steel 150 lb. flanges; 2 inch through 20 inch shall be full threaded lug style to allow the flange of either side of the valve to be removed with the valve remaining in place to provide full equipment isolation. Valve body shall be cast iron (ASTM A-126, Class B) with 2 inch minimum neck for full insulation. Lugged valves shall have mechanically retained seat and shall provide tight shutoff on dead-end or isolation service without the use of downstream flanges. Discs shall be aluminum bronze. Shafts shall be 416 stainless steel and be supported on three (3) self-lubricating bronze or TFE coated stainless steel bearings. Valve seats shall be hard backed phenolic cartridge EPDM liner. Valves are to be Milwaukee valve #L-223-E-MS (Handle) or #L-323-G (gear) or equal.

5. 2-1/2 inch and larger for steam and condensate return shutoff shall be gate valve.

   a. Provide Milwaukee Model No. F-2885-M or equal. Valves shall be OS&Y ANSI 125 S.W.P., iron body, bronze mounted, solid wedge, rising spindle flanged. Where located more than 6 feet above floor provide complete with chainwheel.

   b. Valves larger than 6 inch shall be complete with a totally enclosed weatherproof screw gear operator with handwheel and position indicator.

6. 2-1/2 inch and larger for steam and condensate return balancing shutoff shall be globe valves.

   a. Provide Milwaukee Model No. F-2981-M or equal. Valves shall be OS&Y ANSI 125 S.W.P., iron body, bronze mounted, solid wedge, rising spindle flanged. Where located more than 6 feet above floor provide complete with chainwheel.

   b. Valves larger than 6 inch shall be complete with a totally enclosed weatherproof screw gear operator with handwheel and position indicator.

7. Horizontal swing check valves shall be as follows:

   a. For 150 S.W.P. service, provide Milwaukee valve No. 510 or equal for 2-inch and smaller. Valves to be bronze body and trim, integral, bronze seat, regrindable bronze and screw cap.

   b. For 150 S.W.P. service, provide Milwaukee valve no. 2974-M or equal for 2-1/2 inch to 8 inch. Valve to be cast iron bodies with bronze trim, flanged ends, replaceable bronze seat, renewable disc and bolted cover.

   c. For refrigerant check valves, provide Mueller A156 Series.

8. Silent lift check valve shall be as follows:

   a. For 150 psi service, provide for 2 inch and smaller bronze body with bronze seat and disc, S.S. spring and guide pin and guided lift, wafer style 125 lb. ANSI.

   b. 2-1/2 inch and larger, semi-steel body with bronze seat and disc., S.S. spring and guide pin and guided lift, globe style 125 lb. ANSI, FM approved. Provide Milwaukee Valve no. 1800 or equal.

   c. Provide at the discharge of all water pumps.

9. Manufacturers

   a. Gate, globe, and swing check valves shall be Milwaukee, Hammond, Walworth, Crane, or equal.

   b. Butterfly valves shall be Milwaukee, DeZurik, Hammond, Centerline or equal.

c. Silent lift check valves shall be Milwaukee, Muessco, Metroflex, Hammond, or equal.

d. Ball valves shall be Milwaukee, Hammond, Apollo, Walworth, or equal.

e. Refrigeration valves and specialties of all descriptions shall be Mueller Refrigeration Company, Inc. or equal by Sporlan, Superior, Henry or Virginia KMP. This shall include ball valves, compressor valves, check valves, angle valves, line filter/dryers, sight glasses, fittings, relief valves.

2.9 UNIONS

A. All unions are to be ground joint type, brass to iron seat.

B. Unions are to be provided in all cases to provide access to valves, coils and pumps where piping is 2-inches diameter or less. For access to equipment and valves connected to 2-1/2 inch and larger pipe, provide welding flanges.

C. Unions for refrigerant piping shall be flare type, swage-lok or Mueller, specifically engineered for refrigerant. Use only at removable, replaceable components all within 12 inches of an isolation valve and charging port set.

2.10 AIR VENTS

A. Automatic air vents, Armstrong 1 Av, Sarco, Taco, or equal complete with isolating gate valves shall be installed at all high points where mains are trapped, where shown on the drawings, and where shown on Typical Detail Sheets. Pipe outlet from each vent to a drain pan, condensate/drain receptor, drip pan or floor drain.

B. Manual air vents, screwdriver or key type, shall be installed at each unit heater, cabinet unit heater, convector, fin tube radiation section, duct mounted coil and fan coil unit with pressure rating equal to valve serving the item.

2.11 ACCESS PANELS

A. All work shall be installed such that all parts requiring inspection, operation, maintenance and repair are readily accessible. Minor deviations from the drawings may be made to accomplish this, but changes of magnitude shall not be made without written approval from the Architect.

B. Furnish access panels for installation in walls and ceilings at locations indicated on drawings or as required to permit access for adjustment, removal or replacement and servicing of all equipment such as splitter and balancing dampers, reheat coils and all other items requiring maintenance and adjustment.

C. Access doors shall be installed under other appropriate sections for the surface or construction upon which the panels are located.

D. All access panels and doors shall be located in closets, storage rooms and/or other non-public areas, in a workmanlike manner, positioned such that the junction can be easily reached and the size shall be sufficient for this purpose (minimum 18 inches by 18 inches). When the access doors are required in corridors, lobbies or other areas, they shall be located as directed by the Architect.

E. Access panels and doors shall be prime painted and furnished with cylinder lock and two keys as manufactured by Inland Steel Products Company "Milcor", Wash-Hannon, Inc. or "Way-Loctor" or equal. Type shall be as follows:

1.	Acoustical Tile Ceiling	"Milcor" Type A
2.	Plastered Surfaces	"Milcor" Type K
3.	Masonry Construction	"Milcor" Type M
4.	1-1/2 Hour, 3-Hour or 4-Hour Rated	"Milcor" rated to equal rating of surface doors installed in.
5.	Gypsum Wallboard	"Milcor" Type DW

F. Access panels and doors in structural or glazed tile walls shall be equal to Continental Metal Products No. 1212MF, 14 gauge Type 304 satin finish stainless steel, minimum 12 inches by 12 inches.

G. Access panels and doors shop drawings shall be submitted to the Architect for approval.

H. This Subcontractor shall inform the Applicable Section Contractor where access is required through ceilings in order that special clips for access can be provided.

I. Access panels and doors shall be 2, 3 or 4 hour rated as required to maintain rating of surface they are installed in.

2.12 EXPANSION TANKS

A. Provide for each closed or potentially closed water system, diaphragm or bladder-type (as shown on plans) expansion tanks suitable for tanks equal to 125 psi working pressure with red oxide paint finish. Provide TACO, Bell & Gossett, John Wood Company, Amtrol, or approved equal.

B. Each expansion tank shall be complete with a brass fitted and valved water gauge, vent connection and drain connection piped to a floor drain. Provide Schrader type charging valve. Factory or field charge to static cold fill pressure with dry nitrogen.

C. Refer to drawings for capacity and size information.

D. Construct each tank to ASME standards and provide a Title XIII stamp on each expansion tank with ASME pressure rating.

2.13 GAS-FIRED CONDENSING BOILERS

A. General:

1. This specification covers minimum requirements gas-fired condensing boilers across a number of specific manufacturers, each of whom may have their own specific technologies. Specific features noted below are not to be construed as a limited list;

manufacturers may provide other devices standard to their line and these shall be furnished consistent with each product's listing. Listed manufacturers and models as specified and scheduled will be acceptable as noted. Furnish and install one (1), complete and operable in all respects.

2. Notwithstanding individual boiler manufacturers means and methods, all boilers shall have the following common features and benefits:

a. Condensing operation with natural gas, that is, operation which reduced flue gasses below their dewpoint and which have no minimum entering water temperature. Boilers constructed of materials specifically engineered for corrosion resistance against the condensed combustion products and with a minimum 20 year warranty against corrosion and thermal shock resistance. (Fuel quality based on minimum 95% methane (CH_4) and 1,000 BTU's per cubic foot producing 10.5% or less CO_2.)

b. Modulating fire: Smooth, infinite variation in fuel input at a minimum ratio of 4:1 (100% to 25%). Fuel modulation and air modulation shall be parallel such that combustion product ratios are maintained within 5 percent of high fire values across the entire modulation range. Boilers exhibiting greater fuel modulation ranges will be acceptable.

c. Thermal efficiencies of not less than 89% at high fire and 94% at low fire, with return water temperatures of 110 degrees F. and with CO_2 in flue gas of less than 10.5 percent. In addition, low fire operation with 80 degree F. return water shall produce thermal efficiencies in any boiler selection exceeding 97%.

d. Direct sealed venting of combustion products and intake of outside air as an integral system, specifically designed, engineered, listed and accepted for such applications. Boilers which require room-delivery of combustion air will not be acceptable. Horizontal venting shall be capable of extending a minimum of 80 feet without draft inducer assistance. Positive pressure venting material and systems are required; actual system to be as recommended by the final accepted boiler manufacturer matched to their product.

e. Boilers shall, although capable of operating below the flue gas dewpoint, be capable of producing 180 degree F. hot water supply temperatures when so controlled.

f. Boilers shall have internal safety devices including but not limited to draft-proving switches, water pressure switches, low water cut-off device, thermal and operating high limits. The entire boiler shall be UL Listed, AGA and ASME Section IV listed and with an "H" stamp on the pressure vessel. Boiler shall include combustion sensing. Any device which may be internal on some boiler models but not furnished as part of the actual installed boiler shall be field-furnished, installed and wired by the HVAC Subcontractor at no additional cost to the Owner, as if part of the boiler package. Boiler internal safety and combustion controls shall include electronic ignition, intermittent proved pilot, safety shutdown, flame supervision, safe-start verification, pre and post purge cycles.

g. Boilers shall have integral operating controls including outdoor reset, scheduled operation, night setback, parallel shift of supply water temperature, tracking of return water temperature to optimize combustion efficiency. All line, indoor and outdoor sensors shall be provided, ready for field wiring under 15500 Part 4; AUTOMATIC TEMPERATURE CONTROLS. Controls shall accept external outputs from common DDC system protocols but shall also operate independently of a central DDC system should such system fail for any reason. Any such controls not furnished as part of the boiler shall be field-furnished, installed and wired by the HVAC Subcontractor at no additional cost to the Owner.

h. Combustion pathway shall be counter-flow to water flow, specifically boiler initial combustion (highest temperature) occurring at the leaving water port or ports. Conversely, the entering coldest return water shall occur proximate to the coldest leaving combustion flue gasses. The path of combustion products shall be generally downward, forcing condensation products to a point of collection for disposal and toward cooler zones to prevent re-evaporation and acid deposition. Forced draft is required.

i. Boilers shall be fully condensing, that is, they shall not be a modification of a previous conventional or low temperature non-condensing design with "backpack" or enhanced/add-on heat exchangers used to achieve condensing performance.

j. Boiler shall be capable of operation at the scheduled incoming gas pressure without the use of gas pressure boosters or gas trains over-sized from the standard offering.

B. Products:

1. Boilers shall be manufactured by Hydrotherm KN series (KN-6), Lockinvar Knight KB-500, or equal.

2. Available Manufacturers: Manufacturer shall be a company specializing in manufacturing the products specified in this section with minimum five (5) years experience. Subject to compliance with requirements, manufacturers offering boilers that may be incorporated into the Work include, but are not limited to, the following:

a. Design: Boilers shall be AGA/CSA design certified as a condensing boiler. Boilers shall be designed for a minimum of 4:1 continuous turn down with constant CO_2 over the turndown range. The boiler shall operate with natural gas and have a AGA/CSA certified input rating as scheduled on the drawings, and a thermal efficiency rating of 88% at rated input and 99% at minimum input. The boiler shall be symmetrically air-fuel coupled such that changes in combustion air flow or flue flows affect the BTUH input without affecting combustion quality. The boiler will automatically adjust input for altitude and temperature induced changes in air density. The boiler will use a proven pilot interrupted spark ignition system. The boiler shall use a UL approved flame safeguard ignition control system using UV detection flame sensing. The UV detector shall be air cooled to prevent condensate formation and so designed as to prevent misalignment. The design shall provide for silent burner ignition and operation. The boiler shall be down fired counter flow such that formed condensate always moves toward a cooler zone to prevent re-evaporation. A corrosion resistant condensate drain designed to prevent pooling and accessible condensate trap shall be provided. Boiler shall be able to vent a horizontal distance of 80 equivalent feet.

b. Service Access: The boilers shall be provided with access covers for easily accessing all serviceable components. The boilers shall not be manufactured with large enclosures, which are difficult to remove and reinstall. All accesses must seal completely as not to disrupt the sealed combustion process. All components must be accessible and able to adjust with the removal of a single cover or cabinet component.

3. Combustion chamber and pathway materials shall be 316L or 430 Series stainless steel or specifically configured eutectic cast iron (Hydrotherm KN)

4. The burner and gas train shall be provided with the following trim and features:

a. Burner Firing: Full modulation with minimum 4:1 turndown at continuous CO_2 and not over 12.0 PPM nitrous oxides.

b. Burner Ignition: Intermittent spark

c. Safety Controls: Energize ignition (14,000 volts), limit time for establishing flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, and allow gas valve to open.

d. Flue-Gas Collector: Enclosed combustion chamber with integral combustion-air blower and single venting connection.

e. Gas Train: Manual gas valves (two), main gas valve (solenoid), ‘B’ valve, pilot gas pressure regulator, and automatic pilot gas valve. All components to be State of Maine Code compliant, factory mounted and meet the applicable Fuel Gas Code.

f. Safety Devices: Low gas pressure switches, air-flow switch, and blocked flue detection switch. All safeties to be factory mounted.

5. Boiler Trim

a. Safety-Relief Valve: 30 PSIG ASME rated, factory set to protect boiler and piping. Boiler operating pressure rating to be minimum 60 PSIG.

b. Gauge: Combination water pressure and temperature shipped factory installed. LCD inlet/outlet temperature gauges to be an integral part of the front boiler control panel to allow for consistent easy monitoring of temperatures factory mounted and wired.

c. Low Water Cut Off: Prevent burner operation when water falls below a safe level. Low water cut off (with manual reset) shall be factory mounted and wired. Provision for installation of a low water cut off shall be provided.

d. Operating Controls: Boilers shall be provided with a Honeywell RM7897C or equal series digital flame safe guard display module standard. The flame safe guard shall be capable of both pre and post purge cycles.

e. Operating Temperature Control: Shall be a digital controller adjustable from 80 to 220 degrees F. Control shall be factory mounted and sense the inlet and outlet temperature of the boiler through min. 1 kOhm resistance sensors.

f. High Limit: Temperature control with manual-reset limits boiler water temperature in series with the operating control. High Limit shall be factory mounted and sense the outlet temperature of the boiler through a dry well with heat conductive compound.

g. Condensate Receiver Pan with MPT drain port.

h. Low Air Pressure Switch

i. Blocked Flue Detection Switch

j. Manual Reset Low Water Cut Off (CSD-1 Factory Mounted and wired)

k. Modulation Control

l. Temperature/Pressure Gauge

m. Manual Reset High Limit

n. Air Inlet Filter (Washable)

o. Inlet/Outlet Temperature Display

p. Full Digital Text Display for all Boiler Series of Operation and Failures

q. Variable Frequency Drive and Combustion Air Fan

r. Indicating lights: Each boiler shall include a diagnostic control panel with a full text display indicating the condition of all interlocks and the BTUH input percentage. Access to the controls shall be through a completely removable cover leaving diagnostic panel intact and not disrupted.

6. Motors

a. Refer to 15500 2.1 for general motor requirements. Boiler-mounted motors shall comply with that section.

b. Boiler Blower Motor: Open drip-proof motors will be acceptable where satisfactorily housed or remotely located during operation. Blower motor shall be externally mounted for ease of service. There shall be no requirement to remove covers or gas train components to remove the blower motor. Blower motor shall not exceed the scheduled amperage draw or horsepower.

7. Accessories and Appurtenances

a. To the extent offered as factory accessories (and to be provided by the HVAC Sub-Contractor if not), the following ancillary accessories and appurtenances shall be provided in support of a complete and operable installation:

1) Combustion condensate neutralization system (marble / limestone chip vessel with vents and drains).

C. Submittals:

1. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model indicated.

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

3. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

4. Source Quality Control Tests and Inspection Reports: Indicate and interpret test results for compliance with performance requirements before shipping.

5. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

6. Maintenance Data: Include in the maintenance manuals specified in Division 1. Include parts list, maintenance guide, and wiring diagrams for each boiler.

D. Quality Assurance:

1. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.

a. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.

b. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

c. ASME Compliance: Boilers shall bear ASME "H" stamp and be National-Board listed.

d. FM Compliance: Control devices and control sequences according to requirements of FM.

e. IRI Compliance: Control devices and control sequences according to requirements of IRI (GE GAP).

f. Comply with NFPA 70 for electrical components and installation.

g. CSD-1

h. SCAQMD Rule 1146.2 for low NOx equipment

i. BACT Compliant (Best Available Control Technology)

j. Test and inspect boilers according to the ASME Boiler and Pressure Vessel Code, Section IV. Boilers shall be test fired in the factory with a report attached permanently to the exterior cabinet of the boiler for field reference.

E. Coordination:

1. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements per Division 3 Section "Cast-in-Place Concrete".

2. Coordinate all electrical requirements including any field-furnished and factory-furnished control and safety devices to be installed in the power train or safety circuit. The HVAC Sub-Contractor shall keep himself and other sub-contractors informed though the General Contractor regarding all ancillary and inter-disciplinary devices required to be furnished, installed and wired.

F. Warranty:

1. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents. Installing contractor shall provide one year of warranty parts and labor.

2. Special Warranty: Submit a written warranty, executed by the contractor for the heat exchanger.

   a. Warranty Period: Manufacturer’s standard, but not less than 10 years from date of Substantial Completion on the heat exchanger. Warranty shall be non-prorated and not limited to thermal shock. Additional minimum 20 year thermal shock warranty on heat exchanger.

G. Examination and Installation:

1. Examine area to receive boiler for compliance with requirements for installation tolerances and other conditions affecting boiler performance. Do not proceed with installation until unsatisfactory conditions have been corrected.

   a. Install boilers level and plumb, according to manufacturer’s written instructions and referenced standards.

   b. Install gas-fired boilers according to NFPA 54.

   c. Support boilers on 4-inch- (100-mm-) thick concrete base, 4 inches (100 mm) larger on each side than base of unit.

   d. Install electrical devices furnished with boiler, but not specified to be factory mounted.

   e. Install a 1 inch drain valve on the outlet piping prior to the first shut off valve.

   f. Connect gas piping full size to boiler gas-train inlet with union.

   g. Connect hot-water piping to supply- and return-boiler tapings with shutoff valve and union or flange at each connection.

   h. Install piping from safety-relief valves to nearest floor drain.

i. Connect breeching to boiler outlet, full size of outlet. The boiler shall operate under positive (Category IV) or negative (Category II) stack pressure. Vent material must be a listed Stainless Steel Double Wall type for condensing appliances.

j. Electrical: Comply with applicable requirements in Division 16 Sections.

k. Ground equipment.

l. 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.

H. Cleaning:

1. Flush and clean boilers on completion of installation, according to manufacturer's written instructions. This work shall be in concert with flushing and cleaning of the piping system, however both systems shall be treated separately so as to avoid flushing piping-side contaminants into the boiler. Once systems are both to specified conditions may they be conjoined.

2. Water treatment and final water conditions shall be verified with the boiler manufacturer as to conductivity, hardness, pH. The HVAC Subcontractor shall direct the Water Treatment Sub-Subcontractor to make all adjustments in water quality to meet the boiler manufacturers recommendations. This shall be part of the water treatment annual program.

I. Factory Representative Required:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to supervise the field assembly of components and installation of boilers, including piping and electrical connections. Report results in writing.

a. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

b. Manufacturer's representative shall supply a factory authorized service technician to start up the boilers.

c. After completing boiler installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes including chips, scratches, and abrasions with manufacturer's touchup paint.

J. Commissioning:

1. Engage a factory-authorized service representative to provide startup service. Start up to be performed only after complete boiler room operation is field verified to offer a substantial load, and complete system circulation. One-year warranty shall be handled by factory authorized tech.

a. Verify that installation is as indicated and specified including water quality, venting, pressure and flow.

   1) Verify that electrical wiring installation complies with manufacturer’s submittal and installation requirements in Division 16 Sections. Do not proceed with boiler startup until wiring installation is acceptable to equipment Installer.

b. Complete manufacturer’s installation and startup checklist and verify the following:

   1) Boiler is level on concrete base.

   2) Flue and chimney are installed without visible damage.

   3) No damage is visible to boiler jacket, refractory, or combustion chamber.

   4) Pressure-reducing valves are checked for correct operation and specified relief pressure. Adjust as required.

   5) Clearances have been provided and piping is flanged for easy removal and servicing.

   6) Heating circuit pipes have been connected to correct ports.

   7) Labels are clearly visible.

   8) Boiler, burner, and flue are clean and free of construction debris.

   9) Pressure and temperature gages are installed.

   10) Control installations are completed.

c. Ensure pumps operate properly.

d. Check operation of pressure-reducing valve on gas train, including venting.

e. Check that fluid-level, flow-switch, high-temperature interlocks are in place. Test each device in the safety circuit, individually and record results.

f. Start pumps and boilers, and adjust burners to maximum operating efficiency.

   1) Fill out startup checklist and attach copy with Contractor Startup Report.

   2) Check and record performance of factory-provided boiler protection devices and firing sequences.

   3) Check and record performance of boiler fluid-level, flow-switch, and high-temperature interlocks.

4) Run-in boilers as recommended or required by manufacturer.

K. Perform the following tests for each firing rate for high/low burners and for 100, 75, 50 and 25 percent load for modulating burners. Adjust boiler combustion efficiency at each firing rate. Measure and record the following at each stage:

1. Gas pressure on manifold.

2. Combustion-air temperature at inlet to burner.

3. Flue-gas temperature at boiler discharge.

4. Flue-gas carbon-dioxide, carbon monoxide, NOx and oxygen concentration. Provide date-stamped printout of combustion analysis at each firing stage.

5. Natural flue draft, inches W.G.

6. Measure and record temperature rise through the boiler. Confer with balancing contractor to determine coincident water flows.

7. Verify outdoor reset temperature schedule for outdoor temperature at time of test. Schedule test for outdoor temperatures of 32 degrees F. or below.

L. Demonstration:

1. Engage a factory-authorized service representative to train Owner’s maintenance personnel as specified below:

a. Operate boiler, including accessories and controls, to demonstrate compliance with requirements.

b. Train Owner’s maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

c. Review data in the maintenance manuals. Refer to Division 1 Section “Contract Closeout.”

d. Review data in the maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data".

e. Schedule training with Owner with at least 7 days’ advance notice.

2.14 BOILER VENT AND COMBUSTION AIR SYSTEM

A. Furnish and install, where indicated on drawing, positive pressure Category IV zero clearance vent system expressly designed and engineered for condensing boiler application. Systems shall be as manufactured by Protech Systems, Inc, Z-Flex U.S., Inc., Metalbestos Systems, Ampco, Metal-Fab, Schebler, Heat-FAB or an approved equal. Chimney and breeching shall be equal to laboratory-tested and listed by Underwriters' Laboratories, Inc. standard UL 1738 and as described in NFPA-54/ANSI Z223.1.

B. The vent system shall have a minimum wall thickness of 0.017 inch for up to 12 inch O.D. and 0.024 inch for all larger sizes. For exterior portions of the exhaust, there shall be a minimum two (2) inches insulation between the walls. The gas-carrying pipe shall be type AL29-4C stainless.

C. The vent system shall be installed according to its installation instructions and the limitations of its listing, and according to the boiler manufacturer's recommendations. The system shall comply with the National Safety Standards and Building Codes. Inner pipe joints are to be sealed during field assembly with a listed sealant. Built-in gasket/locking band systems will be acceptable when conforming to their listing.

D. Chimney pipe extending above roof surfaces must terminate no less than five (5) feet above the roof or at the point directed away from the building as noted on drawings. All exposed metal supports (which are not made of stainless steel) are to be protected by a minimum of one coat of heat and corrosion resistant primer as well as one finish coat of heat resistant paint of color selected by the Architect. The chimneys shall have no exposed supports on the roof. Provide bases, wall guides, cleanouts, drains, tee sections, roof thimbles and flashing. Refer to drawings.

E. A parallel combustion air intake duct shall be provided in accordance with Section 15500, Paragraph 2.20, Sheetmetal, including insulation for interior portions for outside air ductwork. The exterior portions exposed to view and the weather above the roof shall be of the same material as the boiler exhaust vent material.

2.15 COLD CONDENSATE PUMP SETS

A. Furnish and install where shown on the plans and where required by field conditions prohibiting gravity drainage, cold waste water condensate pump sets. These are specific to but not limited to the lowest floors and slab on grade areas, for disposal of cooling coil condensate where gravity drainage is not possible.

B. Pump sets shall consist of an ABS plastic receiver, cover, pump set with motor and controls. Pump shall have a stainless steel shaft and polypropylene impeller and be constructed for condensing furnace application regardless of actual use. It is intended to allow occasional application of chlorine/halazone disinfectant tablets to the reservoir and thus corrosion protection is required.

C. Internal controls shall consist of a float switch, thermally protected motor, accessory or integral high limit or overflow switch. Float shall cycle the pump to drain the receiver. The high limit switch shall have contacts allowing wiring to the related fan coil unit starter to shut down the fan coil unit upon activation and close an alarm contact. In addition, a local piezo buzzer or LED light shall be provided and wired all by the ATC Subcontractor.

D. Pump capacity shall have sufficient lift for the installation. The HVAC contractor shall coordinate all aspects of fit, connection, lift, etc. prior to ordering. Pump discharge shall be a barb fitting with accessory or integral removable check valve. Install all connections per the manufacturer's latest literature.

E. Electrical cord shall be provided to allow hard wiring with a disconnect switch. Plug-in models will not be acceptable for concealed locations. Pumps shall be 115 Volt single-phase power unless noted otherwise.

F. Condensate pumps shall be as manufactured by Little Giant Pump Company or equal by Teel, shall be UL listed and labeled.

2.16 UNIT HEATERS

A. Hot Water Propeller Type:

1. Provide Vulcan, Trane, Rittling, Sigma or equal of type, capacity and sizes shown on drawings. Refer to 15500-2.1 and 2.2 for motor types and minimum efficiencies.

2. Capacities shall be based on entering water temperature or steam pressures as scheduled. Coils shall be copper tube with aluminum fins expanded to tubes silver soldered to steel headers and shall be minimum 250 psig. w.p.

3. Furnish with the following:

a. Adjustable discharge louvers.

b. Wire motor guards.

B. Electric Propeller Type:

1. Provide type, capacity and sizes shown on drawings. Units shall be Q-Mark, Brasch, Electromode or approved equal.

2. Furnish with the following:

a. Adjustable discharge louvers.

b. Wire motor guards.

c. Thermostat.

d. Factory installed disconnect switch.

e. 18 gauge steel die formed cabinet.

f. Casings shall be phosphate coated and finished with baked enamel.

g. Mounting brackets for ceiling or wall mounting as required.

h. Metal sheath heating elements with copper clad steel sheath and aluminum fins.

i. Automatic reset thermal overheat protection.

j. Totally enclosed, continuous heavy-duty motor with built-in thermal overload protection.

k. Aluminum fans directly connected to fan motor, designed specifically for unit heater application.

l. Low voltage control kit with remote thermostats.

3. Units shall be U.L. listed and meet the requirements of the National Electric Code.

C. Hot Water Cabinet Type:

1. Provide Vulcan, Rittling, Sigma or equal as noted on the drawings.

2. Types, sizes and capacities shall be as shown on the drawings.

3. Capacities shall be based on entering water temperatures or steam pressures indicated on the drawings.

4. Furnish with disposable polyfiber filter, built-in starter/disconnect and built-in multispeed control switch. Refer to 15500 2.1 and 2.2 for motor types and minimum efficiencies.

5. Coils shall be rated for a minimum of 250 psig w.p. Coils shall be copper tube with aluminum fins expanded to tube with tubes silver soldered to steel headers.

6. Provide with integral thermostat, or remote thermostat, as noted on the drawings. Provide access panel(s) to the controls and piping valves with tamperproof hardware.

D. Electric Wall Type:

1. Provide electric wall heaters by Q-Mark, Trane, Brasch or equal, as scheduled on the drawings and where shown on plans.

2. Heater grille shall be 16 gauge steel with closely spaced downflow discharge bars. Finish shall be duronodic baked enamel.

3. Thermostat shall be integral with adjustment range between 55°F. and 85°F. Thermostat shall be tamper resistant.

4. Heating elements shall be steel finned metal sheath elements.

5. Fan motor shall be totally enclosed and permanently lubricated.

6. Heater shall contain automatic reset thermal overheat protector to disconnect power in event of overheating due to accidental blockage.

7. Heater shall contain built-in fan delay switch to energize fan motor only after elements are heated. When heat shuts off, switch shall de-energize fan motor after residual heat has been dissipated.

8. Heater shall contain built-in double-pole disconnect switch.

2.17 HYDRONIC FIN TUBE RADIATION AND ENCLOSURE

A. Capacities for radiation shall be based on average water temperatures (low temperature from condensing boilers), as indicated in the drawings. Three-tier is a basis of design.

B. Provide sliding saddle hangers in two pieces to allow expansion of the element within the enclosure.

C. Provide gasket at the rear of each wall-mounted unit.

D. Enclosure shall be 14 gauge bonderized steel with prime coat finish. Provide floor supports at each end and at a maximum of three feet on center for pedestal radiation. No surface overlaps shall be permitted on any enclosure. All corners and bends shall be at right angle construction.

E. Radiation element and enclosures shall be provided by the HVAC Subcontractor.

F. Types, sizes and capacities and active element lengths shall be as shown on the drawings.

G. Enclosure shall be wall-to-wall, column-to-column, or completely free standing, as shown on the Drawings, and shall be manufactured to suit the details shown on the Drawings. Do not penetrate wall vapor barrier. Wall-to-wall and column-to-column enclosure shall be provided with end caps and corner pieces. Provide with multiple piano hinge flush access doors with tamperproof cam lock operated by Allen wrench at each end to service valves where valves are located in enclosure.

H. Fin tube radiation and enclosure shall be Vulcan, Sterling, Rittling or equal. Provide custom built enclosures where indicated on the drawings.

2.18 DUCT COILS

A. Hot Water Duct Coils:

1. Provide duct mounted coils where shown and of sizes and capacities as indicated on the drawings and as described below.

2. Primary surfaces shall be 5/8 inch O.D. round seamless copper tubing on 1-1/2 inch center, hydraulically expanded into the fins and expanded into cast iron headers. Secondary surface shall be aluminum configured continuous plate fins.

3. Coil supply and return connections shall be located on the same end of the coil. Coil supply and return connections shall be union nut and tailpiece with threaded adapter.

4. Coil casings shall be galvanized steel and shall have flanged and punched end tube sheets with tube holes drawn into a smooth collar and sized to permit free expansion and contraction of the finned core without chafing the tube. Coils shall be readily removable and completely drainable.

5. Coil shall be tested with 300 lbs. pneumatic pressure under water. Provide with vent connection and vent valve for each coil.

6. Ratings shall be in accordance with ARI standards and stamped accordingly.

7. Hot water heating coils shall be Trane, Heatcraft, TSI, AAF, Aerofin Corp., or equal.

B. Electric Duct Coils:

1. Duct heaters shall be Indeeco, type QUA, Brasch or equal standard slip-in heaters or equal. Full infinite sine-curve rectifier (SCR) control is required, integrity an external proportional signal.

2. Heaters shall meet the requirements of the National Electric Code and shall be listed by Underwriter's Laboratories for zero clearance to combustible surfaces.

3. Type QUA heating elements shall be open coil, 80% nickel, 20% chromium, type A resistance wire. Type C alloys containing iron or other alloys are not acceptable. Coils shall be machine crimped into stainless steel terminals extending at least 1 inch into the airstream and all terminal hardware shall be stainless steel. Coils shall be supported by ceramic bushings staked into aluminized steel supporting brackets.

4. Heater frames and terminal boxes shall be aluminized steel. Unless otherwise indicated, the terminal box shall be NEMA 1 construction and shall be provided with a hinged, latching cover and multiple concentric knockouts for field wiring.

5. All heaters shall be furnished with a disc type, automatic reset thermal cutout for primary overtemperature protection. All heaters shall also be furnished with disc type, load carrying manual reset thermal cutouts, factory wired in series with heater stages for secondary protection. Heat limiters or other fusible overtemperature devices are not acceptable.

6. Heaters shall be rated for the voltage, phase and number of heating stages indicated in the schedule. All three phase heaters shall have equal, balanced, three phase stages. All internal wiring shall be stranded copper with 105°C insulation and shall be terminated in crimped connectors or box lugs.

7. Terminal blocks shall be provided for all field wiring and shall be sized for installation of 75°C copper wire rated in accordance with NEC requirements.

8. Heaters shall be furnished with the Control Option specified and described below.

   a. In addition to these electronic components, Control Option K includes the following:

      1) Disc type automatic and manual reset thermal cutouts and a differential pressure airflow switch. The manual reset thermal cutouts always de-energize the heater load directly. The automatic cutout and airflow switch are normally wired in the control circuit. However, when single phase KW ratings do not exceed the values in Table V, the automatic reset cutout carries the heater load directly and the airflow switch either carries the load directly or is wired into the gate circuit of the SCR, eliminating the need for magnetic contactors.

      2) A safety contactor controlled by the automatic reset cutout when the KW exceeds the ratings in Table V.

TABLE V

Single Phase Voltage	120	208	240	277
Maximum KW	3.0	5.2	6.0	6.0

      3) Proportional control of input/output based on a variable proportional input signal from a space sensor/controller. Control input shall be field

switchable via dip switches as standard. Coordinate with appropriate requirements (0-10 VDC, 4-20mA, 4-10 VDC, etc.).

4) Fuses to protect each circuit in any heater drawing more than 48 amps.

5) A transformer, with any overcurrent protection required by UL or the NEC, to supply the internal control circuit of heaters with a SOLITECH step controller or ratings above 277 volts. All other heaters have line voltage control circuits. Wiring to remotely mounted thermostats can be Class II since thermostat circuits are low voltage limited power circuits.

6) A built-in, snap-acting disconnect switch with door interlock to protect service personnel.

2.19 FANS

A. Refer to Fan Schedules for model numbers, duty, motor horsepower and other relevant data.

B. Fans to be AMCA certified for both air and sound performance and be UL labeled.

C. Sound power values shall be provided with shop drawings, and in no case shall exceed the levels of the scheduled equipment.

D. Major deviations from overall dimensions of apparatus will not be accepted without written permission.

E. Submit certified performance curves for all fans for complete operating ranges of equipment approval with shop drawings.

F. Refer to 15500 - 2.1 and 2.2 for motor types and minimum efficiencies.

G. All fans (and motors which are not isolated from the airstream) used for smoke exhaust must be tested and rated to operate at 250°C (482°F) for a period of not less than 90 minutes.

H. Roof Exhaust Type:

1. Shall be ACME, Greenheck, Cook, or equal. All aluminum construction with integral prewired disconnect switches.

2. Unit shall be centrifugal downflow type as designed for use as a general exhaust fan or upblast type as designed for use as a kitchen exhaust fan or laboratory exhaust. Type to be as noted on the drawings. Kitchen exhaust fan shall be UL listed (UL 762) for kitchen exhaust use. Units shall be statically and dynamically balanced at the factory to acceptable vibration band levels. Fans used for dishwasher exhaust must be furnished in AMCA-A all aluminum construction including motor plate as well as all support brackets. Provide fan system complete with stainless steel shafts, and hardware.

3. Units shall be completely weatherproof and complete with bird screens and nailing cant on 18 inch high welded aluminum insulated curb. Provide sound curbs where

noted on the plans. Provide backdraft damper. Fan shall be welded to the integral curb cap.

4. Provide kitchen exhaust fan with NFPA required 18 inch high, vented, galvanized steel roof curb, complete with grease collector and assembly, heat shield to protect motor bearings and hinged curb arrangement. Provide grease collector/filter system to avoid grease accumulation on the roof.

5. Provide baked phenolic coatings complete with a UV protective coating for fan wheel and all parts exposed to air stream for vented storage cabinet and laboratory fume hood exhaust fans.

6. Secure fans to curb with 3/16 inch diameter X 2 inch long lag bolts every 18 inch on center, eight bolts minimum (two per side) per fan.

7. Provide roof curbs which compensate for any angle the roof may be pitched to ensure fans to be mounted level unless noted otherwise. Fan base must be a minimum of 12 inch clear of the roof pitch.

8. Provide cast iron bearing assembly. Provide cast iron motor sheave (adjustable type).

I. Propeller Type:

1. Provide direct and belt driven, wall mounted type, where indicated on the drawings.

2. Unit shall be constructed of square heavy gauge cold rolled, steel panels with Venturi inlet. The steel power assembly is to be welded to the panel. Provide with low leak backdraft damper for exhaust fans unless noted otherwise on the drawings.

3. Wheels shall have aluminum or steel blades with steel hubs and spiders and shall be pinned to shaft or adjustable pitch injection molded, glass reinforced, polyphenylene blades and hubs.

4. Zinc plated wire guard for motors and blades shall be provided.

5. Motors shall be PSC with prelubricated ball bearings.

6. Manufacturers shall be ACME, Greenheck, Chicago Blower, Cook, or equal.

J. Tubular In-Line Centrifugal:

1. Furnish and install Cook CIC Tubular Centrifugal fans, Greenheck, Twin City or equal of the wheel and inlet/outlet size and capacity shown on the fan schedule.

2. Each unit shall employ the standard CLV belt drive system with belt guard.

3. Construction shall be steel housing with a centrifugal extruded aluminum true airfoil wheel, heliarc welded with non-overloading characteristics.

4. Heliarc welded straightening vanes shall be integral part of the unit at the discharge to eliminate turbulence, having a straight airflow for maximum exhaust.

5. Belt drive units shall have the motor externally mounted with adjustable motor sheave and base with lubricated tubes provided from the shaft bearing to the CLV housing for lubrication. Provide 200,000 hour L10 bearings and dual belt drive with 24,000 hour non-static belts complete with an aerodynamic belt tube. Refer to 15500 - 2.1 and 2.2 for motor types and minimum efficiencies.

6. Provide with wheel access door.

K. In-Line Centrifugal:

1. Fans shall be belt-driven in-line or direct drive type, as noted on drawings. The square shaped fan housing shall be of heavy gauge galvanized steel. The motor shall be mounted isolated from the airstream and shall have belt guard with TACH opening. The belt and pillow block ball bearings shall be protected from the airstream by an enclosure. The shaft shall be keyed to both the wheel and pulley. Provide wheel access for cleaning and maintenance access.

2. The fan inlet shall be a spun Venturi throat overlapped by a backward curved centrifugal wheel with spun cone for maximum performance.

3. Provide solid state variable speed controllers for all direct drive fans. Controllers shall provide capacity reduction to 50% of the noted full flow. Controllers shall also function as "ON-OFF" switch.

4. Refer to 15500 - SHEETMETAL for carbon monoxide and welding exhaust fan specifications.

5. Fans shall be Greenheck Model SQB or SQD as noted on the drawings, Cook SQI, ACME, Twin City, or equal. Fans shall be UL listed.

2.20 CIRCULATING PUMPS

A. Base Mounted End Suction: (Vertical In-Line same as noted in left column)

1. Furnish and install base mounted pumps as manufactured by Sulzer, TACO, Aurora or equal. Capacities shall be as scheduled on the drawings. Pump shall have positive seal chamber circulation and be factory assembled and tested. Pump rating curves shall be the result of testing and rating in accordance with procedures of the Hydraulic Institute. Refer to 15500-2.1 and 2.2 for motor types and minimum efficiencies.

   Pump shall be suitable for use with up to 40% glycol solution.

2. Pumps shall have one piece structural steel bases and shall be so constructed such that they provide positive bearing support with a foot mounted bearing frame providing for two point alignment and easy serviceability.

3. Pumps shall have sound dampening non-metallic flexible couplers, designed to absorb all types of shock, vibration, parallel misalignment, angular misalignment and end float. Furnish with coupler guards.

4. All pumps shall have mechanical seals with external circulating line to a separate seal chamber. The line shall include a factory installed Puro-mesh TACO #12 filter with replaceable cartridge Filter shall have the ability to remove particles down to five

microns in size. Seals shall be capable of operating at 250°F and will be suitable for use with PPM chromites. PPM suspended solids filter shall be TACO Permalife #1, Permalife #2 or equal. All seals shall be compatible with a 40% solution of propylene glycol.

5. Pumps shall be non-overloading. Grout pump base to concrete housekeeping or inertia pad, shimmed level and dynamically balanced once in place.

6. Pumps shall have center-line discharge to insure self venting and shall have a built-in diffuser section in the suction. Suction and discharge connections shall be drilled and tapped for gauges and flanged to utilize either 150 psi or 125 psi ASA flanges or 400 psi as noted on the drawings. Suction and discharge connections shall be the same size. Motors shall be open drip proof.

7. Provide EPT ceramic mechanical seals (rated to 250°F) and cupro-nickel sleeves and sleeve bearings.

8. Pump casing for 125 psig pumps shall be close-grained, high tensile strength gray iron, with smooth waterways, and fitted with bronze replaceable wear ring. Impeller shall be bronze enclosed accurately machined and statically and dynamically balanced and, where applicable, hydraulically balanced. The impeller shall be fitted to shaft with a key and locked in place. Motor shaft stainless steel one piece or steel with bronze shaft sleeve. Pump casing impeller and seals for 175 psig working pressure pump shall be cast iron construction.

B. Single Stage Horizontal Split Case Double Suction Horizontal:

1. Furnish and install, as shown on drawings and as described in these specifications, Sulzer type KPS, TACO, Aurora, or equal bronze fitted, single stage double suction, horizontally split case centrifugal pumps.

2. Pumps shall be mounted on a fabricated steel base with, and direct-connected through a heavy-duty flexible coupling to a ball bearing drip-proof standard domestic make, electric motor. Motor shall be of such size that it will operate continuously without exceeding its HP rating, exclusive of service factor, at the design capacity and head. Coupling shall be protected by a heavy gauge steel OSHA coupling guard. Refer to 15500 - 2.1 and 2.2 for motor types and minimum efficiencies.

3. Pumps shall have casing divided at the horizontal center line, with casing halves accurately machined, and bolted and doweled together. Casing shall be of close-grained high tensile strength gray iron, with smooth waterways suitable for 250 psi working pressure. Removal of upper half casing and bearing housings shall permit removal of the complete rotating assembly without disturbing pipe connections.

4. Pumps shall be selected to operate at or near their point of maximum efficiency thus allowing for operation at capacities approximately 25% beyond design flow. In addition, the design shall not be more than 90% of the head obtainable at the design flow with the largest diameter impeller available for the pump model. Pumps shall be non-overloading at any point on its curve for the horsepower selected.

5. Impeller shall be enclosed, double suction design, accurately machined and dynamically balanced. It shall be fitted to shaft with a key and locked in place either by threaded locknuts or threaded sleeves.

6. Pump shall be furnished with high strength steel shaft and bronze shaft sleeve.

7. Pump shall be fitted with bronze renewable casing wear rings, doweled to casing. Pump shall have mechanical shaft seals, of extra-hard carbon ceramic type. All seals shall be compatible with a 40% solution of propylene glycol.

8. Condenser pumps shall have deep stuffing boxes, with split type glands for ease of serving.

9. Pump ball bearings shall be deep groove type with cartridge mounting locked to shaft with positive locks, of ample size to withstand all thrust and radial loads. Pumps with 4 inch suction or larger shall have a minimum bearing life of 10 years at the worst condition of load.

10. Pump and motor shall be realigned by the contractor, according to the standards of the Hydraulic Institute, after grouting of base and connection of piping.

11. Pumps shall be non-overloading. Grout pump base to concrete housekeeping or inertia pad.

C. In-Line Type:

1. Furnish and install as shown on the schedule and plans, TACO 1600 series, Sulzer VL, Bell & Gossett, Aurora, or equal. Pump and motor shall be equipped with sleeve bearings for quiet operation. Pumps shall be suitable for up to 175 psi working pressure and up to 300°F water temperature as per ASSA B16.1. Pump rating curves shall be the result of testing and rating in accordance with the procedures of the Hydraulic Institute.

2. Pump shall be non-overloading throughout the range of the curves and shall have center-line discharge for positive venting, flanged bodies and same size suction and discharge.

3. Pumps shall incorporate a disc-type lubrication system and be so designed that the bearing assembly can be removed in one piece. One bearing assembly shall be suitable for all sizes on the in-line pumps furnished. Pump oil temperature may not exceed 180°F when circulating 250°F water with a 90 degrees ambient. Vent and drain openings at least 3-square inches in area and a water slinger shall be provided between the mechanical seal and bearing area.

4. Pump shafts shall be alloy steel with cupro-nickel sleeve, and shall be coupled to the motor shaft by a noiseless seal and bearing area, non metallic coupler. All seals shall be compatible with a 40% solution of propylene glycol.

5. Pumps shall have two piece mechanical seal assembly easily replaceable without the use of special tools.

6. Motors shall be resilient mounted, 1750 RPM and require no external overload protection when used with single phase current. Refer to 15500-2.1 and 2.2 for motor types and minimum efficiencies.

7. For type, service, capabilities, and horsepower characteristics, see drawings.

8. All pumps shall be installed. aligned and started in accordance with the manufacturer's recommendations. Engineers to be supplied with certified gauge readings at time of start-up. Shop drawings shall include certified pump performance curves.

9. Pump gland and seals shall be selected for operating duty of the pump. Static heads shall be considered in gland and seal selection.

D. Pumps shall be selected to operate at or near their point of maximum efficiency thus allowing for operating at capacities approximately 25% beyond design flow. In addition, the design head shall not be more than 90% of the head obtainable at the design flow with the largest diameter impeller available for the pump model. Pumps shall be non-overloading at any point on its curve for the horsepower selected.

2.21 ROOF VENTS

A. Provide outdoor air intake, exhaust and relief vents of the sizes and type noted in the drawings. Units shall be based on Cook, Ruskin, Airolite, Arrow, Construction Specialties or equal.

B. Units shall be all aluminum construction with all seams continuously welded and shall be provided with roof vent manufacturer's 18 inch high roof curb for exhaust/relief vents and 24 inch high roof curb for intake vents. Roof curbs shall be pitched as required to ensure vents to be mounted level where the lowest point of vent meets the above stated requirement unless noted otherwise.

C. Provide all units with anti-condensate plastic coating on the underside of roof vents. Provide low leak backdraft dampers on exhaust or relief vents unless noted otherwise on the drawings.

D. Provide outdoor intake units with weather bars to minimize water and snow entrainment.

E. All units shall be equipped with aluminum birdscreens.

F. Unit sizes shall be as listed on the drawings.

G. All units shall be constructed in recognition of ASCE 7-88. Designed for 100 MPH wind load and 101.5 lbs. per square foot snow load. Unit cap to be minimum .051 inch, unit base shall be minimum .080 inch.

H. Secure vents to curb with 3/16 inch diameter X 2 inch long lag bolts every 18 inches on center, eight bolts minimum (two per side) per vent.

I. Intake ventilator to be 200% free area as compared to listed throat size. Relief vent to be 150% free area as compared to listed throat size.

2.22 CONVECTORS

A. Heating element shall be non-ferrous consisting of 1/2 inch diameter copper tubing and .012 thick aluminum plate fins with full-flanged collars. The tubes shall be expanded mechanically into fin collars to form a permanent thermal bond. Fins shall be protected front and back by formed shield plated fitted to each fin and running entire length of element. Headers shall be cast brass provided with top and bottom threaded piping connections. Heating elements shall be tested by manufacturers at 200 psi air pressure under water. Elements shall be supported from support brackets on sides of cabinets by means of threaded bolts which shall allow for proper pitching of the element. Units shall be Vulcan, Trane, Rittling or equal.

B. Units shall be tested and rated in conformance with Commercial Standards CS 140-1476 as developed cooperatively by the Trade and National Bureau of Standards, U.S. Department of Commerce, and shall have been approved by the Convector Rating Committee.

C. Cabinets shall be formed from cold rolled steel and shall be suitably braced and reinforced where necessary to provide stiffness and accurately fitted to prevent air leakage. Cabinet fronts shall be flanged top and bottom for added rigidity. All exposed edges of cabinets shall be smoothly formed with 3/8 inch inside radius.

D. Air outlet louvers and inlet louvers where required shall be the venetian type. #16 gauge cold rolled steel heating element support brackets shall be spot welded to inside ends of all convector cabinets except the plaster front. All cabinets 48 inch long or 32 inch high and greater shall have a stiffening channel spot-welded to inside front of cabinet.

E. After fabrication, all cabinets shall be thoroughly cleaned, phosphatized and provided with a high quality baked gray prime coat. Knock-outs shall be provided on sides of cabinets for piping connections as required.

F. Cabinets shall be constructed from not less than #18 gauge CRS with beveled metal front not less than #16 gauge CRS. Front edges of cabinets shall be flanged outward to act as plaster stops and to receive the beveled edge metal front. Fronts shall fasten with sufficient number of Phillips head screws to insure a tight seal. Metal front shall be provided with venetian type air outlet grille. Metal front cabinets shall be 4-side overlap for mounting above floor.

G. Units shall be provided with two access doors. Access doors shall be 5-1/8 inch x 4-1/8 inch and shall be located in the inlet louver area. Access doors shall be hinged on side with straight shaft type hinge and shall fasten with cam-type locking device with Allen-head operator.

2.23 ELECTRIC STEAM HUMIDIFIERS

A. Humidifier shall be a VAPORSTEAM model as manufactured by DRI-STEEM HUMIDIFIER CO.

B. Stainless Steel Construction: Vaporizing chamber, cover and fittings shall be constructed of stainless steel with heliarc welded seams.

C. Quick Removal Cover shall be secured by widely spaced quick removal threaded knobs. The gasket shall be held in place by flanges that are formed as part of the cover and as part of the evaporating chamber. These flanges shall interlock in such a way that the sealing gasket is trapped between them.

D. Immersion Heater(s) shall be INCOLOY alloy sheathed resistance type heater(s) designed for up to 90 watts per square inch. They shall be threaded and screwed into the front face plate of the vaporizing chamber thus providing for convenient removal for inspection.

E. Electronic Water Level Control system shall provide for automatic refill, low water cut off and skimmer blow down functions. System shall consist of:

1. Water level sensing unit compromised of three TEFLON coated stainless steel probes screwed into a threaded probe head. Probe head shall incorporate probe isolation skirts and be mounted on the face plate of the vaporizing chamber.

2. A solenoid operated fill valve factory mounted on the face plate.

3. A solid state electronic logic control module mounted and wired in the control panel.

F. Surface skimmer shall be provided which is field adjustable to provide for optimum mineral removal with minimum water waste.

G. Control cabinet shall be UL LISTED and to be factory mounted on humidifier. Sub-panel shall be enclosed in a UL LISTED JIC enclosure and contain magnetic contactor(s), control circuit transformer, multiple heater fuses, logic control system module, numbered terminal strip and all interconnecting wiring.

H. Automatic Drain: Motor driven brass bodied drain valve shall be factory mounted and wired. Timer and drain controls shall be incorporated into electronic level control system which provides for drain and flush at timed intervals. Frequency of drain shall be field adjustable from 5 to 50 hours of "on" time, the duration of drain period shall be field adjustable from 1 to 30 minutes. Provide accessory "Drane Kooler" with full NPCW piping, drain, and hook-up accessories.

I. Vapor Hose Kit: Humidifiers shall be supplied with appropriate quantity of vapor hose kits which allow for remote mounting of the humidifier. Each kit shall consist of one 10 foot section of 1-1/2 inch I.D. reinforced vapor hose, two stainless steel hose clamps, a two-piece escutcheon plate tube to extend the width of the duct and shall be fitted with two rows of high temperature. Thermoplastic inserts arranged to discharge the steam in V-pattern. Each insert shall extend through and into the center of the dispersion tube and incorporate a properly sized calibrated orifice.

J. Rapid Absorption Tube Bank: (Dri-Steem "ultra-sorb") Tube bank shall consist of a horizontal header and necessary quantity of vertical dispersion tubes necessary to achieve the required steam absorption distance. Header shall span the width of the air handling unit, be constructed of stainless steel and be fitted with 1-1/2 inch tee outlets for dispersion tube connections. The dispersion tubes shall extend the height of the duct and shall be fitted with two rows of high temperature Thermoplastic inserts arranged in a V-pattern. Each insert shall extend through and into the center of the dispersion tube and incorporate a properly sized calibrated orifice.

K. SCR Controller (full modulation): A 100% solid state, power controller shall be mounted and wired in the control cabinet. A compatible humidistat shall be shipped loose for field installation. System shall modulate humidifier output from 0% to 100% of maximum capacity.

L. Air Flow Proving Switch: Model RH-3, diaphragm operated, airflow proving switch shall be provided for field installation. Switch shall have an adjustable control point range of 0.05 inch W.C. to 12 inch W.C. and be rated for 1/4 H.P. at 125 VAC.

M. Factory Insulation: Humidifier shall be covered with 3/4 inch thick, rigid, foil faced fiberglass duct insulation. Insulation shall be covered with reinforced aluminum foil. All surfaces except front panel shall be covered.

N. Wall Brackets: Two wall brackets, for supporting humidifier from a vertical surface, shall be provided.

O. High Limit Duct Humidistat: Compatible high limit duct humidistat shall be shipped loose for field installation. Humidistat shall sense humidity level within the duct and provide protection against saturation of air stream. 65% RH initial set point.

P. VAV Control Package: Provide a DRI-STEEM variable air volume humidity control system package that automatically monitors both space and duct relative humidity. The system shall automatically compensate for changes in humidity load due to air volume changes and modulate the humidifier output to maintain the desired space humidity while preventing the flooding of the air stream with steam. The system shall consist of an anticipating modulating controller and two electronic humidity sensors (one space mounted and the other duct mounted) both feeding their inputs into the anticipator which, in turn, modulates the humidifier output.

Q. The system controller shall be factory mounted, wired and calibrated in the humidifier control panel and wired with humidity sensors to be shipped loose for field installation. Mounting instructions and a wiring diagram shall be included. Spare dry contact shall be provided to shut down the unit upon pan water detection and a set of contacts for general alarm.

2.24 HEATING and VENTILATING UNITS AND HEATING, VENTILATING and AIR CONDITIONING UNITS

A. The following items that apply to HVAC, AHU, AC and H&V units shall be Trane, York (MCC) (Solution), Carrier (39M), or equal.

B. The unit casings shall include complete double wall, minimum 18 gauge construction for exterior and minimum 20 gauge for interior panels, and shall be fabricated of heavy-gauge galvanized steel reinforced, rolled and braced with galvanized steel angle framework for maximum rigidity. Factory-assembled sectionalized modules with closed cell foam gasketing shall be provided where modules are joined and shall include separate fan, coil and filter sections. Removable panels in fan and coil sections shall provide access to all internal parts. Coils shall be removed through full size access doors with safety handles. Metal parts of casing and all accessories with exception of coil casings, supports, and drain pans shall be chemically cleaned, phosphatized and given protective enamel finish or shall be G-140 minimum galvanized. Provide access doors and separate sections as noted on the drawings or herein. All sections shall have 2-inch 1-1/2 pound density glass fiber blanket insulation.

C. 304 stainless steel drain pans shall be provided under complete fan and coil section of the units. Drain pan shall have the drain connections on both sides and shall be double wall insulated stainless steel. Humidifier section (upstream of cooling coil on AHU-3) shall also be 304 stainless steel.

D. A one piece drain pan shall be provided under the complete coil and plenum section. Drain pan and coil sections shall be as described in Paragraphs B and C.

E. Damper assembly shall have Class 1 opposed blade dampers, independently operated. Damper operators to be furnished and installed by ATC Sub-Subcontractor. Dampers to be heavy gauge, double walled, low leakage type, maximum leakage 1-1/2 percent of air flow at full capacity and static pressure.

F. Fans shall be internally isolated from the unit with spring isolators, thrust restraints and flexible outlet collar. Fans shall be multi-blade centrifugal with fan wheel type as noted on the drawings. Variable volume fans shall be of a non-overloading type fan design (B.I. or A.F.). All fans shall be statically and dynamically balanced and tested after being installed on properly sized hollow or solid shafts. Fan shafts shall not pass through their first critical speed as unit comes up to rated rpm. Refer to 15500-2.1 and 2.2 for motor types and minimum efficiencies. All motors shall be premium efficiency totally enclosed fan cooled (TEFC) for HVAC, AHU and AC units. Inverter compatible motors shall be matched to drives scheduled.

G. Fan housings shall be constructed from die-formed stream-lined inlets and side sheets. Fan bearings shall be grease lubricated ball bearings selected for 200,000 (L-10) hours average life. Units shall have greased lubricated externally mounted fan bearings with grease fitting extended to service side of unit, i.e. side with pipe connections. Fan type shall be as noted in the drawings with internally isolated fans and motors on adjustable base with beltguard. All internal isolators shall have 2 inch deflection springs.

H. Provide V-belt drive selected with minimum service factor of 1.50 based on fan brake horsepower. Drives to be fixed pitch and with a minimum of two (2) belts. Adjustable drives shall be acceptable only for initial start-up and determination of optimum RPM, where upon they shall be replaced with fixed sheaves.

I. Standard length preheat coil frame shall be designed to hold one or two-row coil. Coil pitched for proper drainage. Inlet and outlet flanges shall have bolt holes compatible with unit and other accessories. Coils to have same end supply and return connections. The coil casing and supports shall be #304 stainless steel.

J. Cooling and dual temperature coils shall be standard type as manufactured by the unit manufacturer and conforming to these specifications. They shall be mounted pitched in the unit casing removable through a unit access door; shall be completely drainable type; and shall have Type 304 stainless steel sheet casings and supports.

1. Coils shall have supply and return connections at same end, easily drainable through the piping and drain connections and fabricated of 5/8 inch O.D., 0.025 inch wall thickness (minimum) with staggered copper tubes and with 0.035 inch (minimum) wall tube bends and 0.010 inch thick (minimum) aluminum fins for use with water. Aluminum fins shall be permanently bonded to the tubes hydraulically or by mechanical expansion. Fin spacing shall not exceed ten (10) fins per inch.

2. Coils shall be ARI Standard 410 rated and stamped accordingly.

3. The casing and tube sheet supports for coils shall be 304 stainless steel construction having provisions for bolting to the unit. Headers shall be non-ferrous type red brass or Schedule 40 steel. All joints shall be brazed to ensure permanent leakproof construction.

4. Provide an air vent connection and vent valve for each separate coil section.

5. Coils shall be factory tested for 300 psig air under water and suitable for 200 psig at 400°F.

6. All cooling coils shall be guaranteed to operate without moisture carry-over in the configuration shown and at the velocity levels specified. If required to meet this condition, provide at no extra cost, six surface, five bend, three hook, stainless steel, 1-1/8 inch center-to-center eliminators downstream of cooling coil section. Fan horsepower, wiring and starters shall be increased to overcome additional static pressure loss through eliminators. All subsequent extra costs caused by the addition

of eliminators including all engineering and contractual labor and material expenses shall be borne by the HVAC Subcontractor.

7. Coils shall be by the air handling unit manufacturer.

8. Refer to drawing details for coil piping details.

9. Coils shall be of the capacity and characteristics listed on the drawings. The air side pressure drops scheduled for all cooling coils shall be strictly adhered to. Coils shall provide listed capacity with glycol solution where design includes water/glycol solution.

10. Evaporator coils shall have aluminum plate fins (minimum wall thickness of 0.010 inch) mechanically bonded to seamless copper tube (minimum wall thickness of 0.035 inch) with all joints brazed. Tube sheet openings shall be belled to prevent tube wear. Evaporator coil shall have intertwined circuiting and be full face active type during full or part load conditions.

11. Maximum cooling coil face velocities shall be as scheduled, but at no time shall exceed 450 feet per minute. Maximum coil face velocities for 100% outdoor air systems shall not exceed 400 feet per minute or lesser if scheduled.

K. Provide for external motor type as well as internal motor type, OSHA type expanded metal belt guard having sides of mill galvanized steel and expanded metal face with opening for tachometer.

L. Provide extended lubrication lines from fan bearing to unit casing mounted and prepacked with grease at the factory. Lubrication lines to be Type K seamless soft drawn copper hose connected to the bearings with a Zerk fitting on the unit casing. All grease fittings shall be on the drive side of the fan.

M. Unit AHU-3 shall have a humidifier section upstream of the second stage DX refrigerant cooling coil and downstream of the chilled water cooling coil. Each of these sections shall have full individual insulated 304 stainless steel drain pans with 1-1/2 inch MPT stainless steel low drain ports and a higher "overflow" port.

N. All filter sections shall be designed to hold 2 inch pleated throw-away filters upstream of subsequent filters. Inlet and outlet flanges shall have bolt holes compatible with unit accessories. Provide medium capacity angle filter sections with one access door for filter servicing. The HVAC Contractor shall provide two sets of Farr 30/30 filters, one in unit, one as spare. Size filter sections for a maximum velocity no greater than 500 feet per minute.

O. Provide filter sections as shown on the drawings to house 2 inch pleated MERV-8 filters in front of 12 inch deep, MERV-14 cartridge filters. Provide all hardware and gaskets required as well as proper access for servicing. Provide two (2) sets of both Farr MERV-8 and 12 inch deep MERV-14 cartridge filters. Size filter sections for a maximum velocity no greater than 400 feet per minute.

P. Provide filter sections or combination filter mixing sections or separate filter mixing sections as indicated on the drawings, complete with manometers individually piped across each filter section and as noted on the drawings.

1. Filter gauges shall be Dwyer "Magnehelic" 2000 Series. Select with mid-point of scale at mid-point of filter loading (clean to changeout).

2. Provide all filter gauges with static pressure pitot tubes, aluminum tubing and vent valves for isolation and zeroing.

3. Provide tees in tubing with additional vent valves so that individual filter banks may be isolated and read by a common gauge.

Q. Provide internally mounted outside air and return air dampers on all mixing and filter/mixing sections. Dampers to be Ruskin #CD60 or approved equal of the ultra low leakage design. Dampers shall be of airfoil design and galvanized construction; they shall be either parallel or opposed blade type (manufacturer to select type to ensure proper mixing of airflows) with metal compressible jamb seals and extruded vinyl blade edge seals on all blades. Blades shall rotate on stainless steel sleeve bearings. Maximum damper blade length shall be 60 inches. Leakage rate shall not exceed 1-1/4 cfm/square foot at one inch w.g. and 10 cfm/square foot at 4 inches w.g. Damper operators shall be furnished and installed by the ATC Subcontractor. Provide dampers without mechanical interlocks linking the return and outdoor air dampers. Provide dampers for individual actuators.

R. Provide all sections as indicated on plans and as specified. Provide elevated base rails to raise units for drainage from cooling coils, humidifiers, etc. to waste or to pumps.

S. As required for routine service access, unit shall be supplied with full height, galvanized, double-wall, hinged, removable access doors where shown on plans and on both sides of all access sections. Access door shall have a full perimeter automotive type gasket to prevent air leakage and ventlock style handle(s) that can be opened from the exterior of interior of the unit. Refer to plans for extra doors that may be required.

2.25 SELF CONTAINED CONTROL VALVES

A. Non-electric control valves shall be Macon Controls, Oventropp, Taco, Amatrol, or equal.

B. Control head shall be liquid expansion design with an acetone liquid fill. Material of the head is to be constructed of chrome plated brass. Temperature setting range to be 55°F - 85°F. Freeze protection setting to be below 50°F. Integral steel pins shall be provided for lock setting temperature at the factory or in the field. Control shall be Direct Sensing with 5 feet-0 inch concealed capillary tubing, or remote sensing and control adjustment with 13 feet-0 inch capillary tubing secured to wall in manner approved by the engineer where exposed, as directed on the drawings. Where valve head contains control adjustment provide tamperproof high impact plastic cover.

C. Valve bodies to be constructed of cast brass or bronze, nickel or chrome plated, with EDPM seats and metal disc. Valves shall have "0" ring and rubber sac seals. Gland seals to be replaceable without draining system. Hot water ratings shall be minimum 150 psi at 250°F service and 15 psi steam depending on usage. Refer to drawing for water and steam service. All valve bodies capable of withstanding 200 psi test pressure and 250°F temperature. Valves shall shut off against a minimum pressure differential of 17 psig, when fitted with standard head, and 30 psig when fitted with a 24 volt power head.

D. Provide vandal proof covers for valves both new and existing and similar for exposed controllers where they are shown. Refer to drawing for cover detail.

E. Provide straight through or angle type valves as shown on drawings. Valves must fit within radiation enclosures or convector covers. Provide for all convectors unless shown on drawings otherwise. Provide for all radiation which is not shown served by a remote thermostat or interlocked with air system controls.

2.26 SHEETMETAL

A. General:

1. Except where specifically mentioned otherwise in this section or on the drawings, all ductwork shall be constructed from galvanized steel sheets of lock forming quality.

2. "Ductwork" shall refer to but shall not be necessarily limited to ducts, manual volume dampers, diffusers, grilles, VAV terminals, sound attenuators, registers, access doors, joints, stiffeners, hangers, internal duct insulation, sealers, gaskets, tape and caulking compounds. All manual and automatic dampers, access doors, hangers and joint items installed inside or outside ductwork shall be constructed of same material as "Ductwork". All equipment and items listed in Section 15500, Paragraph 2.26 shall be considered "Ductwork".

3. Except where specifically specified otherwise, the sheetmetal trade shall construct all ductwork in strict accordance with Table and Plate Numbers of the "HVAC Duct Construction Standards" second edition prepared by SMACNA for + 2 inch pressure class and as per details on the drawings. Construction shall be also as per ASHRAE. Button punch snap lock seams shall not be allowed. No duct metal gauges less than 24 gauge will be acceptable. Refer to the following Table and text for applications. Submit similar schedule with the sheetmetal shop standards shop drawing submittal.

DUCT CONSTRUCTION TABLE

APPLICATION	MATERIAL	PRESSURE CLASS	MINIMUM SEAL/ LEAKAGE CLASS	INSULATION WITH VAPOR BARRIER	LINING Y/N	SPECIAL
Supply, constant volume HVAC ductwork. Including FCU's, unit ventilators, and all supply fan systems.	G-90 galvanized	2.0 inch positive	A/3	Yes, 1-1/2 inch	(1)	
Supply ductwork for VAV HVAC units from unit to sound attenuator connection or for first 50 linear feet from unit connection, whichever is	G-90 galvanized	6.0 inch positive	A/3	Yes, 1-1/2 inch	(1)	

APPLICATION	MATERIAL	PRESSURE CLASS	MINIMUM SEAL/ LEAKAGE CLASS	INSULATION WITH VAPOR BARRIER	LINING Y/N	SPECIAL
further away from unit.						
Supply ductwork for VAV HVAC units from termination of the 6 inch pressure class ductwork complete through to the connection to the VAV terminal.	G-90 galvanized	4.0 inch positive	A/3	Yes, 1-1/2 inch	(1)	
Supply ductwork from 12 inch upstream of humidifier to 10 feet-0 inch minimum after humidifier (AHU-3).	4004 Aluminum 18 gauge minimum	2.0 inch positive	A/3 + hard cast	Yes, 1-1/2 inch	No	Pitch to low point drain trough at end.
Return/exhaust ductwork on constant volume HVAC and HV units, fan coil units, unit ventilators and ducted unit heaters; from connection to the return/ exhaust grille to return/ exhaust fans or unit connection.	G-90 galvanized	2-0 inch negative	A/3	(2) 1-1/2 inch	(1)	
Return/exhaust ductwork for VAV HVAC systems from unit duct connection to	G-90 galvanized	4.0 inch positive and negative	A/3	(2) 1-1/2 inch	(1)	

APPLICATION	MATERIAL	PRESSURE CLASS	MINIMUM SEAL/ LEAKAGE CLASS	INSULATION WITH VAPOR BARRIER	LINING Y/N	SPECIAL
sound attenuator connection or for the first 25 linear feet upstream of unit connection including the return/exhaust fan connections.						
Return/exhaust ductwork for VAV HVAC systems from termination of the 4 inch pressure class ductwork through to the connection to the return/ exhaust grille.	G-90 galvanized	2.0 inch negative	A/3	(2) 1-1/2 inch	(1)	
Return/exhaust ductwork from discharge of fan to unit and exhaust vent/ louver connection.	G-90 galvanized	2.0 inch positive and negative	A/3	(2) 1-1/2 inch	(1)	
Outside air ductwork from plenum connection to unit.	G-90 galvanized	2.0 inch negative	A/3	Yes, 2 inch	No	
Outside and exhaust air plenums connected to building louvers.	G-90 galvanized cross broken panels with stiffeners.	2-0 inch negative and positive	A/4	Yes, 2 inch	No	
Exhaust air; general and toilet exhaust.	G-90 galvanized	2-0 inch negative	A/3	(2) 1-1/2 inch	(1)	

APPLICATION	MATERIAL	PRESSURE CLASS	MINIMUM SEAL/ LEAKAGE CLASS	INSULATION WITH VAPOR BARRIER	LINING Y/N	SPECIAL
Exhaust air; locker/shower and all moisture laden airflows.	Aluminum, 4006	2-0 inch negative	A/3	(2) 1-1/2 inch	No	Silicone joints. No bottom joints. Drain low points.
Transfer air ductwork.	G-90 galvanized	2-0 inch positive or negative	A/4	No	Yes, 1 inch	WMS on openings, Nosing at liner ends.
Kitchen hood exhaust ductwork.	Black iron or stainless steel	16 gauge for black iron, 18 gauge for stainless steel	100% welded	Yes (4)	No	
Smoke exhaust ductwork (which cannot be integrated with fire dampers) such as hoistway exhaust ductwork when top of hoistway does not terminate at roof.	Black Iron	16 gauge minimum	100% welded	Yes (4)	No	Welded (4)

TABLE NOTES: (1) Lining to be provided only as shown on plans or as specified in this Section. Provide sheetmetal nosing in and out. Otherwise, no lining as a general principle.

(2) Insulate portions of ductwork (with 2 inch foil faced wrap) within unconditioned space and extending 12 inches within conditioned space at juncture. Intent is to minimize condensation within ductwork and heat gain on return ductwork.

4. All mechanical devices furnished as part of the HVAC trade to be duct mounted, shall be installed by the Sheetmetal Sub-subcontractor. Refer to Automatic Temperature Controls for automatic dampers.

5. Where aluminum duct is specified, metal thickness shall be 44% thicker than gauge for equivalent size galvanized duct, as per SMACNA. The adjustments which must be

made for reinforcements and dimensional adjustments shall conform to Tables 1-16 and 1-15 as per SMACNA HVAC Duct Construction Standards - Second Edition. Provide aluminum ductwork for complete Locker/Shower area exhaust, glass wash and sterilizer exhaust, swimming pool supply and exhaust, unit ventilator duct from outdoor air louver to unit (interface to use a 3/8 inch thick, closed cell neoprene gasket material similar to Durodyne Reddi-Stik, Model BN-38-34), as well as exposed Locker/Shower area supply fan system ductwork.

6. Kitchen exhaust shall be 100% welded and shall be 16 gauge welded black iron or 18 gauge type 304 stainless steel. All welding methods shall comply to NFPA 96. Butt welded ends are not allowed. Externally welded bell or flared ends that avoid pockets and allow grease drainage downward to grease trap or hood are mandated. Kitchen (grease) ductwork shall be configured (within it's rated shaft) to maintain clearances (as per NFPA 96) and shall terminate so as to allow for a hinged, vented curb at the roof level. When coded clearances (18 inch to combustible materials, 3 inch to limited-combustible material and 0 inch to non-combustible material) cannot be maintained, the horizontal ductwork (on the floor level which the Kitchen hood is located) may be enclosed as per NFPA-96, 1-3.2.1 to reduce required clearances. Provide code required cleanouts for Kitchen hood ductwork including cleanouts at a minimum of twelve (12) foot intervals on center (twelve (12) foot intervals when sized at less than 18 inches X 18 inches) and at each change of direction. The Sheetmetal Subcontractor shall coordinate ductwork and provide rated enclosure where required at no additional cost to the Owner. Square elbows shall not be provided.

7. Provide continuously welded (sealed) 316 stainless steel ductwork with finish for ductwork connected to dishwasher exhaust, acid waste room exhaust, laboratory fume exhaust hoods and chemistry storage cabinet exhaust complete with stainless steel hardware and supports. Refer to specification herein, 15500 - 2.26 - Y, for below grade ductwork.

8. Where aluminum ductwork passes through concrete walls, provide 1 inch clearance all the way around the duct to prevent reaction between aluminum and lime.

9. Ductwork shall not be penetrated by piping, conduit or any structural member except where unavoidable, wherein all locations shall be subject to Owner's approval prior to installation. The work of the Sheetmetal Sub-subcontractor shall be coordinated with work of all the Mechanical, Electrical, and other trades working in the area.

10. All seams, joints (transverse and longitudinal), locks, screw holes, connections to air outlets (supply-exhaust-return collars), etc., of all supply, return and exhaust duct systems (including all existing ductwork where the ductwork is accessible, during the construction of the project) shall be sealed with water based Hardcast DS-321 or equal. Seal to also meet the pressure classification-criteria. Where ductwork is exposed, apply sealant on inside of joints prior to duct assembly to provide a smooth sealant free exterior surface suitable for finish painting. Ductwork shall be sealed as per SMACNA "Seal Class A", and leakage "Class 4" for all pressure classifications listed.

11. Seal all existing ductwork as noted herein above. Utilize sealant that allows for the application of paint as specified under applicable section. Also patch with sheetmetal and seal all openings created by existing HVAC, Plumbing, Fire Protection or Electrical piping, conduit, hangers, etc. that penetrates existing ductwork where these items, remain or where they are removed under the scope of this project.

12. All discharge sections of variable volume or constant volume terminal units - boxes shall be provided with fifteen (15) linear feet of (1 inch thick) lined ductwork downstream of the terminal unit, if a specific sound attenuator is not scheduled. Roof exhaust fans shall be provided with sound attenuating roof curbs in addition to providing a sound attenuator as scheduled.

13. Line all transfer ducts with 1 inch duct liner. All ducted fan coil units shall be provided with fifteen (15) feet of ductwork liner on both the supply and return sides of the unit.

14. Ductwork locations shown on plans are approximate. Except as allowed in isolated areas, the ductwork shall not be installed over ceiling grid lines - grid intersection points. The drawings are diagrammatic and ductwork shown over the grid lines does not imply this is allowed.

15. Dampers shall be free to move in either direction without binding and shall not vibrate or produce perceptible noise.

16. All square elbows shall be equipped with 24 gauge turning vanes assembled in top and bottom rails. All turning vanes shall be factory fabricated. For ducts less than 36 inch in width use single thickness vanes and where duct size is equal to or exceeds 36 inch in width use airfoil type double thickness vanes. No square elbows shall be accepted in Kitchen hood or Laundry exhaust ductwork.

17. Duct transformation shall be made with expansion fittings having slopes not exceeding 1 to 7 and contraction fittings having slopes not exceeding 1 to 4.

18. Unless described otherwise, round ductwork shall conform to the standards for 10 inch pressure class ductwork.

19. Round duct fittings shall be welded slip joint construction. Wipe pipe and fittings with duct sealer before assembly. Secure joints with selftapping screws, then brush again with thick coat of duct sealer. Final coating shall be brushed smooth to the Architect's satisfaction on all exposed ductwork.

20. Round elbows through 8 inch diameter shall be die-formed from 20 gauge galvanized steel. Larger elbows shall be 5 section construction. All elbows shall have a centerline radius of 1.5 times duct diameter.

21. Construct and seal ductwork to limit leakage in the entire ductwork system to 2 percent maximum airflow at the rated ductwork pressure of the system(s). This standard shall be borne out by random orifice reading pressure testing of selected systems by the HVAC Subcontractor and at the direction of the Engineer. A minimum of two (2) such tests shall be conducted. The results shall be included in the close-out documents. In addition, there shall be no leakage audible nor detectable to the hand. All such leakage shall be repaired and retested at no additional expense until this requirement is met.

22. Install supply return and exhaust air terminals in strict accordance with final reflecting ceiling plans and architectural interior elevations.

23. Birdscreens required for inlet or relief air exhaust louvers shall be furnished under another division of the specifications. The Sheetmetal Sub-subcontractor shall remove, trim and reinstall provided birdscreen for all active louvers to install an

automatically draining plenum. Provide aluminum birdscreen on all unprotected louvers. The bottom of all plenums shall be welded continuously along all seams up to the midpoint of the lowest duct or unit connection, a minimum of 6 inches.

24. Conform to applicable articles of sound and vibration control for inserts, restraints and hangers. Make provisions for expansion and contraction of ductwork. Support flexible ductwork such that no stress is imposed on air terminals and light troffers.

25. Ducts plenums and casings shall present a workmanlike appearance and shall be installed plumb and level.

26. Where acoustic insulation is required, increase the overall duct dimensions in both directions by twice the thickness of the acoustic insulation.

27. Where sheetmetal work will be insulated externally, make provisions for neat insulation finish around thermometers, control elements, quadrants and access doors. Mount metal collars of suitable size and depth to allow insulation to be properly finished.

28. A reasonable allowance in the bid price shall be made for offsets required due to interference with work of other trades.

29. Where hoods and other sheetmetal devices are furnished by the equipment manufacturer to be integrated into their respective exhaust systems, and/or where these items have been assembled to their respective equipment, the Sheetmetal Sub-Subcontractor shall provide all materials and labor necessary to connect these devices to the exhaust systems, including final connections complete and ready for operation. Provide type 304 welded stainless steel ductwork for all exposed ductwork.

30. Pitch humidifier duct to drain. Seal humidifier duct watertight. Provide 1 inch drain line from base of duct trough, counter break to pitch toward drain connection and pipe to nearest floor drain.

31. Refer to 15500 - 3.6 HANGERS.

32. Provide either 45° takeoff duct openings or Bellmouth fittings at all branch ductwork fittings for low pressure ductwork. Bellmouth fittings can be used up to a 14 inch diameter size and can include an integral single blade balancing damper. Bellmouth fittings shall be galvanized steel with a minimum of 24 gauge for fitting and damper blade. Provide air tight seal with a neoprene gasket.

33. The Sheetmetal Sub-subcontractor shall provide, for the Engineer and Architect's approval, an example of the unit ventilator installation complete with a demonstration of the non-destructive removal of the unit from the outdoor air connection wall.

34. No "spin-in" branch duct connections will be allowed. All branch connections shall be "eased" Bellmouths or tapered.

35. All exposed and/or exterior HVAC supply and return ductwork shall be double-wall type complete with insulation.

36. Refer to 15500 – 1.12, 1.14 and 1.15 regarding Record Drawings, Shop Drawing and Coordination Drawing requirements.

37. Install all devices furnished by others inside ducts such as duct smoke detectors, static pressure sensing stations, temperature and pressure sensors, etc.

38. Provide seismic ductwork supports for all exposed ductwork including that ductwork routed on the roof as per Paragraph 2.30 of this specification.

B. Low Pressure (2 inch Pressure Class) Duct System:

1. All rectangular HVAC and H&V units and supply fan supply ductwork in their entirety as well as all rectangular return/exhaust for all HVAC and H&V units and rectangular exhaust fan ductwork shall be constructed to the standards of 2 inch classification except as noted under item 15500-2.26 C and the Duct Construction Table, paragraph 2.26 A.3.

2. Sheetmetal gauges and construction to be per SMACNA and ASHRAE. Where ducts are exposed in occupied spaces and are not externally insulated, all joints shall be flush seam without stiffeners.

3. Sheetmetal thickness shall be not less than 24 gauge, SMACNA standards notwithstanding.

C. High-Pressure (10 inch Pressure Class) and Medium Pressure (4 inch and 6 inch Pressure Class) Duct Systems:

1. Sheetmetal gauges and construction shall be per SMACNA and ASHRAE, unless noted otherwise as being more stringent. Where ducts are exposed in occupied spaces and are not externally insulated, all joints shall be flush seam without stiffeners.

2. Provide as per the Duct Construction Table, 4 inch and 6 inch pressure class rectangular ductwork, or round, for all supply ductwork from supply fan discharge to VAV or VAV fan powered or constant volume terminal units - boxes. Provide also for variable volume exhaust including fume hood exhaust system boxes, from box outlet to exhaust fan intake.

3. All round heating and ventilating supply, return-exhaust and exhaust ductwork shall be high pressure spiral wound and 10 inch pressure class and shall be fabricated to the standards of that classification. 10 inch pressure class round spiral wound exposed ductwork is required at the inlets of the VAV terminals and where shown on the drawings on supply, exhaust and return/exhaust due to aesthetic requirements of the Project Architect and the Owner.

4. Woodshop dust collection and welding fume exhaust ductwork shall be 10 inch pressure class smooth wall. Takeoffs shall have conical fittings as shown on drawings.

5. Sheetmetal gauges and construction for ductwork shall be as per SMACNA tables and ASHRAE.

6. Testing 4 inch, 6 inch and 10 inch pressure class ductwork

   a. 4 inch, 6 inch and 10 inch pressure class ductwork shall be tested as per SMACNA by the Sheetmetal Trade.

   b. The tests shall be performed in the presence of the Owner and the Air Balance Technician who shall accept or reject any leakage test.

7. Gauges and Construction of Round Ducts

   a. Round ducts shall be the product of SEMCO, United Sheet Metal, USM, or equal.

   b. Sheetmetal gauges and construction of circular ducts shall be as manufactured by SEMCO, United Sheetmetal Corporation, USM, or equal and shall be SMACNA high pressure spiral lock seam with slip joints up to 22 inch diameter. Over 22 inch use companion flange, all welded construction.

   c. Fittings and elbows shall have joints and seams continuously welded. Care shall be taken to eliminate projection of metal edge into air stream. Elbows and fittings shall be fabricated by the same manufacturers. Tees shall be either 45 degrees lateral or conical, except for woodshop collection system and metal fabrication system where 30 degree fittings shall be used. High efficiency takeoffs from rectangular main ductwork to round branch ductwork shall be used complete with a 45° slope body (with or without dampers).

   d. Hangers and Supports shall be per SMACNA. Provide strap hanger wrapping duct and meeting/joining at top center of duct and rising vertically to provide single point strap support at each hanger point.

   e. Seal all joints with Hardcast DS-321 or equal, per the manufacturer's recommendations.

   f. For construction required of exposed ductwork, refer to details on drawings.

   g. The Air Balance technician shall, during the first leakage test, review the procedures and methods used and provide instruction and advice where required.

   h. Following the installation of the ductwork and before ductwork is enclosed, all concealed sections of the duct shall be individually tested for leakage.

D. Flat-Oval and Double-Walled Round 6 inch Pressure-Class Exposed Ductwork:

1. Sheetmetal gauges and construction shall be per SMACNA and ASHRAE. At no instance shall the gauge be lighter than 22 in any duct size/ configuration. All joints shall be flush seam without stiffeners, installed conforming to a minimum of SMACNA "Seal Class A", and "Leakage Class 4".

2. Provide 6 inch pressure class flat-oval ductwork for all supply, return and exhaust ductwork exposed in the space where called for on the drawings. Negative pressure

applications shall be limited to a maximum negative pressure of 1.0 inch w.g. yet shall meet 6 inch pressure class construction.

3. All flat-oval exhaust air ductwork and fittings shall be single-wall, galvanized steel meeting ASTM A-527-67. Duct shall be fabricated as spiral "unseal" duct through 20 inch minor axis with longitudinal seam duct for minor axis of 22 inches or larger. All fittings shall be by the same manufacturer as the ductwork (manufactured with continuous weld).

4. All exposed supply and return air ductwork and fittings from HVAC duct systems shall be flat-oval or round (as indicated on plans) which shall be double-wall, galvanized steel meeting ASTM A-527-67 with a minimum of 22 gauge outer pressure shell. The inside wall is of perforated galvanized steel with 1 inch fiberglass insulation between duct walls with a thermal conductivity "K" factor of 0.27 BTU/HR./ SQ. FT./IN./°F at 75°F mean temperature. The construction shall have mechanical means to maintain positive concentricity of liner with shell and mechanical means to retain insulation against dislocation by assembly process. Adhesives of any type are not permitted. All fittings shall be by ductwork manufacturer with continuous weld.

5. All flat-oval products shall conform to published performance test data for energy loss of duct and fittings.

6. All hangers, supports and connection hardware are to be approved for use and procedure by ductwork system manufacturer and SMACNA.

7. Seal all joints as per manufacturer's recommendations to allow for painting this exposed ductwork.

8. Provide all transition fittings from flat-oval to rectangular ductwork configurations by flat-oval manufacturer. Design duct system to minimize the amount of exposed rectangular ductwork.

9. Single-wall flat-oval ductwork shall be the product United McGill, SEMCO, United Sheet Metal or equal. Refer to plans for extent of this ductwork.

10. Double-wall flat-oval and round ductwork shall be the product of United Sheet Metal (Acousti-K27, Type P), SEMCO, United McGill or equal. Refer to plans for extent of this ductwork.

11. All exposed flat-oval ductwork shall be located as per HVAC plans. Architect to review shop drawings before work is released.

12. Leakage tests shall be performed as per SMACNA and manufacturers guidelines on all flat-oval ductwork.

E. Thermal and acoustic lining (dimensions noted on the drawings are inside clear dimensions). Provided by the Sheetmetal Trade.

1. Refer to SHEETMETAL, Section 15500, Paragraph 2.26A.13 for ductwork requiring lining. Internally insulate with a thermal-acoustic duct insulation, Manville Permacote Linacoustic Type S-0127, 1-inch thick, 1.5 p.c.f. nominal density, smooth, durable

acrylic airstream surface coating and fire retardant. Line also ductwork, including round ductwork, as noted on the drawings.

2. Secure insulation with solid coat of adhesive, coat to top and bottom section to overlap sides, all joints butted with end thoroughly coated with adhesive. Provide stik-clips or weld pins on all ducts on not more than 12 inches on center. Insulation shall comply with NFPA 90A and Underwriters' Laboratories Standard for Safety #UL 723, as a whole; fuel contributed 25, flame spread 25, smoke density 50 (when tested in accordance with ASTM E84) and a thermal conductivity 0.24 at 75°F.

3. Install acoustic lining per SMACNA requirements and as per the pressure classification of the duct system.

4. Lining shall be rated to withstand cleaning by methods approved by the Thermal Insulation Manufacturers Association (TIMA). Liner shall be of type which does not support mold and fungus growth. All edges shall be complete with a factory-applied edge coating.

F. Registers, Grilles, Diffusers, and Linear Diffusers:

1. Provide all registers, grilles, diffusers, and linear diffusers (RGD's) of size and type shown on the drawings and as specified hereinafter, suitable for installation in the pertinent surface or structure with plaster frames provided where required. Right is reserved to vary dimensions and locations of air devices to a very reasonable extent, as the work progresses with final locations as determined by Owner. Curved surfaces shall have curved units. Refer to architectural plans.

2. Unless specifically mentioned otherwise, diffusers, registers and grilles shall be constructed of steel or aluminum. Linear diffusers shall be extruded aluminum.

3. Finish shall be off white enamel paint unless otherwise noted on the drawings.

4. Provide aluminum air devices for all devices connected to the pool, janitor closets, kitchen, dishwasher, shower and locker/shower systems and systems serving these areas including devices for supply, return and exhaust.

5. Opposed blade dampers shall be furnished for all supply, exhaust and return diffusers, registers, and linear diffusers. The diffusers shall be constructed with an integral collar extending not less than one inch above the core to accommodate duct connection.

6. All sidewall registers shall be furnished with flanged frames, mitered corners for rigidity and seamless appearance, air pattern adjustable, heavy gauge baffle control - OBD - damper, face key operated (key removable) to match diffuser. Supply registers shall be double deflection adjustable type.

7. Seal duct connections to collars. Collar corners shall have welded angles on the outside to prevent leakage and assure that the integral duct connection can be made secure. Where face operated dampers are required, the raised mounting frame shall be sufficiently high to accommodate the installation of the damper.

8. Provide sealed sheetmetal duct connection between supply duct and air device collar. Flexible ductwork, refer to 2.26 O, shall only be used where specifically shown on the drawings.

9. Registers, grilles, diffusers and linear diffusers shall be Titus, Tuttle & Bailey, Kruger, Agitair, Metalaire or equal. Refer to drawings for model numbers.

10. All outlets and inlets shall be compatible with the ceiling and wall type shown on the Architectural Plans. Make special note to insure that outlet/inlet frame is flush with ceiling or wall surface.

G. Dampers:

1. Provide manual volume control dampers with indicating device and lock where indicated on the drawings, and where additionally recommended by the Balancing Technician and as per details on the drawings. Provide backdraft dampers where indicated and splitter dampers only where indicated. The Sheetmetal Trade shall transmit Sheetmetal Shop Drawings to the Balancing Technician before ductwork is reviewed for installation so that any additional dampers required may be noted on the drawings by the Balancing Technician and shall be provided by the Sheetmetal Sub-Subcontractor at no added cost.

2. Fabrication of sheetmetal and submission of sheetmetal shop drawings shall not commence prior to Balancing Technician's review. Shop drawings submitted to Engineer without Balancing Sub-Subcontractor's review stamp shall be returned.

3. Manual Volume Control Dampers for low pressure 2 inch pressure class ductwork shall be opposed blade, maximum blade depth 4 inches for ducts 8 inch or higher or single blade for ducts less than 8 inch high, and under. Refer to SMACNA Figures #2.14 and 2.15.

4. Provide volume dampers in all outside air, return air and exhaust ducts of economizer systems. Locate dampers adjacent to the systems' automatic temperature control dampers.

5. Dampers shall be installed in accessible areas, and shall include appropriate access panels. When a concealed location is unavoidable, provide remote cable worm-gear operated dampers equal to Young Regulator Company, with actuator key location in an accessible area. Label each actuator as to device and area served.

6. Dampers shall be by Airstream, Ruskin, Young Regulator, Air Balance, United Sheetmetal or equal.

H. Fire Dampers and Fire Doors:

1. Provide UL listed (issued June 1, 1999 as well as UL 555 [Sixth Edition]) dynamic fire dampers and fire doors in ducts where indicated on the drawings and where ducts pass through fire rated walls, partitions, passageways, corridors, stairwells, and where they penetrate shaft walls and at penetrations through floors. Fire dampers shall be stainless steel when installed in aluminum or stainless steel ductwork.

2. The Sheetmetal Contractor shall review the Architectural Drawings and shall provide at no additional costs, all required dampers to maintain the fire ratings of all walls and floors.

3. All fire dampers shall be built in accordance with standards of the National Fire Protection Bulletin #90A, and related NFPA Bulletins, for design velocity and pressure. All fire dampers shall be certified as Leakage Class I.

4. Fire dampers shall be fabricated by firms regularly engaged in the manufacture of these items, and shall withstand temperatures up to 1800 degrees F. for 1-1/2 hours. Submit test data to verify these conditions. Shop fabricated bladed type dampers will not be acceptable. All blades out of air stream (Type "B") except where space limitations are encountered, in which case interlocking blades shall be compactly grouped at head of frame for minimum pressure drop (Type "A"). Provide 3 or 4 hour rated fire doors where noted on drawings and as required to maintain ratings.

5. Fire dampers installed vertically shall be spring-assisted downward closing type: Horizontal fire dampers shall require coiled stainless steel springs to close and positively latch the blades to form a solid steel curtain. Fire dampers located in 2 inch class ductwork shall be designed for a velocity of 3,000 FPM (resulting in a 6 inch w.g. pressure level) and all other fire dampers shall be rated for a minimum velocity of 4,000 fpm (resulting in an 8 inch w.g. pressure level).

6. Circular duct shall have square damper assembly with full size round connections equal to duct size (Type "C").

7. Fire dampers may be of the type which permit replacement of fusible links from duct exterior without access to duct interior.

8. Fire dampers shall be Ruskin, Air Balance, Inc., Airstream Products, Buensod, or equal.

9. Provide medium or high pressure dynamic fire dampers to suit the service.

10. All fire dampers shall be arranged for proper maintenance access and access panels/doors shall be labeled "FIRE DAMPER" and coordinated to permit said access.

11. Coordinate with Sheetmetal Drawings for exact damper sizes.

12. Provide multi-blade dampers as required for large ducts. Provide the appropriate fire damper arrangement (vertical mount or horizontal mount applications) as required.

I. Automatic Dampers:

1. Automatic dampers shall be supplied by the Automatic Controls Trade, and installed by the Sheetmetal Trade except where they are furnished as part of a manufactured mixing box section of an air handling unit.

2. Framing for automatic dampers shall be supplied and installed by the Sheetmetal Trade according to Shop Drawings prepared by the ATC Sub-Subcontractor.

3. All dampers mounted in medium or high pressure ductwork shall be flange type.

4. Coordinate with Sheetmetal Drawings for exact damper sizes.

J. Smoke Dampers:

1. Provide smoke dampers and the associated actuator where these items are not provided under 15500 - AUTOMATIC TEMPERATURE CONTROL. Smoke dampers to isolate the unit from the rest of the system shall be installed as indicated on the

drawings for units with capacities of 15,000 cfm or more. Dampers and actuators shall be assembled and tested as an integral unit and shall comply with NFPA standard requirements for Class II smoke damper construction, be UL classified and labeled in accordance with UL-555S (Fourth Edition) and comply with 15500 - PART 4 ATC damper construction requirements.

2. The damper leakage rating under UL555S shall be no higher than leakage class I (4 CFM/sq. ft at 1 inch w.g.).

3. Provide 20 psig pneumatic damper operator, or electric as per ATC spec, and damper end switch installed by the damper manufacturer at the time of damper fabrication.

4. Smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 350°F.

5. Dampers shall be airfoil shaped, double skin construction with 14 gauge equivalent thickness maximum 6 inch wide with parallel action.

6. Dampers shall be Ruskin Model SD102 or approved equal for ductwork pressure class of 6 inch or greater. Dampers shall be Ruskin Model SD 60 or approved equal on ductwork pressure class lower than 6 inch. Dampers shall be flange type.

7. Coordinate with Sheetmetal Drawings for exact damper sizes.

K. Drip Pans:

1. Drip pans shall be provided where piping installed by the HVAC Trade passes over Security Rooms, Computer Rooms, Telephone and Data/ Communication Rooms or controls equipment. Provide watertight drip pans 3 inches deep of 16 gauge sheetmetal, reinforced, all seams and joints soldered watertight, interior painted with rust resistant paint and properly supported. Provide 3/4 inch copper drain outlet to bottom of pan for drain pipings. Piping from outlet to indirect waste shall be 3/4 inch type L copper, provided by HVAC Trade. Drip pan shall be equipped with a water detector if a drain cannot be provided. The water detection alarm shall be interlocked to the ATC system for remote reporting.

L. Access Doors in Ducts and Plenums:

1. Provide access doors in ducts for access to all instruments, automatic and manual controls, regulating devices, dampers, both sides of coils, fire dampers, and wherever else indicated on the drawings.

2. Sizes, except where noted otherwise, shall not be less than 16 inches by 12 inches. Where duct size does not permit, provide 12 inch by 10 inch doors. Expand duct as required to fit access doors.

3. Doors for insulated and uninsulated ducts shall be manufactured items of approved manufacturers, except where space limitations prevent swing of door, then for 2 inch pressure systems, provide a door with latches only. Refer to SMACNA Figure 2.12. For insulated doors, insulation thickness for door shall be equal to thickness of insulation on ducts. Where ducts are uninsulated, standard door insulation shall be acceptable.

4. All doors shall be provided with one coat of rust preventative paint.

5. All hardware for doors shall be cadmium plated, heavy duty.

6. Where access doors are concealed in hung ceilings, provide indicator buttons in the ceiling immediately below the access door.

7. Doors shall be a purchased item, and shall not be manufactured by the Sheetmetal Contractor. They shall have gaskets and shall be Ruskin GPAD, or equal by Air Balance, Inc., United Sheet Metal, or Semco.

M. Flexible Connections:

1. Connections between all air handling units, interior fans, and floating and rigid equipment, ductwork, etc., shall be with a flexible connector fabricated from synthetic rubber of 29 ounce neoprene coated fiberglass cloth to eliminate vibration transmission. Connectors shall be sealed by double metallic bands to prevent air leakage. The clear space between connected parts shall be a minimum of 3 inch and shall have 3 inch length minimum of slack material. Air handling equipment such as centrifugal fans shall be erected on isolators and leveled with fan operating before duct connection is made. Insure that duct position is in proper alignment and that proper longitudinal separation exists between fan and ductwork for installation of the connector.

2. Flexible connectors, similar to the above in construction, shall be installed in ductwork where shown on the drawings.

3. Plasticized flexible connections shall be welded to ducts or equipment collars. In cases where flexible connections are installed as expansion joints, provide a suitable support or hanger at each end of flexible connections. In cases where flexible connections are provided for connection to fans or equipment, provide a support or hanger at unsupported locations.

4. Connectors shall meet NFPA requirements, UL 181 and be in accordance with the BOCA Mechanical Code (1987) Section M-303.0.

5. No flexible connections will be allowed on VAV or CV exhaust terminal boxes or air valves that are part of fume hood or are part of a corrosive exhaust system (hard duct connections only).

6. Provide heavy duty type material on all axial fans which are acceptable with fan manufacturer. Install using the provided companion flanges in an approved manner as to not allow this connection to impair performance of the fan(s).

N. Flexible Insulated Ductwork: (NOT ALLOWED ABOVE NON-ACCESSIBLE CEILINGS)

1. Flexible insulated ductwork shall be lightweight duct, with core of corrosion resistant reinforcing steel wire helix within multiple layers of reinforced aluminum foil laminate, insulated with 1-1/2 inch thick, 3/4 lb. density fiberglass flexible insulation and covered with a fire retardant aluminized reinforced vapor barrier. Duct shall meet NFPA 90A requirements and be listed as Class I Air Duct Material, U.L. Standard 181. It shall be as manufactured by Wiremold Co. type WCK, Thermaflex Type M-KC or equal, rated

for 10 inch positive and 2 inch negative pressure W.G. Secure at each end with metal drawbands.

2. To be provided at the inlet of fan powered terminal units and as noted on the drawings (two foot maximum length).

3. Five foot maximum length at air terminal outlets, only where this arrangement is noted on the drawings as being acceptable, with ductwork supported at midpoint.

O. Test Openings:

1. Supply and install Lawson Taylor test openings in all ducts entering and leaving AHU's. Install test openings at 6 inch intervals across the long dimension of rectangular ducts, and at 90 degree intervals around circular ducts.

P. Plenum:

1. Plenum construction shall be 2 inches standing seam with screwed lock and angle reinforcing every 4 feet for rigidity. Support plenums from floor structure as required. Provide access doors for all plenums for maintenance and cleaning. Plenums and connections to plenums shall be sealed airtight with Hardcast DS-321 or equal.

2. Joints in fresh air intake and exhaust plenums (and ductwork) from the bottom up to 6 inches of sides to be TIG or MIG welded watertight. All plenums which have ductwork connections within this 6 inches of the bottom shall be welded continuously along all seams watertight half-way up from lowest ductwork or unit connection.

3. Where duct cannot be pitched to drain back through louver, provide 1 inch copper drain outlet connection on 6 feet-0 inch centers, on center line and at bottom of each plenum. Bottom of plenum to slope towards drain connections. Piping from drain connections to open floor drain shall be provided by the HVAC Subcontractor.

Q. Duct Mounted Sound Attenuators:

1. General Requirements

a. Silencers shall be of the size, configuration, capacity and acoustic performance as scheduled on the drawings. Silencers installed in aluminum or stainless steel ductwork shall be fabricated from the same type of material. Silencers shall be shipped and stored on site in shrink-wrap plastic protecting all open ends from exposure. Silencers shall be by Vibroacoustics, I.A.C., Kenetics, Dyna Sonics or equal.

b. Insertion losses listed in the schedule are minimums, pressure drops are maximums allowable. Silencer performance, including silencers with fiberglass cloth and mylar encapsulated media, must have been substantiated by an NVLAP (National Voluntary Laboratory Accreditation Program) accredited laboratory testing according to ASTM E477-99 and so certified when submitted for approval. Submittals which do not list this criteria will be returned without being reviewed any further. Acoustical ratings shall be based on a duct-to-reverberant room test under dynamic conditions for both forward and reverse flow patterns.

c. All silencers shall be factory fabricated and supplied by the same manufacturer. Silencer inlet and outlet dimensions must be equal to the duct sizes shown on the drawings. Duct transitions at silencers are not permitted unless shown on the contract drawings. A sheetmetal elbow in combination with a rectangular silencer is not acceptable as an elbow silencer.

2. Construction

a. All RD low velocity, RFL low velocity and RNM low velocity rectangular silencers shall be constructed with a 20 gauge galvanized steel outer casing and 26 gauge galvanized perforated steel liner.

b. All ELB and RED elbow silencers shall be constructed with an 18 gauge galvanized steel outer casing and 22 gauge galvanized perforated steel liner, except as noted below.

c. All RDMV and RDHV rectangular, ENMV elbow, CNMV circular and CENMV circular elbow reactive silencers shall be constructed with an 18 gauge galvanized outer casing and 24 gauge galvanized perforated steel liner. All casing seams and joints shall be lockformed and sealed.

d. All CD and CFL circular and AC cone diffuser silencers shall be constructed with a galvanized steel casing as noted below and 20 gauge galvanized perforated steel. Rectangular casings are not acceptable as a substitute for circular casings.

INLET DIAMETER	CASING GAUGE
Less than 30 inch	20
30 inch to 54 inch	18
Over 54 inch	16

e. All perforated steel liners shall be adequately stiffened to insure flatness and form.

f. Media in absorptive silencers shall be incombustible, acoustic quality, shot-free fiberglass insulation with long, resilient fibers bonded with a thermosetting resin. Fiberglass density shall be as required to insure conformance with laboratory test data. Fiberglass shall be packed with a minimum of 15% compression during silencer assemble. Media shall be bacteria, mold, and fungus resistant (similar to "Mold Block" Media), resilient such that it will not crumble or break, and confirming to irregular surfaces. Media shall not cause or accelerate corrosion of aluminum or steel. Mineral wool will not be permitted as a substitute for fiberglass.

g. Where indicated in the silencer schedule, reactive silencers shall be supplied. Reactive silencers shall not contain absorptive media of any kind. Attenuation shall be achieved with controlled impedance membranes and broadly tuned resonators.

h. Media shall be encapsulated in mylar or fiberglass cloth to prevent shedding, erosion and impregnation of the fiberglass. All cone diffuser silencers shall have a fiberglass cloth lining.

i. Where indicated in the silencer schedule, silencers shall have high transmission loss (HTL) walls externally applied and completely sealed to the silencer casing by the silencer manufacturer to assure quality controlled transmission loss. The HTL walls shall consist of media, airspace, mass and outer protective metal skin, as required, to obtain the specified room noise criteria. Standard acoustical panels will not be accepted as HTL walls. If requested by the Engineer, breakout noise calculations for each air handling and fan system shall be provided with the silencer submittal to insure compliance with the room noise criteria. Breakout noise calculations shall be based on the sound power levels of the specified equipment.

j. Where indicated in the silencer schedule, silencers shall be supplied with an access door to permit fire damper service. Access doors shall be supplied as an integral part of the silencer by the silencer manufacturer. Where HTL walls are also supplied, the access doors shall not reduce the effectiveness of the HTL walls.

k. Provide stainless steel sound attenuators where downstream of humidifiers. Do not install within 10 feet of humidifiers.

R. Installation of Smoke Detectors:

1. Refer to DIVISION 16 ELECTRICAL and the HVAC drawings for number and approximate location of smoke detectors to be installed in ductwork of HVAC and air handling equipment. Location of detectors in ducts to be a minimum of six duct widths downstream from any duct opening, deflection plate, sharp bends or branch connections. Actual location to be per manufacturer and NFPA requirements. Indicate exact location on sheetmetal shop drawings.

S. Safing:

1. Provide all sheetmetal around dampers to effectively close opening between dampers and ductwork, casing or other equipment. Refer to Automatic Temperature Controls and Drawings.

T. Blank-Offs:

1. Sheetmetal Sub-subcontractor shall provide insulated blank-off panels on unused portion of all louvers and all unused louvers. The HVAC Subcontractor and the Sheetmetal Sub-Subcontractor shall review the HVAC and Architectural plans and elevations to identify all louvers regarding this scope of work. Refer to Architectural and Mechanical Drawings for locations. Panel shall be metal sandwich type field fabricated with 3 inch fiberglass 6 p.c.f. Metal shall be 18 gauge with side exposed to weather provided with corrosion resistant paint of color selected by the Architect. Panel shall be sealed airtight. Provide also at unused louvers. Insulation and sheetmetal by Sheetmetal Sub-subcontractor. The installation shall provide an airtight fit with all joints sealed with duct mastic.

U. Flow Measuring and Static Pressure Stations: (Option 1)

1. Provide on all variable air handling units, combination static and velocity air measuring pressure duct stations - FMS - by Air Monitor or Air Sentinel. Provide stations in main supply and return at each VAV supply and return - return/exhaust fan.

2. Provide on all variable volume AHU's with terminal units, static pressure measuring stations in the supply ductwork downstream, two per AHU, located as shown on the drawings or directed by the Engineer.

3. Each device shall be designed and built to comply with, and provide results in accordance with accepted practice as defined for system testing in the ASHRAE Handbook of Fundamentals as well as the Industrial Ventilation Handbook.

4. Airflow measuring stations shall be fabricated of double walled, insulated with 1 inch/4 lb. density insulation sandwiched between heavy gauge galvanized steel casing with 90 degree connected flanges in a configuration and size equal to that of the duct it is mounted into. Each station shall be complete with an air directionalizer and parallel cell profile suppresser across the entering airstream and mechanically fastened to the casing, equal - area and equal weighted averaging total pressure sensors and manifold bullet-nose shaped static pressure sensors with averaging manifold, internal piping, and external pressure transmitter ports. An identifying label shall be placed on each unit casing listing model number, size, area, and specified airflow capacity.

5. Static sensing stations used for sensing the supply (or return) air distribution system static pressure shall be fabricated in accordance with that outlined for airflow measuring stations except that multiple bullet-nose shaped static pressure sensors with averaging manifold will be furnished in lieu of the total pressure sensors and manifold. Unit shall be full size of duct it is installed in.

6. The maximum allowable pressure loss through the unit shall not exceed 0.01 inch w.g. at 1000 fpm or 0.03 inch w.g. at 2000 fpm. Each unit shall be capable of measuring the airflow rate within an accuracy of 2% of full scale as determined by U.S. GSA certification tests and shall contain a minimum of one total pressure sensor per thirty-six square inches of unit measuring area.

7. Stations shall be installed in strict accordance with the manufacturer's published requirements. These stations serve as the primary signals for the airflow control systems, therefore, it shall be the responsibility of the contractor to verify location and installation to assure that accurate primary signals are obtained.

8. The units shall have a self-generated sound rating of less than NC40, and the sound level within the duct shall not be amplified nor shall additional sound be generated.

V. Flow Measuring and Static Pressure Stations: (Option 2)

1. The ATC Subcontractor shall furnish and the Sheetmetal Subcontractor shall install on all variable volume air handling fans (two stations on double-inlet type), as indicated on drawings, airflow traverse probe(s) for fan inlets for the measurement of air flow quantity. Units(s) shall be Air Monitor volu-probe/FI, Ultratec, Paragon or an approved equal.

2. Station(s) shall measure static pressure and total pressure where velocity pressure shall be the working means of measuring flow rate (the result of total pressure to provide ATC with area measurement at inlet where station is installed. Install probe(s) as per manufacturer's recommendations. At no time shall probe interfere with VAV mechanism operation on fan.

3. Fan inlet airflow traverse probes (two per inlet) shall have dual end support swivel brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings, and shall be of aluminum construction and hard anodized finish.

4. The fan inlet airflow traverse probes shall not induce a measurable pressure drop, nor shall the sound level within the system be amplified by its pressure in the fan inlet bell. The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 3% of actual flow over a fan operating range of 6 to 1 capacity turndown.

W. Air Terminal Units:

1. Provide single duct variable volume control pressure independent assemblies of the sizes and capacities shown on the plans. They shall be constructed of 22 gauge minimum galvanized steel casing. They shall be internally lined as specified under Paragraph 11, this Section. Insulation and/or liner must meet all requirements of UL 723, ASTM C665 bacteriological standards for growth and ASTM-84 flame spread criteria. The damper blades shall be 16 gauge aluminum. Units to be normally open to allow morning warm-up without additional controls. The assembly shall have a leakage rate of less than 1% of maximum cataloged airflow when subjected to three (3) inches of pressure at the inlet and one (1) inch pressure at the outlet.

2. Assemblies shall be pressure independent and shall be able to be reset to any airflow between zero and the maximum catalogued cfm. Devices using cfm limiters will not be accepted. The differential static pressure of the basic assembly shall not exceed 0.10 inches water gauge for all sizes with maximum inlet velocities of 2000 fpm or less. With an attenuator, but with no other accessories, the static pressure across the assembly with a 2000 fpm or less inlet velocity shall not exceed 0.25 inches water gauge.

3. The damper shafts shall operate in rust-proof Delrina, self-lubricating bearings. The damper shall seat against gasketed stops. The damper leakage shall not exceed 2 percent, as rated by Air Diffusion Council Standards.

4. The DDC controller shall be furnished by the ATC Contractor for installation at the factory. The DDC actuator shall be furnished and factory mounted by the assembly manufacturer and shall be compatible with controls provided under item 15500-PART 4 - AUTOMATIC TEMPERATURE CONTROL. Flow curve for field balancing shall be affixed to terminal casing.

5. The unit inlet shall be equipped with a cross-shaped flow sensor with a minimum of one pick-up for each 2-1/2 inch of inlet diameter with amplifying pressure pickup points connected to central averaging chambers. The sensor shall amplify the duct velocity pressure by a factor of 1.75 and shall maintain control accuracy with the same size inlet duct in any configuration. All sensor tubing shall be UL listed fire retardant (FR) type. The assembly shall incorporate an amplified nondirectional flow sensor. The pneumatic consumption for the operation of the device shall not exceed 0.012 scfm at 20 psi.

6. The unit inlet shall be equipped with a cross-shaped flow sensor with a minimum of one pick-up for each 2-1/2 inch of inlet diameter with amplifying pressure pickup points connected to central averaging chambers. The sensor shall amplify the duct velocity pressure by a factor of 1.75 and shall maintain control accuracy with the same size

inlet duct in any configuration. All sensor tubing shall be UL listed fire retardant (FR) type. The assembly shall incorporate an amplified nondirectional flow sensor. The pneumatic consumption for the operation of the device shall not exceed 0.012 scfm at 20 psi.

7. Model numbers noted for standard variable volume assemblies are by Enviro-Tec. Refer to plans for type (designated "V" on plans), size and capacities. Design based on Enviro-Tec SDR, Titus ESV, Trane Model VSDD or equal.

8. Constant volume assemblies (designated "CV" on plans) shall be pressure independent similar to Enviro-Tec SDR, Titus ESV, Trane Model VSDD or equal.

9. All constant and variable/constant volume supply terminals as well as all fan powered terminals shall be equipped with hot water heating coils where indicated on the schedule or plans. Coils shall be furnished by the terminal manufacturer as a complete assembly, with capacities and other characteristics as scheduled on the drawings. Coils shall be enclosed in an insulated sheetmetal casing to match the size of the terminal. Coils shall be connected to the terminal with slip and drive connections to allow for coil removal. Terminals with water coils shall have access doors upstream of the coil for cleaning access. Coils shall have left or right hand connections to suit job conditions, and shall be two-row. Coils shall have aluminum plate fins (10 fpi), and shall be tested with 400 psig hydrostatic pressure (underwater). All coils shall be performance certified in accordance with ARI 410 Standard (latest Edition).

10. All "V" and "CV" terminal units shall be provided with internal lining which shall be attached and reinforced with 3/4 inch - 4 p.c.f. non-porous scrim stitched metalized white polypropylene/polyester fiberglass blend fabric equal to Enviro-Tec Enviro-Guard. Fabric shall be provided for requirements of high indoor air quality standards and hospital facilities. Fabric shall be attached with flame resistant adhesive or stick pin construction. The material must comply with UL 181, NFPA 90-A, and shall meet bacteriological standard ASTM-C665 for model resistance and burning characteristics ASTME-84 for flame spread and smoke developed. All insulation edges must be mechanically fixed to the box casing at all seams utilizing full length metal strips. Units with an access door must maintain the same construction specifications on the door and opening.

11. Two-row hot water coils to be provided at all terminal units, but selected in any case for the available hot water temperature.

12. Acoustic Ratings of VAV Terminals

    a. Acoustic Performance. Acoustic criteria shall be met while terminal boxes are operating at 100% of design air volume capacity and at maximum pressure drop indicated in the contract documents.

        1) Octave band sound pressure levels due to discharge radiation and/or casing radiation shall not exceed the noise criteria values as listed in Section 15500 3.19, Background Noise Criteria of these Specifications. The noise criteria shall not be exceeded either directly under any single box due to casing radiation or in the individual rooms due to the combined effects of casing-radiated and discharge noise of any box or boxes.

2) Boxes shown on the drawings are sized to conform to mechanical requirements. The supplier shall resize boxes and/or provide whatever additional sound control apparatus is required to bring the boxes into conformance with the above acoustic criteria, even if such apparatus is not expressly called for in these Specifications or on the Drawings.

b. Submittals: The supplier shall submit sound power level data to the Architect at octave band center frequencies from 63-4000 Hertz, inclusive, certified in accordance with ARI Standard 880-1998. The supplier shall submit calculations substantiating that the terminal boxes operating in the installed configurations as per plans and specifications will conform to the acoustic criteria specified above. Calculations shall be in accordance with methods and data described in Chapter 46 of the 1999 ASHRAE HVAC Applications Handbook. Noise criteria predictions based on arbitrary room constants and/or arbitrary ceiling attenuation factors are not acceptable.

c. Test: Within the first six (6) months after the building has been accepted by the Owner, the Owner may choose to check the terminal boxes for conformance with the specified acoustic criteria. Owner will pay the costs of this testing. The supplier shall bear the costs of redesign, corrective measures, and/or follow-up testing should the terminal boxes not conform to the specified acoustic criteria. An Acoustical Consultant approved by the Owner shall perform all testing.

X. Supply Air Boots and Flexible Ducts: (NOT ALLOWED ABOVE NON-ACCESSIBLE CEILINGS)

1. Provide supply air boots and flexible ducts as noted on the drawings. It is intended that this equipment shall be provided by the Sheetmetal Contractor and that this equipment be connected to the branch ductwork.

2. Supply air boots shall be of the indicated air quantities and shall be fabricated from galvanized steel and painted black inside. SAB's shall be adaptable to fit between open parallel tee bars with bars by others. They shall be modular in design, flexible as to placement and fully adjustable after installation. Refer to schedules for types, sizes, capacities, and dimensions.

3. All SAB diffusers shall have separate adjustable air pattern controllers for full 180 degree air pattern selection and each shall be split into two sections to allow two independent air flows.

4. The NC sound level and the minimum static pressure for the required air quantities shall be measured in a certified air diffusion council laboratory and shall not exceed published values of specified unit. NC 35 is the maximum allowable at the listed cfm.

5. The physical dimension of the diffusers shall be designed to suit the ceiling systems. Refer to detail on drawings.

6. Sample unit shall be provided with special dimension fitting the ceiling system. The manufacturer shall be responsible for all modifications to the unit and shall guarantee draftless air distribution. Units shall integrate with cove light selected for installation on the project.

7. Refer to details and schedules on drawings for information on SAB's provided by HVAC Contractor. The Sheetmetal Contractor shall provide a volume damper in each duct connection to each SAB.

8. SAB's based on Titus and with 1/2 inch thick internal duct liner-insulation, Agitair, or equal with volume damper at duct collar.

Y. All ductwork shall be installed clean. Ductwork shall be shipped to site with caps or shrink-wrapped to prevent construction debris, dust, dirt or other contaminants from entering duct systems. All partially installed duct runs shall be capped. Ducts to be cleaned during installation and prior to installation of final filters.

Z. Noise Control In Duct Systems:

1. Other contract documents affecting work of this section include, but are not limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications. Refer to 15500 - 2.24 for associated sheetmetal scope of work.

2. Work Included: Provide elements of duct systems where shown on the Drawings, as specified herein, and as needed for a complete and proper installation including, but not necessarily limited to:

   a. Acoustical internal duct lining.

   b. Duct sound attenuators.

   c. Sound attenuating expansion plena.

   d. Flexible duct connections.

   e. Acoustically sealed penetrations.

   f. Acoustical sealants.

   g. Sound pressure levels for diffusers, registers and grilles.

   h. Acoustical fan housings.

   i. Fan sound power level.

3. Quality Assurance: Use skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

4. Submittals

   a. Internal Duct Lining: Provide catalog cut sheets indicating sound absorption coefficients, manufacturer's recommended application procedures, burning characteristics, and compatible fire resistive adhesive.

b. Duct Sound Attenuators: Submit catalog cut sheets and schedules indicating dynamic insertion loss, regenerated noise by octave band, and pressure drop in the installed configuration, tested in accordance with ASTM E 477-96. Submit schedule of attenuators showing module sizes and splitter orientation. Submit full acoustic test reports for representative attenuators if products by manufacturers other than those pre-approved are submitted. Submit manufacturer's recommendations for supporting horizontally oriented splitter baffles for large size attenuators.

c. Plena Lining: Submit catalog cut sheets indicating sound absorption coefficients, density, manufacturer's recommended application procedures, burning characteristics and compatible adhesives.

d. Acoustical Sealants: Submit manufacturers' data sheets showing physical characteristics in compliance with all specified requirements, and compatibility with other materials and paints.

e. Air Terminals

1) Submit NC ratings for all terminals using the required submittal format shown below. Calculate NC ratings from laboratory certified octave band sound power level data, developed in accordance with ASHRAE Standard 70-1991. The submittal must indicate the assumed room effect used to convert from octave band sound power levels to NC ratings.

2) The submittal must show every terminal device, reported in the following format. Any submittal of catalog charts without detailed project-specific information in the required format will be rejected.

3) Example

	Example	Sample Data
a)	Air Terminal Device Tag	Room #100, SA-4
b)	CFM	500
c)	Device Size	24x24
d)	Neck size (where applicable)	14 inch
e)	Model Number	TMSA
f)	NC rating of device	NC-20
g)	Assumed room effect	8 dB
h)	RC criteria of room	25
i)	Accessories included integral balancing damper, air straighteners, etc.	

f. Acoustical housings: Submit sound absorption data by octave band tested by an independent acoustical laboratory in accordance with ASTM C423-90a, Type D mounting. Submit sound transmission loss data by octave band tested by an independent acoustical laboratory in accordance with ASTM E90-

97. Submittals based upon NRC or STC ratings shall be rejected. Submit manufacturer's installation recommendations. Submit shop drawings of all plenum components including doors & windows.

g. Fan sound power levels: Submit sound power levels measured in accordance with ASHRAE 68-1986 or AMCA 300-85. Report test method used, site of test and clearly indicate which level is being reported (total sound, discharge, fan inlet, cabinet inlet, casing radiated, etc.).

h. Air balance report: Submit copy of air balance report to the Acoustical Consultant for review prior to final acoustical observation visit.

5. Standards

a. ASTM C423-90a; Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method, 1990.

b. ASHRAE 68-1986 (AMCA 330-86); Laboratory Method of Testing In-Duct Sound Power Measurement Procedure for Fans, 1986.

c. AMCA 300-85; Reverberant Room Method for Sound Testing of Fans, 1985.

d. ASTM E90-97; Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements, 1997.

e. ASTM E477-96; Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers, 1996.

f. ASHRAE 70-1991; Method of Testing for Rating the Performance of Air Outlets and Inlets, 1991.

g. SMACNA; HVAC Duct Construction Standards Metal and Flexible, Second Edition 1995.

6. Acoustical Internal Duct Lining

a. Provide lining in all supply, return, and exhaust ductwork as noted herein and on the "Duct Construction Table" in Paragraph A of the Sheetmetal Section of this specification.

b. Lining shall be bonded glass fiber mat or semi rigid board with the air stream surfaces covered with a protective coat to reduce airflow resistance and erosion. Lining and adhesive shall be odor free. Lining shall be 1-1/2 lbs. per cubic foot nominal density.

c. Surface burning characteristics, in accordance with Underwriters Laboratories Inc. (UL) standard number 723 shall be:

1) Flame spread not more than 25.

2) Smoke development not more than 50.

d. Lining shall meet the Life Safety Standards as established by NFPA 90A.

e. Minimum sound absorption coefficients tested in accordance with ASTM C423-90a and Type A mounting in accordance with ASTM E795-93 shall be:

	Octave Band Center Frequency (Hertz)						
Lining Thickness	125	250	500	1000	2000	4000	NRC
1 inch	.09	.19	.48	.65	.78	.83	.65
2 inch	.22	.47	.76	.89	.89	.91	.80

f. Lining shall be by the following manufacturers or approved equal:

1) Johns Manville, Denver, Colorado.

2) Knauf Fiber Glass, Shelbyville, Indiana.

3) Certain Teed Corp., Valley Forge, Pennsylvania.

4) Owens-Corning Fiberglas, Toledo, Ohio.

7. External Duct Lagging: Gypsum board covering, when used, shall be 2 layers of 5/8 inch, 2 pounds per square foot per layer minimum weight. Plaster covering, when used, shall be 1 inch thick, 50 pound per cubic foot minimum density or equivalent surface weight. Glass fiber duct wrap shall be semi rigid board, 3 lbs. per cubic foot minimum density. Loaded vinyl should have an aggregate weight of 4 pounds per square foot. This work shall be provided by the HVAC Subcontractor.

8. Duct Sound Attenuators

a. Attenuators shall be factory fabricated standard or custom products of the following manufacturers or approved equal. Products may be supplied by more than one manufacturer.

1) Vibro-Acoustics, Toronto, Ontario

2) VAW Systems, Winnipeg, Manitoba

3) Industrial Acoustics Company, Bronx, New York

4) SEMCO, Columbia, Missouri

b. Exterior casing shall be 22-gauge minimum with lock-formed seals filled with mastic or continuously welded seams. Interior casing shall be 26-gauge minimum galvanized perforated steel. Attenuators shall be airtight and shall not fail structurally when subjected to a differential pressure of 8 inch water gauge across the casing.

c. Where attenuators are exposed to grease, humidity, moisture or are used to serve food service areas, their sound absorbing filler material shall be wrapped in 1 mil Mylar film or approved equal.

d. Acoustic rating of attenuators shall be determined in a duct-to-reverberant room test facility that provides airflow in both directions through the test silencer. The test procedure shall eliminate all effects caused by end reflection, directivity, flanking, standing waves, and test chamber sound absorption. Acoustics ratings shall include dynamic insertion loss (DIL) and self-noise power levels with airflow up to 2000 feet per minute entering face velocity.

e. Dynamic insertion loss shall be equal or greater than requirements listed on the attenuator schedule. Static pressure loss of each silencer shall be no greater than the maximum scheduled.

9. Sound Attenuating Expansion Plena

a. Provide lining of one layer of 2 inch thick non-coated rigid fiberglass insulation board covered with one layer of 2 inch thick coated rigid duct liner or one layer of 3 inch thick non-coated insulation board covered with one layer of 1 inch thick coated rigid duct liner.

b. Provide 3 lbs. per cubic foot minimum density semi rigid fiberglass insulation board without facing having maximum flame spread of 25 and maximum smoke development of 50. Minimum sound absorption coefficients tested in accordance with ASTM C423-90a and Type A mounting in accordance with ASTM E795-93 shall be:

	Octave Band Center Frequency (Hertz)						
Board Thickness	125	250	500	1000	2000	4000	NRC
1 inch	.02	.20	.52	.73	.82	.84	.60
2 inch	.12	.67	.99	.97	.91	.87	.90

c. Provide 3 pounds per cubic foot minimum density semi rigid fiberglass board duct liner with a polymeric facing on one side to prevent erosion. Liner shall meet all other requirements for duct lining described elsewhere in these Specifications. Minimum sound absorption coefficients tested in accordance with ASTM C423-90a and Type A mounting in accordance with ASTM E795-93 shall be:

	Octave Band Center Frequency (Hertz)						
Liner Thickness	125	250	500	1000	2000	4000	NRC
1 inch	.09	.19	.48	.65	.78	.83	.65
2 inch	.22	.47	.76	.89	.89	.91	.80

d. Provide lining by the following manufacturers or approved equal:

1) Johns Manville, Denver, Colorado.

2) Knauf Fiber Glass, Shelbyville, Indiana.

3) Certain Teed Corp., Valley Forge, Pennsylvania.

4) Owens-Corning Fiberglas, Toledo, Ohio.

10. Flexible Duct Connections: Prefabricated, closely woven 30 ounce glass fabric, coated on both sides with neoprene and secured by double lock seams to 26 gauge minimum galvanized steel connectors on ends. Connectors shall be not less than 6 inch long. Material shall be UL approved and similar to "Ventglas" manufactured by Ventfabrics, Inc. or approved equal.

11. Acoustical Sealants: Provide permanently resilient, non-hardening, non-bleeding caulking material. In exposed locations products shall be skinning type Ohio Sealants SC-175 Sound Sealant, US Gypsum Acoustical Sealant, GE Pensil-100, GE Pensil-300, Hilti FS-601, or approved equal. In concealed locations products shall be non-skinning type, Tremco Acoustical Sealant, or J.M. Clipper "Duxseal", Pecora Acoustical Sealant BA-98 or approved equal.

12. Sound Pressure Levels For Air Terminals: For spaces listed in Section 15040, Background Noise Criteria, the NC ratings for diffusers, registers and grilles shall not be greater than the RC criteria listed minus 3 decibels, where an 8 decibel room effect is assumed. Where a 10 decibel room effect is used, the NC rating shall not be greater than the RC criteria minus 5 decibels.

13. Fan Sound Power Levels: Levels shall not exceed limits as scheduled.

14. Internal Duct Lining: Install to achieve 100% coverage, with coated side facing air stream. Adhere liner to all interior sides of duct with a minimum of 50% coverage of fire retardant adhesive. When duct width exceeds 12 inch, or height 24 inch, further secure liner with mechanical fasteners on 12 inch maximum centers. All joints shall butt closely, and all corners shall fit snug. Protect leading edges against erosion with 24 gauge minimum galvanized metal. Heavily coat exposed edges, joints, fasteners and damaged sections of coating with fire resistive adhesive.

    a. Duct dimensions shown on drawings must be clear inside airway sizes. Increase sheet metal size in both directions by liner thickness.

15. Sound Attenuators

    a. Install in proper direction with respect to airflow, and in accordance with manufacturer's and SMACNA recommendations.

    b. Install rectangular attenuators with splitter baffles oriented as scheduled, or in the same plane as the nearest upstream elbow if not scheduled. Center attenuators in duct runs between elbows and transitions to minimize pressure drop unless otherwise noted on drawings. Provide stiffeners for horizontal splitter baffles as recommended for large attenuators as recommended by the manufacturer.

    c. Provide flanges and angles for connection to adjacent lined ductwork in such a manner that the internal dimensions of the attenuator and ductwork lining are equal.

d. Make smooth duct size transitions to match attenuators, even when not specifically called out on the Drawings.

e. Make all duct connections to attenuators airtight. Blank and seal perimeter and joints in attenuator banks.

f. Support attenuators independently of ductwork.

g. Where attenuators are covered with insulation, lagging or other material, clearly and permanently mark covering material to indicate location, extent, size, manufacturer, model designation, and unit tag of the attenuator.

16. Sound Attenuating Expansion Plena

a. Construct plena to dimensions shown on the Drawings, which shall indicate minimum clear inside dimensions, unless noted otherwise.

b. Secure insulation board and duct liner to the plenum surfaces with the coated face of the liner facing the air stream. Use mechanical fasteners spaced 24 inch maximum on vertical surfaces. Space fasteners 12 inch maximum on overhead horizontal surfaces. Washers shall be 2 inch minimum diameter or 2 inch x 2 inch minimum rectangular dimension. Do not compress the lining with fasteners more than 1/2 inch.

c. Line internal plenum surfaces unless noted otherwise. Cover completely internal plenum surfaces designated to be lined. Offset joints in the top layer (duct liner) with respect to joints in the lower layer (insulation board). Firmly butt joints with no gaps. Overlap corner pieces and offset joints. Support horizontal top pieces by vertical side pieces.

d. Cover exposed edges with adhesive. Repair damaged areas of the polymeric coated air stream surface with adhesive. Follow manufacturer's recommendations regarding compatible adhesives.

17. Flexible Duct Connectors: Install where shown on Drawings and at inlet and discharge locations of all resiliently mounted fan units unless noted otherwise. Maintain 3 inch minimum separation between mated duct segments. Seal joints and seams airtight.

18. Acoustical Sealant: Prepare substrate and backing for proper application of sealant. Apply sealant to achieve a 1/4 inch minimum thickness and to achieve an airtight seal.

19. Acoustically Sealed Penetrations

a. Provide sleeves of 22 gauge minimum steel, grouted rigidly in place, for all duct, pipe, and conduit penetrations through all concrete or masonry walls, and all ceilings, and floors of machine rooms as well as where noted on drawings. Make inside dimension of sleeve 1/2 inch to 3/4 inch greater than outside dimension of penetrating item on all sides. Pack annular space to full depth of penetration with clean fiberglass batt or blanket material flush to ends of sleeve. Seal full perimeter of both ends of sleeve with liberal bead of acoustical sealant to be airtight.

b. Provide wood blocking or steel sleeve for all penetrations of duct, pipe, and conduit through lightweight walls, ceilings, and floors of every room listed as RC-35 or lower in Specification 15040 as well as where noted on drawings. Make annular space 1/2 inch to 3/4 inch on all sides, and pack and seal as in section 3.08A above.

20. Air Terminals: Do not offset flexible duct used between rigid ductwork and air terminals more than 1/8 the diameter of the flexible duct.

21. Acoustical Housings: Install per manufacturer's recommendations. Make all joints and penetrations airtight. Fill all voids in joints with acoustically absorptive material.

22. Fan Sound Power Levels: Provide noise reduction accessories (enclosures, mufflers, etc.) as necessary to achieve allowable sound power levels as called out in Specification 15500 - 2.22 and 2.33 and on the drawings.

2.27 INSULATION

A. General Requirements:

1. All insulation shall be installed as per The Maine State Building Code (IBC) as a minimum requirement for piping, ductwork and equipment specified hereinafter.

2. It is required and intended by this Section to insulate all surfaces and components with a minimum surface temperature (in operation) of 5°F lessor or greater than its ambient, and whenever condensation, heat loss, heat gain or human contact with hot surfaces may occur.

3. It is noted that the design includes cooled supply air temperature air systems below space or ambient dew point. Proper installation and sealing of insulation is critical and will be strongly adhered to including insulation on colder duct systems.

4. All insulation for ductwork internally insulated shall be Thermal/Acoustic Vapor Barrier insulation as specified under Sheetmetal.

5. All internal insulation for ductwork shall be provided by the Sheetmetal Contractor, where specified.

6. All external insulation including piping and ductwork and equipment shall be provided by the Insulation Subcontractor.

a. Piping to be insulated shall include all piping (hot and cold surfaces) as indicated in 15500 - 2.27 - G. PIPE INSULATION.

b. Ductwork to be externally insulated shall include ductwork indicated in 15500 - 2.27-H.

c. Equipment to be insulated shall be indicated in 15500-2.27-I.

d. For internally lined sheetmetal, refer to 15500 - 2.26 Sheetmetal.

7. All valves and fittings of all piping and equipment indicated to be insulated shall also be insulated.

8. No insulation shall be applied to any surface subject to air or hydrostatic tests, until after such tests have been complete and the systems accepted as tight against leakage.

9. Insulation need not be provided under this item for the following:

   a. Exhaust air ducts that are indicated on the drawings to be internally insulated. All other exhaust air ductwork shall not be insulated except as noted hereinafter.

   b. Pneumatic piping systems.

   c. Fin tube piping within radiation enclosures, and which are downstream (on room side) or control valves.

B. Definitions:

1. Insulation thickness shall include insulation and factory applied jacket if the jacket is included in the manufacturer's published dimensions. The thickness shall not include thickness of the mastic applied over the insulating material.

2. Indications on charts and tables for "No" vapor barrier indicates that it is not required but that a finished appearance (All Service Jacket) is required in any event.

C. Flame Spread and Smoke Development:

1. All components of all insulation systems hereinafter specified, including coverings, mastics, and adhesive shall conform to the requirements of The National Fire Protection Association No. 90A "Standard For The Installation of Air Conditioning and Ventilating Systems". Flame spread and smoke development ratings shall be established by tests conducted in accordance with NFPA No. 225 "Method of Test of Surface Burning Characteristics of Building Materials". Flame spread rating not to exceed 25; fuel contributed and smoke development rating not exceeding 50 when tested in accordance with ASTM E84.

D. Manufacturers:

1. The insulation material specifications are based on products manufactured by Owens Corning Fiberglass Corp., Schuller International, Certain Teed or equal.

2. The mastic and adhesive specifications are based on products manufactured by Benjamin Foster Co., Flinkote, InsulCoustic, Chicago Mastic Company or equal.

E. Shop Drawings:

1. Shop drawings shall be submitted for all insulation components and integrated insulation assemblies.

F. Insulation Subcontractor:

1. All insulation pertaining to Section 15500 HVAC shall be carried out by one firm specializing in insulation work.

2. Attain a complete and continuous vapor barrier over insulation applied to cold and dual temperature piping, sheetmetal and equipment. Use either factory applied vapor barrier, all service jacket or field applied re-enforced Foil Flame Resistant Kraft (R.F.F.R.K.) vapor barrier jacket. Apply to piping, fittings, valves, and inline components, sheetmetal and fittings, and equipment.

3. Seal longitudinal and circumferential laps with Benjamin Foster 82-07 Flintkote 230-04 or equal. Apply to piping, fittings, valves and inline components, sheetmetal and fittings, and equipment. If vapor barrier jacket is not lapped, seal joints with self-adhering 4 inch wide plain aluminum foil tape, or adhere 4 inch wide aluminum foil tape with Benjamin Foster 92-07 or Flinkote 230-04 or equal adhesive.

G. Pipe Insulation:

1. On hot piping applications, insulation shall be held in place with flare type staples. Seal the raw edges of insulation as noted above.

2. On cold and dual temperature piping applications, apply vapor barrier jacket and seal longitudinal and circumferential laps with Benjamin Foster 82-07 or InsulCoustic. Further secure with staples applied to ensure vapor barrier. Seal the raw edges of insulation as noted above.

3. Provide "Childers" 0.016 corrugated aluminum seamless jacket joined with rivets on exterior insulated pipe and PVC insulation cover on exposed pipe within 9 feet-0 inch above finished floor or where susceptible to damage in finished occupied spaces, not mechanical rooms. Bracket pipe every four feet off of wall. Jacket to be joined at lap seam by rivets every three (3) inches on center.

4. Provide heavy gauge PVC jacket on exposed (insulated) pipe within 9 feet-0 inch above finished floor or where susceptible to damage in finished occupied spaces, not mechanical rooms. Bracket pipe every four feet off of wall. Jacket to be joined at lap seam every three (3) inches on center.

5. Apply vapor barrier over insulation on cold and dual hot/cold temperature piping.

6. Insulate fittings and valves with fabricated mitered or preformed sections of specified insulation with PVC fitting covers Zeston, Speedline, or equal or insulate and finish with and reinforce with a glass membrane material. PVC fittings, if used, shall be installed in strict accordance with manufacturer's printed directions.

7. Insulate over flanges and flange valves with specified insulation and thickness sized to suit flange diameters as described hereinbefore for fittings.

8. Insulate chilled water, dual temperature and HTHW pumps but do not insulate hot water pumps.

9. Do not insulate terminal unit automatic control valves installed in hot piping. Insulate unit automatic control valves which are installed in cold piping.

10. Leave access for removal of pipeline strainer screens.

11. Insulated pipe on all low temperature systems, dual temperature systems and hot systems where roll hangers are used must be supported by hangers on the outside of the insulation. Special high density inserts of calcium silicate cellular glass or other approved, weight-bearing material of the same thickness as adjacent insulation shall be installed at points of hanger support. Insulation inserts shall be either 180 degrees or 360 degrees and not less than 18 inches in length. The entire insert shall be covered with a vapor barrier facing of the same appearance and quality as the facing on adjacent covering. Saddles or shields shall be provided by the HVAC Subcontractor.

12. Pipe insulation for all piping except where indicated otherwise, shall be of the following type, and as scheduled in the Pipe Insulation Table.

    a. Fiberglass Pipe Insulation with factory applied fire retardant all service jacket. Density of insulation shall be 4.0 pounds per cubic foot.

    b. Where provided for the cold pipe, fiberglass type ASJ Jacket with factory supplied butt strips on cold and dual temperature applications and selfseal lap adhesives on longitudinal and butt joints shall be used.

13. Pipe and Equipment Insulation Table

Duty	**Thickness**	**Vapor Barrier**
Domestic cold water connecting to HVAC equipment.	Thickness and type to match attached plumbing piping.	Yes
Hot water mains, risers and runouts.	Insulation Conductivity Btu/F. hr. square foot at temperature F to equal 0.25 at 125°F required.	
NOTE: Dual temperature hot/chilled water systems to have same insulation thickness as noted below for hot water, except provide vapor barrier.		
1 inch and less	1-1/2 inch	No
1-1/4 inch to 4 inch	1-1/2 inch	No
5 inch to 8 inch	2 inch	No
10 inch to 14 inch	2-1/2 inch	
16 inch and larger	3 inch	
For runouts up to 1 inch diameter and 4 foot or less in length.	1/2 inch	No

Duty	Thickness	Vapor Barrier
Chilled water piping.		
Insulation Conductivity 0.23 at 75°F required.		
1 inch and less	1 inch	Yes
1-1/4 inch to 3 inch	1 inch	Yes
4 inch and larger	1-1/2 inch	Yes
For runouts up to 1 inch diameter and 12 feet and less in length.	1/2 inch	Yes

Duty	Thickness	Vapor Barrier
Condensate drains both gravity and pumped.	1 inch	Yes

Duty	Thickness	Vapor Barrier
Refrigerant suction piping - Armaflex, Imco-lock/Imco-shield by IMCOA, or Insul-Tube by Halstead Ind., insulation with exterior material sealed.		Yes, plus 0.30 UV protective PVC jacket system outdoors.
1 inch and less	1 inch	
1-1/4 inch and above	1-1/2 inch (2 layers of 3/4 inch thickness)	

Duty	Thickness	Vapor Barrier
Exterior insulated piping of all services. Cover entire (including fittings and valves) insulation with "Childers" 0.016 corrugated waterproof aluminum jacket or solvent sealed UV resistant 0.030 (30-mil) PVC jacket system equal to Ceel-Tite UVR-	Insulation thickness to be double the thickness of normal interior service piping but not less than an additional 1.5 inches than that listed above or below,	Yes, plus UV resistant jacket over all.

300. Seal around seams. Heat tracing shall be provided by the HVAC Subcontractor.	for the service application. "Nesting" of insulation may yield greater thickness by default.

Duty	**Thickness**	**Vapor Barrier**
Low pressure steam piping, all condensate return, all pumped condensate return, all boiler feedwater, all boiler feed, all pumped boiler feed and all deareator piping.		
(201-250°F)		
Less than 1 inch	1-1/2 inch	No
1 inch to 1-1/4 inch	2-1/2 inch	No
1-1/2 inch and larger	3 inch	No

(The above is included to assist in terminating existing steam services to be cut back and capped.)

14. Existing Pipe

a. The removal of any existing pipe insulation containing asbestos materials shall not be included under the scope of this HVAC Contractor's Contract. The HVAC Contractor shall be responsible, however, for the reinsulation of any existing piping designated to remain, from which asbestos insulation has been removed by others. The HVAC Contractor shall also be responsible for the reinsulation of existing piping on which the existing non-asbestos pipe insulation has been damaged and become unsuitable for service or where the existing piping is presently not insulated. Reinsulation of all existing piping being reused shall be according to the above table.

b. Portions of the existing pipe system requiring reinsulation or insulation are noted on the drawings. These notes are provided for the contractor's assistance. These notes are not intended to fully define the scope of work. The contractors shall fully inspect the existing pipe system and review the anticipated asbestos removal work and piping to remain prior to submitting bid.

c. Reinsulate or insulate existing piping as soon as the asbestos removal work has been completed.

d. Piping as noted above shall include piping, fittings and valves.

e. Visit the site prior to submitting a bid to become fully aware of the scope of work. Insulation thickness shall be per the previous item 13.

15. Temporary Insulation

a. All existing HVAC piping from which asbestos insulation is being removed, or which is presently uninsulated shall be reinsulated by this Insulation Contractor. The only exception is HVAC piping from which asbestos insulation is being removed or which is presently uninsulated where the HVAC contractor has scheduled the existing piping to be removed prior to the piping being active. All existing HVAC piping and it's new insulation shall be classified as either "Temporary" or "Long Term".

b. All existing HVAC piping that is to be removed as part of this project shall be considered "Temporary". All other existing HVAC piping that is to remain active after completion of this project shall be considered "Long Term".

c. Both "Temporary" and "Long Term" existing HVAC piping shall be insulated as specified herein under Insulation, with the exception that "Temporary" piping shall have insulation installed only in 3 feet-0 inch long sections. Piping that would remain uninsulated by not utilizing cut sections of insulation shall be left uninsulated. Elbows, fittings and valves shall be left uninsulated.

d. Reinsulation of existing piping shall be scheduled to occur immediately after completion of the piping asbestos removal work.

e. The Insulation Contractor and the HVAC Contractor shall jointly review the existing conditions, contract documents and project schedule to assign piping into the classifications previously noted.

H. Sheetmetal Insulation (External):

1. Prior to finishing of insulation of hot and cold exposed rectangular ductwork. Seal all joints. Supply and install corner beads similar to roll-on-type.

2. Apply vapor barrier over insulation on cold and dual temperature ducts. Utilize insulation manufacturer approved mastics, adhesives, etc.

3. Ductwork lined with acoustic insulation shall not be externally insulated except for a minimum 12 inch overlap at junction of lined/insulated ductwork.

4. Fire dampers, reheat coils, duct coils, flow measuring stations, sound attenuators, acoustic plenums, static pressure measuring stations, i.e., all items that are not furnished lined by manufacturers that are installed in a lined or insulated duct system, shall be externally insulated.

5. External sheetmetal insulation shall be one of the following types, and as scheduled in the sheetmetal insulation table.

a. Type D1: Fiberglass rigid duct insulation 6 pounds per cubic foot density. Impale insulation on welded pins located at not greater than 12 inch centers. Glued/peel and stick type pins will not be accepted. Secure insulation with speed washers. Seal all penetrations and butt joints with matching vapor barrier type material. Insulation to have FSK vapor barrier. Provide corner beads on ductwork located within 6 feet of floor.

b. Type D2

1) Fiberglass flexible duct insulation 3/4 pounds per cubic foot density with FSK vapor barrier facing. Blanket insulation shall be wrapped around ducts with points tightly butted together or lapped. Maximum compression after installation shall be 25%.

2) Insulation shall be wrapped tightly on the duct work with all circumferential joints butted and longitudinal joints overlapped a minimum of 2 inch. Adhere insulation to metal with 4 inch strips of insulation bonding adhesive at 8 inch O.C. Additionally secure insulation to the bottom of rectangular ductwork over 24 inch wide with welded fasteners at not more than 18 O.C. Glued/peel and stick type pins will not be accepted. On circumferential joints, the 2 inch flange of the facing shall be secured using 9/16 inch flare-door staples applied 6 inch O.C. and taped with minimum of 3 inch wide foil reinforced Kraft tape. On Longitudinal joints, the overlap shall be secured using 9/16 inch flare-door staples applied 6 inch O.C. and taped with minimum 3 inch wide foil reinforced Kraft tape. In exposed applications cover all joints with 3 inch wide Foil Reinforced Kraft tape. All laps, seams, punctures, staples, etc. shall be taped and sealed over the laps with vapor barrier mastic.

6. Sheetmetal Insulation Table

Duty	**Insulation Type**	**Thickness**	**Vapor Barrier**
Supply ductwork for full extent of rectangular and/or round duct system. Provide for return air ductwork of HVAC systems and exhaust duct systems serving cooled spaces when installed in non-cooled spaces. Provide type D1 rigid insulation on the exterior of the ductwork where the ductwork is exposed in the space it serves.	D2	1-1/2 inch	Yes

Duty	**Insulation Type**	**Thickness**	**Vapor Barrier**
Panels behind unused portions of	D1	3 inch	Yes

louvers (Sheetmetal Contractor to provide metal panels)

Duty	Insulation Type	Thickness	Vapor Barrier
Outside air plenums and ducts including for unit ventilators, combustion air ductwork connected to condensing boilers, mixed air plenums and ducts.	D1	2 inch	Yes

Duty	Insulation Type	Thickness	Vapor Barrier
Supply ductwork associated with AHU-3 (air temperature below 50°F).	D2	2 inch	Yes, plus paintable canvas jacket.

Duty	Insulation Type	Thickness	Vapor Barrier
Relief and exhaust air plenums, and ductwork from plenum to automatic induct damper. 50-55 degree supply ductwork exposed within space served.	D1	1-1/2 inch	Yes

Duty	Insulation Type	Thickness	Vapor Barrier
Supply ductwork associated with AHU-3 (air temperature below 50°F) and exposed in the rooms served.	D1	2 inch	Yes, plus paintable canvas jacket.

Duty	Insulation Type	Thickness	Vapor Barrier
Boiler breeching and domestic water heater breeching (which is not in a premanufactured insulated, double walled system).	1200°F mineral wool with 1 inch diamond mesh screen and 1/2 inch troweled	3 inch for breeching	No

plastic cement and
rewettable glass
cloth cover.

I. Equipment Insulation:

1. Insulation over 1-1/2 inch thickness shall be applied in two layers, with staggered joints.

2. Apply vapor barrier over insulation on cold and dual temperature equipment.

3. Equipment insulation shall be one of the following types, and as scheduled in the equipment table:

a. Type El: Fiberglass 4.5 pounds per cubic foot density. Cut and miter insulation to suit surface contours. Impale insulation on mechanically fastened pins located at not greater than 12 inch centers. Apply expanded metal lath and lace edges with 16 gauge, galvanized, annealed wire. Secure insulation and metal lath with 1-1/2 inch O.D. speed washers. Apply two 1/2 inch coats of hydraulic setting insulation cement. Second coat shall be mixed with 25 percent Portland cement. Allow to dry to smooth finish before recovering.

b. Type E2: Armaflex FR A-22 sheet, 5.7 pounds per cubic foot density. Apply to clean and dry metal surfaces to be joined. Use the manufacturer's compression fit method of butt joining sheets.

4. Equipment Insulation Table

Duty	**Insulation Type**	**Thickness**	**Vapor Barrier**
Air separators.	E1	2 inch	No

Duty	**Insulation Type**	**Thickness**	**Vapor Barrier**
Chilled water pumps	E2	1-1/2 inch	Yes

Duty	**Insulation Type**	**Thickness**	**Vapor Barrier**
Chillers, portions of evaporator, suction or hot gas lines not factory insulated or which are damaged.	E2	1-1/2 inch	Yes, plus UV PVC jacket.

Duty	Insulation Type	Thickness	Vapor Barrier
Chilled water air separators.	E2	1-1/2 inch	Yes

J. Protection:

1. Protect the work of other trades with tarpaulin.

2. Protect the work of this trade from being defaced by other trades. Correct any damage and leave in perfect condition, ready for final painting.

K. Installation:

1. Apply insulation over clean, dry surfaces, firmly butting all sections together.

2. Do not cover equipment nameplates.

3. Coordinate related work with other Divisions.

4. Access doors in ductwork and equipment shall be insulated to same degree as the ductwork and equipment and insulation shall allow proper use of door. Name plates and equipment information shall not be covered.

5. Any insulation which becomes wet or damaged before the installation is approved shall be removed and replaced. Protect insulation from damage and notify the contractor for his cooperation.

2.28 SOUND AND VIBRATION CONTROL AND SEISMIC RESTRAINT SYSTEMS

A. Description:

1. Furnish and install vibration control devices, seismic restraint systems, materials, and related items. Perform all work as shown on the drawings and as specified herein to provide complete vibration isolation systems and seismic restraint systems in proper working order. All equipment, piping and ductwork shall be adequately restrained to resist seismic forces as required in the Building Code.

2. Design seismic forces shall be determined in accordance with the following requirements:

   a. Effective peak velocity - rated acceleration (A_v.) = **[**0.12**]**.

   b. Seismic Hazard Exposure Group = **[**I**]** **[**II**]** **[**III**]**.

   c. Seismic Performance Category = **[**C**]**.

B. Material and Equipment:

1. All vibration isolation mounts and seismic restraint systems shall be supplied by one of the following approved manufacturers.

    a. Amber/Booth Co. - A.B.; Houston, TX.

    b. Mason Industries, Inc. - M.I.; Hollis, NY

    c. Kinetics Noise Control, Inc.; K.N.C.; Dublin, OH

    d. Vibration Mountings & Controls, Inc. - V.M.&C. Butler, NJ

    e. Novia Associates, Inc. - NAI; Salem, NH

2. Substitution of equal equipment beyond the alternatives listed will be permitted only with the written permission of the Architect. Accompany each request for acceptance of substitute equipment with manufacturer's certified data proving the equivalence of the proposed substitute in quality and performance. The Architect shall be the final judge of the validity of the data submitted.

C. Quality Assurance:

1. Coordinate the size, location and special requirements of vibration isolation and seismic restraint equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.

2. Provide vibration isolators and seismic restraint systems of the appropriate sizes and proper loading to meet the specified deflection requirements.

3. Supply and install any incidental materials needed to meet the requirements stated herein, even if not expressly specified or shown on the drawings, without claim for additional payment.

4. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specifications.

5. Should any rotating equipment cause excessive noise or vibration, the Contractor shall be responsible for rebalancing, realignment, or other remedial work required to reduce noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the unit in question.

6. Upon completion of the work, the Architect or Architect's representative shall inspect the installation and shall inform the installing contractor of any further work that must be completed. Make all adjustments as directed by the Architect that result from final inspection. This work shall be done before vibration isolation and seismic restraint systems are accepted.

D. Speed and Balance Requirements for Rotating Equipment:

1. Fans and other rotating mechanical equipment shall not operate at speeds in excess of 80% of their true critical speed.

2. Vertical vibration of rotating equipment shall not be greater than the levels indicated. The vibration shall be measured on the equipment or steel frame equipment base when the equipment is mounted on its vibration isolation mounts. If the equipment has an inertia base, the allowable vibration level is reduced by the ratio of the equipment weight alone to the equipment weight plus the inertia base weight.

Equipment Speed	Vibration Displacement (MILS peak-to-peak)
Under 600 rpm	4
600 to 1000 rpm	3
1000 to 2000 rpm	2
over 2000 rpm	1

E. Submittals:

1. Refer to related sections elsewhere for procedural instructions for submittals. A complete submittal using actual equipment installed is required before any vibration isolation and seismic restraint equipment is to be installed. Submittals must be reviewed by the Acoustical Consultant (when applicable) and the Engineer before ordering fabrication or installation of any material.

2. Detailed selection data for each vibration isolator and seismic restraint supporting equipment, including:

a. equipment mark;

b. isolator type;

c. actual load;

d. static deflection expected under the actual load;

e. specified minimum static deflection;

f. additional deflection to solid under actual load.

g. ratio of spring height under actual load to spring diameter.

h. maximum rated isolator operating load.

i. Number, size and type of anchor bolts, cable restraints, seismic snubbers, etc., for each piece of equipment and groups of pipes and ducts.

3. Steel rails, steel base frames, and concrete inertia bases showing all steel work, reinforcing, vibration isolator mounting attachment method, and location of equipment attachment bolts.

4. Special details necessary to convey complete understanding of the work to be performed.

5. Submission of samples may be requested for each type of vibration isolation or seismic restraint device. After approval, samples will be returned for installation at the job. All costs associated with submission of samples shall be borne by the HVAC Subcontractor.

6. Anchor bolt calculations, signed and stamped by a registered professional engineer, shall be submitted showing adequacy of the bolt sizing, and type. Calculations shall include anchor embedment, minimum edge distance and minimum center distance. The design lateral forces shall be distributed in proportion to the mass distribution of the equipment. Calculations shall be furnished for anchors on restraint devices, cables, isolators and on rigidly mounted equipment. The seismic designer must perform final jobsite inspection to verify anchor installation.

7. Restraint of rigidly mounted piping and ductwork may conform to "National Uniform Seismic Installation Guidelines", NUSIG or "Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Systems", SMACNA. Calculations need not be submitted for restraint systems conforming to these guidelines.

8. The Seismic and Vibration Control manufacturer shall determine the number, size and type of anchor bolts, cable restraints, seismic snubbers, etc., for each piece of equipment and groups of pipes and ducts.

9. Provide complete engineering calculations and drawings for all vibration and seismic requirements for all equipment, piping and ductwork per approved shop drawings.

10. Provide documentation clearly indicating the State professional stamp of the Engineer who is responsible for the design and operation of the Vibration and Seismic System.

11. Provide details for all the isolators and seismic bracing with snubbers proposed for items in this specification and on the drawings.

12. Provide clearly outlined procedures for installing and adjusting the isolators, seismic bracing and snubber.

F. Vibration Isolation Mount Types:

1. All metal parts of vibration isolation and seismic restraint units installed out-of-doors shall be hot-dip galvanized cadmium plated or neoprene coated after fabrication. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14.

2. Isolator types are scheduled to establish standards. At the contractor's option, labor-saving accessories can be an integral part of isolators supplied, to provide initial lift of equipment to operating height, hold piping at fixed elevations during installations and initial system filling operations, and similar installation advantages. Accessories must not degrade the vibration isolation or seismic restraint system(s).

3. Static deflection of isolators shall be as provided herein and as shown on the drawings. All static deflections stated are the minimum acceptable deflection for the mounts under actual load not rated maximum load. Isolators selected on the basis of rated deflection are not acceptable and will be disapproved.

4. Unit FSN-ER (Floor Spring and Neoprene)

   a. A welded structural steel housing and an adjustable, removable spring package designed to resist seismic forces in all directions. Restraint surfaces which engage under seismic motion shall be cushioned with a resilient elastomer, neoprene or equal, to protect equipment. Restraints shall allow a maximum of 1/4 inch movement before engaging and shall not interfere in normal operation. Housing shall allow for visual inspection and removal of the spring package. The entire assembly shall have a certified minimum rating of 1/2 g in all directions.

   b. Isolator shall be a stable spring with a minimum Kx/Ky of 1.0 and the spring shall be isolated from the housing by an internal elastomeric pad on its base for sound absorption. Spring shall have a combination leveling bolt and equipment fastening devices. Nuts and bolts shall be zinc-electroplated to prevent corrosion. Adjusting bolt and equipment attachment shall have a minimum rating 1/2 g. Bolting equipment to isolator with bolts smaller than main adjusting bolt will not be allowed. Baseplate shall have adequate means for bolting to the structure. If elastomeric pad for sound absorption is on baseplate of housing, anchor bolts are to be isolated with elastomeric grommets.

   c. Unit FSN-ER isolators shall be one of the following products with the appropriate neoprene pad (if used) selected from unit DNP or approved equal.

Type SWSR	-	A.B.
Type SSLFH	-	M.I.
Type FYS	-	K.N.C.
Series AWMR	-	V.M.& C.

   d. Type XL - (Exterior or Wet Area Usage) An aluminum-housed, adjustable spring mounting having telescoping top and bottom sections separated by resilient elastomeric inserts to limit horizontal motion. Steel or cast iron housings may be used if they are hot-dip galvanized after fabrication. An elastomeric pad having a minimum thickness of 1/4 inch shall be bonded to the base plate. Nuts, adjusting bolts and washers shall be zinc-electroplated to prevent corrosion.

5. Unit FSNTL-ER (Floor Spring and Neoprene Travel Limited)

   a. A unitized adjustable, open-spring isolator and seismic restraint housing which serves as a blocking device during equipment installation. The spring package shall be isolated from the housing by an internal elastomeric pad for sound absorption. Nuts, adjusting bolts, and washers shall be zinc-electroplated to prevent corrosion. Isolators with sliding interlocking housings are not permitted.

   b. The spring assembly shall be removable and shall fit within a welded steel enclosure consisting of a top plate and rigid lower housing. Isolated seismic restraining bolts which shall connect the top plate and lower housing to resist seismic forces in all directions. Surfaces which engage under seismic motion shall be cushioned with a resilient elastomer, neoprene or equal, to protect equipment. Entire assembly shall have a minimum rating of 1/2 g as certified by a registered professional engineer. Top plate shall have adequate means for fastening to the equipment and baseplate shall have adequate means for bolting to the structure. All bolting or attachment shall have a minimum rating of 1/2 g. If elastomeric pad for sound absorption is on base plate of housing, anchor bolts are to be isolated with grommets.

c. Unit FSNTL-ER isolators shall be one of the following products:

Type CTER	-	A.B.
Type SLR	-	M.I.
Series AWR	-	V.M.& C.
Type FLS	-	K.N.C.

6. Unit FN (Floor Neoprene)

a. Neoprene isolators shall be double deflection neoprene-in-shear type with steel reinforced top and base. All metal surfaces shall be covered with neoprene. Bolt holes shall be provided in the base and the top shall have a threaded fastener.

b. The mounts shall include leveling bolts that may be rigidly connected to the equipment.

c. Unit FN isolators shall be one of the following products or approved equal:

Type RVD	-	A.B.
Type ND	-	M.I.
Type RD	-	K.N.C.
Series RD	-	V.M.& C.

7. Unit NP (Neoprene Pad)

a. Neoprene pad isolators shall be one layer of 1/4 inch to 5/16 inch thick ribbed or waffled neoprene. Neoprene shall be 40 to 50 durometer. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.

b. Unit NP isolators shall be one of the following products or approved equal:

Type NR	-	A.B.
Type W	-	M.I.
Type NPS	-	K.N.C.
Series Shear Flex	-	V.M. & C.

8. Unit DNP (Double Neoprene Pad)

a. Neoprene pad isolators shall be formed by two layers of 1/4 inch to 5/16 inch thick ribbed or waffled neoprene, separated by a stainless steel or aluminum plate. These layers shall be permanently adhered together. Neoprene shall be 40 to 50 durometer. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.

b. Unit DNP isolators shall be formed from one of the following products or approved equal:

Type SP-NR	-	A.B.
Type WSW	-	M.I.
Type NPS	-	K.N.C.
Series Shear Flex	-	V.M. & C.

9. Unit HN (Hanger Neoprene)

a. Vibration isolation hangers shall consist of a neoprene element, contained within a steel housing. The neoprene element shall be manufactured with a grommet (or other element) to prevent the hanger rod from contacting the hanger housing. A steel washer shall be provided in the neoprene element to evenly distribute load onto the neoprene. Hanger housing lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the housing.

b. Unit HS isolators shall be one of the following products or approved equal:

Type BRD	-	A.B.
Type HD	-	M.I.
Type SH	-	K.N.C.
Type RHD	-	V.M. & C.

10. Unit HSN (Hanger Spring and Neoprene)

a. Vibration isolation hangers shall consist of a free standing laterally stable spring and a neoprene in series, contained within a steel housing. A neoprene neck bushing (or other element) shall be provided where the hanger rod passes through the hanger housing to prevent the rod from contacting the hanger housing. Spring diameters and hanger housing lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the housing. Spring elements shall have a minimum additional travel to solid equal to 50% of the actual deflection. The neoprene element shall be designed to have a 0.5 inch minimum static deflection.

b. Unit HSN isolators shall be one of the following products or approved equal:

Type BSRA	-	A.B.
Type 30N	-	M.I.
Type SRH or SFH	-	K.N.C.
Type RSH 30A	-	V.M.& C.

G. Equipment Bases:

1. Unit BSR (Base - Steel Rail)

a. Steel rail bases shall consist of structural steel sections sized to provide a rigid beam which will not twist, deform, or deflect in any manner which will negatively affect the operation of the supported equipment or the vibration isolation mounts. Rail bases shall include provisions for attachment of vibration isolators.

b. Unit BSR bases will be supplied by the isolator manufacturer and shall be one of the following products or approved equal:

Type C or SR	-	A.B.
Type R or ICS	-	M.I.
Type KRB or KFN4B	-	K.N.C.
Type WFR or ATR	-	V.M.& C.

2. Unit BSF (Base - Steel Frame)

a. Steel base frames shall consist of structural steel sections sized, spaced, and connected to form a rigid base which will not twist, rack, deform, or deflect in any manner which will negatively affect the operation of the supported equipment or the vibration isolation mounts. Frames shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. The depth of steel frame bases shall be at least 6 inch and at least 6 inch and at least 1/10 the longest dimension of the base but not more than 12 inch. Frame bases shall include side mounting brackets for attachment to vibration isolators.

b. Unit BSF bases shall be supplied by the isolator manufacturer and shall be one of the following products or approved equal:

Type SFB	-	A.B.
Type WFSL	-	M.I.
Type SFB or SRB	-	K.N.C.
Series WFB	-	V.M.& C.

3. Unit BIB (Base - Inertia Base)

a. Concrete inertia bases shall be formed of stone-aggregate concrete (150 lbs./cubic foot) and appropriate steel reinforcing cast between perimeter structural steel channels.

b. Inertia bases shall be built to form a rigid base which will not twist, deform, deflect, or crack in any manner which would negatively affect the operation of the supported equipment or the vibration isolation mounts. Inertia bases shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure.

c. Inertia base thickness shall be at least 1/12 the longest dimension of the inertia base but not less than 6 inch. Inertia bases shall include side mounting brackets for attachment to vibration isolators.

d. The steel frame and reinforcement shall be supplied by the vibration isolator manufacturer. Concrete may be provided by the General Contractor.

e. Frame and reinforcement for Unit BIB bases shall be one of the following products or approved equal:

Type CPF	-	A.B.
Type KSL	-	M.I.
Type CIB-L or CIB-H	-	K.N.C.
Series WPF	-	V.M.& C.

f. Modular and bolt together bases are unacceptable.

H. Resilient Penetration Sleeve/Seal:

1. Resilient penetration sleeve/seal shall be field fabricated from a pipe or sheet metal section that is 1 inch larger in each dimension than the penetrating element and is used to provide a sleeve through the construction penetrated with a minimum clearance of 3/8 inch. The sleeve shall extend 1 inch beyond the penetrated construction on each side. The annular space between the sleeve and the penetrating element shall be packed tightly with glass fiber or mineral wool to within 1/4 inch of the ends of the sleeve. The remaining 1/4 inch space on each side shall be filled with acoustical sealant to form an air-tight seal. Alternatively, the entire annular space may be filled with silicone fire-safing foam. Alternatively, prefabricated sleeves accomplishing the same result are acceptable.

I. Resilient Lateral Guides:

1. These units shall be the standard product of the vibration isolation mounting manufacturer, incorporating neoprene isolation elements which are specifically designed for providing resilient lateral bracing of vertically rising ducts or pipes.

2. Resilient lateral guides shall be one of the following products or approved equal.

Type AG	-	A.B.
Type ADA	-	M.I.
Type RGN	-	K.N.C.
Type MDPA	-	V.M.& C.

J. Flexible Pipe Connections:

1. Flexible pipe connections shall be fabricated of stainless steel hose and braid (Type 321) with carbon steel plate flanges.. Flexible connections shall be able to accept comprehensive, elongative, transverse, and angular movements.

2. The flexible connections shall be selected and specially fitted, if necessary, to suit the system temperature, pressure, fluid type. No rods or cables shall be used to control extension of the connector.

3. Connectors for pipe sizes 2 inch or smaller shall have threaded female union couplings on each end. Larger sizes shall be fitted with metallic flange couplings.

4. Flexible pipe connections shall be Amber Booth Style SS-FP or equal. Provide connections as noted on the drawings.

5. Provide at all water, steam and refrigerant pipe connections to motor driven equipment such as water pumps, cooling towers and additional as noted on the drawing.

K. Restraints:

1. Snubbers

a. A restraint assembly for floor mounted equipment consisting of welded steel interlocking assemblies welded or bolted securely to the equipment or the equipment base and the supporting structure. Restraint assembly surface which engage under seismic motion shall be lined with a resilient elastomer, neoprene or equal, to protect equipment. Restraints shall be field adjustable and be positioned for 1/4 inch clearance both vertically and horizontally or clearance as required to prevent interference during normal operation, stopping or starting. Restraint assembly shall have a minimum rating of 1 g as certified by independent laboratory test.

b. Snubbers shall be one of the following products:

Type ER	-	A.B.
Type Z1225	-	M.I.
Type SR	-	V.M.&C.
Series KSS; HS-2	-	K.N. C.

2. Thrust Restraints

a. Thrust restraints shall consist of a spring element in series with a neoprene pad. The unit shall be designed to have the same deflection as specified for the isolators supporting the equipment. The spring element shall be contained within a steel frame and can be designed so it can be preset at the factory for thrust and be adjusted in the field to allow for a maximum of 1/4 inch movement during starting or stopping of the equipment.

b. The assembly shall be furnished complete with rods and angle brackets for attachment to both the equipment and the adjacent fixed structural anchor.

c. Thrust restraints shall be Mason Industries Type WB, Kinetics Noise Control Type HSR, or an equal product of the manufacturer supplying the isolators.

d. Provide at all axial fans.

3. Cable Restraints

a. A restraint assembly for suspended equipment, piping or ductwork consisting of flow steel cable attached to steel thimbles with neoprene sleeve all specifically designed for cable service and securely fastened to the equipment, or the equipment base and the building structure with structural steel angle brackets. Cables shall be installed to prevent excessive seismic motion and so arranged that they do not engage during normal operation, starting or stopping.

L. Grommets:

1. Grommets shall be Mason Industries HLIB/HLIW, or be custom made by combining a neoprene washer and sleeve at least 1/4 inch thick. Neoprene durometer is to be between 30 and 50. Grommets shall be specifically formed to prevent bolts from directly contacting the isolator base plate.

M. Acoustical Sealant:

1. Sealants for acoustical purposes as described in this specification shall be one of the non-setting sealants indicated below or an approved equivalent:

Acoustical sealant	-	D.A.P.
BR-96	-	Pecora
Acoustical sealant	-	Tremco
Acoustical sealant	-	U.S.G.

N. Application:

1. General

a. The static deflection of all isolators specified herein are the minimum acceptable deflections for the mounts under actual load not the isolator maximum rated load.

b. Unless otherwise shown or specified, all floor mounted major equipment shall be set on 4 inch high concrete housekeeping pads. See Architectural or Structural drawings for details.

c. Types and minimum static deflections of vibration isolation devices for major equipment items shall be as scheduled on the drawings or specified hereunder. Minimum isolation efficiency shall be 90%.

d. Flexible pipe connections shall be installed at all pipe connections to vibration isolated equipment in the positions shown on the drawings.

e. Electrical connections to vibration isolation equipment shall be flexible, as called for in the electrical portion of the specifications.

2. Seismic Systems

a. All HVAC equipment requiring seismic protection shall be installed with the following guidelines:

b. Isolated Equipment

1) Floor and roof mounted isolated equipment shall be protected with unitized isolator and restraint or with separate restraints (minimum of

4) and non seismic isolators. For equipment with high center of gravity, additional cable restraints shall be furnished, as required to limit forces and motion caused by rocking.

2) All suspended isolated equipment and vessels shall be protected with cable restraints. Cables shall be installed to prevent excessive seismic motion and so arranged that they do not engage during normal operation, starting or stopping.

3) All seismic restraints for isolated equipment shall be designed and furnished by the isolation manufacturer or supplier.

c. Isolated Piping

1) All isolated piping 2-1/2 inch and over shall be protected in all planes by cable restraints, designed to accommodate thermal movement as well as restrain seismic motion. Tanks and vessels connected to isolated piping shall be restrained same as piping. Locations shall be as determined by the isolator supplier and shall include, but not be limited to:

a) At all drops to equipment connections.

b) At changes in direction of pipe.

c) At horizontal runs of pipe.

d) On both sides of flexible connectors.

2) Seismic restraints are not required on the following:

a) Piping in Mechanical Equipment Rooms less than 1-1/4 inch I.D.

b) Piping located outside of Mechanical Equipment Rooms less than 2-1/2 inch I.D.

c) All devices hung pipe suspended by individual hangers 12 inch in length (or less) as measured from the top of the pipe to the bottom of the support for the hanger.

d. Isolated Ductwork

1) Isolated ductwork 6 square feet and larger in cross sectional area of 26 inch diameter and larger shall be protected in all planes by cable restraints. Locations shall be determined by the isolator supplier and shall include, but not be limited to:

a) At all equipment connections.

b) At all duct runs and duct run ends (transverse bracing).

c) At horizontal runs.

2) Isolated ductwork under 6 square feet in cross sectional area or under 26 inch diameter, need not be additionally restrained.

e. Rigidly Mounted Equipment

1) Rigidly mounted roof, floor, and suspended equipment and vessels and all rigidly mounted wall mounted equipment shall be protected by properly sized anchor bolts or hangers rods and bracing and, if required, by additional seismic restraints as described above for isolated equipment. The need for additional restraints shall be determined by and. if required, furnished by the supplier of the seismic restraints for the isolated equipment.

f. Rigidly Mounted Piping

1) All non-isolated piping shall be protected in accordance with the SMACNA Guidelines. At contractor's option, for ease of installation, cable restraint system may be used as described above for isolated piping.

g. Rigidly Mounted Ductwork

1) All rigidly mounted ductwork shall be protected as for rigidly mounted piping.

h. Installation

1) All seismic restraints are to be securely anchored or fastened to the equipment and supporting structure in accordance with the approved submittal data.

2) Operating clearances are to be adjusted so that restraints do not interfere during normal operation of the equipment.

3) Upon completion of the installation, the supplier of the seismic restraints shall inspect and report in writing to the designer that restraints have been installed properly and in accordance with his recommendations.

3. Additional application guidelines are as follows; this schedule is intended to provide minimum isolation requirements. Consult schedule on drawings for specific equipment requirements.

NOTES	EQUIPMENT DESCRIPTION	ISOLATOR TYPE	MINIMUM STATIC DEFLECTION	BASE TYPE
1 & 2	Centrifugal Chillers:			
	Slab on Grade	FSNTL-ER	0.5 inch	--
	Above Structural Span	FSNTL-ER	1.0 inch	--

NOTES	EQUIPMENT DESCRIPTION	ISOLATOR TYPE	MINIMUM STATIC DEFLECTION	BASE TYPE
1 & 2	In-Line Pumps	HN or FN	0.2 inch	--
1 & 2	Base-Mounted Pumps:			
	Slab on Grade	BIB-SWR	1.0 inch	--
	Above Structural Span	FSN	1.0 inch	BSF-C
3	Air Compressors			
	Up to 5 HP	FSN-ER	0.3 inch	
	Over 5 HP	FSN-ER	1.0 inch	
4	Fan-Coil Units	HN or FN	0.2 inch	
4 & 5	Air Handling Units & Fans			
	Up to 5 HP	HN or FN	0.3 inch	
	Over 5 HP	HSN or FSN-ER	1.0 inch	

NOTES: #1. Regardless of the minimum static deflection of the isolator type shown, each isolator shall be selected for minimum isolation efficiency of 90%.

#2. Variable speed motor drives may need to be programmed for a minimum speed setting or to skip critical speed to maintain isolation efficiency. The Supplier of the equipment shall coordinate this requirement.

#3. The HVAC Contractor shall provide Type BIB inertia bases for reciprocating compressors with motors larger than 5 HP and also for rotary compressors if recommended by the manufacturer to control movement.

#4. Internal or external isolators are acceptable for factory assembled units. For built up units, refer to the drawings for isolator locations.

#5. In addition to the requirements listed above for all fans, all fans with greater than 1.5 inch static pressure shall be provided with isolated Thrust Restraints.

4. Pipes

a. All chilled water, hot water, refrigerant and condenser water piping within mechanical - fan rooms or within 50 feet total pipe length (whichever is longer) of connected vibration isolated equipment (chillers, pumps, air handling units, etc.), and all piping that is 6 inch or larger, shall be isolated from the building structure by means of vibration isolation mounts, resilient pipe guides, and resilient penetration sleeve/seals.

b. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators is greater than 1/2 inch, proper isolators (whichever is applicable to the mounting condition) shall be used. When the required static deflection is less than or equal to 1/2 inch, proper isolators (whichever is applicable to the mounting condition) shall be used.

c. All other pipe support isolators within the specified limits shall be either FN or HN (whichever is applicable to the mounting condition) achieving 0.25 inch static deflection.

d. Where lateral support of pipe risers is required within the specified limits, this shall be accomplished by use of resilient lateral supports.

e. Pipes within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetrating sleeve/seals.

f. Drain piping connected to vibration isolated equipment shall not contact the building structure or other non-isolated system unless it is resiliently mounted as described above.

g. Provide flexible pipe connections in piping systems as called for specified herein and wherever shown on the drawings.

O. Installation of Vibration Isolation Equipment and Seismic Restraints:

1. General

a. Locations of all vibration isolation equipment shall be selected for ease of inspection and adjustment as well as for proper operation.

b. Installation of vibration isolation equipment and seismic restraints shall be in accordance with the manufacturer's instructions.

2. Isolation Mounts and Seismic Restraints

a. All vibration isolators shall be aligned squarely above or below mounting points of the supported equipment.

b. Isolators for equipment with bases shall be located on the sides of the bases which are parallel to the equipment shaft.

c. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plate shall rest entirely on the pad.

d. Seismic restraints and hanger rods for vibration isolated support shall be connected to structural beams or joists, not from the floor slab or roof deck between beams and joists. Provide intermediate support members as necessary.

e. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360° without contacting any object.

f. Parallel running pipes may be hung together on a trapeze which is isolated from the building. Isolator deflections must be the largest determined by the provisions for pipe isolation. Do not mix isolated and non-isolated pipes on the same trapeze.

g. No pipes or equipment shall be supported from other pipes or equipment.

h. Resiliently isolated pipes shall not contact the building construction or other equipment.

i. The installed and operating heights of vibration isolated equipment mounted on isolators shall be identical. Limit stops shall be out of contact during normal operation.

j. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

3. Bases

a. No equipment unit shall bear directly on vibration isolators unless its own frame is suitably rigid to span between isolators and such direct support is approved by the equipment manufacturer. This provision shall apply whether or not a base frame is called for on the schedule. In the case that a base frame is required for the unit because of the equipment manufacturer's requirements and is not specifically called for on the equipment schedule, a base frame recommended by the equipment manufacturer shall be provided at no additional expense.

b. Unless otherwise indicated, there is to be a minimum operating clearance of 1-1/2 inch between inertia bases or steel frame bases and the floor beneath the equipment. Position isolator mounting brackets and adjust isolators so that the required clearance is maintained. The clearance space shall be checked by the HVAC Contractor to ensure that no construction debris has been left to short circuit or restrict the proper operation of the vibration isolation system.

4. Thrust Restraints

a. Snubbers shall be adjusted to clear the equipment base and to provide lateral restraint during on/off cycling, but be out of contact during normal operation of the equipment.

b. Thrust restraints shall be attached at the centerline of thrust and symmetrically on each side of the unit. Adjust the restraints to limit equipment movement to the specified limit.

5. Resilient Penetration Sleeve/Seals

a. Penetration seals shall maintain an air-tight seal around the penetrating elements and shall prevent rigid contact between the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal air-tight on both sides of the construction penetrated with acoustical sealant.

2.29 FLUID TREATMENT AND CHEMICAL CLEANING

A. General:

1. The HVAC Contractor shall engage the services of a reputable water treatment contractor, such as New England Systems and Supply, Inc., Barclay Chemical, Mogul, or equal, to provide a complete fluid treatment service, designed to minimize corrosion and scale formation in the piping systems. Model numbers and brand names listed herein are based on New England Systems and Supply, Inc.

2. All necessary mechanical equipment, cleaning chemicals, treatment chemicals, control equipment and services shall be provided by a single water treatment consulting firm for individual responsibility. A one year contract for each system shall be made to cover the supply of chemical treatment and service. The fluid treatment supplier shall receive written notice prior to temporary or permanent start-up of any system requiring chemical treatment system. Make-up water piping shall conform to the Board of Health and all Town, State, and Federal Code requirements.

3. The fluid treatment supplier shall forward within 90 days from job acceptance, the following for approval to the Owner:

a. System installation drawings and diagrams.

b. Product information sheets on each component, device, pump, controller, valve, etc., being supplied in the system.

c. Analysis of Raw Water supplying each system.

d. Product information sheets on all chemical products being supplied for each system, including cleaning chemicals.

e. Recommended feed rates on each chemical product.

f. Recommended operating conditions for each system, including cycles of concentration, chemical test limits and limits of water treatment system set points.

B. Chemical Cleaning:

1. The new and existing piping systems shall be thoroughly flushed out of cutting oils and other loose extraneous materials. This shall include piping installed now and capped for future use. The cleaning chemicals shall be added by the HVAC Subcontractor. The chemical supplier shall instruct as to the proper feed rates, shall check that the cleaning solution is actually in each system, shall instruct the HVAC Subcontractor as to when to flush the systems and shall check each system following flushing to insure all cleaning chemicals have been removed from each system. The HVAC Subcontractor shall block open all modulating valves, zone valves and all other system restrictions. If building pumps are not available, this contractor shall provide portable pumps to circulate water for cleaning purposes.

2. Chemical used for cleaning of system shall comply with the recommendations of the manufacturers of the major components in the system.

3. A certificate of cleaning shall be provided by the cleaning chemical supplier to the Owner. The supplier shall supervise the cleaning.

4. Cleaning chemicals for the water, oil, glycol, steam and condensate return piping systems shall be an industrial cleaner equivalent to Dearborn BC-45 cleaner. Systems shall be circulated for at least 48 hours and then thoroughly flushed so that remaining total alkalinity shall not exceed 200 ppm and maximum flushing time shall be 24 hours. Supervision of the cleaning process shall be by the Water Treatment Contractor. Cleaning solution shall not remain in systems longer than the 48 hours noted.

5. Provide cleaning and addition of chemical listed in item C. below as each phase of the project is accepted and a complete full system cleaning and addition of chemical listed in item C. at the completion of the final phase.

C. Closed Systems:

1. The systems shall each have a 5-gallon capacity Shot Feeder installed as shown on the Drawings. The system shall be thoroughly flushed and cleaned with Dearborn BC-45 Cleaner and charged with Dearborn B-239 Nitrate Corrosion Inhibitor after cleaning. Control limits of 800 to 1000 ppm shall be maintained.

2. The feeders shall have:

a. Inlet opening (3/4 inch NPT).

b. Outlet opening (3/4 inch NPT).

c. Bottom drain with drain valve.

d. Mounting bracket.

e. Top opening for chemical addition (2 inch minimum).

f. Pressure test as required.

g. Install feeders in a two valve bypass arrangement around the most convenient circulating pump. 3/4 inch NPT feeder lead-in line shall be taken from the circulating line on the discharge side of the pump. 3/4 inch NPT feeder outlet line shall run to the circulating line on the suction side of the pump.

D. System shall be, after thorough flushing passivation and testing, be filled and charged with propylene glycol solution (40% by weight) using pre-mixed glycol. See Paragraph 2.36, Automatic Propylene Glycol Feed System.

E. The HVAC Subcontractor shall notify the Water Treatment Company prior to the operation of any Water System so that they can be initially charged with chemical.

F. Consulting Analysis Service:

1. Provide installation, cleaning, start-up supervision, and training of Maintenance Personnel.

2. Provide written instructions, dosage rates, control limits, and a complete supply of test kits, reagents and test materials.

3. Provide a minimum of 4 quarterly Consulting Analysis Service Visits with written reports and recommendations submitted. Provide a 1-year supply of all chemicals from date of initial start-up.

2.30 AIR COOLED LIQUID CHILLER

A. System Description:

1. Microprocessor controlled, air-cooled liquid chiller utilizing scroll compressors, and low sound fans.

2. Unit shall be rated in accordance with ARI Standard 550/590, latest revision (USA). Energy efficiency shall meet the Maine State Energy Code of 13.2 SCER, whichever is greater.

3. Unit construction shall comply with ASHRAE 15 Safety Code, UL 1995, and ASME applicable codes (USA codes).

4. Unit shall be manufactured in a facility registered to ISO 9001:2000 Manufacturing Quality Standard.

5. Unit shall be full load run tested at the factory.

6. Manufacturers equal to Carrier, Trane, Smardt, McQuay, TSI.

B. Delivery, Storage and Handling:

1. Unit controls shall be capable of withstanding 150°F (66 C) storage temperatures in the control compartment.

2. Unit shall be stored and handled per unit manufacturer's recommendations.

C. Equipment:

1. Factory assembled, single-piece or factory-matched duplex chassis, air-cooled liquid chiller. Contained within the unit cabinet shall be all factory wiring, piping, controls, refrigerant charge (R-410A), and special features required prior to field start-up. R-22 refrigerant will be acceptable provided that R410A units are not available from any of the bidding manufacturers.

2. Unit Cabinet

a. Frame shall be of heavy gauge (14 minimum) roll formed or structural member, painted galvanized steel.

b. Cabinet shall be galvanized 18 gauge steel casing with a baked enamel powder or pre-painted finish.

c. Cabinet shall be capable of withstanding 500-hour salt spray test in accordance with the ASTM (U.S.A.) B-117 standard.

3. Fans

a. Condenser fans shall be direct-driven, 9-blade airfoil cross-section, reinforced polymer construction, shrouded-axial type, and shall be statically and dynamically balanced with inherent corrosion resistance.

b. Air shall be discharged vertically upward.

c. Fans shall be protected by coated steel wire safety guards.

4. Compressor/Compressor Assembly

a. Fully hermetic scroll type compressors.

b. Direct drive, 3500 rpm (60 hertz), protected by motor temperature sensors, suction gas cooled motor.

c. External vibration isolation rubber-in-shear.

d. Each compressor shall be equipped with crankcase heaters to minimize oil dilution.

5. Evaporator (Cooler)

a. Shell-and-tube type, direct expansion.

b. Tubes shall be internally enhanced seamless-copper type rolled into tube sheets.

c. Shall be equipped with Victaulic-type fluid connections.

d. Shell shall be insulated with 3/4-inch (19-mm) PVC foam (closed-cell) with a maximum K factor of 0.28.

e. Design shall incorporate a minimum of two independent direct-expansion refrigerant circuits.

f. Cooler shall be tested and stamped in accordance with ASME Code for a refrigerant working side pressure of 445 psig (3068 kPa). Cooler shall have a maximum fluid-side pressure of 300 psig (2068 kPa).

6. Condenser

a. Coil shall be air-cooled with integral subcooler, and shall be constructed of aluminum fins mechanically bonded to seamless copper tubes.

b. Tubes shall be cleaned, dehydrated, and sealed.

c. Assembled condenser coils shall be leak tested and pressure tested at 656 psig (4522 kPa).

d. Coils shall be copper fins on copper rubes (cu/cu) and have a phenolic coating specifically engineered for marine/salt spray environments. Carrier "E" coating or equal.

7. Refrigeration Components

a. Refrigerant circuit components shall include replaceable-core filter drier, moisture indicating sight glass, electronic expansion device, discharge service valve and liquid line service valves, and complete operating charge of both refrigerant R-410A and compressor oil. Hot gas bypass shall be provided on one (1) circuit for low load operation down to 10% of net total.

8. Controls, Safeties, and Diagnostics

a. Unit controls shall include the following minimum components:

1) Microprocessor with non-volatile memory. Battery backup system shall not be accepted for this function.

2) Separate terminal block for power and controls.

3) Control transformer to serve all controllers, relays, and control components.

4) ON/OFF control switch.

5) Replaceable solid-state controllers.

6) Pressure sensors installed to measure suction and discharge pressure. Thermistors installed to measure cooler entering and leaving fluid temperatures.

b. Unit controls shall include the following functions:

1) Automatic circuit lead/lag.

2) Hermetic scroll compressors shall be maintenance free and protected by an auto-adaptive control that minimizes compressor wear.

3) Capacity control based on leaving chilled fluid temperature and compensated by rate of change of return-fluid temperature with temperature set point accuracy to 0.1°F (0.06°C).

4) Limiting the chilled fluid temperature pull-down rate at start-up to an adjustable range of 0.2°F to 2°F (0.11°C to 1.1°C) per minute to prevent excessive demand spikes at start-up.

5) Seven-day time schedule.

6) Leaving chilled fluid temperature reset from return fluid and outside air temperature.

7) Chilled water pump start/stop control and primary/standby sequencing to ensure equal pump run time.

8) Dual chiller control for parallel chiller applications without addition of hardware modules, control panels.

9) Timed maintenance scheduling to signal maintenance activities for pumps, strainer maintenance and user-defined maintenance activities.

10) Low ambient protection to energize cooler and hydronic system heaters.

11) Periodic pump start to ensure pump seals are properly maintained during off-season periods.

12) Single step demand limit control activated by remote contact closure.

13) Night time sound mode to reduce the sound of the machine by a user-defined schedule.

c. Diagnostics

1) The control panel shall include, as standard, a Scrolling Marquee display capable of indicating the safety lockout condition by displaying a code for which an explanation may be scrolled at the display with time and date stamp.

d. Information included for display shall be:

1) Compressor lockout.

2) Loss of charge.

3) Low fluid flow.

4) Cooler freeze protection.

5) Cooler set point.

6) Chilled water reset parameters.

7) Thermistor and transducer malfunction.

8) Entering and leaving-fluid temperature.

9) Evaporator and condenser pressure.

10) System refrigerant temperatures.

11) Chiller run hours.

12) Compressor run hours.

13) Compressor number of starts.

14) Time of Day

a) Display module, in conjunction with the microprocessor, must also be capable of displaying the output (results) of a service test. Service test shall verify operation of every switch, thermistor, fan, and compressor before chiller is started.

b) Diagnostics shall include the ability to review a list of the 30 most recent alarms with clear language descriptions of the alarm event. Display of alarm codes without the ability for clear language descriptions shall be prohibited.

c) An alarm history buffer shall allow the user to store no less than 30 alarm events with clear language descriptions, time and date stamp event entry.

d) The chiller controller shall include multiple connection ports for communicating with the local equipment network, the Carrier Comfort Network® (CCN) system and access to chiller control functions from any point on the chiller.

e) The control system shall allow software upgrade without the need for new hardware modules.

15) Crankcase heater failure.

e. Unit shall be equipped with safety devices including thermistors and all necessary components in conjunction with the control system to provide the unit with the following protections:

1) Loss of refrigerant charge.

2) Reverse rotation.

3) Low chilled fluid temperature.

4) Thermal overload.

5) High pressure.

6) Electrical overload.

7) Loss of any power phase.

8) Condenser fan and factory pump motors shall have external overcurrent protection.

D. Operating Characteristics:

1. Unit shall be capable of starting and running at outdoor ambient temperatures from 32°F to 125°F (0° to 52°C) for all sizes and down to -20°F with low ambient control.

2. Unit shall be capable of starting up with 95°F (35°C) entering fluid temperature to the cooler.

E. Motors:

1. Condenser-fan motors shall be totally enclosed single speed, 3-phase type with permanently lubricated bearings and Class F insulation.

F. Electrical Requirements:

1. Unit/module primary electrical power supply shall enter the unit at a single location (some chiller voltage/size combinations require two power supplies).

2. Unit shall operate on 3-phase power at the voltage shown in the equipment schedule.

3. Control points shall be accessed through terminal block.

4. Unit shall be shipped with factory control and power wiring installed.

G. Chilled Water Circuit:

1. Chilled water circuit shall be rated for 300 psig (2068 kPa) unless provided with optional pump package which shall be rated for 150 psig (1034 kPa) working pressure.

2. Thermal dispersion proof of flow switch shall be factory installed and wired.

3. Field pipe connections shall be Victaulic type with welding bevel.

H. The following accessory features shall be provided:

1. Low Ambient Head Pressure Control: Unit shall be capable of starting and running at outdoor ambient temperatures down to –20°F (–29°C) with the addition of antifreeze in the cooler circuit, wind baffles, and field-installed or factory-installed solid-state head pressure control with condenser coil minimum step capacity temperature sensor.

2. Unit-Mounted Non-Fused Disconnect: Unit shall be supplied with factory-installed, non-fused electrical disconnect for main power supply.

3. Remote Enhanced Display: Unit shall be supplied with indoor-mounted, remote, 40-character per line, 16-line display panel for field installation.

4. Minimum Load Control: Unit shall be equipped with factory (or field) installed, microprocessor-controlled, minimum-load control that shall permit unit operation down

to a minimum of 15% capacity, without use of hot gas bypass. In addition, hot gas bypass shall be provided to assure a minimum of 10% net operating capacity.

5. Energy Management Control Module

   a. A factory or field-installed module shall provide the following energy management capabilities:

   b. 4 to 20 mA signals for leaving fluid temperature reset, cooling set point reset or demand limit control; two-step demand limit control (from 0% to 100%) activated by a remote contact closure.

6. Condenser Coil Trim Panels and Security Grilles: Unit shall be supplied with factory or field-installed coil covers and painted grilles to protect the condenser coil and internal chiller components from physical damage.

7. Hail Guards: Field-installed accessory kit shall include set of metal grilles for the protection of the condensing coils from hail and general damage.

8. BACnet™ Translator Control: Unit shall be supplied with field-installed interface between the chiller and a BACnet Local Area Network (LAN, i.e., MS/TP EIA-485), and to the Johnson Controls, Inc. (JCI) N2 bus.

9. Navigator™ Hand Held Display

   a. Portable hand held display module with a minimum of 4 lines and 20 characters per line, of clear English, Spanish, Portuguese or French language.

   b. Display menus shall provide clear language descriptions of all menu items, operating modes, configuration points and alarm diagnostics. Reference to factory codes shall not be accepted.

   c. RJ-14 connection plug shall allow display module to be connected to factory-installed receptacle.

   d. Industrial grade coiled extension cord shall allow the display module to be moved around the chiller.

   e. Magnets shall hold the display module to any sheet metal panel to allow hands-free operation.

   f. Display module shall have NEMA 4x housing suitable for use in outdoor environments.

   g. Display shall have back light and contrast adjustment for easy viewing in bright sunlight or night conditions.

   h. Raised surface buttons with positive tactile response.

10. Leaving chilled fluid temperature reset from return fluid, outdoor air temperature, space temperature (requires additional sensor and the Energy Management Control Module) or 4 to 20 mA input (requires Energy Management Control Module).

11. Removable Core Filter Drier: Standard units are equipped with a removable core filter drier. An option exists for non-removable core filter driers for value engineering purposes. This option is not available with the Medium Temperature Brine option.

12. Compressor Suction Service Valve: Standard refrigerant discharge isolation and liquid valves enable service personnel to store the refrigerant charge in the cooler or condenser during servicing. This factory-installed option allows for further isolation of the compressor from the cooler vessel.

13. Suction Line Insulation: Insulation is tubular closed-cell insulation.

14. Freeze Protection Cooler Heaters: Cooler heaters provide protection from cooler freeze-up to –20°F (–29°C).

15. Service Outlets: Provides a remote service port for Navigator connection and a factory-installed convenience outlet includes 4-amp GFI (Ground Fault Interrupt) receptacle with independent fuse protection. Convenience outlet shall be 115-V female receptacle.

16. Low-Sound Compressor Enclosures: Provide sound reduction for the scroll compressors.

2.31 AIR COOLED CONDENSING UNIT

A. Furnish and install, complete and operable in all respects, an air-cooled condensing unit as detailed and scheduled in the plans. Set and install on seismically rated vibration isolators so that they are level and properly supported in accordance with manufacturers' recommendations. Capacity ratings shall be based in accordance with ARI Standard 210-240. Condensing unit shall consist of casing, compressors, condenser coil, condenser fans, motors, and unit controls including low ambient operation to -20°F. The entire assembly shall be designed in accordance with UL specifications. Units shall be as manufactured by Carrier, Trane, McQuay, York, or approved equal. Provide a minimum efficiency of 13.0 SEER. Condensing unit shall be specifically matched to the evaporator coil with regard to capacity, staging, refrigerant type (R-410a) and modulating characteristics (TXV control).

B. Casing shall have 14 gauge removable panels and a 14 gauge welded galvanized steel frame to provide complete access to compressors, controls, condenser fans and motors. Openings shall be provided for single refrigerated and single electrical connections. Condensing unit shall be shipped from factory complete as one unit, tested and calibrated, with all internal piping and wiring completed at the factory. One manufacturer shall provide these and connecting units.

C. All exposed surfaces of the unit casing shall have a phosphatized zinc clad finish for maximum paint adhesion, phenolic epoxy primer, and baked enamel. Finish applied to exposed surfaces shall be capable of withstanding 500 hour 20 percent salt spray test in accordance with Federal Test Method 6061, Standard Number 141.

D. Compressor shall be of hermetic, scroll or semi-hermetic type, 1750 RPM and designed for air-cooled condensing. Compressor lubrication shall be of the forced feed type with positive displacement reversible oil pump, crankcase sight glass, and crankcase heater where required. Backseating access valves shall be provided on suction and discharge ports. Compressor shall provide capacity control through cylinder unloading and/or using multiple compressors. Dual compressor or two-stage units shall be provided with 100% - 67% or 100% - 50% gross capacity range. Provide 90% efficiency spring isolators with 2-1/2 inch deflection. Provide 5 year compressor guarantee from the point at which the Owner receives beneficial use of the equipment.

E. Condensing unit operating and safety controls shall include high pressure cutout, low pressure cutout, oil pressure cutout, and compressor winding thermostat cutout. Three-leg compressor overload protection shall be provided. Condenser fan motors shall be protected by inherent devices providing both thermal and overload protection. Control panel shall include magnetic contactors for compressor and condenser fan motors.

F. Condenser coil shall be of seamless copper tubing mechanically bonded to heavy duty 0.010 inch plate phenolic coated aluminum fins. A liquid accumulator and sub-cooling circuit shall be included as a standard part of the condensing section. Unit shall be equipped with a backseating liquid line service access valve. Condenser coils shall be factory tested at 425 psig air pressure under water and vacuum dehydrated at 17°F. All condenser fan motors shall have permanently sealed ball bearings. Multiple fans, with separate motors for each, shall be provided. Condenser fan shall be of the propeller type with all exposed fan and shaft surfaces suitably weatherproofed and a safety guard provided. Condenser fan shall provide vertical air discharge.

G. Provide single source electrical connections with suitable fusing or breakers on duplex units. Disconnect switches are furnished under DIVISION 16. Kilowatt ratings scheduled on plans are not to be exceeded. Refer to 15500 - 2.1 and 2.2 for motor types and minimum efficiencies.

H. Provide refrigerant liquid receiver, charging ports, filter, dryer, sight glass, compressor discharge, and check valves.

I. All controls shall be contained within a weatherproof cabinet. Dual compartments shall isolate safety and operating controls from starting equipment. Control center shall include system on-off switch, compressor on-off switch, oil safety switch, high and low pressure controls, and fan cycling thermostat, control transformer, pressure relief valves, and time guard circuit to prevent compressor from starting more than every 5 minutes. Dual compressor/staged units shall have time delay relay sequenced start. Power and starting equipment for compressor and fan motors shall include solid state 3-leg overload protection, starting contactors and power terminal block.

J. The ATC Subcontractor shall furnish for approval to the Engineer a system wiring diagram which shall show complete interlocking of the compressor condenser and the automatic control system. This Subcontractor shall have complete overall responsibility for control wiring of the system including the cost of same. Wiring shall conform to requirements of Section 16000 - Electrical. The wiring shall be done to accomplish the following:

1. Air handling unit shall operate in accordance with the automatic temperature control sequence.

2. Thermostat controlled expansion valve modulates and admits refrigerant to cooling coil. Thermostat cycles the compressor run staging contactors in parallel with the valve.

3. Control relay closes and completes circuit to dual pressure control (DPC). Provide Honeywell #W7100A discharge air controller with factory supplied, field installed

discharge air sensor. Provide preventive coil frost protection for compressor unloading based on refrigerant circuit suction temperature to prevent coil frosting with minimum energy usage.

4. Provide Honeywell W973 controller with two cooling plus TXV modulation steps for all constant volume application systems. Provide with hot gas bypass capabilities.

5. When load is satisfied, TX valve closes and control relay drops out.

K. The HVAC Subcontractor shall furnish and charge the refrigeration system with refrigerant R-410a as required to obtain optimum operating conditions. In addition, a factory trained engineer shall review both the equipment and system installation, then submit written and detailed certification that the installation is proper. The HVAC Subcontractors shall make whatever changes are necessary in piping sizes and specialties to place the system and equipment in proper operating condition. A piping system isometric diagram shall be included with the shop drawing submittal complete with the manufacturer's approval.

L. Provide low ambient solid state head pressure control for winter operation to - 20° and condenser coil grille.

M. The system shall be started and commissioned by the unit manufacturer. The factory engineer shall then provide start-up service, making adjustments until the unit and related system operate correctly to the satisfaction of the Owner.

2.32 DESTRATIFICATION FANS

A. Furnish destratification fans of a style directed by the Architect. Technical operation shall be equal to those by Leading Edge, Strato Fan, Emerson or equal Model L industrial destratification fans with 650 fpm velocity with enclosed cast iron motor, impedance protected.

B. Fans shall have permanently lubricated double shields ball bearings. Furnish 3/4 inch downrods with clevis pins at all joints, rubber mountings, complete "J" hook assembly with spring steel safety clips, 48 inch U.L. power cord with grounding plug. "Vibra-tite" treated blade bolts. Furnish with extended stems as required to coordinate with field conditions, work of other trades and as may be directed by the Architect.

C. Furnish with variable speed motor 50 - 320 RPM.

D. Fans shall have sealed chrome ball bearings, be all metal construction with baked enamel finish.

E. Furnish fan speed control and on/off switch assemblies. Fans to be mounted by Division 16 at height as directed by the Architect. Controllers shall allow synchronous control of dual fans in a single room.

2.33 HEAT RECOVERY WHEEL

A. Energy Recovery Units are to be rotary air-to-air heat exchangers having an equal latent and sensible efficiency as listed in equipment schedules. The transfer media shall be non-asbestos and bacteriostatic. The rotor media shall be constructed of a corrugated aluminum treated with inorganic compound. Wheel shall be integral with AHU-2.

B. The transfer media shall not allow air flow to be radial and shall be capable of passing solids up to 300 microns.

C. The transfer media shall, when exchanging energy at the efficiency as listed in the schedule, run dry to the touch and not require a condensate drain for summer or winter operation.

D. The casing of the rotary air-to-air heat exchanger shall have a built-in purge section allowing a maximum cross contamination of particles of .2% and .04% by volume of exhaust air.

E. The unit casing shall be constructed of heavy gauge steel to insure rigidity and stability. Casing side panels shall be removable to provide easy access to internal parts.

F. Casing seals shall be provided on periphery of the rotor as well as on duct divider and purge section. Seals are to be adjustable and constructed of neoprene. Seals are to be held in place with clips fastened to stud welded bolts and compressed by a factory set and checked at installation.

G. The rotor shall be driven by a belt around the outside of the rotor powered by either a variable speed fractional HP motor. The variable speed motor is to have a 100 D.C. field winding with a 90 volt D.C. armature winding. The variations in rotor speed are to be produced by an SCR varying the armature voltage in response to signal from an airstream thermostat mounted in the supply duct sensing the temperature being delivered. The complete drive assembly shall operate on 110/1/60 service.

H. The drive motor, thermostat body and SCR power supply shall be factory mounted and wired on the side panel of the rotary air-to-air exchanger. The drive motor for variable speed operation will be a fractional AC motor.

I. The rotary air-to-air heat exchanger shall be an Enthalcorr Wheel as manufactured by The Wing Company, Cranford, New Jersey, Air Enterprises or equal.

J. Provide summer/winter changeover electronic system with thermistors and thermostat.

K. Provide duct flanges and rotation detector.

L. Provide variable speed drive and thermostat.

2.34 FAN COIL UNITS

A. Provide two-pipe fan coils. Provide vertical cabinet models and horizontal ceiling models furred-in with plenum architecturally concealed unless otherwise noted. Units based on vertical high-rise type. Equals by International, Trane, Carrier. Also Whalen (vertical high rise only). Refer to drawings and 15500-2.1 and 2.2 for motor types and minimum efficiencies. Enviro TEC HLP (horizontal concealed ducted with plenum) VFC (vertical concealed) and VH Series "Enviro-stac" vertical high rise) with powder coated baked enamel finished cabinet.

B. Quality Assurance:

1. Unit shall be tested and certified in accordance with ARI Standard 441, latest edition.

2. Base unit, without special features, shall be UL listed.

3. Each coil shall be factory tested for leakage at 100 psig air pressure with the coil submerged in water. All water coils shall be burst tested at 450 PSIG (air). All water coils shall have a minimum working pressure rating of 250 PSIG.

4. Insulation and adhesive shall meet NFPA-90-A requirements for flame spread and smoke generation.

5. All special feature equipment shall be wired and assembled in accordance with NEC requirements.

C. Vertical Console Fan Coil Equipment:

1. General

a. Factory assembled vertical console blow-thru type, cabinet model fan coil units for exposed, floor mounted installation. Unit shall be complete with water coils, centrifugal fans, motor, drain pan, filter, and all required wiring, piping, controls and special features.

2. Unit Cabinet

a. Base unit casing panels shall be constructed of 18 gauge galvanized steel.

b. Interior surfaces of casing panels shall be lined with 1/2 inch thick glass fiber insulation.

c. Cabinet shall be free-standing; constructed of cold-rolled steel; bonderized and painted with a baked, recoatable enamel finish.

d. Two tamper proof access doors and a stamped supply-air grille shall be included in the top of the cabinet.

e. Drain pan shall be constructed of 18 gauge galvanized steel, extending under the full length and width of the coils and pitched for positive drainage. The inside and outside surfaces of the pan shall be fully coated with a fire-retardant, closed-cell foam insulation. An auxiliary insulated drain pan shall be provided for jobsite installation under water valves.

f. Cabinet shall include filter track and 1 inch thick polyfiber throw-away filters. Provide a minimum rated MERV-8 filter. All controls shall be mounted no higher than 48 inch AFF to conform to ADA requirements.

D. Horizontal Fan Coil Equipment:

1. General

a. Factory assembled, horizontal, blow-thru fan coil unit for furred-in, ducted installation above the ceiling. Unit shall be complete with water coil, centrifugal fan, motor, drain pan and all required wiring, piping, controls, and special features.

2. Unit Cabinet

a. Casing panels shall be constructed of 18 gauge galvanized steel.

b. Interior surfaces of accessing panels shall be lined with 1/2 inch thick glass fiber insulation.

c. Casing shall include a 1 inch long collar for supply duct connection.

d. Drain pan shall be constructed of 18 gauge galvanized steel, extending under the full length and width of the coils and pitched for positive drainage. The inside and outside surfaces of the pan shall be fully coated with a fire-retardant, closed-cell foam insulation. An extension insulated pan (drip leg) shall be provided for jobsite installation under water valves.

e. A factory-installed plenum section shall be provided. Plenum shall enclose the fan/motor assemblies and shall be lined with 1/2 inch thick glass fiber insulation. A removable panel shall be provided for access to the fan/motor assemblies and coil valves.

E. Fans:

1. Centrifugal fans shall be directly-driven by electric motors.

2. Fan wheels shall be double-width type with forward curved blades and shall be statically and dynamically balanced.

3. Fan wheels and scrolls shall be constructed of galvanized steel.

F. Coils:

1. Unit shall be equipped for installation in a two-pipe system.

2. Coils shall have staggered 1/2 inch OD copper tubes and aluminum plate fins bonded to the tubes by mechanical expansion and shall be suitable for a working pressure of 250 psig.

3. Each coil shall have a manual air vent and sweat connections for 5/8 inch OD copper tubes.

G. Controls and Safeties for Vertical Units:

1. Unit shall be equipped with three-speed, four-position fan switch, factory installed, in the cabinet.

2. All internal wiring from motor and valves shall be in flexible metal conduit and shall terminate in a unit junction box.

3. Unit fan motors shall be equipped with integral motor protection.

H. Controls and Safeties for Horizontal Units:

1. Unit shall be equipped with a three-speed, four-position fan switch on a wall plate for field mounting on the side of the unit.

2. Unit fan motors shall be equipped with integral motor protection.

I. Operating Characteristics:

1. A two-coil unit installed in the four-pipe system shall be capable of providing sequenced heating and cooling.

J. Electrical Requirements:

1. Standard unit shall operate on 115V., 1 phase, 60Hz electric power. All internal wiring shall be in flexible metal conduit in horizontal units.

K. Motors:

1. Fan motors shall be three-speed, 115V., 1 phase, 60Hz tap wound permanent split capacitor (TWPSC) type. Motor leads shall be run in flexible metal conduit in horizontal units.

2. Motor bearings shall be of the sleeve type with oil tubes and oversized oil reservoir to ensure positive lubrication.

L. Special Feature To Be Provided:

1. For installation in a two-pipe system. Unit shall be equipped with multiple row coils to meet scheduled loads. Coil connections to be as shown on the equipment drawings and coordinated with field conditions prior to purchase.

2. Filter track and throw-away filter shall be installed in the plenum of horizontal units.

3. Extra throw-away polyfiber filters shall be furnished for field installation. In addition to the shipping filter, provide six (6) changes for the Owner's inventory and source of supply.

4. Drain pan shall include a second drain connection located above the main drain connection to act as an indicator that the main drain is plugged for the horizontal units.

5. Leveling legs shall be factory installed on the unit. Legs shall permit a maximum adjustment of 3/4 inch. The HVAC Contractor shall fasten the unit to predetermined furring channels. Channels to be provided by others.

6. Tamper-proof, positive-locking, quarter-turn fasteners shall be provided on access doors.

7. Cabinet shall be painted with the color or colors selected by the architect from the manufacturer's color chart.

8. Manual stop (ball), balancing and combination valves shall be factory furnished and installed. Provide "T" handles on ball valves to conserve space.

9. Motorized two-way valves shall be factory furnished and installed.

10. Sequenced heating and cooling thermostat shall be factory furnished for field installation for horizontal units and internally mounted for vertical units.

11. Provide automatic condensate pump units (based on Little Giant Model VCC-20 ULS) which are to be wired from the fan coil unit power wiring (complete with safety controls) for all units which the drain piping cannot be pitched to drain by gravity (a minimum pitch of 1/4 inch per foot), as shown on the Contract Documents.

2.35 VARIABLE SPEED DRIVES

A. General:

1. This specification is to cover a complete adjustable speed motor drive consisting of a pulse width modulating inverter for use on a inverter compatible NEMA Design B induction motor. The drive shall be as manufactured by Asea Brown Boveri Model ACH 550, Robicon, Graham, Toshiba, Siemens or equal. It is required that the drive manufacturer have existing sales representative, independent service organization and parts stocking depot within 100 miles to the installation site.

2. The variable speed drive(s) (VSD's) shall be solid state, complete with a pulse width modulated (PWM) output wave form, VVI, six-step, where current source drive(s) are not acceptable. Provide 18-pulse drives for all 60 horsepower drives or larger. A/C input line reactors shall not be required for 18-pulse drives. The entire VSD shall be in a NEMA 1 enclosure, completely assembled and tested by the manufacturer. The VSD enclosure shall be gasketed and all venting shall be filtered to prevent construction and general debris from entering the VSD. The VSD shall employ a full wave rectifier to prevent input line notching, DC bus choke, DC bus filter capacitors, and insulated Gate Bipolar Transistors (GBT's) as the output switching device. SCR's, GTO's and Darlington Transistors are not acceptable. The drive efficiency shall be 97% or better at full speed/full load conditions. The fundamental power factor shall be 0.95 or better at all speeds and loads.

3. All printed circuit boards shall be completely tested and burned in before being assembled into the completed VSD. The VSD shall then be subjected to a preliminary functional test, eight hour burn in, and computerized final test. The burn in shall be at 104 degrees F, at full rated load. Furnish a copy of the test standards with submittals if different from the above.

4. The VSD shall be U.L. listed. The VSD(s) shall be designed to meet the requirements of the following standards: IEC 801-2, IEC 801-4 and IEC 255-4.

5. Adaptable Electronic Motor Overload - The electronic motor overload protection shall protect the motor based on speed, load curve and external fan parameter. Circuits that protect the motor only at full speed are unacceptable.

B. Specification For Variable Speed, Variable Torque Type:

1. Input 208 VAC +10%, -10%, 3 phase.

2. Output 0-208 VAC 3 phase, 6 to 60 Hz.

3. Built-in 30 character, plain English, digital display, door mounted control interface card and protection features (viewed with door closed) shall include:

   a. Output frequency, output voltage, DC bus voltage and output amperes.

   b. Overcurrent - OC (to 200% of the VSD's variable torque current rating).

   c. Overvoltage - OV (to 130% of the VSD's rated voltage).

   d. Undervoltage - IV (to 60% of the VSD's rated voltage).

   e. Current Limit - CL

   f. Voltage Limit - VL

   g. I^2T Protection - MT

   h. Ground Fault - GF

   i. Improper input voltage selected - LO-V, HI-V

   j. Minimum and maximum speed improperly adjusted - MNMX

   k. Overtemperature - OT (heat sink temperature)

   l. Motor Speed (RPM).

   m. Elapsed Time Meter

   n. Calculated Motor Power (HP)

4. The following customer adjustments, controls and outputs must be supplied and adjusted on control interface board.

   a. Two (2) programmable critical frequency lockout ranges to prevent the VSD from continuously operating at an unstable speed.

   b. PI set point controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the VSD, using the VSD for the closed loop control, eliminating the need for external controllers.

   c. Two (2) programmable digital relay outputs. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 amps at 250 VAC. Maximum voltage 300 VDC and 250 VAC. Continuous current rating 2 amps RMS.

d. Seven (7) programmable preset speeds.

e. Five (5) programmable digital inputs for maximum flexibility in interfacing with energy management system.

f. Independent adjustable acceleration and deceleration ramps. These ramps shall be adjustable from 1 to 600 seconds.

g. Ramp or Coast to a stop.

h. One (1) programmable analog outputs to provide a 4-20mA signals linear to output frequency and output current.

i. Automatic restart after an overcurrent, overvoltage or loss of input protective trip. The number of restart attempts and trail time shall be programmed.

j. Set point mode of operation from a transducer input signal.

k. RS232 Port communication capacity must be provided for customer control and monitoring of the drive unit

l. An automatic power loss ride through circuit that will utilize the inertia of the load to keep the drive powered. Minimum power loss ride through shall be 1 cycle based on full load and no inertia.

m. An integral input line reactor to reduce the harmonics to the power line.

5. Acceptable Speed Command Inputs shall include: Where one of command inputs c or d is required - coordinate with Automatic Temperature Control Subcontractor.

a. Keypad

b. RS-485 Communications

c. Two (2) analog inputs, each capable of accepting a 4-20 mA, signal input isolated from ground and programmable via the keypad for different uses. Analog inputs shall have a programmable filter to remove any oscillation of the reference signal. The filter shall be adjustable from 0.01 to 10 seconds. The analog input shall be able to be inverted so that minimum reference corresponds to maximum speed and maximum reference corresponds to minimum speed.

d. Direct Serial Communications Bus Network compatible with the ATC Subcontractor's BMS system with complete protocol to accomplish all analog and binary I/O points.

e. 3 to 15 PSI Pneumatic Reference. Connector on bottom of VSD to allow direction of pneumatic tubing to drive without the use of external pressure to electric transducers (optional).

6. The drive shall have the ability to start into a rotating load (forward or reverse) and accelerate or decelerate without safety tripping or component damage. The VSD(s)

shall include the option of either (1) displaying a fault or (2) running at a preset speed if the input reference is lost. A choice of one of the following start/stop commands shall be required (coordinate with ATC Subcontractor):

a. Three wire start/stop with built-in holding contact.

b. Closure of a contact or switch.

c. Application and removal of input power.

d. Application and removal of 115 VAC on-off signal.

7. Accessories to be furnished and mounted by the drive manufacturer and contained in a single enclosure. (The use of more than one enclosure is not acceptable.)

a. Prewired three position Hand-Off-Automatic switch and manual speed potentiometer.

b. Door interlocked disconnect. (Pad lockable in off position.)

c. Manual three contactor transfer to line power including Class 20 bimetal motor thermal overload relays and fuse protection while in bypass operation. Refer to Paragraph 2.2 of this Specification for other starter requirements. Provide reduced voltage starter where indicated in this paragraph.

d. Service switch which provides the ability to service the controller (electrically isolated) while in bypass operation without having to remove power to the motor.

e. Customer Interlock Terminal Strip - provide a separate terminal strip for connection of fire, smoke, freeze contacts and external start command. All external interlocks and start/stop contacts shall function with the drive in hand, auto or bypass. Provide isolated power for the control circuits.

f. Input line fuses.

g. Output line reactor (3%) to extend the life of the motor and to protect the VSD upon motor failure.

8. A/C Input Line Reactors

a. Provide an A/C input line reactor for all six-step VSD's which shall be sized and provided by the VSD manufacturer to ensure compliance with IEEE Standard 519-1992, Guide for Harmonic Control and Reactive Compensation for Static Power Converters. The VSD manufacturer shall provide calculations, specific to this installation, showing that the total harmonic voltage distortion is less than 5%. Input reactors shall be "Sine Guard", manufactured by TCI, Milwaukee, WI or equal. The harmonics of the drive(s) shall pass New England Power Services guide lines (furnished upon request).

b. Provide a Harmonic trap filter, "Harmonic Guard" as manufactured by TSI or equal for all VSD's controlling 75 horsepower motors or larger. The HVAC Subcontractor shall provide all interlock wiring between the drive and Harmonic trap filter.

9. Service, Parts, Warranty and Approval

a. Start-up service performed by a factory approved and certified technician. To be included with this service, for a period of 12 months after initial start-up, is a full parts and labor ON SITE warranty at NO ADDITIONAL COSTS.

b. A two-year parts warranty must be provided.

c. The drive is to be manufactured in the USA.

d. Independent lab testing label must be provided. ETL, CSA, UL or FM approval are acceptable.

e. The VSD(s) shall have a programmable carrier frequency range of 1 KHZ to 12 KHZ. The Carrier frequency shall be adjustable by the start-up engineer on all units to be optimized for sound on each specific application.

10. Compliance to IEEE-519

a. Three phase A.C. input line reactors shall be provided. The line reactor is to provide attenuation of line side voltage transients, thus preventing overvoltage trips or other unnecessary VSD shutdowns and provide a reduction in harmonic current distortion. Line reactors shall be housed inside the drive enclosure and shall be as manufactured by TCI of Milwaukee, WI and must meet the following requirements: provide a minimum of 5% line impedance, have a saturation rating which is no less than 2.5 times the continuous current rating, and be U.L. recognized.

b. The VSD manufacturer shall provide calculations specific to this installation showing that total harmonic distortion reflected into the electrical distribution system is limited to the level defined by IEEE-519 (1992 edition) for general systems. Harmonic analysis shall be included with VSD submittal for approval by the Engineer.

c. VSD manufacturer shall conduct on site Harmonic measurements before and after start-up of the VSD's. Results of the measurements showing harmonic contribution of VSD's shall be provided to the engineer one month after start-up.

2.36 AUTOMATIC PROPYLENE GLYCOL FEED SYSTEM

A. The hot and chilled water systems shall be filled with a brine solution of 40% by volume part inhibited propylene glycol. Anti-freeze shall be Dow "Dowfrost HD", Noble "No-Burst 100" Union Carbide UCAR-17 or Monsanto inhibited propylene glycol. The Contractor shall account for the actual amount of propylene glycol content in the undiluted antifreeze solution due to corrosion inhibitors and other additives which will require a higher percentage solution of the antifreeze product. The mixture shall be thoroughly mixed in a separate container before it is put into the system. Connections to the tanks from the main headers shall be with four-ply braided rubber hose having a burst pressure of 360 psi. A full-flow valve shall be included in the supply and return lines of each tank on the system side of the removable flexible connector. System leak protection shall be provided by liquid level and/or pressure switches in the expansion tank. All tank bottoms shall be level, supported over their entire area, and insulated from their supporting surface with insulation supplied by the tank manufacturer. All system piping shall be insulated with 2 inches of insulation.

B. The HVAC Subcontractor shall furnish and install a completely preassembled packaged glycol mixture feed system, as manufactured by Axion Industries Neptune Chemical Pump Company, Wingert, Pulsafeeder or approved equal.

C. The chemical transfer pump shall be a Axion SF100-HP with construction compatible with glycol mixture as specified. The pump shall be a positive displacement piston pump with a capacity of 78 gph against a pressure of 85 psi minimum. Power shall be furnished by an electric motor operating through a flexible coupling to an extra heavy duty gear reducer. The gear reducer output shaft shall be at least 3/4 inch in diameter; the gear reducer shall also have an input horsepower rating in excess of the drive motor. The piston crosshead shall be bearing bronze (case hardened steel crossheads are not acceptable). The connecting rod bearing must be of the uniball type with grease fittings; bronze sleeve bearings, (bearing bushing combinations are not acceptable). The pump packing shall be preset at the factory and shall be spring loaded; adjustable packing glands are not acceptable. Stroke adjustment shall be manual with the pump stopped and adjustment shall be made through a control switch.

D. The pump motor shall be a drip proof 1/6 HP, 0.9 amperes, 120 volt/1 phase/60 Hz./1750 rpm. The pump shall be energized automatically through a pressure switch which shall start the pump on a fall in pressure in the glycol system.

E. The chemical feed tank shall be 48 gallons volume fabricated of polyethylene mounted in a steel frame. The pump platform shall be an integral part of the tank. The tank shall include hinged cover, bronze strainer, having a 60 mesh monel screen, and a suction valve. The tank shall also be provided with a clear, nylon reinforced PVC suction piping; rigid steel piping is not acceptable. A pressure relief valve, with a single spring range of 50 to 500 psi, shall be provided, and shall be piped into return with clear, nylon reinforced PVC tubing. The tank shall be completely prepiped to the suction side of the proportioning pump.

F. Provide a 55 gallon drum of glycol in the Mechanical Room after the initial system fill in addition to the automatic feeder. The glycol drum shall be fitted with a hand pump to hand feed the main tank.

G. Provide a liquid level switch and pump shutoff control and alarm. Monitor the liquid level in the tank and shut the pump off when the level in the tank reduces to 20%. An audible alarm (Axion RIA-10-1) shall be provided with this control and shall be prewired to the pump control at the factory.

H. Provide in the close-out documents, the exact amount of propylene glycol used to fill each hydronic system.

2.37 EXISTING HV AND HVAC SYSTEMS CLEANING

A. General: The Air Duct Cleaning Subcontractor shall provide all labor, materials and equipment to thoroughly clean all the existing, (reused) heating, ventilating and air conditioning systems in accordance with the herein listed applicable documents and as shown on the drawings.

B. Cleaning: The Subcontractor shall clean all interior surfaces of ductwork and internal associated equipment in accordance with applicable documents. Any and all inaccessible areas must be reported in writing prior to project completion and must be approved by the Architect.

C. Cleaning Methodology: Any method used must be employ source removal only. Under no circumstances will adhesives, encapsulates or any other foreign substances be applied to non-porous ductwork interior without source removal operations first taking place and written authorization given by the Architect (i.e., detergents, biocides).

D. Sanitizers: Any sanitizers, disinfectants or fungicides used subsequent to the cleaning process must be EPA registered.

E. Biocides: All sanitizing and biocidal treatments to be performed in accordance with ACGIH Guidelines. Biocides will only be used after thorough source removal.

F. Inspection: The Subcontractor shall visually inspect the vent ductwork services for corrosion, rust, holes, split seams, defective joiner flanges and defective closure fittings.

G. Report: The Air Duct Cleaning Subcontractor, together with the HVAC Contractor, shall submit to the Architect a written report of the results, with recommended repairs as required, within 24 hours of inspecting all ductwork (internal and external), surfaces and closure fittings, coils, pipes, valves or components located within the ductwork services.

H. Applicable Documents:

EPA 400-1-91-033 Building Owners and Managers Guide for Building Air Quality

NADCA 92-01 mechanical Cleaning of Non-Porous Air Conveyance System Components

NFPA 90A Air Conditioning Systems

NFPA 90B Warm Air Heating and Air Conditioning

ASHRAE 52-76 Air Cleaning Devices

ASHRAE 62-89 Ventilation for Acceptable Indoor Air Quality

SMACNA Construction Standards

NAIMA Cleaning Fibrous Glass Insulated Air Duct Systems

AIA Hospital and medical Facilities Guidelines

ACHIH Bio-Aerosols Guidelines

I. Quality Assurance:

1. Trained Personnel: For all vent cleaning work items, the Subcontractor shall demonstrate that workers are completely trained and adequately supervised to ensure the cleaning and inspection requirements outlined herein are carried out in accordance with this standard specification. This Subcontractor shall:

a. Note and take action to safeguard Subcontractor personnel against any health hazards that may occur during the performance of the work items described herein.

b. Provide the Architect with 72 hours advance written notice of each pending inspection.

2. Failure Responsibility: If any cleaning or inspection fails to meet the requirements herein, the Subcontractor shall:

a. Certify that all deficiencies have been corrected and withhold acceptance of any portion of work until the Architect, during reinspection, accepts the corrective action.

3. Required Inspections: Inspections required herein are the minimum required and are not intended to supplant any controls, examinations, inspections or tests normally employed by the Subcontractor to ensure the quality of services provided.

J. Additional Requirements:

1. Lockout/Tagout: This Subcontractor must possess, employ and enforce lockout/tagout procedures.

2. Confined Space Entry: This Subcontractor must possess, employ and enforce a confined entry policy. Maintain a written log on-site, available for Architect's periodic review.

3. Respiratory Protection: This Subcontractor must possess, employ and enforce a respiratory policy in full accordance with OSHA requirements.

a. All materials used must be registered for the application for which they are to be used and/or meet the same criteria as materials commonly used in the application. Refer to EPA, UL, ASTM and NFPA Standards.

b. All materials which possess health and safety threats must be accompanied with MSDS information.

c. Final evaluation and testing will be performed in accordance with NADCA Standard 1992-01 by an AIHA accredited laboratory.

K. Final Acceptance:

1. Final acceptance will occur with the duct system completely assembled and all vent system related components are in place and operational.

2. Final acceptance when biocide is used shall be done with the system completely assembled but clearances for cleaning quality via the NADCA Standard need to be performed prior to spraying a biocide while access panels are still placed in temporarily. The following reasons apply:

   a. To make sure the system is clean enough before coating it.

   b. The Contractor will have only a few screws in place on the access panels until the project's done and can be fully screwed in for the long term.

2.38 ELECTRICAL HEAT TRACING FOR PIPELINES

A. Furnish and install a complete UL listed system of heaters, components, and controls to prevent pipelines from freezing.

B. Products:

1. The self-regulating heater shall consist of two (2) 16 AWG tinned-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heater to be crossed over itself without overheating, to be used directly on plastic pipe, and to be cut to length in the field. The heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket.

2. For installation on plastic piping, the heater shall be applied using aluminum tape (AT 180). To provide a good ground path where none exists and to enhance the heater's ruggedness, the heater shall have an outer braid of tinned-copper and an outer jacket of modified polyolefin (-CR).

3. In order to provide energy conservation and to prevent overheating, the heater shall have a self-regulating factor of at least 90 percent. The self-regulation factor is defined as the percentage reduction, without thermostatic control, of the heater output going from 40°F pipe temperature operation to 150°F pipe temperature operation.

4. The heater shall operate on line voltages of (select: 120, 208, 220, 240, and 277) volts without the use of transformers.

5. The heater shall be sized according to this table. The required heater output rating is in watts per foot at 50°F.

Pipe Size	Minimum Ambient - 10°F	Temperatures - 20°F
3 inch or less	5 watt	5 watt
4 inch	5 watt	8 watt
6 inch	8 watt	8 watt
8 inch	2 strips - 5 watt	2 strips - 8 watt
12 inch to 14 inch	2 strips - 8 watt	2 strips - 8 watt

6. The heater shall be XL-Trace as manufactured by Raychem Corporation or approved equal.

7. Power Connection, end seal, splice, and tee kits components shall be applied in the field.

8. The system shall be controlled by a switch either directly or through an appropriate contactor.

9. The system shall be controlled by a bulb-sensing thermostat (choose: AMC-1B or AMC-F5) set at 40°F either directly or through an appropriate contactor.

10. The system shall be controlled by an ambient sensing thermostat (choose: AMC-1A or AMC-F5) set at 40°F either directly or through an appropriate contactor.

C. Installation:

1. Apply the heater linearly on the pipe after piping has been successfully pressure tested. Secure the heater to piping with cable ties or fiberglass tape.

2. Apply "electric traced" signs to the outside of the thermal insulation.

D. Tests:

1. After installation and before and after installing the thermal insulation, subject heat to testing using a 2500 VDC megger. Minimum insulation resistance should be 20 to 1000 megohms regardless of length.

PART 3 - EXECUTION

3.1 CUTTING, PATCHING AND CORE DRILLING

A. Refer to the General and Supplementary Conditions and DIVISION 1.

B. Provide notification in time to other trades of openings required for Mechanical Work. Supply accurate details of location and size. When this requirement is not met, bear the cost of cutting and patching.

C. All cutting and patching required for the installation of the HVAC work shall be provided by the General Contractor.

D. Obtain written approval of Structural Engineer before cutting any openings through structural members.

E. All core drilling required for the installation of the HVAC systems shall be done by this HVAC Subcontractor. This Subcontractor shall carry all costs for core drilling. The General Contractor will not be responsible for any circular penetrations required for the proper installation of the HVAC systems. Locate all required openings and, prior to coring, coordinate the opening with the General Contractor and all other trades. Do not disturb existing systems. Thoroughly investigate the existing conditions in the vicinity of the required opening prior to coring. This Subcontractor shall be responsible for damage to the building and its systems from the coring operation. Disturbances from coring shall be kept to a minimum.

3.2 CONNECTIONS TO EQUIPMENT

A. Provide unions or flanges at all connections to equipment. Ensure that piping adjacent to equipment is readily removable for servicing and/or removal of equipment, without shutting down the entire system.

B. Install unions in piping up to and including 2 inch pipe size. Install flanges in piping 2-1/2 inch pipe size and larger.

C. Prevent galvanic corrosion by isolating copper and steel. Use bronze-bodied valves at all of these interfaces.

3.3 PROVISIONS FOR PIPE EXPANSION

A. Make provision for pipe expansion and contraction with suitable anchors and offsets or expansion loops. If a mechanically coupled piping system is utilized, use bona-fide flexible couplings equal to Metraflex "Metraloop" or expansion loops.

B. Install piping to allow freedom of movement in all planes without imposing undue stress on any section of the main piping, branch piping, equipment and structure.

C. Use offsets at takeoffs to radiation, unit heaters, risers and other branch lines.

D. Select expansion joints for the calculated movement according to the following temperature ranges:

1. For cold pipes, from minimum operating temperature to 100 degrees F., plus 25 percent safety factor.

2. For warm and hot pipes, from minimum ambient, but not higher than 0 degrees F., to maximum operating temperature, plus 25 percent safety factor.

3. When ambient temperature during installation is higher than operating temperature, use precompressed expansion joints.

4. Expansion joints shall be selected to withstand system test pressure, as well as operating pressures and temperatures.

5. Install expansion joints in accordance with manufacturer's published installation instructions.

6. Refer to Drawings for operating temperature of system.

E. Where shown on the Drawings, and where space limitations do not permit the use of expansion loops or offsets, use Flexonics Expansion Joints according to the following schedule:

1. For piping up to and including 2-1/2 inches, select ends to suit specified pipe fittings. Pressure shall be external to the bellows:

   a. Steel Piping - Metraflex Metraloop MLT Expansion Compensators with two-ply stainless steel bellows. Use on other than fin tube radiation.

   b. Copper Piping - Metraflex Metraloop MLS Compensator with two-ply bellows, all bronze construction.

2. For piping 3 inches and above, use flanged ends.

   a. Steel Piping - Metraflex Metraloop MLF - Flexing Expansion joint with stainless steel pressure carrier, flanged ends type MLG for grooved piping.

   b. Copper Piping - Metraflex Metraloop MLS - Flexing Expansion Joint with Monel pressure carrier, and brass flanged ends.

   c. Refer to Drawings for additional details.

3.4 PIPE GUIDES AND ANCHORS

A. Provide pipe guides for expansion joints according to expansion joint manufacturer's published recommendations. Use at least two guides each side of expansion joint or expansion loops.

B. Install manufacturer or field fabricated alignment guides to allow movement in axial direction only. Install vertical risers properly anchored and guided to maintain accurate vertical position of piping. At time of start-up, clean and lubricate guides, and adjust to allow free sliding at operating conditions.

C. For piping up to and including three (3) inches, guide pipes at every floor or every thirteen feet. Guide larger pipes at every second floor or every twenty-five feet.

D. Fabricate anchors from structural steel channels, plates or angles secured to the structure.

E. Take care to avoid introduction of excessive reactive forces and operating weights into the structure and onto equipment and piping.

F. Provide thermal break on guides and anchors used for cold piping.

G. Prepare and submit for review, prior to installation, drawings showing the location of expansion joints and anchors. Show details of proposed connection to structure.

H. Prior to installation, the magnitude of reactive forces and operating weights on the structure shall be approved.

3.5 INSERTS

A. Properly locate and firmly secure inserts to form before concrete is poured.

B. Where inserts must be placed after concrete has been poured, use self-drilled expansion anchors where approved by Structural Engineer, such as Hilti Drop-in Anchor or Hilti KBII Anchor.

C. Place inserts only within main structure and not in any finishing materials. Do not hang items from Terra-Cotta.

D. When inserts are required in precast concrete, supply inserts and location drawings to the precast concrete supplier for casting into the material. Otherwise, include the cost of having the precast concrete supplier install inserts at the site.

E. Use wedge type concrete inserts, similar to Grinnell Fig. 281, for duct, pipe and equipment hangers, supports and anchors, adequately sized for loads to be carried.

F. If inserts cannot be placed in formwork, Hilti torque-controlled expansion anchors or Hilti HIT-T2 anchor rod (with Hilti HY-150) or equal may be used where approved by the Structural Engineer. Inserts in the new construction areas shall be approved by the Structural Engineer.

3.6 HANGERS

A. Suspend piping, ductwork and equipment with all necessary hangers and supports required for a safe and workmanlike installation. Ensure that pipes are free to expand and contract and are graded properly, and that each hanger is adjusted to take its full share of the weight.

B. Suspend hanger rods directly from the structure or slab where allowed by the Structural Engineer. All piping 4 inch and larger shall be hung from the structural steel only and not directly off the slab. Do not suspend rods from pipes, ducts, equipment, metal work, or ceilings.

C. Furnish and install auxiliary structural steel angles, channels and beams where ductwork, piping and equipment must be suspended between joists or beams.

D. Hangers shall be spaced to ensure that structural steel members are not overstressed. In no case shall pipe hangers be further apart than indicated in the tables. When requested, submit detailed drawings showing locations and magnitude of ductwork, piping and equipment loads on the structure.

E. The use of trapeze-type hangers for support of piping shall be subject to prior acceptance. Where permitted, fabricate from angle or channel frames and space hangers to suit the smallest pipe size.

F. Do not use hooks, chains, or straps to support equipment, piping or materials.

G. For precast concrete work, if inserts cannot be cast into members, pass hanger rods between the members and weld to steel plate resting on the upper surface of the precast interval or use drilled-in anchors that have been tested in similar precast concrete material. Drilled-in anchors shall be by Hilti, Inc. or approved equal. To prevent raising of the hanger rod, apply a lock nut and two (2) inches minimum diameter slot washer tight against the upper surface of the precast material.

H. Ensure that copper materials are completely isolated from ferrous materials. Use either plastic coated hangers and clamps, or use lead inserts between copper piping and ferrous materials, and between copper piping and copper-coated ferrous materials.

I. All hangers shall have provision for adjustment. Hangers and rods in equipment rooms shall have a prime coat of rust inhibitive paint or cadmium coating.

J. Use round steel threaded rods, which shall conform to ASTM Spec. A-36. Sizes shall be not less than the sizes shown in the tables.

K. The following tables establish minimum standards of rod sizes and hanger spacing.

1. For steel piping refer to the following table:

Pipe Size	Maximum Horizontal Spacing of Supports (feet)	Rod Size (inches)
1/2	5	3/8
3/4	6	3/8
1-0	7	3/8
1-1/4	8	3/8
1-1/2	9	3/8
2-0	10	3/8
2-1/2	11	1/2
3-0	12	1/2
4-0	14	5/8
5-0	16	5/8
6-0	17	3/4
8-0	19	7/8
10-0	22	7/8
12-0	23	7/8
14-0	23	1
18-0	23	1
24-0	23	1

2. For copper pipes, refer to the following table:

Pipe Size	Maximum Horizontal Spacing of Supports (feet)	Rod Size (inches)
1/2	5	3/8
3/4	6	3/8
1-0	6	3/8
1-1/4	7	3/8
1-1/2	8	3/8
2-0	9	3/8
2-1/2	10	1/2
3-0	10	1/2
4-0	12	5/8
5-0	13	3/4

L. In addition to these basic requirements, furnish and install hangers in the following locations.

1. Where required to eliminate vibration. Refer to applicable articles of the Specifications under SOUND AND VIBRATION CONTROL AND SEISMIC RESTRAINT SYSTEMS including item 15500 - 2.28 N and O.

2. At points of vertical and horizontal change in direction of pipe.

3. At valves and strainers.

4. On piping mains at branch takeoffs.

5. Where required to avoid stress on equipment connections.

M. Refer to applicable articles of the Specifications regarding thermal insulation requirements. Unless shown specifically on Drawing Details, conform to the following methods of support:

1. For insulated warm, (up to 210 degrees F), and uninsulated piping, attach hangers directly to the piping, except as noted for roll hangers provide protection shields to prevent crushing of insulation.

2. For domestic cold water, chilled water, chilled/glycol, condenser water, heat pump where insulated, steam piping, hot piping above 210°F and refrigerant piping, hangers shall be large enough to fit over specified pipe covering. At each point of support, use galvanized insulation protection shields, similar to Grinnell Fig. 167, with sufficient length to prevent crushing of insulation.

N. Install spring hangers or other special supports as specified in applicable articles of Sound and Vibration Control and Seismic Restraint Systems.

O. Ductwork shall be supported as per SMACNA guidelines.

P. Support vertical duct risers at each floor with rolled angle collars bearing on building structure.

Q. Provide specified inserts or Grinnell Fig. 229 or 292 beam clamps which shall have extended collars such that hanger rod can be removed in future without disturbing fireproofing over beam flange. Clamp the rod assembly at beam.

R. Do not use inserts in existing buildings unless approved by the structural engineer. All equipment, sheetmetal and piping must be supported from existing beam flanges with beam clamps or supplemental steel as approved by the structural engineer.

S. Pipe riser clamps shall be similar to Grinnell Fig. 261 for steel piping, and similar to Grinnell Fig. 261C- 121C (plastic coated) for copper piping. Set clamps on adequately sized bearing plates.

T. For other types of piping, such as plastic transits, or those which have mechanical joints or fused or packed joints, supports shall be selected and spaced according to the pipe manufacturer's published recommendations or be supported continuously, if necessary, to prevent sagging.

U. Standard pipe hangers shall be similar to:

Piping Material	Finished Installation or Bare Pipe Size	Hangers
Steel	to 3 inch	Grinnell Fig. 286 adjustable wrought iron.
Steel	4 inch up to 6 inch	Grinnell Fig. 286 adjustable wrought clevis
Copper	to 4 inch	Grinnell Fig. CT-99C (plastic adjustable wrought ring.)

V. For steel piping 8 inch and larger suspended from above, use single pipe rolls similar to Grinnell 171. For piping supported from below, use adjustable pipe rolls, similar to Grinnell Fig. 271. In conjunction with roll type supports, use protection saddles similar to Grinnell Fig. 160, and Fig. 167 for insulation protection.

W. Conform to applicable items within 15500 - 2.28 SOUND AND VIBRATION CONTROL AND SEISMIC RESTRAINT SYSTEMS.

X. All hanger rods installed in pipe tunnels or areas with less than 7 feet-0 inch from bottom of hanger rod to floor shall have rods cut back to eliminate protruding rod ends. Cut off ends of existing rods.

3.7 WIRING

A. Where wiring is to be provided under SECTION 15500 including PART 4 - AUTOMATIC TEMPERATURE CONTROLS, it shall conform to the requirements of DIVISION 16, ELECTRICAL of the Specifications.

B. Install wiring materials parallel and perpendicular to building planes. Identify materials parallel to building planes. Identify as per DIVISION 16 Specifications.

C. Conduit and wiring materials shall be provided in strict accordance with the requirements of DIVISION 16, ELECTRICAL.

3.8 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 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. This shall include surfaces behind grilles provided by others to which sheetmetal connects.

F. Prime coat material shall conform to SECTION 09901 - PAINTING of this Specification.

G. Finish painting will be carried out by SECTION 09901 - PAINTING of this Specification.

3.9 SLEEVES, WALL PLATES, FLOOR PLATES

A. Set sleeves for piping and ductwork in conjunction with erection of floors and walls. Locate sleeves accurately and in accordance with Shop Drawings. Comply with 15500 - 2.28 H and O. Sleeves shall also be provided when new piping and ductwork penetrates existing floors and/or walls.

B. Size sleeves to provide 1 inch clearance around piping and ductwork, and to allow continuous runs of insulation where specified. Ensure that piping and ductwork do not touch sleeves.

C. Firestop all sleeves and penetrations through fire rated construction with a Through Penetration Firestop System that has been tested in accordance with ASTM E-814 "Standard Method of Fire Tests of Through Penetration Firestop". The test shall be documented by an independent test agency such as UL, Omega Pont or another approved test agency. The installed Through Firestop System shall provide an "F" and "T" rating where applicable, at least equal to the assembly being penetrated. The installed system shall be capable of preventing water from passing through. The HVAC Subcontractor shall submit manufacturer's product information and UL numbers for each type of through penetration that is made. If no UL system exists for an application, submit an Engineered Judgement Drawing prepared by the manufacturer's Fire Protection Engineer. The Engineered Judgement Drawing shall indicate the name of the project, contractor, and UL system number that is closest to the application.

D. Piping sleeves shall be according to the following:

1. Through interior walls, use 18 gauge rolled and tack welded galvanized steel sleeves, set flush with finished surfaces on both sides. Refer to Room Finish schedule.

2. Through exterior walls above grade and roofs, use machine cut and reamed standard weight steel piping, set flush with finished surfaces on inside and to suit flashing on outside.

3. For floors in mechanical equipment rooms, and similar areas where a water dam is required to avoid pooling water from leaking through the floor slab, use machine cut

and reamed standard weight steel piping set flush to underside of structure and extending 6 inches above finished floor or use a cast-in-place firestop device with an integral water seal gasket such as Hilti CP 680 or CP 682, set 6 inches above finish floor. Water dams (for both ductwork and piping) are required at all floor penetrations where the floor is pitched to a floor drain. Water dams are also required at all piping floor penetrations where terminal equipment is being connected to with concealed piping such as finned tube radiation, unit ventilators, fan coil units, floor mounted air conditioning units, etc.

4. For other floors, use 18 gauge rolled and tack welded galvanized steel, or standard weight steel piping set flush to both finished surfaces. For fire-rated floors, use a cast-in-place firestop device such as Hilti CP 680 or CP 682 that has been tested in accordance with ASTM E-814.

5. Refer to drawing details for sleeving through below grade walls.

6. Cover pipe sleeves in walls and ceilings of finished areas other than equipment rooms with satin finish stainless steel, or satin finish chrome or nickel plated brass escutcheons, with non-ferrous set screws. Do not use stamped steel split plates. Split cast plates with screw locks may be used.

E. Duct sleeves shall be minimum 18 gauge galvanized steel. Provide adequate bracing for support of sleeves during concrete and masonry work. For fire rated floors and walls, build fire dampers into structure to attain fire rated construction, in a manner acceptable to the Local and State authorities.

F. Cover exposed duct sleeves in finished areas with 18 gauge galvanized steel plates in the form of duct collars. Fix in position with non-ferrous metal screws.

G. Prepare and submit detailed drawings showing accurate size and spacing of sleeves. Submit for review at least four weeks before installation.

3.10 FLASHING AND CURBS

A. Curbs, except pre-manufactured roof curbs, required for Section 15500 work and shown on the Structural or Architectural Drawings, will be provided under other Divisions of the Specifications. Pre-manufactured curbs furnished under Section 15500 shall be installed by the Contractor under applicable Sections.

B. Other curbs required for Section 15500 work, including reinforcing steel, will be provided by others at the expense of SECTION 15500 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 floors. Provide roof curbs which will correct for any pitch the roof may have to enable mounting of roof equipment level except where denoted otherwise.

D. Roof curbs shall be minimum 18 inches height above finished roof. Refer to Drawings for specific requirements exceeding this minimum.

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

F. Fill spaces between curbs and pipes and ducts with thermafibre firestopping. Caulk with fire resistant waterproofing compound, Flintguard 120-13 or equal, to provide a watertight connection.

G. Flashing will be carried out under Roofing Contract for roof curbs shown on the Architectural or Structural Drawings.

H. Provide flashing for pipe openings or pre-manufactured roof curbs.

I. Carry out all counterflashing for pipes and ducts passing through roof. Fit counterflashing over flashing or curb. Pitch pockets are not acceptable.

3.11 CONCRETE

A. Concrete work required for Section 15500 work and shown on the Structural or Architectural Drawings, will be carried out under SECTION 03300 - CAST-IN-PLACE CONCRETE.

B. Other concrete work required for Section 15500 work, including reinforcing steel, and concrete required for inertia pads bases, will be carried out under SECTION 03300, at the expense of the HVAC Subcontractor in accordance with Section 03300.

C. Supply and set in position floating reinforced concrete inertia bases, which are specified under Sound and Vibration Control and Seismic Restraint Systems.

3.12 LINTELS

A. Supply all reinforcing steel or structural steel required over openings required solely by HVAC Subcontractor and not shown on Architectural or Structural Drawings.

B. Ensure that openings are formed in accordance with Architectural and Structural requirements before installation of mechanical work.

3.13 STEEL

A. Steel required for Section 15500 work, and not shown on Structural or Architectural Drawings, shall be supplied and installed by the HVAC Subcontractor.

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 curvature to match exactly the equipment. Other equipment shall be supported continuously.

D. Steel supports exposed to weather or in contact with water or humidity conditions shall be either hot-dipped galvanized after fabrication (all welds shall be ground and brushed clean) or fabricated from materials having approved corrosion resistance.

E. Refer to SOUND AND VIBRATION CONTROL AND SEISMIC RESTRAINT SYSTEMS - 15500 paragraph 2.28 of the Specifications. Mechanical Trade shall insure that equipment is sufficiently rigid for point supported by specified isolators. Provide auxiliary structural steel supports if required.

3.14 SYSTEM BALANCING AND TESTING OF EQUIPMENT

A. Before and during initial occupancy of the building, completely balance all air, water and control systems to conform to specified quantities and to the intent of the design of the mechanical system. Balance existing systems to values noted on drawings.

B. Work shall be performed by a fully qualified and experienced System Balancing Technician. This technician shall be named in the shop drawing submission together with a summary of his qualifications. The technician shall spend full time on the job supervising and directing the work listed below.

C. Obtain, pay for, and supply to the technician, a complete set of HVAC Drawings. Supply to the technician certified performance data for all equipment.

D. For specified test openings, refer to SHEETMETAL. Provide additional openings required for pitot tube traverses. Openings shall be closed using removable gasketed plugs.

E. Air balances shall be initiated by accurate fan capacity tests including for each fan system, a pitot tube traverse, static pressures across the fan, fan BHP and RPM. Cross check each set of readings with manufacturer's fan curves. Take into account condition of filters and, if necessary, adjust fan speed to suit system design requirements.

F. Following this, the required number of distribution air balances shall be carried out, and adjustments made in order to obtain required terminal air flows within + 5%. At least one additional fan capacity test shall be carried out as described above, after the distribution balance has been carried out. All air systems shall be balanced with outside air dampers in their normal minimum position. Test all modes of operation.

G. Where similar or typical conditions exist, submit for review, simplified checking procedures for portions of the balancing work. These procedures may be accepted if proposed procedures do not decrease the quality of the air balance.

H. Water balance shall be initiated by checking each pump BHP, and suction and discharge pressures, and pressure drops across rated equipment (e.g. chillers, unit heaters, coils, etc.).

I. Where necessary to obtain design flows, impeller diameters will be altered. Water distribution shall be checked and adjusted to all equipment by means of measuring air on and off conditions at coils and for water temperature change entering and leaving coils. Procedure shall be governed by good practice and field conditions in order to obtain design flows within + 5%.

J. Control balance shall be initiated by checking, calibrating and recording the operating and sensitivity of all controls under all operating conditions.

K. Check and record air and water supply temperatures at source and at end of each system. Check and record each unit discharge air temperature with thermostat set midpoint, maximum and minimum. Correct deficiencies and record results. This procedure shall be carried out with system on all cycles.

L. Check safety controls and record control sequence. Check freezestats using ice water. Check flow switches to ensure proper interlocking of equipment.

M. Air temperature on and off coils shall be checked and recorded on 3 feet X 3 feet grid at not less than three (3) different supply water temperatures or flow quantities. Water temperatures entering and leaving coils and where practicable, pressure drops shall be recorded.

N. Scheduled air and water control, and changeover controls shall be checked and operation recorded by simulating complete operating cycle.

O. After all systems have been balanced satisfactorily, mark final positions of dampers and valves. Submit a report in triplicate for checking, along with one copy of the requested balances required to obtain final results. This report shall contain the following:

1. Suction and discharge pressure gauge readings and water flow (GPM) for each pump.

2. Pump curve for each pump showing plotted design conditions, and field conditions.

3. Water on and off temperature at each major piece of equipment such as boilers, chillers, heat exchangers, towers, and coils. Heating systems must be balanced after November 1st and before March 1st. Cooling systems must be balanced simulating the hydronic flow conditions of the summer months.

4. Detailed summary of velocity traverses and calculated air quantities for each fan, unit ventilators, fan coil units and fans that comprise fan powered VAV terminal units.

    a. All unit ventilators minimum and maximum outside air quantities shall be tested, balanced and reported.

5. Fan curve for each fan showing plotted design and field conditions.

6. Static pressure readings across filter banks, coil banks of each air handling system, showing design and actual readings.

7. Measured suction, discharge and total static pressure for each fan using pitot tube measurement.

8. Summary showing design and actual CFM from each low pressure outlet, complete with description of the method used to obtain same.

9. Outside air, on and off coils, and terminal air supply temperature for each air handling system and all unit ventilators.

10. Rated and actual motor current, in amperes, of every motor at full load conditions.

11. Schematics for all systems with all outlets numbered or "marked-up" sepia with same information.

12. When directed, make capacity test of equipment. Tests for heating and cooling shall be made at different times of the year.

13. Complete report on smoke exhaust system operation and any system, connected to emergency power, verifying that they perform as per design.

14. All minimum outdoor air quantities and assembly minimum outdoor air quantities shall be verified in conjunction with the ATC Subcontractor to ensure minimums (fresh air minimum flow takes priority) are attained in all air handling systems and unit ventilator systems. Provide verification of this cooperative procedure within the context of the Balancing Report by way of a dated, signed document by the ATC Sub-Subcontractor.

P. As part of this contract the HVAC Subcontractor shall make any changes in belts, pulley, damper and add any dampers required to provide a completely balanced system, at no expense to the Owner.

Q. The HVAC Subcontractor shall carry out not less than the following pressure tests on new piping systems, ductwork systems and new portions of the piping or ductwork systems which are connected to the existing piping or ductwork systems and shall perform these tests in the presence of the Owner.

1. Bring systems up to maximum operating temperatures and test at pressure as per ASME code.

2. Carry out tests required by the authorities having jurisdiction.

3. If tests are required by an authority having jurisdiction, tests shall be made in the presence of each governing authority's authorized inspector and certified by that person.

4. Tests not required by the authorities shall be certified by the installing contractor.

5. Perform tests before piping is covered or before piping or ductwork is concealed. Test ductwork as per SMACNA recommendations.

6. Remove all components which will not withstand test pressure and replace after tests.

7. Eliminate leaks, or remove and refit defective parts. Caulking of threaded or welded joints will not be permitted.

8. Repeat tests as often as necessary to obtain certification.

9. Pressure test oil piping with compressed air, not water.

10. Test new piping system prior to making final connections to existing system and after final connections.

R. Perform operational tests on all motor driven equipment and run continuously for at least 40 hours. Notify Owner and Engineer before test. Correct defects in noise, vibration, misalignment and in balance.

S. Refer to 15500-2.26-G. Sheetmetal Dampers. Review all sheetmetal fabrication shop drawings prior to fabrication as noted therein.

T. Comply with applicable items in 15500 - 2.28. Note Item 15500 - 2.28 D.

3.15 COMPLETION

A. Run-in all bearings and gear boxes. Follow manufacturers' written instructions. After running-in, flush out and refill with recommended lubricants.

B. Remove oil and dirt from equipment surfaces and bases.

C. Check and align all drives. Adjust belts for proper tension.

D. Clean all fixtures and equipment.

E. Check and align all pumps to manufacturer's acceptable tolerances.

F. Remove all temporary protection and covers.

G. Vacuum clean the inside of all air handling systems, including fans, ducts, coils, and terminal units to ensure that they are free from debris and dust.

H. Drain, flush for a minimum of 24 hours and refill piping systems as often as required to ensure clean piping systems. This work shall be performed to the satisfaction of the chemical treatment supplier.

I. Change air and water filters.

J. Remove, clean and reinstall pipeline strainer screens in the presence of the Owner's representative. Obtain proof in writing of final cleaning.

K. Leave mechanical work in as new working order.

L. Refer to SECTION 01700 - Contract Close-out.

3.16 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.

3.17 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 instruction period.

B. Thoroughly instruct the Owner's authorized representative in the safe operation of the systems and equipment. This instructional procedure shall be video taped by the HVAC Subcontractor and two (2) copies shall be provided to the Owner.

C. Arrange and pay for the services of qualified manufacturers' representatives to instruct Owner on specialized portions of the installation such as automatic temperature control, water treatment, etc.

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. Names persons of being instructed.

6. Other people present.

E. Instructional period shall be carried out during a continuous period of 30 days.

F. Instructions required for prepurchased equipment is the responsibility of the manufacturers. This Subcontractor shall coordinate all instruction between Owner's representative and manufacturer's representative.

G. Refer to 01700 CONTRACT CLOSE-OUT.

3.18 INSPECTION

A. Periodic inspections of the work in progress will be made to check general conformity of the work to the Drawings and Specifications.

B. Correct all deficiencies immediately upon notification.

C. Final review of the work shall not commence until such time as the Balancing Report is received in an approved form and the HVAC system is operational including the control system operating on automatic.

3.19 EXISTING HV AND HVAC SYSTEMS CLEANING

A. Personnel Protection: This Sub-subcontractor shall ensure that personnel wear eye protection and respiratory protection at all times while working in the area of the ventilation system.

B. Securing Power: This Sub-subcontractor shall, in cooperation with the Electrical Subcontractor, isolate, secure the power and tag equipment, such as ventilation fans, heating and cooling coils serving the specified ventilation system(s), "out of service" in accordance with OSHA tagout procedures. Once the system is cleaned and certified, the HVAC Subcontractor shall prevent the operation of existing equipment which may not yet be demolished and removed.

C. Temporary Filter: Temporary filters shall be installed over or behind all supply diffusers. media used must possess a minimum ASHRAE rating of 30 percent.

D. Protective Covering: The Sub-subcontractor shall wrap, cover or make equipment and machinery in the immediate area of the vent system access covers and screen removals to prevent contamination while vent work is in progress.

E. Vents: Remove all vent system access covers and clean all vent interior surfaces.

F. Duct Access: All access doors must be SMACNA approved, leaktight and securely fastened. Tape must not be used to secure access ports.

G. Fan Motor and Blades: Wipe down any reused vent system fan blades and vacuum the fan motor exterior to remove accumulated dirt.

H. Dampers: Vacuum and inspect dampers to ensure there are not obstructions to restrict air flow.

I. Scrubbing Vents in Place: If vent ducts are scrubbed in place, ensure water does not damage the surrounding area equipment.

J. Inside Vent Equipment: Inspect all reused heating and cooling coils, piping, valves and associated equipment located within the ductwork services for leaks, corrosion, ruse or defective components.

K. Witnessing: The Architect will be present during all inspections.

L. Duct Insulation: After cleaning and inspecting, visually inspect any damage of disturbed insulation on the cleaned ducts; renew damaged insulation in accordance with SMACNA Construction Guidelines.

M. Access Cover Installations: After inspection and required cleaning and repairs, reinstall all access covers. Install all required access panels to complete cleaning scope. Refer to item 2.26 Sheetmetal for material spec. for access panels.

N. Safety Inspection: The Sub-subcontractor shall ensure all toils, rags and other foreign materials are removed from ducts before installing access covers.

O. System Inspection: After completing all required work and inspections, the Sub-subcontractor shall ensure the duct system is completely assembled with all covers installed.

P. "Out-of-Service: Tags Removal: The Sub-subcontractor shall remove the "out-of-service" tags and energize the vent circuits.

Q. Operational Testing: Energize each system fan motor (existing reused or new - whichever is permanent in the design) independently and operationally test for five (5) minutes. Ensure all personnel shall stand clear of outlets during this test.

R. Outlet Screen Reinspections: Visually reinspect all vent outlet screens and remove any accumulated loose material, clean area as required to return space to existing conditions.

S. Protective Covering Removal: After removing all protective coverings, clean all areas disturbed by cleaning and inspection.

PART 4 - AUTOMATIC TEMPERATURE CONTROL SYSTEM

4.1 GENERAL

A. All control system components shall be the latest state-of-the-art in manufacture and performance. System design is based on common open protocol platforms (BACnet) as manufactured and installed by Automated Logic Corporation (ALC), Landis & Staefa/Siemens or Tour/Andover Controls (TAC) subject to meeting this Specification. Any proprietary language in this Specification is not intended to be a limitation of vendor. A fully compliant "front-end" system shall be provided including a select access web based interface. The control system shall be installed by competent control mechanics and electricians regularly employed by the temperature control subcontractor. All control equipment shall be the product of one manufacturer including all direct digital control panels.

B. The control system is based on a DDC central system with electric actuation for control valves and dampers. Any references to pneumatic system components shall be for the purposes of capping and removal of obsolete portions while retaining operation of the existing portions to remain.

C. The control system must be compatible and fully operational with all past and present dates including dates that have the same potential problems as 01/01/00.

D. The existing electro-pneumatic control system shall be sequentially decommissioned and removed as new work advances, while remaining pneumatic controls operable at any phase of work, remain operable. It is intended that upon completion, all controls shall be DDC and all pneumatic controls removed from renovated portions in an orderly manner.

4.2 SCOPE

A. The control system shall consist of all thermostats/sensors, temperature transmitters, controllers, automatic valves and dampers, damper operators, control panels, and other accessory equipment along with a complete system of electrical control wiring, pneumatic tubing and distribution to fill the intent of the specifications and provide for a complete and operable system. All control equipment shall be fully proportioning, except as noted otherwise. Control valves and dampers at AHU's, pressure differential bypass valves and dampers at louvers and exhaust fans to include operators. Terminal box dampers and hot water control valves at terminal box duct coils, unit heaters, radiation interlocking, fan coil units and cabinet unit heaters to be Electric/Electronic DDC.

B. The following outline narrative of major systems is included here for reference:

1. Overall a Class A building standard shall be adhered to. Intent shall be solid, practical, economic operation consistent with good IAQ principles. The building shall have several schedules and modes of operation, so scheduling, setbacks, warm-up periods and the like shall apply.

2. Building cooling shall be served by a new air cooled chiller. Pressure and temperature point extraction, alarms outside of normal operation shall be provided.

3. Building heating hot water provided by high efficiency condensing boilers located within the building. Pumps (100% standby pumps). VFD control for DP control shall be provided.

4. Note that all pumps above shall be paired primary/standby with inconsistent status alarm and changeover, (flow verification via current sensors/transformers) and lead-lag scheduling.

5. Air Handling Units

a. Conventional heating, cooling and economizer functions plus 100% outside air direct ventilation types as scheduled. Use of in-duct reheat coils, both hot water and electric, for trimming of temperature, dehumidification with reset of cooling coil discharge and air volume trimming by VFD's is required where specified. All shall be indoor units. Refer to Schedules.

(Note: All units shall have VFD's even if essentially constant volume at the zone level. VFD's shall be used for balancing trim, operational optimization of volume for load minimization dehumidification, and to assure measurable airflow under variable conditions of filter loading, building pressure, etc. VAV units shall respond to supply duct SP.)

b. All AHU cooling coils shall be chilled water. Preheat coils shall be hot water as shall be in duct reheat coils where indicated. All preheat coils on units handling outside air shall have single circulators for full coil flow and coil face destratification, using return side modulating two-way valves for temperature control above 38°F (adjustable) outdoor temperature and below. All AHU's handling outside air shall have freezestat protection, enthalpy economizer operation. All units shall have high static pressure shutdown and smoke detector shut down. All dead-end dampers to have end switches.

c. Units handling outside air shall have outside air direct reading of CFM at the minimum levels including logging of data. Carbon dioxide measurement and outside air response applies on an offset from an outside reference. Airflow measuring stations by Ebtron with electronic transducers shall be provided by HVAC for the minimum outside air levels. Provide direct reading of supply and outside air (flow measuring stations). (Ebtron or Air Monitor "FI" probes.)

d. Refer to Sequences of Operation and systems overview paragraph 4.29 of this section.

4.3 INCIDENTAL WORK BY OTHERS

A. The following incidental work shall be furnished under SECTION 16100 by the designated contractor under the supervision of the control contractor.

1. The Electrical Contractor shall:

a. Provide, on magnetic starters furnished under DIVISION 16, all necessary auxiliary contacts, with buttons and switches in the required configurations.

b. Provide duct smoke detectors and power wiring to the detectors as required.

c. Provide 120V power to ATC panels where shown on the electrical drawings. Where 120V power is required for automatic temperature controls, but not shown on the electrical plans, the ATC Subcontractor shall provide it. Power feeds to direct digital controllers, panels and central hardware shall be from dedicated independent emergency power circuits.

d. Provide connection of all lighting power circuits through lighting control relays mounted in lighting relay panels. ATC contractor shall provide mount and program lighting relay panels.

2. The Sheetmetal Contractor shall:

a. Install all automatic dampers.

b. Provide necessary blank-off plates (safing) required to install dampers that are smaller than duct size.

c. Assemble multiple section dampers with required inter-connecting linkages and extend required number of shafts through duct for external mounting or damper motors.

d. Provide necessary sheetmetal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation and affix and seal permanently in place only after stratification problem has been eliminated.

e. Provide access doors in duct or other approved means of access through ducts for service to control equipment.

3. The HVAC Contractor shall:

a. Install automatic control valves and separable wells that are specified to be furnished by the ATC Contractor.

b. Provide all necessary valved pressure taps, water, drain and overflow connections and piping.

c. Provide, on magnetic starters furnished under SECTION 15500, all necessary auxiliary contacts, with buttons and switches in the required configuration.

4.4 REQUIREMENTS OF REGULATORY AGENCIES AND STANDARDS

A. Regulatory Agencies:

1. State of Maine, State Building Code (International Building Code 2003 and appendix Mechanical Code).

2. City of Portland including all Public Safety Departments

B. Reference Standards:

1. American Society for Testing and Materials (ASTM).

2. Underwriters' Laboratories, Inc. (UL).

3. National Fire Protection Association (NFPA).

4. American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc. (ASHRAE).

5. National Electrical Code (NEC).

6. National Electrical Manufacturers Association (NEMA).

4.5 ELECTRICAL WIRING

A. All electrical wiring connections required for the installation of the temperature control system as herein specified, except power wiring to ATC panels which shall be provided under SECTION 16100, shall be provided by the temperature control contractor unless specifically shown on the electrical drawings or called for in the electrical specifications.

B. All wiring shall comply with the requirements of SECTION 16100 of the specification.

4.6 QUALITY ASSURANCE

A. Acceptable Manufacturers: All products, material, and equipment shall be manufactured by one company to the maximum extent possible and subject to Owner review and open book pricing agreements if the manufacturer is to be selected as a sole-source vendor. The ATC system shall be designed and installed, commissioned and serviced by factory trained personnel. Distributors or licensed installing contractors will be considered but the Owner is under no obligation.

B. Scope of Work:

1. This specification defines the minimum hardware and performance requirements for a computer-based Energy Management and Automatic Temperature Control System.

2. As the ATC Contractor, furnish and install all equipment, accessories, wiring and instrument piping required for a complete and functioning Energy Management System and Automatic Temperature Control System.

3. All materials and equipment used are to be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. All systems and components are to be thoroughly tested and proven in actual use. All material and equipment are to be installed by the manufacturer. Installing representatives will not be acceptable.

4.7 SUBMITTALS

A. Manufacturer's literature and illustrations.

B. Manufacturer's specifications and engineering data.

1. Materials.

2. Parts.

3. Devices.

4. Accessories.

5. Performance Data.

C. Shop Drawings:

1. Assembly.

2. Installation.

3. Wiring Diagram.

4. Provide electronic format for control documentation (drawings, sequence of operation, and parts list).

5. Control drawings with detailed piping and wiring diagrams, including bill of material and description of operation for all systems.

6. Panel layouts and nameplates lists for all local and central panels.

7. Valve and damper schedules showing size, configuration, capacity and location of all equipment.

8. Data sheets for all control system components.

9. 1/16 inch plans indicating exact thermostat locations.

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

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

F. Operation and Maintenance Manual:

1. The manual shall include the following data.

a. Installation instructions.

1) Assembly.

2) Installation.

3) Alignment.

4) Adjustment.

5) Checking.

b. Operation instructions:

1) Start-up.

2) Routine and normal instructions.

3) Regulation and Control.

4) Shut-down.

c. Maintenance instructions.

d. Guide to Trouble Shooting.

e. Parts List.

4.8 INSTRUCTION AND ADJUSTMENT

A. Upon completion of the project, the control contractor shall:

1. Completely adjust, ready for use, all thermostats, controllers, valves, damper operators, relays, etc., provided under this Section.

2. Furnish two (2) instruction manuals covering the function and operation of the control systems on the project for the use of the Owner's operating personnel. A competent technician shall be provided for two days for instruction purposes.

4.9 WARRANTY

A. Provide a one (1) year warranty from date of final acceptance by the owner or Certification of substantial completion, whichever occurs later, for items furnished that shall cover.

1. Faulty or inadequate product design.

2. Improper assembly or erection.

3. Defective workmanship and materials.

4. Leakage, breakage or other failures.

4.10 PRODUCTS

A. The ATC Contractor shall incorporate the following:

1. A network of independent, Modular Building direct digital control units and local control unit networks, integrated with the facility network.

2. A modem interface for communications to existing remote workstations at the university(ies) facilities maintenance and operations. The ATC network in the building shall be accessible through the network from any remote workstation utilizing the ATC system vendor's flagship control suite, with all with appropriate controlled access. The operation must be able to access, command, and edit all point and program information in the new network from any existing designated remote workstation and via Web Access.

3. A network of independent terminal box Direct Digital Control units.

4. A trunk interface for communication to the master console or remote consoles.

5. Field sensors per the input/output summary and as necessary to accomplish the sequence of operation.

6. System Alarm Monitoring

   a. All system alarms (including critical) shall be annunciated at the existing master console in the Facilities Building.

   b. Critical alarms shall be annunciated at the existing remote workstation in the university(ies) Maintenance and Operations Office. Critical alarms shall then be sent from the remote workstation to the Maintenance Personnel Alpha Pagers. Alarms shall have customized text messages with analog value of alarm. Page by this type of alarm - HVAC, maintenance, or life safety. Page to groups or single pages.

7. The following systems shall be provided with a software gateway to provide monitoring and alarming of that system with the ATC system in the Maine Historical Society Maintenance and Operations Office.

   a. Variable Speed Drives.

   b. Fire Alarm System.

   c. Chillers via on-board control panel.

   d. Building hot water system and domestic hot water production.

   e. Lighting Control System (provide rely panels as directed by 16100).

8. The ATC Contractor shall conform to the following standard for Date Data Compliance:

   a. The system shall not produce errors when processing date data to the extent that the date information provided from other systems is accurate.

   b. The ATC supplier shall provide documentation to support the individual device(s) Date Data Compliance. This document shall include a listing of compliance by device and any exceptions to the above definition.

9. Lighting Control System

   a. The ATC contractor shall provide, ample panel capacity made ready to mount, and program a complete lighting control system as directed by 16100. The lighting panel to be supported shall include all smart microprocessor based lighting relay panels with NEMA 1 enclosure, LCD display and standard magnetically held 20 Amp. 120/277 Volt relays. Quantity of panels to be supported shall be not less than four (4). Each panel shall be provided with capability for a maximum of 32 relays to control its associated lighting electrical circuits. Each panel with an RS-485 communications shall communicate to the ATC system through a software communications driver. Emergency lighting switch-back shall restore normal lighting conditions from emergency lighting conditions. Provide all relays and interlocks.

B. Distributed Processing:

1. Each Network Control Module (NCM) shall be capable of performing all specified control functions in a complete independent manner.

2. "Independent" shall be defined as:

a. If any one control unit or communications processor malfunctions within the system, all other control units will continue to control, monitor, have the ability to be accessed and programmed without being in a degraded mode.

C. Networking:

1. Each Modular Building Control unit shall be capable of sharing point information with other such units, such that control sequences or control loops executed at one control unit may receive input signals from sensors connected to other units within the network without the intervention of the host computer or any hardware other than the modular building controller.

2. If the network communication link fails or the originating control unit malfunctions, the control loop shall continue to function using the last value received from the failed modular building controller or programmed to take special procedures.

3. Each modular building controller shall have an RS-232 port for use by an ASCII text terminal.

4. This port shall be capable of communicating with the entire network without moving the operators terminal to other MBC's or providing any other hardware or software.

5. Failure of the host shall not affect network and panel to panel communication.

6. Failure of one modular building controller shall have no other effect upon any of the units in the network.

4.11 COMPUTERS

A. Owner shall be furnished with a new BMS "Front End" terminal with system software and graphics package to current standards and protocols. All proposals shall include a linked compatible notebook computer with all cables for field use by the Owner. Owner shall set a budget allowance and standards for network compatibility, processor, memory and general features. ATC contractor to provide the computer, verified for mutual compatibility with the ATC system software platform.

B. Full graphic user interface (GUI) capabilities shall be provided. Web based access shall feature the same GUI functionality.

C. The following specifications are the standard for graphics.

4.12 OPERATOR'S TERMINALS (COLOR GRAPHIC/CONTROL)

A. Color Graphic Command and Display Operator's Terminal Software:

1. The dynamic color graphic display and command terminal shall be provided which can display alphanumeric data and dynamic color diagrams simultaneously.

   a. The unit shall display real-time data, generate color schematics of building equipment or areas being monitored, and allow operator commands and report system activity.

   b. The unit shall support point devices which will allow the operator to make menu selections, execute graphic commands, choose graphic symbols and make freehand drawings.

   c. The unit shall upon command, generate color schematics of building equipment, or groups of building equipment or areas being monitored, and simultaneously display the current measured variables associated with the equipment or area.

   d. The color graphic displays shall be dynamic in that point data or calculated values will change continuously while being observed.

   e. The color terminal shall have a flashing feature to indicate off-normal conditions.

   f. The color terminal display at least sixteen colors selected from at least 64 combinations.

   g. The flat screen shall provide the operator with the ability to command control points from the graphical display, provide change of state message and dynamically update the graphic without the operator requesting the graphic a second time.

2. The systems various point lists shall also be dynamic in that they will update change of state or value when displayed on the flat screen without re-request by the operator.

3. The color terminal shall have an associated keyboard including all standard ASCII characters, a separate numeric keypad and a mouse to position the cursor on the screen.

   a. In addition, a function keypad shall be provided which shall include a minimum of twelve user-definable keys.

4. The color terminal display shall be arranged in a format which allows easy user interaction.

   a. It shall provide the building operator with the ability to monitor and control his facility through the graphic display screens, without the need for commands or function keys.

b. The display format shall be divided into four areas, allocated to specific functions, as follows:

1) Main Menu Area.

2) Main Display Area.

3) Alarm Area.

4) Side Menu Area.

5. The Main Menu Area shall always remain on screen, and shall provide menu choices to the operator for ICON function selections.

a. It shall be possible for the operator to access and control the system by progressing through various levels shown sequentially in this area.

6. The Main Display Area shall display all main screen information resulting from operator request.

a. It shall also serve as the display area for user-defined graphics and system reports, and shall be used as a graphic editor workspace.

7. The Alarm Area shall always remain on the screen, and shall show, in summary form, the alarm status of the system at all times.

8. The Side Menu Area shall appear only when needed.

a. It shall be the area where pull-down menus appear for various operator functions.

9. Build the following color graphic displays:

a. Chilled Water System, integrated with dual temperature system C.

b. Heating Hot Water Systems, integrated with dual temperature system C.

c. Combined portions of above, as dual temperature system.

d. Each Air Handling System and exhaust fan system.

e. 24/7 cooling system.

f. Humidifiers and sensing of humidified rooms. Alarm of high and low variables.

g. Each floor of Building – Each floor shall be the actual CAD Architectural/ Mechanical drawing. The ATC contractor shall obtain the CAD floor plans from the HVAC Contractor. Floor plans shall display the following:

1) Room number.

2) Major mechanical, Plumbing, Electrical and Security equipment.

3) Accurately located devices – air terminal units, control devices, etc. Provide for individual graphic display of each terminal unit.

4) Device data and space temperatures.

h. All points within a system shall be included on at least one (1) graphic.

i. Provide software links to enable an operator to access an individual equipment/device data starting with an overall facility building plan to individual building plan, floor by floor plan and finally the area/department plan displaying the equipment/device.

j. Provide software links between floor plans and associated air handling unit and from the air handling unit to the cooling tower, chiller and boiler graphics.

k. Provide graphic displays showing point logs for terminal boxes. Graphics to display each terminal box space temperature set point and airflow. Temperature set point shall be adjustable from the graphics.

l. Provide separate Fire Alarm Floor Plan graphics that indicate the location of each fire alarm system device and alarm during alarm mode.

4.13 SYSTEM PRINTERS

A. A new compatible color printer shall be provided. Owner to set allowance for laser or ink jet type. ATC contractor to set up with all drivers and integrate with the front end workstation.

4.14 SENSORS

A. Provide the following instrumentation as required by the monitoring, control and optimization functions.

1. Temperature Sensors

a. Room temperature:

Temperature monitoring range	+20/+120°F (0/49°C)
Output signal	Changing resistance
Accuracy at Calibration point	0.5°F (+/- 0.3°C)

b. Liquid immersion temperature:

Temperature monitoring range	+22/+220°F (0/104°C)
Output signal	Changing resistance
Accuracy at Calibration point	+/-0.5°F (+/- 0.3°C)

c. Duct (single point) temperature:

Temperature monitoring range	+40/+150°F (4.4/66°C)
Output signal	Changing resistance
Accuracy at Calibration point	+/-0.5°F (+/- 0.3°C)

d. Duct (average) temperature:

Temperature monitoring range	+20/+120°F (-7/+49°C)
Output signal	4 - 20 mA DC
Accuracy at Calibration point	+/-1°F (+/- 0.6°C)
Sensor Probe Length	25' L (7.3 m)

e. Outside air temperature:

Temperature monitoring range	-58/+122°F
Output signal	4 - 20 mA DC
Accuracy at Calibration point	+/-0.5°F (+/- 0.3°C)

2. Liquid Differential Pressure Transmitter

Ranges	0-5/30 inches H20 0-25/150 inches H20 0-125/750 inches H20
Output	4 - 20 mA DC
Calibration Adjustments	Zero and span
Accuracy	+/-0.2% of span
Linearity	+/-0.1% of span
Hysteresis	+/-0.05% of span

3. Differential Pressure

a. Unit for fluid flow proof shall be Penn P74.

Range	8 to 70 psi
Differential	3 psi
Maximum differential pressure	200 psi
Maximum pressure	325 psi

b. "Wet-to-wet" pressures and differentials shall be Setra.

Range	8 to 70 psi
Differential	3 psi
Maximum differential pressure	200 psi
Maximum pressure	325 psi

c. Unit for air flow shall be Siemens Building Technologies SW141 or equal by Setra.

Set point ranges	.05 inch WG to 1.0 inch WG 1.0 inch WG to 12.0 inch WG

4. Static Pressure

a. Static Pressure Sensor

Range	0 to .5 inch WG • to 1 inch WG • to 2 inch WG • to 5 inch WG • to 10 inch WG
Output Signal	4 - 20 mA VDC
Combined static error	0.5% full range
Operating Temperature	-40 to 175°F.

Static pressure shall be resettable via the DDC system based on lowest pressure demand. See Sequences of Operation.

5. Humidity Sensors

Ranges	0 to 99% RH
Sensing Element	Bulk Polymer
Output Signal	4 - 20 mA DC
Accuracy	At 77°F ± 2% RH

6. Insertion Flow Meters (Equal to Onicon Series F-1200)

Sensing Method	Impedance Sensing
Accuracy	± 2% of Actual Reading
Maximum Operating Pressure	400 PSI
Output Signal	4 - 20 mA

Bi-directional where required.

4.15 CONTROL VALVES (All control valves shall have electric actuators.)

A. Electric Control:

Rangeability	40:1
Flow Characteristics	Modify. equal percentage
Control Action	Normal open or Closed as Selected.
Medium	Water, glycol
Body Type	Screwed ends 2 inch and smaller, flanged valves 2-1/2 inch and larger
Body Material	Bronze
Body Trim	Bronze
Shutoff Disk on two-way	Replaceable 2 inch EPT, 2 inch Composition
Shutoff Disk on three-way	Replaceable 2 inch EPT, 2 inch Bronze
Stem	Stainless Steel
Actuator	0-10 VDC, 4–20 MA or 2 position 24 VAC/ 120 VAC

B. All automatic temperature control valves in water lines shall be provided with characterized throttling plugs and shall be sized for minimum 25% of the system pressure drop or 5 psi, whichever is less.

1. Provide control valves with close off pressure suitable for pressure encountered.

2. Two position valves shall be line size.

C. Automatic temperature control valves up to 1-1/2 inch size and where modulating shall be of the characterized ball valve type.

4.16 DAMPER ACTUATORS

A. Damper actuators shall have open air direct coupled actuators, by Belimo or equal .

B. Electric damper actuators for use at small dampers shall be Brushless DC Motor Technology with stall protection, bi-directional, fail safe spring return, all metal housing, manual override, independently adjustable dual auxiliary switch.

1. The actuator assembly shall include the necessary hardware and brackets to allow proper mounting and connection to a standard 1/2 inch diameter shaft or damper blade.

4.17 CONTROL PANELS

A. Shall be manufactured of furniture grade steel with a powder coat enamel finish. The panel doors shall be hinged locking type. Control panels shall contain all central control devices, such as controllers, relays, switches, pilot lights, terminal blocks, and all other accessories as required for a workable environmental control system. All components within the control panels shall be prewired to numbered terminal strips, ready for field connection to field mounted control components.

B. All controllers, relays, switches, etc., for equipment located within the mechanical equipment rooms shall be mounted on enclosed control panels with hinged lock type door mounted adjacent to the system controller. All temperature settings, adjustments and calibrations shall be made at the system control panel.

C. Provide on the local panels, remote transmission thermometers at least 3-1/2 inch in diameter. Temperature indications shall be provided for each point of temperature measurement for control and additionally for those points as outlined in this specification or shown on the plans.

D. Details of each panel shall be submitted for approval prior to fabrication. Locations of each panel are to be convenient for adjustment and service. Provide engraved nameplates beneath each panel-mounted control device and air gauge clearly describing the function of said device and range of operation. All manual switches, dial thermometers, and indicating air gauges shall be flush mounted on the hinged door.

E. All electrical devices within the panels shall be factory pre-wired to a numbered terminal strip. All wiring within the panel shall be in strict accordance with NEMA and UL standards and shall meet all local codes.

F. See Section 15500, Paragraph 1.23, Protection of Electronic Devices. Provide suitable protection from current fluctuations as required therein.

4.18 MISCELLANEOUS DEVICES

A. Thermostats:

1. Room thermostats shall be of the gradual acting type with adjustable sensitivity.

2. They shall have a bi-metal sensing element capable of responding to a temperature change of one-tenth of one degree. (Provide all thermostats with limit stops to limit adjustments as required.)

3. Thermostats shall be arranged for either horizontal or vertical mounting.

4. In the vertical position thermostat shall fit on a mullion of movable partitions without overlap.

5. Mount the thermostat covers with tamperproof socket head screws.

B. Freezestats:

1. Install freezestats on the upstream fans of cooling coils handling previously unconditioned outside air and provide protection for every square foot of coil surface area with one linear foot of element per square foot of coil.

a. Upon detection of low temperature, the freezestats shall stop the associated supply fans and return the automatic dampers to their normal position. Provide manual reset and alarm output.

C. Firestats:

1. Provide manual reset, fixed temperature line voltage type with a bi-metal actuated switch.

a. Switch shall have adequate rating for required load.

D. Electronic Airflow Measurement Stations and Transmitters (At Duct Locations):

1. Stations: Each insertion station shall contain an array of velocity sensing elements and straightening vanes. The velocity sensing elements shall be of the RTD or thermistor thermal dissipation type. The sensing elements shall be distributed across the duct cross section in a quantity to provide accurate readings. The resistance to airflow through the airflow measurement station shall not exceed 0.08 inches water gage at an airflow of 2,000 fpm. Station construction shall be suitable for operation at airflow of up to 5,000 fpm over a temperature range of -40 to 120°F, and accuracy shall be plus or minus 3 percent over a range of 125 to 2,500 fpm scaled to air volume. Each transmitter shall produce a linear, temperature compensated 4 to 40 mA DC, output corresponding to the required velocity pressure measurement. Manufactured by Ebtron, FMT or Tekair or equal by Air Monitor Corporation Fan Evaluator with Veltrol II controller.

2. Provide at minimum outside air entries, supply and return fan inlets.

E. Fan Inlet Airflow Measuring Station:

1. Fabricate of galvanized steel, size for fan inlet in which mounted. Maximum pressure loss through station of 0.08 inches water gage at 1500 fpm. Station shall have accuracy of 2%. Identify by model number, size, area, and specified airflow capacity. Manufactured by Ebtron, FMT or Tekair, equal by Air Monitor Corporation Model FI. Where of the pressure differential type, each station shall contain parallel air straightener, total and static pressure sensing manifolds, internal piping and external pressure transmission ports with flexible tubing and quick-connect fittings. Where such devices are not recommended for application at fan inlet (e.g., mixed flow fans), an in-duct array shall be provided.

F. Current Sensing Relay:

1. Provide solid-state, adjustable, current operated relay. Provide a relay which changes switch contact state in response to an adjustable set point value of current in the monitored A/C circuit. Products equal to Veris "Hawkeye" #735.

2. Adjust the relay switch point so that the relay responds to motor operation under load as an "on" state and so that the relay responds to an unloaded running motor as an "off" state. A motor with a broken belt or sheared coupling is considered an unloaded motor.

3. Provide for status device for all fans and pumps.

G. Automatic Dampers:

1. Balanced type with pressed or elliptical steel blades with interlocking edges, mounted horizontally in welded steel frames. Rectangular dampers 12 inches or more in direction perpendicular to axis shall be louvered, with blades not over 8 inches wide. Provide steel trunnions in bronze sleeve bearings or ball bearings. Dampers shall be not more than 48 inches in length between bearings.

2. Dampers shall close with 10 CFM/SF maximum leakage at 4 inch WG differential pressure and provide substantially full area of opening when open. Dampers shall have neoprene edges and end seals cemented and riveted in place during fabrication.

3. Modulating dampers shall be opposed blade type. Two-position dampers shall be parallel blade type.

4. Damper blade linkages including operating rods, bearings and operator mounting plates shall be designed to withstand twice the required operator force without deflection. Provide for field adjustment of full open position. Provide jack shafts across multiple enjoined dampers that operate together

5. Dampers for relief air, master outside air or where normally a thermal barrier would (exist including sporadically or manually operated systems) shall be of the insulated type, per item 6.b. below.

6. Acceptable Product

   a. Conventional Dampers: Ruskin CD-60, equal by Penn or Arrow.

b. Insulated Dampers: Ruskin CTD1-50 or equal by TAMCO.

H. Carbon Dioxide Sensor:

1. Provide CO_2/VOC sensors which are designed for sensing indoor air quality in rooms or air ducts. The microprocessor-based units consist of a photo-acoustic CO_2 sensor and a Volatile Organic Compound (VOC) sensor. This unit provides a 0-10 VDC signal based on CO_2. Sensors shall be equal to Vaisala, GE Telaire, Sensata, Johnson or Siemens.

I. Unit Heater Control Kits:

1. Provide unit heater control kits for all new and existing to remain cabinet unit heaters consisting of a wall thermostat, relay, control valve, strap-on reverse acting return line aquastat.

2. Furnish aquastat to HVAC for installation on HWR pipe with heat conductive paste. Wiring in Series within power train by 16100.

3. Furnish HW control valve (two-way/two-position) to HVAC for installation.

4. Furnish relay with transformer to Electrical Contractor for power wiring and under 16100. ATC to mount thermostat, relay/transformer and to provide all low voltage wiring in conduit (where exposed).

5. Exposed thermostats shall match those used elsewhere in appearance.

4.19 TRANSMISSION NETWORK

A. Distributed Communication Processor:

1. The system shall use an intelligent Distributed Communication Processor (DCP).

a. It may be a wall-mounted or desk-top unit.

b. This processor shall be microprocessor based and shall interface the central processing unit and remote units or modular building controllers.

c. The transmission shall be asynchronous and utilize a token-pass networking method.

d. The system shall utilize a cyclic redundancy check or dual transmission with parity check to ensure signal reliability.

e. The network will support up to 100 modular building controllers and additional associated multiple and digital point units.

f. The transmission network shall utilize a twisted shielded pair.

g. The transmission speed shall be a minimum of 100K baud and operate in a half-duplex mode.

4.20 MODULAR BUILDING CONTROLLERS AND ACCESSORIES

A. The system shall utilize intelligent distributed Modular Building Controllers (MBC) or Mechanical Equipment Controllers (MEC) to interface sensors being monitored and equipment being controlled by the facility management and control system.

1. Each unit shall be microprocessor based and perform the following functions:

a. Acquire, process, and transfer information to the central computer, network computer, or other remote units.

b. Accept, process, and execute commands from the central computer, network computer, other remote units or other input devices.

c. Record, evaluate, and report changes of state and/or value that occur among points associated with the remote unit.

d. Locally perform direct digital control (DDC) of all common mechanical system functions, such functions shall be programmed using a sequential, numbered statement programming language. (See Software.)

e. Support Local Area Network (LAN) trunks.

f. Each MBC shall execute all applicable programming, calculations and commands via a 16-bit microcomputer resident in the unit.

g. The microcomputer shall permit floating point calculations to enable the performance of energy calculations.

h. Each MBC shall contain a real-time clock to enable the unit to automatically perform time based functions.

i. Each control unit shall be capable of full operation either as a completely independent unit or as a part of the building wide control system.

1) All units shall contain the necessary equipment for direct interface to the sensors and actuators connected to it.

2) Control strategies shall be owner definable at multiple control unit locations, and for all control units in the system from any one operator terminal.

j. Each modular building controller shall include its one microcomputer direct digital controller, power supply, input/output modules, and battery.

1) The battery shall be self-charging and be capable of supporting all memory within the control unit if the commercial power to the unit is interrupted or lost for a minimum of 60 days. Provide low battery alarm at the operator's station.

k. Each unit shall perform continuous diagnostics, and any malfunction shall be annunciated at the operator's console as well as visually indicated at the remote unit.

1) Failure of any unit on the system shall not affect the proper operation of the remaining system components.

l. The system shall be capable of phased start-up.

1) That is, any unit shall be capable of properly communicating with the rest of the system while remaining units are being installed.

m. Surge transient protection shall be provided in each unit for the purpose of suppressing inducted voltage transients.

n. All units shall be listed by Underwriters Laboratories (UL) against fire and shock hazard as a signal system appliance unit.

o. The unit shall also be listed by UL Canada (ULC) and Canadian Standards Association (CSA).

p. Units shall have all metal cabinets.

1) Each unit including cabinet, power supply, function cards and termination modules shall be approved by UL.

q. Each unit shall have a pin-hinged door and master keyed lock.

1) Remote units shall be capable of proper operation in an ambient environment of 32°F and 10% to 90% RH.

B. Input/Output Types:

1. Each modular building controller shall be capable of accepting multiple point inputs and outputs.

2. These shall be of four types corresponding to industry nomenclature.

3. They are as follows:

a. DIGITAL IN for monitoring status, alarms and accumulating pulses.

b. DIGITAL OUT for commanding two and three state devices.

c. ANALOG IN for measuring values.

d. ANALOG OUT for positioning set points.

1) Provide individual manual positioning switch and analog gauge for each analog outputs at the DDC cabinet.

4. It shall be possible for each unit to monitor the following type of inputs, without the addition of equipment outside the unit cabinet:

   a. Analog inputs

      1) 4 - 20 ma

      2) Thermistors

      3) RTD

   b. Digital inputs

      1) Dry contact closure.

      2) Pulse accumulator.

5. The control unit shall directly control actuators and control devices.

6. Each control unit shall be capable of providing the following control outputs without the addition of equipment outside the remote unit cabinet (all outputs for this project shall be electronic):

   a. Digital outputs (contact closure)

      1) Motor starters, sizes 1-4

   b. Analog outputs

      1) 4-20 mA

      2) 0 - 10 VDC

7. Provide manual override switch at the modular building controller for each digital-out and analog-out point. The digital-out switch will be a hand-off-auto and the analog-out switch a hand-auto with a gradual position switch. DDC system will supervise the position of the override switch for the central operator.

C. Operator Interface:

1. The facility management and control system shall permit full operator communication including obtaining information about the performance of his system; allowing the operator to change the system operation; and diagnosing system malfunctions.

2. Operator communication shall be through the use of any one of the following operator terminals which can be directly connected to the modular building controller. Provide two RS-232 serial data communication ports per modular building controller.

   a. Printer

   b. 19 inch flat panel monitor.

c. Central computer. Budget allowance for central CPU and peripherals not including monitor shall be $2,000 (two thousand dollars) with appropriate dual processors and memory units within that budget.

d. Portable operators terminal. Compatible in features and budget with central CPU.

D. User Programmability:

1. All temperature control strategies and energy management routines shall be definable by the operator through an operator's terminal or a portable programming unit.

2. The system shall be provided complete with all equipment and documentation necessary to allow a trained operator to independently perform the functions listed below:

a. Start or stop equipment.

b. Monitor the status of equipment being controlled.

c. Read the set point of a control loop.

d. Determine the control strategies that have been defined for a specific piece of equipment.

e. Generate displays of control strategies.

f. Add/delete control loops to the system.

g. Add/delete points to the system.

h. Create, modify or delete control strategies.

i. Assign sensors and/or actuators to a control strategy.

j. Tune control loops through the adjustment of control loop parameters.

k. Enable or disable control strategies.

l. Generate hard copy records of control strategies on a printer.

m. Select points to be alarmable and define the alarm state(s).

E. Self-Diagnostics and Alarm Reporting:

1. Each modular building controller shall contain self-diagnostics that continuously monitor the proper operation of the unit.

2. A malfunction of the unit will be reported, and will inform the operator of the nature of the malfunction and the control unit affected.

3. It shall be possible to annunciate malfunctions as well as other control unit alarms at a selected operator's terminal.

4.21 COMPUTER SOFTWARE

A. General:

1. Control software shall be as existing and maintained on the existing front end computer. It is not intended that the cost of a complete upgrade be borne by this project. Rather, the system performance shall be consistent with that described here, programmed for this building.

B. Operator Access:

1. Operator/System Communication

a. The ATC shall have three levels of security passwords.

b. The levels shall be used to allow or disallow use of features of the system by password.

c. The Master Console shall be able to replace and/or change the network passwords and shall maintain additional security on the ATC System.

d. All log on and log off attempts shall be reported by the system to the alarm printer in the building and to the color graphic command/control consoles where a record can be printed of successful and unsuccessful attempts.

C. Point Database:

1. Logical point names, point descriptions and engineering units shall be operator definable on a per point basis.

D. Time of Day Scheduling:

1. The operator shall be provide a simple means, based an entry through the CRT into the MBC, a scheduled format to access a comprehensive program to automatically start and stop designated point according to a stored time.

2. The system shall allow 100 commands per point per day.

3. The TOD system will have a preprogrammed override sequence to allow the operator to override the normal time on or off command for special events with few keystrokes.

4. The system will also have holiday and special day schedules for the operator to assign this information.

a. When the system sees a special day, holiday or override schedule it will apply that time schedule to the assigned equipment.

E. User Control Over System Configuration:

1. Data Base Creation and Modification

a. The intent of this specification is to allow the Owner to independently do their own modifications to the system.

2. All changes shall be done utilizing standard procedures and must be capable of being done while the system is on-line and operational.

   a. To aid an operator, instructive prompting software shall be provided.

3. Operator shall be required to simply answer to "yes" and "no" type questions as well as provide information such as desired engineering units, point descriptors, and so forth.

4. The Owner must have the minimum capability to do the following:

   a. Add and delete points.

   b. Modify any point parameter.

   c. Change, add or delete English language descriptors.

   d. Change, add or delete engineering units.

   e. Change, add or delete points in start/stop programs, trend logs, and so forth.

   f. Select analog alarm limits.

   g. Adjust analog differentials.

   h. Create custom relationships between points.

F. Provide network software that automatically notified the host CPU of an changes made to any modular building controller by the portable terminal.

1. Changes made shall be automatically transmitted by the modular building controller to the host CPU database so that the CPU has the changed data, set point, alarm limit and so forth.

G. ATC Functions:

1. The following ATC software shall be provided as a minimum:

   a. Historical Trending - The system software shall provide the ability to historically trend operator selectable points.

      1) The operator able to assign any system point, analog or binary, real or calculated to a trend group.

         a) Trend groups shall consist of a single point or multiple point groups.

      2) Operator assignments shall be through the operator's terminal, Master or LAN console in simple English language.

         a) Points assigned to a trend group shall be by the point's logical name.

3) Trended values shall be historically retained on the system disk of the Master Console, when attached, for future inquiry.

4) Operator able to request trended values to be retrieved from disk and printed out at operator defined time intervals.

5) Operator able to define time intervals to one minute resolution.

b. Point Trending: Provide the following trending for points as indicated on the Input/Output Summary. Initially provide one (1) minute trend intervals for all air handling temperature control loops including valve position, the corresponding duct and/or room temperature and relative humidity conditions to assess tuning stability. Once initial stability is acceptable, provide 15 minute trend intervals for the same points to assess general and seasonal control response. For energy assessment, provide point groups of all floor zone temperatures, zone reheat valve positions, zone airflow volumes, and zone damper positions. Also provide trend of the zone points mentioned to assess control stability and to assess long term energy use patterns. System hardware memory capacity shall be capable of storing 15 minute trend interval data for all system points for a minimum of six (6) months.

c. Power-fail/Automatic System Restart - Power Failures affecting the ATC system shall cause the modular building controller to go into an orderly shutdown with no loss of memory under any circumstances. A 15 minute uninterruptible power supply (UPS) equal to APC shall be provided for the main ATC computer, with additional surge protection equal to price wheeler "Brickwall", regardless of this protection.

1) Upon resumption of power to the modular building controller, the system shall automatically restart and print-out the occurrence of the power failure.

2) The restart program shall automatically restart affected field equipment. Provide staggered start-up of the HVAC system to minimize inrush.

3) Restart shall be of static nature (restart of operator pre-assigned equipment) or an appropriate state restart (places the building equipment in the proper operational state as of the time of return to commercial power).

4) The nature of the restart program shall be user-definable.

H. Energy Management Control Functions: The following energy management software shall be provided as a minimum for the purpose of optimizing energy consumption while maintaining occupant comfort. See input-output summary to determine which energy management control functions are to be implemented to each piece of HVAC equipment.

1. Time of Day Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or groups of points according to a stored time.

a. It shall be possible to individually command a point or group of points.

b. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start or stop within that group.

c. The operator shall be able to define the following information:

1) Time, day.

2) Commands such as on, off, auto, and so forth.

3) Time delays between successive commands.

4) Special days and holidays, with different schedules.

5) There shall be provisions for manual overriding of each schedule by an appropriate operator.

2. Start/Stop Time Optimization: The ATC system shall include a software program to perform optimized start-up and shut-down of selected equipment.

a. The SSTO program shall start HVAC equipment at the latest possible time that will still allow the equipment to achieve the desired zone conditions by time of occupancy.

b. The SSTO program shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period, and still maintain desired comfort conditions.

c. The SSTO program shall operate in both the heating and cooling seasons.

1) It shall be possible to apply the SSTO program to individual fan systems.

2) The SSTO program shall operate on both outside weather conditions as well as inside zone conditions and empirical factors.

d. The empirical factors shall relate to the dynamic responsiveness of each particular zone, such as heat retention and transfer coefficients.

e. The SSTO program shall meet the local code requirements for minimum outside air while the building is occupied.

f. The system operator shall be able to, for each zone under control of the SSTO program, establish and modify the following parameters:

1) Occupancy period.

2) Desired occupancy temperature.

3) Heating/cooling transfer coefficients.

4) Heating/cooling retention coefficients.

5) Primary equipment lag time.

3. Duty Cycle Control: The ATC shall include a Duty Cycle Control Program (DCCP).

a. The DCCP shall periodically stop and start loads according to various patterns.

b. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.

4. Supply Air Reset: The ATC shall include a software program to perform supply air reset (SAR).

a. The program shall monitor the status of space sensors in all zones and adjust the supply air temperature set point.

5. Economizer Control: The ATC will control the position of the air handler relief, return, and outside air dampers. If the outside air enthalpy falls below changeover set point the ATC will modulate the dampers to provide 100 percent outside air. The user will be able to quickly changeover to an economizer system based on outside air enthalpy and will be able to override the economizer cycle and return to minimum outside air operation at any time. Economizer operation shall be overridden based on a high level of outside air humidity.

6. Electric Demand Monitoring and Control: The EMCS will monitor the building kW demand at the main electric meter, continuously display the value, and update it at least every five (5) minutes. The timing of the EMCS measurement and updating of the kW value will correspond with the calculation of demand utility.

Once the on-peak electric demand reached a predefined limit for the given month, the ATC will be capable of the following demand reducing actions:

a. Reducing the speed of all variable speed supply and return fans.

b. Shutdown of all return air fans.

c. Reducing the chiller demand limit setting.

d. Allowing zone temperature to rise up to 3°F above set point.

7. Chilled Water System

a. Chilled Water Reset: The ATC will be capable of resetting the chilled water supply temperature based on the outside air temperature, the chilled water return temperature, or the demand control algorithm. The reset schedule will be user definable and user changeable. Also, an operator will be able to override the reset schedule at any time and set a chilled water supply temperature value to be held constant.

b. Chiller Demand Limiting: The ATC will be capable of resetting the demand limiting set point of the chiller, including staging.

c. Chiller kW Measurement: The ATC will directly measure the kW draw of the chiller using kW transducers or other means. Estimation of chiller kW from amps is not acceptable.

d. Chiller kW/Ton Analysis: Using the chilled water flow rate and the supply and return the measured chilled water temperature differential, the ATC will calculate tons of cooling for the chiller. Using the kW measured at the chiller, the ATC will calculate and display the kW/ton for the individual chiller operating.

4.22 EQUIPMENT CONTROLLERS for AIR TERMINAL UNITS (VARIABLE and CONSTANT VOLUME BOXES)

A. Provide for control of each Air Terminal Unit. See Paragraph 4.29 Sequences of Operation for applicable specifics.

B. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control, allowing for interface to a variety of modulating actuators. Terminal equipment controllers utilizing proprietary control signals and actuators shall not be acceptable.

C. Each controller performing space temperature control shall be provided with a matching room temperature sensor. The sensor may be either RTD or thermistor type providing the following minimum performance requirements are met:

Accuracy:	+/- 1°F. (+/- 0.6°C).
Operating Range:	35°F to 115°F. (2°C to 46°C.)
Set Point Adjustment Range:	55°F to 95°F. (2°C to 30°C).
Set Point Modes:	Independent Heating, Cooling, Night Setback-Heating, Night Setback-Cooling.
Calibration Adjustments:	None Required.
Installation:	Up to 100 feet from controller.

1. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. Each room sensor shall also include the following auxiliary devices:

   a. Set Point Adjustment Dial.

   b. Style and finish of space mounted sensors shall be reviewed by the architect for final approval. Architect may choose the type of sensor from the manufacturers standard cataloged sensors only. Items a. and b. may be deleted by the architect/engineer for designated sensors.

2. The set point adjustment dial shall allow for modification of the temperature by the occupant. Set point adjustment may be locked out, overridden or limited as to time or temperature through software by an authorized operator at the central workstation,

DDC Controller, or via the portable operator's terminal. In lieu of an integral adjustment dial, provide a separate dial mounted on a stainless steel wall plate adjacent to the sensor to perform the specified functionality.

3. The temperature indicator shall be a bi-metal or mercury thermometer and shall be visible without removing the sensor cover. In lieu of integral indication, provide a separate thermometer or digital readout mounted on a stainless steel wall place adjacent tot he sensor for local temperature indication.

4. Room sensors shall be provided for wall locations.

D. Each controller shall perform its primary control function independent of other ATC LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real time data from the ATC time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via terminals as specified herein. This functionality shall allow for tighter control of space conditions and shall facilitate optimal occupant comfort and energy savings. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.

E. Provide each terminal equipment controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPSS) of sufficient capacities for all terminal controllers that do not meet this protection requirement. operating <u>programs</u> shall be field selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

F. Constant and Variable Air Volume Box Controllers: Shall support the following types of pressure independent terminal boxes as a minimum:

1. Air Terminal Unit with hot water reheat.

2. Cooling Only Unit

a. All Air Terminal Unit control applications shall be field selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

b. The Air Terminal Unit 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 ATC 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° to 122°F. (0° to 50°C) and 10% to 95% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

c. 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 fpm (0 to 20.4 m/s) and measurement accuracy of +/- 5% at 400 to 400 fpm (2 to 20 m/s), insuring primary air flow conditions shall be controlled and maintained to within +/- 5% of set point at the specified parameters. The ATC contractor shall provide the velocity sensor if required to meet the specified functionality.

d. 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 POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.

e. The Air Terminal Unit controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within +/- 1.5°F. (.9°C) of set point at the room sensor location.

f. Each controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve or cycling up-the three (3) stages of electric reheat as required to satisfy space heating requirements. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handing unit discharge temperature if required to satisfy space cooling requirements. This algorithm shall function to signal the respective ATC Controller to perform the required discharge temperature reset in order to maintain space temperature cooling set point.

4.23 SYSTEM INTEGRATION

A. The ATC contractor shall provide all software and hardware to provide monitoring and alarming to the ATC through software gateways for the following systems.

1. Variable Frequency Drives (VFD’s)

a. The ATC shall communicate with the VFD through both an RS-485 and Ethernet port.

b. Communication capabilities shall include, but not be limited to, run-stop control, speed set adjustment, proportional/integral controller adjustments, current limits, and accel/decel time adjustments. The drive shall have the capability of allowing the ATC to monitor feedback such as output speed/

frequency, current (in amps), % torque, % power, kilowatt hours, relay outputs, and diagnostic fault information.

c. The VFD shall have direct connectivity to the ATC via a single shielded twisted pair of wire. Through this interface the drive must operate as a LAN device. All required information for operation of the VFD must be communicated through the ATC. The VFD supplier will provide all software and hardware internal to the VFD to accomplish this.

2. Fire Alarm System

a. The ATC shall directly communicate with the Fire Alarm System. The ATC shall communicate with the fire alarm equipment to provide monitoring of all status changes for the fire alarm devices such as, smoke detectors, pull station, etc. Status conditions would detect normal, trouble, alert, and alarm modes.

3. Chiller

a. The ATC shall directly communicate with the Chiller Control Panel. The ATC shall communicate with the chiller equipment to provide all control and monitoring functions that are provided within the Chiller Control Panel, but not limited to the control points indicated on the input/output summary.

4. Boiler

a. The ATC shall directly communicate with the Boiler Control Panel. The ATC shall communicate with the boiler equipment to provide all control and monitoring functions that are provided within the Boiler Control Panel. But not limited to the control points indicated on the input/output summary.

b. The above is required to establish a demand set point on the plant which is outside of this building.

5. Lighting Control System

a. The ATC shall directly communicate with the future Lighting Control Relay Panels. The ATC shall then be able to communicate with the lighting relay panels to provide all control, monitoring and time of day functions, allow and effect emergency lighting sequence and restoration of normal lighting when normal power is restored. Provide all required relays and interlocks. Coordinate all panels with the Electrical Subcontractor prior to purchase.

6. Integration Start-Up and Check-Out Procedure

a. The ATC supplier shall independently start-up, check-out, and test all software and verify communication between all components. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that all terminations are tight. Verify that all analog and binary input/output points read properly. Verify all alarms and interlocks.

7. Integration Joint Commissioning - Verify Operation of the Integrated System

   a. Upon review of software, a point to point test of the integrated control installation shall commence. The system supplier representative in conjunction with a ATC contractor representative shall test actual field operation of each control and sensing point. Compare the values read in the ATC to those indicated on the system equipment.

   b. When the point to point input/output testing is successfully completed, a series of hardware/software systems test shall be performed. All groups of points that yield system control shall be tested for compliance with the sequence of operation.

4.24 ATC WIRE

A. General:

1. All ATC input/output signal wiring, Terminal Unit communications wiring shall be in EMT metal conduit or plenum rated cable in listed areas as described in Alternates.

2. All network communications between modular building controllers shall be installed in EMT metal conduit.

3. ATC contractor to provide all power wiring as required by their system. Extend emergency power from a source provided by the electrical contractor to provide power for the following control components: Operator's Workstation.

4. Route conduits in parallel banks with all changes of direction made at 90 degree angles.

B. Locate, size and support temperature sensing elements in air streams to properly sense the representative temperature.

1. In the case of controlling transmitting and indicating elements, locate the sensing device, sized and of the type to sense the average conditions.

2. In the case of safety elements, locate the sensing device and of the type to sense the extreme condition.

3. Sensing elements in double wall casings and insulated cuts shall have the entire active portion within the air stream.

C. Install temperature sensing elements in fluid lines and vessels with Type 304 stainless steel or monel wells filled with a non-solidifying heat conducting paste.

1. Locate sensing elements such that they are in the path of moving fluid and not positioned in stagnant or dead end locations.

2. Wells shall not obstruct the flow of the fluid being measured.

3. Increase all pipes 1 inch and smaller at least one (1) pipe size at the point of insertion.

D. Where insulation on piping, ductwork, or equipment is punctured or penetrated due to the installation of sensing elements or tubing, reseal the openings air and vapor tight.

1. Where control devices are to be located on insulated surfaces, provide brackets to clear the finished surface of the insulation voiding punctures of the vapor seal.

E. Locate, support, enclose, and install control devices and equipment such that they will not be subject to vibration, excessive temperatures, dirt, moisture, or other harmful effects or conditions beyond their rated limitations.

F. Check and verify location of thermostats and other exposed control sensors with plans and room details before installation.

1. Locate thermostats as directed by the Architect in compliance with ADA requirements.

G. Interlock alarms with starter switching to bypass alarm when equipment is manually disconnected.

H. Conceal sensing lines, cables, capillaries, and so forth, in all areas except equipment rooms, and other unfinished spaces.

I. Route sensing lines, cables, capillaries, and so forth, in all areas except equipment rooms, and other unfinished spaces.

J. Install control valves horizontal with power unit up unless indicated otherwise.

K. Install pressure sensing elements in ducts and casings with clean sharp taps to accurately read true static pressure avoiding velocity and turbulence influences.

L. Control valve and damper operators shall be capable of smoothly positioning under load through the full ranges and strokes indicated in both directions without binding or fluttering and shall be further capable of holding steady in any intermediate or extreme position while the respective systems are functioning at design flows, temperatures, and pressures.

M. Unless indicated otherwise, control space temperature within plus or minus 1°F and space relative humidity within plus or minus 5 percent of their set point.

4.25 COMPLETION OF INSTALLATION

A. Provide all necessary relays, switches, boosters, compressed air filters and regulators, gauges, valves, brackets, linkages, control devices, auxiliaries, fasteners, accessories, and connections to result in complete and operable control system shown on the drawings and specified.

B. Provide two (2) spare humidifier airflow switches and one (1) spare duct high limit humidity sensor to Owner at job completion."

4.26 CALIBRATION AND ADJUSTMENT

A. Calibrate and adjust all control devices, linkages, accessories, and components for stable and accurate operation to meet the design intent of the specifications and drawings and to obtain optimum performance from the equipment controlled.

B. Perform the final adjustment, calibration, and checking while the respective controlled systems are in full operation.

1. Cause every device to automatically function as intended to insure its proper operation.

4.27 INSTRUCTIONS TO OPERATIONS PERSONNEL

A. Upon completion of the work a factory representative under direct employ of the temperature control manufacturer shall provide one (1) forty (40) hour period of instruction to operating personnel who have responsibility for the mechanical system, including use of the provided laptop computer, configured to match the central front-end.

1. Additionally, temperature control manufacturer shall provide classroom instruction at the manufacturers facility for two (2) of the Owner's personnel.

2. Classroom instruction shall be the manufacturer's standard course on ATC control and shall be a minimum of two (2) day course. Contractor shall bear all travel costs for off-site training.

4.28 COMMISSIONING

A. Provide all material and labor required to fulfill the commissioning requirements as described herein and as directed by the Owner and the Commissioning Agent.

B. A part of the commissioning/turn-over process, support and participate in the pre-occupancy flush-out to maintain conditions during the process.

4.29 SEQUENCES OF OPERATION

A. The following sequences of operation shall be met. Provide all devices, wiring, instrumentation, software, programming, testing and verification, complete in all respects to assure an effective, repeatable and adjustable system, including through the graphic user interface.

1. Air Handling Sequence Summary/Overview

a. AHU-1 (Mixed return and outside air plus economizer, heating and cooling.) Variable air volume air handling unit with heating and cooling coils for constant temperature output and local high humidity control. Outside air indexed to the greater need of space occupancy indexing or space CO_2 levels. Night/ unoccupied operation is 100% recirculation with enthalpy economizer use as needed. Modulating chilled water control valve; modulating hot water control valve plus coil pump.

b. AHU-2 (100% Outside air supply; heating and cooling): Constant volume 100% air supply to the space, variable speed control for optimal performance and filter loading adjustment via Delta-P sensor and total volume control. Cooling and heating to indexed space temperature with deadband and unoccupied setback, via modulating coil control valves. Distribution to fan-coil served spaces plus a boost ventilation feature to the Meeting Room based on occupancy.

c. AHU-3 (Constant volume fixed limited outside air) serving special collections. No pre-heat coil. Two-stage cooling; Stage 1 by chilled water for base-level cooling, Stage 2 by DX direct expansion refrigerant coil for the greater demand of cooling temperature set point and/or high humidity set point control. Electric terminal reheat for local trimming. Central humidification based on aggregate return RH with individual space monitoring and override if outside range.

d. Fan Coil Units ("two-pipe" heating or cooling) serving offices and conference rooms with separately ducted pre-conditioned outside air. Local override of temperature, limits to adjustment band, occupancy sensor set-back with temperature limit override when unoccupied.

2. Air Handling Units - General and Common Characteristics

a. Air handling units shall be individually instrumented with all sensors, devices, inlet and discharge dampers where noted and with end switches to initiate fan start, valves and controls, to perform the sequences noted hereunder. Low temperature thermostats ("freeze-stat") shall be installed on all units handling outside air, series hard-wired to the starter shutdown safety circuit. High and Low static pressure switches shall be installed across all fans at appropriate locations for all systems with isolation dampers including fire dampers that may cause duct over or under-pressurization. All units shall have smoke detectors located at supply discharge and return air inlets, furnished and wired to power distribution system and fire alarm system by EC, installed by HVAC and wired by ATC to shut down the respective unit upon detection of smoke. In addition, return air inlet points at/leaving each floor shall have return duct smoke detectors furnished and wired by EC (16100) and installed by HVAC. These will respond to the FAS only. All filter pressure drops shall be monitored and addressed for service changeout at prescribed values. The differential pressure signal shall be used to modulate the VFD on constant volume units to maintain total airflow.

b. Boiler hot water plant is presumed to be fully operational during these sequences. A demand set point shall be established to the boiler plant via the DDC system.

c. Unit sequences are written for an individual unit and shall apply for each and all units of the type, singular language notwithstanding.

d. References to "high" and "low" speeds reflect maximum and minimum VFD settings, not two-position operation. Volume derivation and control is required.

e. Air handling units shall be set up for at minimum the following modes of operation (with exceptions noted):

1) Night/unoccupied setback and space monitoring to maintain conditions.

2) Morning/pre-occupancy warm-up/cool down, delayed outside air introduction as applicable.

3) Enthalpy-based (total heat) economizer.

4) Heating and cooling normal activity operation. Daily activity.

5) Dehumidification (dewpoint) high limit priority control with terminal reheat trim. Humidification (low limit control) at AHU-3 only.

6) Outside air volume monitoring and logging with carbon dioxide sensor input and override. Objective is to minimize use of outside air and associated energy loads on a selective basis, while monitoring occupancy and indoor air quality using carbon dioxide as a sentinel gas. This sequence of reduced outside below design minimums shall only be initiated after minimum design outside air cfm is established for a minimum time period. Not applicable to 100% outside air units nor recirculation units.

7) Variable air volume duct pressure-based and fan tracking control (AHU-1). This sequence shall establish a maximum duct static pressure for each system as determined during testing and balancing. Supply duct static pressure set points shall be reset from the maximum in response to sum of terminal box supply volumes. Minimum levels shall also be determined during testing and balancing. It is intended that the most remote terminal box be in stable control operation and at least 80% open position during minimum pressure conditions.

8) Safety device activation and shutdown including unit isolation dampers, smoke detectors, freezestats and high static pressure sensors. An alarm shall be sent via the DDC system.

f. All two-pipe fan coil units and the rooms served shall be set up for at minimum the following modes of operation (with exceptions noted):

1) Space temperature monitoring for heating OR cooling temperatures with deadband offset between modes of operation. Maintain setback temperatures (heating or cooling per season) during scheduled off-hours.

2) Interlock with occupancy sensors to operate fan coil units and associated outside air supply boxes when rooms are occupied. An adjustable 15-60 minute vacancy setback timer cycle to initiate unoccupied mode. Series/Parallel wired such that any one room on a common OA terminal shall enact for all connected rooms.

3) Alternated building-wide heating OR cooling. ("Master changeover") "Per Fan Coil" fan control except where multiple fan coil units serve a common space function.

3. Air Handling Units AHU-1 Modal Sequences (Variable Air Volume; General HVAC)

a. During Night/Unoccupied Setback

1) Unit is "off". Outside and exhaust air dampers remain closed, return dampers remain open. Discharge and OA inlet isolation dampers, remain closed, return dampers remain open. Fan start circuit shall be interrupted by in-series damper end switches at each isolation damper.

2) Space sensors monitor setback space temperature and, where so instrumented, space relative humidity. Polling of selected sensors shall be performed via the DDC system. AHU-1 shall be brought on-line to fill in night time supplemental heating and cooling functions only when fan coil units cannot meet heating nor cooling demand. AHU-1 shall take prime control for high level humidity control demand, taking advantage of the outside air enthalpy capability and starting the chilled water system when outside air is insufficient to dehumidify or cool.

3) Upon reaching the low limit second stage setback temperature (one degree F. below the fan coil unit maintained target setback temperature) adjustable, the AHU-1 supply fan shall start. This forms a second stage for when the fan coil units cannot keep up with the unoccupied period setback heating load. Outside air dampers shall remain closed and return dampers shall remain open (100% recirculation). The hot water control valve shall modulate to maintain space set point plus two (2) degrees adjustable. Upon satisfaction, the coil hot water valve(s) shall close, AHU fan shall stop.

4) Upon reaching the high limit temperature or high-humidity set point during setback cooling mode (based on selected polled sensors in multiple-zone systems or space-specific sensors in single-zone applications) the discharge and inlet dampers, shall open and, via end switches, the supply fan and return/exhaust fan hall start. The DDC system shall compare outside air enthalpy and optimize use of outside air and associated return/relief fans and dampers, when outdoor enthalpy is lower than indoor enthalpy. Otherwise the outside exhaust air dampers shall remain closed, and the return fan shall remain off. The use of chilled water with AHU-1 shall be indexed whenever the outside air to indoor air enthalpy differential is not sufficient alone to cool or dehumidify the spaces. This sequence will require that the central chiller plant be brought on-line. Trend logging shall be provided through at least the first full cooling season to establish this point. Control shall seek to postpone the need and establish the optimum anticipated point that will require chiller plant activation.

5) The chilled water system shall commence operation as directed by the Owner after notification by the DDC system of a need for cooling and/or dehumidification. The control valves shall modulate to maintain a discharge temperature of 53°F (adjustable) subject to space dewpoint control. The hot water reheat coil control valve(s) shall modulate to maintain a setback temperature indexed to relative humidity. Upon satisfaction of both space temperature and relative humidity, the chilled water valve shall close, the fans shall stop, and isolation dampers, as applicable, shall close.

a) Suggested off-hours set points: Cooling - 80°F; Relative humidity - 50% RH all adjustable and all trended to optimize energy use over time.

b. During Morning Warm-up/Cool Down Periods

1) The space set points shall be indexed to their "occupied" settings. The supply fan shall start and the duct static pressure control system shall take control to maintain the indexed, re-set duct static pressure. Terminal boxes and their respective reheat coils shall take control. Outside air and relief air dampers shall remain closed unless beneficial.

2) Respective heating and cooling sequences shall commence to maintain discharge air set points. Optimum start time sequence shall be provided within the DDC logic to assure warm-up or cool-down time (achieving occupied set point) coincides with desired occupancy time.

3) Upon reaching occupied set point and subject to space occupancy, (as indexed by time clock function, or space motion detector as noted herein or elevated carbon dioxide (CO_2) levels) the outside air dampers shall open to their minimum positions, if not already open as a function of enthalpy-based economizer free-cooling.

4) The return, primary relief and penthouse mechanical room relief, and outside air dampers shall take independent corresponding positions, and shall modulate to maintain space temperature and demand-based ventilation in this single-zone system.

c. Occupied Mode

1) The space sensors shall control respective heating and cooling sequences with an adjustable deadband to maintain occupied set points.

2) In heating mode, the hot water control valve shall modulate to maintain discharge air set point 55°F (adjustable).

3) In cooling mode, the chilled water control valve shall modulate to maintain discharge air set point 55°F (adjustable).

4) When space relative humidity (RH) rises above high limit set point, (50% RH, adjustable) dehumidification sequence shall commence. If, after enthalpy-based economizer operation fails to maintain humidity high limit conditions, the chilled water control valve shall override and reset the discharge air temperature downward in 0.5 degrees F. increments at time intervals of 2 to 5 minutes (adjustable) to control space relative humidity. Upon reaching space target RH (less 5% or 45% RH), normal cooling mode operation shall resume and the control valve shall again respond to normal discharge air temperature.

5) The AHU-1 VSD, in normal operation shall respond to supply duct static pressure as set up during initial testing and balancing, to correspond to full design airflow with clean filters. The corresponding return fan shall modulate speed/airflow based on the cfm delivery of the supply fan less an adjustable offset cfm. The outside air, return air and relief air dampers shall individually modulate to maintain discharge air setpoint. Relief air shall be discharged to ventilate the mechanical room and relieved to atmosphere based on mechanical room positive static pressure (0.05 inch W.G. adjustable) via a modulating damper.

6) Upon start of unoccupied mode as indexed either manually by the DDC system, by the DDC system master timeclock or by space occupancy sensor, the fan shall stop and unoccupied setback set points for heating and cooling shall take effect. The unit shall remain off until and unless the unoccupied low or high limit set points are reached.

d. Outside Air Volume Control and Monitoring

1) Outside air volume shall be direct measured and controlled independently of supply or return airflows at unit AHU-1 and 3. AHU-2 is 100% outside air so has no response mechanism. AHU-3 is fixed outside air controlled by a dedicated constant volume terminal box and two-position closure damper. This outside air terminal box shall be adjustable via the DDC system to respond to space humidity or temperature but shall otherwise remain fixed. AHU-1 will have the ability to adapt and respond to both elevated and diminished CO_2 levels, by automatically adjusting outside air dampers beyond temperature based control.

a) All outside air measurements for all units receiving outside air shall be trend-logged at pre-selected intervals and archived on a monthly basis or at the Owner's preference.

b) Means of outside air measurement for AHU-1 shall be temperature diffusion based, similar to Ebtron, interlocked with associated dampers, or pressure-differential based equal to Air Monitor Corporation Fan-Evaluator, or equal by Setra. AHU-3 shall have a dedicated CV box as noted above with trending via a signal transducer through the DDC system.

2) Once minimum CFM values are established for each of the systems space carbon dioxide sensors shall monitor space air CO_2 values and outside air values. Outside air for AHU-1 shall then be reduced below minimum design CFM set points as required to maintain an indoor CO_2 level no greater than 800 PPM in the space or 500 PPM (adjustable) above the outdoor ambient CO_2 level, whichever is lower. Provide dual sensors and differential algorithm. A single common outdoor reference CO_2 sensor may be used for more than one unit.

3) This global CO_2 system shall provide a base average that shall be over-ridden by local space CO_2 sensors. Refer to terminal box sequences of operation with CO_2 influence. When local CO_2 levels are trending towards or exceeding set point, corresponding air handling unit outside air shall, if reduced by global CO_2 measurement, have their minimum design values restored. Nothing in this sequence shall affect greater amounts of outside air as may be needed for economizer free cooling, further gradual CO_2 dilution, dehumidification or make-up air volumes. It is intended by this sequence to allow mitigation of outside air volumes and attendant energy use subject to meeting indoor space comfort and quality conditions.

4) AHU-1 outside air cfm shall be responsive to the greater of:

a) Population based on CO_2 levels as a sentinel gas. See above.

b) Economizer free cooling/discharge temperature.

e. During economizer mode or whenever outside air is being introduced in quantity, the excess air shall be relieved via modulating motorized dampers to ventilate the mechanical penthouse. Secondary dampers shall modulate in response to differential indoor air pressure referenced to outside barometric pressure, to maintain an indoor (penthouse) positive pressure of 0.05 inch (adjustable). The intent is to ensure a positive outflow pressure to minimize external wind driven precipitation or uncontrolled air leakage into the mechanical room.

f. Air Volume/Pressure Control and Monitoring

1) AHU-1 supply duct system shall be instrumented with duct static pressure sensors as indicated on the plans (set point 1.25 inch w.g. or as otherwise noted, all adjustable and as determined during testing and balancing). Reset of duct static pressure set point shall be provided per Section 15500, Paragraph 4.29 A.2.e.7). Once the system has started, the duct static pressure system shall take control. Duct SP signal shall be transmitted via the DDC system to control the supply fan variable frequency drive(s) to maintain constant supply duct static pressure relative to atmosphere.

a) System shall respond to modulation, opening or closing of various indexed and pressure independent terminal boxes responding to room level air management needs.

2) Air Handling Units AHU-1 shall have its supply fan instrumented with inlet probe type flow measuring stations with transducers. These shall be furnished and installed by the ATC sub-contractor to extract instantaneous supply (hence outside air) CFM volume.

4. Air Handling Units AHU-2 Modal Sequences (100% Outside Air with energy recovery)

a. During Night/Unoccupied Setback

1) Unit is indexed to "off" based on the DDC system universal timeclock or as otherwise indexed. Isolation dampers remain closed.

2) Space sensors monitor setback space temperature and, where so instrumented, space relative humidity. Polling of selected sensors shall be performed via the DDC system.

3) Upon reaching the low-limit setback temperature, (one degree F. below radiation/fan coil unit setback temperature set point, adjustable), the fan coil units shall start. The dual temperature water control valves shall modulate to maintain space set point plus two (2) degrees adjustable. AHU-2 shall remain off during unoccupied hours except when outside air enthalpy is suitable for free cooling/dehumidification as noted below.

4) Upon reaching the high limit temperature or high-humidity set point during setback mode (based on selected polled space-specific sensors in this single-zone application) the DDC system shall compare outside air enthalpy and optimize use of outside air, when outdoor enthalpy is lower than indoor enthalpy. Otherwise, AHU-2 shall remain off.

b. During Morning Warm-up/Cool Down Periods-Initiating Occupied Mode

1) The space set points shall be indexed to their "occupied" settings. The supply fan shall start after isolating outside air and exhaust air dampers are proven "open".

2) Respective heating or cooling sequences shall commence to maintain occupied discharge air set points. Modulation hot water/chilled water control valve to maintain discharge air temperature (55°F in summer, 60°F in winter, all adjustable). Optimum start time sequence shall be provided within the DDC logic to assure warm-up or cool-down time (achieving occupied set point) coincides with desired occupancy time.

c. Occupied Mode

1) The space sensor shall control respective heating or cooling sequences with an adjustable deadband to maintain occupied set points

2) The energy recovery wheel shall operate whenever the indoor enthalpy and outside air enthalpy difference exceeds 2.0 *h*, and when the indexed discharge air temperature set point cannot be maintained,

either heating or cooling. When outside air enthalpy is suitable for economizer operation, the wheel rotation shall be "off". When the wheel is off, bypass dampers shall modulate open to avoid unnecessary pressure drop. The unit/system VSD shall modulate fan speed to maintain constant indexed total air volume.

3) Only when the energy recovery wheel is operational and the discharge air set point cannot be maintained, shall the water control valve modulate to expend heating or cooling energy. When the energy recovery wheel is out of commission either manually or under "inconsistent status" alarm, the water control valve shall be allowed to modulate to maintain discharge set point.

4) In heating mode, the water control valve shall modulate to maintain discharge set point.

5) In cooling mode, the water control valve shall modulate to maintain discharge set point.

6) When "polled sensor" space relative humidity (RH) rises above high limit set point and the fan coil units are operational, dehumidification sequence shall commence. The chilled water control valve shall override response to space temperature and control to space relative humidity. Concurrently the unit variable speed drive (VSD) shall reduce to a pre-set stable low speed constant volume setting. Upon reaching space target RH, normal cooling mode operation shall resume, the fan shall revert to normal full speed and the control valve shall again respond to space temperature. It is intended that the fan coil units shall provide baseline humidity control in conjunction with normal AHU-2 dehumidification contribution. When such is insufficient, AHU-2 shall take the above steps before resuming normal operation.

7) The AHU-2 VSD shall in normal operation shall respond to fan CFM as set up during initial testing and balancing, to correspond to full design airflow with clean filters and to maintain an indexed CFM value as set up during testing and balancing (TAB). This will begin as a lower speed; fan speed shall increase as filters load and fan CFM capacity decreases. Upon reaching 60 hertz and a concurrent filter pressure differential set point is reached, a filter change-out alarm shall be sent via the DDC system.

8) Upon start of unoccupied mode as indexed either manually by the DDC system, by the DDC system master timeclock or by space occupancy sensor, the fan shall stop and unoccupied setback set points for heating and cooling shall take effect. The unit shall remain off until and unless the unoccupied low or high limit set points are reached.

5. AHU-3 Modal Sequences including ACCU, Humidity and Terminal Coil Control

a. AHU-3 shall start/stop as indexed by the DDC system central timeclock, but in general shall operate continuously. Any inconsistent status shall be reported as an alarm.

b. Upon activation, the supply fan shall start and outside air isolation damper shall open.

c. The outside air dedicated constant volume terminal box shall take control to provide constant, pressure-independent outside air to the unit. Actual CFM shall be as set up during testing and balancing (TAB) including damper adjustment of return air upstream of the outside air introduction point. This outside air terminal box shall be adjustable above its minimum CFM default setting in response to elevated space temperature or humidity. The default setting shall resume upon satisfaction.

d. Upon a call for cooling, the chilled water control valve shall modulate open to provide a base level of cooling. Discharge air set point shall be monitored with a target temperature of 50°F. The individual space shall have temperature sensors as shall the return air stream.

e. When the control valve is at 100% (adjustable) and the cooling set point is not met, the air cooled condensing unit ACCU-1 compressor and condenser fan shall start. The condensing unit shall operate between high and low stages (100-67% or 100-50%) and operate at low-ambient conditions down to -20°F.

f. At the air handling unit, a Thermal Expansion Valve (TXV) shall modulate to maintain saturated suction pressure based on a demand from the greater need of:

1) Individual space and return air temperature cooling set point (65°F. adjustable) or

2) Space high-limit relative humidity (50% RH high limit, adjustable).

g. In-duct electric heating coils with SCR controls shall modulate output to maintain individual space set points in all conditions. A time-response PID algorithm shall be provided to limit reheat use and ramp speed from off to 100% from 1 to 15 minutes, adjustable, without over-shoot. Initial set point shall be ten (10) minutes with a space temperature sensor polling rate of 500 milliseconds to 2 seconds, adjustable.

1) Space high-limit humidity shall be controlled by temperature priority, using chilled water and DX cooling to dehumidify the air but limiting the space and return air temperature set point to the greater of 65°F. temperature before applying reheat.

2) Reheat operation shall not be used to drive up space temperature as a means of depressing relative humidity unless space temperature falls at least one (1) degree F. below cooling set point while concurrently the relative humidity remains above space set point.

h. Space humidity low-limit shall be maintained by humidifier H-1. AHU-3 and the spaces served shall be instrumented with humidity sensors in each space near the return air extract points and in the AHU-3 return ductwork <u>upstream of the outside air introduction point</u>. Each space sensor shall monitor that space's individual instantaneous requirements including trend-logging. The return duct sensor, set at 30% RH adjustable, shall send it's signal to the humidifier which shall modulate output (steam to the supply airstream) to maintain return air averaged set point. A time-response PID algorithm shall be provided to monitor rate of rise in average return air RH to prevent over-shooting.

1) The humidifier H-1 shall be provided with a factory airflow switch to lock out the humidifier when airflow is not fully established, a duct high-limit to prevent ductwork saturation.

2) All in-pan water detector in the humidifier section of AHU-3 shall be provided to alarm a water condition.

6. Air Terminal Boxes General and Common Characteristics

a. Refer to Section 15500, Paragraph 2.26, subparagraph DD., for terminal box types, specifications, accessories and features, and delivery/installation method of terminal box controllers. Terminal box control is applicable to AHU-1 supply air control and for AHU-3 outside air control.

b. All air terminal boxes shall be pressure-independent, closed-loop and status reporting. By this is intended that each terminal box air damper and controller shall maintain instantaneous cfm regardless of controlling variable (space temperature, preset constant volume or indexed volume) all compensated for varying inlet duct pressures. Further, box controller shall report percentage position open or closed, and cfm delivered at any point, via the DDC system including trending.

c. See individual modes of operation and specific space sequences as applicable. The following sequences are common to several modes and applications. Note that the boxes with reheat coils shall "lock out" their reheat functions until the box controllers and dampers are at their minimum airflow settings.

d. The term "terminal box" or "box" for the purposes of this specification shall be construed to mean an automated air terminal of any description, be it single-duct conventional, single-duct special large volume type, with or without a coil, but including controllers, modulating damper, inlet airflow sensors, pickups, transducers, actuators, control boards and DDC interfaces, in whole or in part as the context so indicates. This also includes minimum outside air controllers maintaining a constant volume of outside air.

7. Single-Duct Variable-Constant Volume Operation, With Reheat, Including Indexed Operation (Occupied/Unoccupied)

a. The terminal box shall maintain an indexed volume cfm air supply based on space temperature under all occupied conditions. The terminal box controller shall modulate the damper between minimum (ventilation based) set point and maximum (cooling based) set point.

b. Upon a continued drop in space temperature, with the box damper at minimum position, the hot water coil control valve shall modulate to maintain space temperature.

c. Radiation, when interlocked with a terminal box, shall have its control valve open at a percentage of coil control valve position. Radiation valve shall "lead" in general.

d. Only at minimum or constant volume settings, the terminal box hot water control valve shall modulate to maintain space temperature.

e. During morning warm-up and cool-down mode, the terminal box damper shall remain in the maximum cfm position and the coil valve open for maximum turn-over and rapid response.

8. Single-Duct Constant Volume Operation; Temperature Dependent With Reheat, Normal Operation

a. The terminal box shall maintain a constant indexed volume cfm air supply under all operational conditions. Upon a continued decrease in space temperature, the terminal box hot water control valve shall modulate to maintain space temperature. This shall include morning warm-up mode.

9. Single-Duct Constant Volume Operation; Temperature Dependent

a. The terminal box shall maintain a constant indexed volume cfm air supply under all operational conditions. Applicable to AHU-3 outside air control.

10. Fans, General and Common Characteristics

a. All fans shall be instrumented to report status (on/off/alarm inconsistent status/ high amperage). Provide all current sensors, interlocks to starters (operation and safety-off) lockouts and programming of sequences to operate with ancillary equipment. Where Variable Frequency Drives (VFD's) are provided, fan speeds shall be indexed based on balancing data, pre-set to individual sequences and modes of operation. Provide all switches for manual control where indicated.

b. All fans isolated by dampers shall be interlocked with damper end switches to enable start sequences. All fans with duct systems penetrating building weather barriers shall have isolation dampers. All dampers at intermittent-use fans and systems (where the damper acts primarily as a thermal barrier) shall be insulated sandwich blade type.

c. Supply and return fans associated with air handling units shall be instrumented per sequences noted within air handling units as applicable. This shall include cfm measurement and tracking of supply airflow.

11. Fan Sequences, Including Associated Systems

a. F-1, (return fan for AHU-1) shall start/stop as indexed by the DDC system central timeclock, but in general shall operate in parallel with AHU-1. When AHU-1 is off, fan F-1 shall be off. Fan cfm shall modulate in parallel with AHU-1 (tracking) per AHU-1 sequence of operation based on real-time CFM airflow all via the F-1 variable frequency drive. Return air dampers shall modulate to return to AHU-1 with excess air relief ventilating the penthouse mechanical room. (A secondary damper shall relieve penthouse air based on an independent positive differential pressure difference.)

b. F-2 serving basement mechanical room shall start/stop based on space temperature high limit (80°F. adjustable) and with the associated outside air intake damper opened. Fan shall continue to run until space drops below set point. When the fan is off, the outside air damper shall close. Space temperature shall be monitored and alarmed both high and low and fan inconsistent status alarmed.

c. F-3 serving basement electrical room shall start/stop based on space temperature high limit (80°F. adjustable) and with the associated outside air intake damper opened. Fan shall continue to run until space drops below set point. When the fan is off, the outside air damper shall close. Space temperature shall be monitored and alarmed both high and low and fan inconsistent status alarmed.

d. F-4 serving penthouse mechanical room shall start/stop based on space temperature high limit (80°F. adjustable) and with the associated outside air intake damper opened. The actual set point shall be set to be at least five (5) degrees above that maintained by AHU-1/F-1 economizer relief to minimize run hours. Fan shall continue to run until space drops below set point. When the outside air temperature rises above 85°F. and the space temperature being controlled rises above 90°F., fan F-4 shall stop and the outside air damper shall close. Fan shall restart when the outside air temperature drops below 80° F. and the space is above cooling set point (high-low floating set point with outside air high limit interrupt). Space temperature shall be monitored and alarmed both high and low and fan inconsistent status alarmed.

e. F-5 serving janitors closet shall operated via the DDC master timeclock to coincide with building hours of occupancy or as otherwise scheduled by the Owner.

f. F-6 serving toilets shall operated via the DDC master timeclock to coincide with building hours of occupancy or as otherwise scheduled by the Owner.

12. Water Pumps: General and Common Requirements

a. All pumps shall be instrumented to report status (on/off/alarm inconsistent status/ high amperage). Provide all current sensors, interlocks to starters (operation and safety-off) lockouts and programming of sequences to operate with ancillary equipment and systems. All pumps shall have off-season cycling, scheduled via the DDC system to exercise bearings and to prevent seizing.

b. All pump systems which are scheduled to be fitted with variable frequency drives (VFD's) shall be instrumented with differential pressure control sensor(s) to maintain a constant pressure gradient between supply and return lines. VFD's may be shared by primary/standby pumps as noted below. Provide sensors and wiring under this section. Installation of sensors and wells shall be by HVAC in piping locations established by the ATC subcontractor in cooperation with the HVAC subcontractor.

c. Where pumps have primary/standby duty, one pump shall operate at a time, the other standby. Index pump operation via the DDC system to switch primary/standby status on a weekly alternating basis, or as otherwise determined by the Owner. VFD's may be shared by primary/standby pumps as noted below. Inconsistent status or failure of any one pump shall cause that pump to be locked out, the alternate pump to start, and an alarm sent via the DDC system. Failure to establish flow shall lock-out connected heat transfer equipment (chiller).

13. Hot Water Pumps P-1 and P-2 (Primary/Standby Alternating)

a. Pump operation shall be initiated via the DDC system by a call for heating hot water based on sensor demand, outside temperature or as otherwise indexed including reheat use. Pump shall start via the VFD shared by those pumps. Pumps P-1 and P-2 shall be able to run at any time of year.

b. Pump operation, status and flow shall be verified. Failure to prove flow shall automatically start the second pump. After switching to the alternate pump shall send an alarm of primary pump failure.

c. Once operational, the pressure differential control system shall take control to maintain a constant pressure gradient between supply and return lines. The VFD shall modulate to maintain constant differential pressure, between maximum and preset minimum VFD settings established during balancing and commissioning.

d. Once hot water flow and pressure control is established, the primary hot water injection control valve shall modulate to maintain building HWS set point. This shall be indexed to an outside air temperature curve providing 140° water at 0° outdoor temperature and dropping this to 120° at 40° outdoor temperature and above, all adjustable. In addition, the valve shall override the curve when the hot water return temperature drops below 50° (adjustable) below the hot water supply set point.

e. A pressure differential control valve arrangement shall be provided under this section, set up to 125% of system differential set point (adjustable) such that it will come into operation in event of VFD failure by low or high VFD HZ level being reached, or switching pumps into manual 100% bypass mode. Valve and controls shall be provided. Valve shall be furnished to HVAC for installation in piping with appropriate isolation valves, strainer and trim.

14. Chilled/Dual Temperature Water Pumps P-3 and P-4 (Primary/Standby Alternating)

a. Pump operation shall be initiated via the DDC system by a call for chilled water based on sensor demand, outside temperature or as otherwise indexed. Pump shall start via their individual VFD's. Pumps serve "limited variable" flow to the chiller. Pump VFD speed limits shall be set for stable chiller operation established during commissioning by actual measured flow. VFD modulation shall be low limited to the predetermined analog gpm flow signal from the chiller flow meter.

b. Pump operation, status and flow shall be verified. A pressure differential control valve arrangement shall be provided under this section, set up to 75% of total pump dynamic heads (adjustable). Valve and controls shall be provided. Valve shall be furnished to HVAC for installation in piping with appropriate isolation valves, strainer instrumentation and trim.

c. See also water cooled chiller sequence of operation.

15. Hot Water Boilers B-1 and B-2

a. Refer to boiler specifications for internal and provided safeties. The boilers shall shut down by activation of any device within the safety circuit including but not limited to space high limit temperature, space CO, low water cut-off (LWCO), manual service switch, exterior red-plate switch (power and fuel cut-off), draft-proof switch, operating safety high limit and other code devices.

b. The boilers shall be enabled and shall fire based on a demand for building hot water heating.

c. The boiler shall fire only after proof of safety circuit closure, draft, pre-purge, pilot ignition and pilot flame establishment. After firing, a post-purge sequence shall commence both on combustion path and water pump circulation, prior to shut down. Inconsistent status shall be alarmed including high and low temperatures

d. Boilers shall be staged lead-lag for even wear and optimized efficiency The boiler control panel shall determine optimum staging based on differential between supply water temperature and return water temperature. An elevated return water temperature shall cause the boiler(s) to down-fire (modulate) to maintain a constant delta-T relationship supply to boiler return temperatures.

e. When starting the plant. one boiler shall fire to meet indexed hot water supply setpoint. When the return water temperature rises above the target return water temperature (T-supply minus differential), the lead boiler shall down-fire to maintain this differential. If during this mode the target supply hot water temperature drops below setpoint, the second boiler shall be brought on-line and both boilers shall modulate in unison to maintain supply water setpoint. Both shall down-fire together upon a rise in boiler return temperature. When system supply water temperature setpoint is satisfied and the boilers are firing at their minimum rates, the lead boiler shall drop out and the lag boiler shall continue operation.

16. Chiller Plant General and Common Characteristics

a. Chiller plant consists of an air-cooled chiller and pumps as specified in Specification Section 15500, Part 2. Operating principle is "limited variable primary flow" with return water reset and pressure differential bypass control. Information listed here shall be considered a general summary and supplemental to information provided elsewhere.

b. Complete interface wiring between chiller gateway and DDC system shall be provided including all software, protocols, binding and command structure programming shall be provided under this section.

c. Provide all sensors and wiring for remote devices and functions, where not provided by the chiller or cooling tower manufacturer.

17. Air Cooled Chiller

a. Chiller shall come complete with its own on-board control panel and diagnostic package, controlling and monitoring all internal operational and safety functions. See Section 15500, Paragraph 2.31 AIR COOLED CONDENSING UNIT for more information. The FMS subcontractor shall, via the DDC system, provide all enabling controls including proof of pump operation and water flow, chilled water supply set point adjustment, chilled water return water reset and adjustment, status, chilled water temperature values, set point adjustments and alarm conditions.

b. Chiller shall stage to maintain chilled water supply temperature set point adjusting to match the building load including hot gas bypass for low load operation. Compressors shall share lead-lag duty for even wear.

c. The chiller shall be operated during commissioning to lowest staged loads and with measured concurrent chilled water flow through the evaporator. The chiller manufacturer's factory service and start-up representative shall be present and set up the chiller operation at reduced water flow (50% initial target or lower) to assure stable chiller operation and to determine the coincident minimum chilled water flow at that point. Pump VFD's serving P-3 and P-4 shall have low-limit stops set at their VFD's and shall modulate downward per variable flow sequence but not lower than the prescribed flow rate based on an analog flow meter input.

18. Dual Temperature Water System (Seasonal Change-Over)

a. The DDC system shall index the change-over of the dual temperature water system (DTWS) from heating to cooling and from cooling to heating, based on any of the following Owner-determined commands:

1) Manually indexed subject to system temperature limits.

2) Based on calendar day subject to system temperature and time limits.

3) Based on outside air temperature subject to system temperature and time limits.

b. The piping system shall be instrumented and fitted with change-over valves, either linked butterfly valve assemblies or three-way diverting valves, temperature sensors and timer functions. Valves shall be set up to stroke from one port to the other from a common inlet port with a variable time-span of 45 seconds to five minutes, adjustable. The intent is to avoid thermal and hydraulic shock to system components.

c. The change-over, when indexed, shall not occur until the following criteria have been met:

1) When changing over from heating to cooling, however indexed, the supply and return water temperatures shall have cooled to not more than 75°F. (adjustable) and a minimum time elapse of at least three (3) hours has occurred since the last boiler firing. It is intended by this

that the system water temperature shall have dropped to a point that will enable the air cooled chiller to start and to avoid rapid switching between heating and cooling and to absorb/purge residual heating energy.

2) When changing over from cooling to heating, however indexed, a minimum time elapse of at least three (3) hours shall have occurred since the last chiller operation. It is intended by this to avoid rapid switching between heating and cooling and to allow time to dissipate and absorb/purge residual chilled water energy.

d. The dual temperature pumps P-3 and P-4 shall operate as described elsewhere in this specification.

19. Cabinet and Unit Heaters

a. Cabinet and unit heaters including existing shall be instrumented, with two-position, two-way, non-modulating control valves and return line reverse-acting (make on rise) strap-on or immersion-well mounted aquastats. Upon a call for heat, the control valve shall open. The return aquastat shall start the fan based on a minimum temperature sensed (95°F adjustable). Upon satisfaction of set point, valve shall close, fan shall continue to run until the return line temperature drops below aquastat set point. These devices may be local control, without DDC interface.

b. Cabinet and unit heaters are "heating only" devices. All control valves shall remain positively closed during the cooling season (chiller operation) and shall be selected to close against chilled water mode operating pressures.

20. Fan Coil Units

a. Fan coil units (FCU's) Two-Pipe; chilled water cooling in summer hot water heating in winter via a common single coil within each.

b. Fan Coil Units shall be set up for normal two-pipe control allowing heating OR cooling with building-wide deadband between set points. Room DDC sensor/thermostat shall be set up for user adjustment with centrally limited set point adjustment and deadband to limit occupant range. This range shall be adjusted individually for any controller and shall also have, via the software, a global "all-command" to a given setting. Rooms with multiple fan coil units such as for perimeter coverage, shall be controlled by a single common set point controller/sensor unless otherwise indicated on plans.

c. Heating mode shall cause the water control valve to modulate open-closed to maintain space heating set point.

d. Cooling mode shall cause the water control valve to modulate open-closed to maintains space cooling set point.

e. Control valves for fan coil units are intended to be furnished by ATC for installation by HVAC. However, nothing herein shall prevent the provision of equivalent control valve (including isolation and balancing valves, drains, etc., meeting the specifications) by the fan coil unit manufacturer.

f. An intermediate and adjustable deadband of at least 2°F. shall be incorporated between heating high limit temperature set point and cooling low limit temperature set point plus a central dual temperature water system algorithm to assure a change in water temperature of 30°F., (adjustable) between heating and cooling modes of operation, both indexed to outside air temperature.

g. A water detector ("WaterBug" or equal with output contactors) placed in the auxiliary condensate overflow drain pan shall shut down any FCU and send an alarm upon detection of water.

h. Room occupancy sensors in each office type room shall shut down the units to a setback temperature after an adjustable vacancy time of 15 minutes (5 to 60 minutes range). The fan coil unit shall remain off unless the setback temperature set point is reached, at which time the unit shall run to reach and maintain the setback set point plus 1°F. Upon detecting occupancy, the unit shall resume normal occupied set point. The room occupancy sensor shall also trigger the ventilation air terminal box set point, reducing the air volume when all rooms served by a given terminal box become vacant and after an elapsed time period of 15 minutes (adjustable). Triggering any occupancy detector shall resume airflow to normal occupied status for all rooms.

21. Standard Variable Constant Volume Terminal Box with Parallel 100% Outside Air from AHU-2 (Conference Room 209)

a. This sequence governs the Conference Room, a room of variable high population, served by standard variable constant volume terminal box and requiring higher outside air volumes during high occupancy.

b. Conference Room 209 base HVAC requirements are served by a terminal box (variable-constant volume with reheat coil) and interlocked radiation. This terminal will maintain base temperature control for both heating, cooling and base ventilation needs. The reheat coil hot water control valve shall not open until the terminal box is at its minimum (ventilation) position and there is a continued drop in space temperature. The radiation hot water control valve shall open only after the terminal box hot water control valve has opened to a predetermined percentage (50% adjustable). This "percentage to radiation" setting shall be owner-adjustable through the graphic user interface.

c. A "Meeting Mode" sequence shall be provided. The meeting mode shall be initiated by any of the following:

1) Manual timer button located in space, programmed for an adjustable period of between one to three (1 to 3) hours. This shall override any other initiation.

2) As scheduled via the DDC system including timer delay.

3) By an occupancy sensor after a 15-minute delay from activation to start of sequence. Intent is to avoid nuisance activation during short-term occupancy or custodial entry.

4) By elevated CO_2 levels above a pre-set adjustable high limit.

d. The "Meeting Mode" sequence shall cause the following to occur:

1) Terminal box shall open to 100% of balanced airflow and maintain a constant volume of airflow at that point. The terminal box coil shall take the lead in providing space temperature control with the radiation following.

2) Supplemental outside air (100% outside air) provided by AHU-2, shall be introduced to the room by a normally closed control damper. (AHU-2 balancing shall be set up with the damper open and this airflow provided. When the damper closes, the remaining spaces shall share the airflow in normal proportion.)

e. "Meeting Mode" shall cease and the space shall revert to normal temperature responsive operation upon all of the following:

1) Lapse of manual timer period.

2) As scheduled via the DDC system including global night setback feature for the building as a whole.

3) Lapse of time from last occupancy sensor activation, 15 minutes, (adjustable from 5 to 30 minutes).

4) By Carbon Dioxide (CO_2) levels below set point as determined by monitoring.

a) After not less than 15 minutes (adjustable from 5 to 30 minutes) from establishment of full airflow and supplemental airflow, the CO_2 sensor input shall be compared to the pre-set value. The pre-set CO_2 value shall be within an adjustable range of between 400 and 1000 parts per million (PPM). Suggested initial high limit set point shall be 725 PPM.

b) Once the CO_2 reading is consistently below that threshold, the DDC system shall first close the AHU-2 100% supplemental outside air damper. After another adjustable time period (5 to 15 minute adjustable) the system shall then release the primary AHU-1 source terminal box to normal temperature responsive operation.

c) It is intended to first establish higher outside air ventilation rates then reduce airflow if space carbon dioxide, as a sentinel gas, falls below acceptable limits.

4.30 ATC POINTS LIST

A. ATC Contractor shall submit a complete list of devices, units, sensing etc., associated with the system. The following is a partial list of points that shall be tied into the SDC's for monitoring, alarming, modifying, etc. Provide additional points to provide the sequences outlines or as indicated elsewhere to provide a complete an operable system. CCS shall connect to the

Building Management System to provide Owner the capability to create displays of each system, as well as all points.

B. All software, hardware, commissioning, etc., shall be provided to make a completely integrated system.

C. Point List: Submit complete list of devices of elements to be controlled or sensed by system. Include sufficient detail to enable engineer and owner to determine that system can perform control sequence of operations listed in HVAC specifications. Point count must contain at least 125% capacity of all points instrumented for control of sequences. These points shall be displayed at the SDC's.

1. List of every component to be sensed or controlled keyed to terminology used in HVAC Control Drawings; that is, Valve V-1, HVAC-1, etc.

2. List of hardware associated with each point; that is, solenoids, contractors, transducers, etc.

3. List of analog inputs to be sensed at each point; that is, temperature, relative humidity, etc.

4. Alarms associated with each point.

5. Control functions associated with each point; that is, start/stop, set point control, etc.

6. The following is a sample list of the minimum points that shall be tied into the field panels for monitoring, control, etc. As a minimum provide these points. Provide additional points as necessary to provide all sequences to provide a complete operable system.

7. Where more than one fan or pump is listed under an item, a separate point is required for each fan, pump, etc. unless noted otherwise. Provide occupied/unoccupied override capability at each panel.

8. Start, Stop, Status and Run Time; Miscellaneous Points and Inconsistent Status Alarms

a. Each air handling unit (AHU) including return fans, VFD hertz/percentage as applicable.

b. Water Cooled Liquid Chiller.

c. Each pump, including plumbing and fire protection pumps, sewage ejector pumps, sump pumps, etc. (Connection to spare contacts provided on equipment.) Includes fuel oil pumps.

d. Summer Boiler including safety circuit.

e. Exhaust fans.

f. Pumps including coil pumps.

g. Flow switch at make-up water to chilled and hot water system. Alarm unattended flow for 30 seconds (adjustable) and report alarm as leak detection. Affect closure of main valves leaving building.

4.31 MISCELLANEOUS

A. Provide five (5) working days of programming for Owner directed topics during the warranty period.

B. ATC Subcontractor shall provide all automatic dampers and actuators at air handling unit's mixing boxes which are to be used for air side economizer, and which are not provided by the unit manufacturer.

C. All devices, equipment, systems shall be UL listed and approved according to their appropriate categories.

D. ATC shall provide control wiring and alarm light to signal boiler failure.

E. Provide thermometers and sensors in walls at the following locations for each system:

1. Outside air temperature (north side of building in shaded enclosure).

2. Mixed air temperature (downstream of filters in each AHU).

3. After AHU heating coil (in access section between heating and cooling coils).

4. After cooling coil.

5. In discharge after supply fan.

6. Return air to each mixed air AHU upstream of return fan.

7. Water system supply and return.

a. At each air handling unit.

b. At hot water entry and exit from the building chillers, supply, and return at the chiller and at the CHWS&R exits from the building.

F. Also provide electronic sensors to allow for reading of these temperatures at the ATC system.

END OF SECTION 15500