SECTION 15010
BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

The General Provisions of the Contract, including General and Supplementary Conditions and Division 1 - Specification Sections and Contract Documents apply to work in this section. Consult them for further instructions and be governed by the requirements thereunder.

1.2 SUMMARY OF WORK

A. Description of Systems

The work of Division 15 includes but is not limited to:

1. Heating, Ventilating and Air Conditioning Systems
2. Plumbing Systems
3. Fire Protection Systems.

B. Work Included

1. Furnish all labor and materials and perform all operations necessary for the installation of complete and operating mechanical systems subject to the conditions of the contract. The work also includes the completion of such mechanical and electrical details not mentioned or shown which are necessary for the successful operation of all systems; this includes the furnishing of all materials for filling systems to make them operable, including water, refrigerant, oil and grease.

2. Prove satisfactory operation of all equipment and controls to the Consulting Mechanical Engineer on request.

C. Work Not Included (Specified elsewhere)

Certain labor and materials may be furnished and/or installed under other divisions of these specifications. Coordinate with other trades and arrange the work to make the parts fit together. The following items are to be accomplished under other divisions of these specifications.

1. Fixed concrete bases for mechanical equipment: Division 3. Anchor bolts, setting diagrams, base sizes and other required information furnished under Division 15.
2. Concrete for inertia bases for mechanical equipment: Division 3. Steel forms provided under Division 15.
3. Masonry wall opening lintels: Division 4.
4. Wall openings and Chases: Under applicable sections according to information furnished under Division 15.
5. Access Panels: Furnished and located by Division 15 installer as specified in Division 8 for installation by appropriate trades.
6. Painting (except mechanical identification systems): Division 9.
7. Roof Curbs

   Curbs for all equipment located on the roof shall be furnished under Division 6 except for any prefab curbs specified herein. Roof flashings to be specified under Division 7. All counter flashing shall be furnished and installed by this Contractor of the same material as specified in Division 7.

D. Related Requirements

1. General Requirements: Division 1 - All Sections.
2. Mechanical: Division 15 - All Sections.
3. Electrical equipment and wiring: This Section.

4. Basic Materials and Methods: Section 15050.
5. Mechanical Identification: Section 15190.
6. Testing, Adjusting and Balancing: Section 15990.

E. Examination of Premises
Visit the premises before submitting bid as no extras will be allowed for lack of knowledge of existing conditions.

F. Inspection
Inspect work proceeding or interfacing with work of Division 15 Sections and report any known or observed defects that affect the work to the General Contractor. Do not proceed with work until defects are corrected.

G. Existing Utilities
1. The plans indicate the location, type and sizes of various utilities within the site where known. These utilities are indicated as accurately as possible. If utilities are encountered during construction which are not shown on the drawings, ask for instructions from the Architect. Any relocation or remodeling required will then be directed by change order. Assume all responsibility for protection of all utilities, shown or not, and repair any damage caused by this construction at no extra charge to the Owner.
2. Investigate with proper authorities for all existing water taps, etc.
3. Owners of all underground facilities shall be notified at least 3 business days prior to excavation so that the owners can locate and mark underground facilities.

H. Definitions
1. "Provide" means Contractor is responsible for the furnishing and installation of.
2. "Exposed" means in equipment rooms, unfinished areas, above "pushup" ceilings, accessible pipe tunnels, etc. where pipe is accessible.
3. "Concealed" means in such spaces as pipe chases, pipe trenches, above plaster ceilings, in walls and buried where pipe is inaccessible when building is completed.
4. “Conditioned” space, as it applies to duct insulation and duct sealing systems, means any space which is heated and/or cooled by the air discharged from a duct system which is located in that space. If air is delivered from a ductwork system in an amount unable to maintain space temperature in the 68°F to 78°F range, then the space is classified as “unconditioned”. Mechanical rooms and ceiling plenums are classified as “unconditioned” spaces.
5. “Mechanical Room” means any space or area which contains equipment providing heating, cooling, ventilation, plumbing distribution, or mechanical/plumbing system utility generation and distribution capabilities. These spaces are defined as “Mechanical Rooms” even if they are called by another name (i.e. boiler room, chiller room, machine room, etc.).

1.3 COORDINATION

A. General
Coordinate and order the progress of mechanical work to conform to the Owner's schedule and the progress of the work of the other trades. Complete the entire installation as soon as the condition of the building will permit.

B. Utility Interruptions
Coordinate mechanical utility interruptions with the Owner and the Utility Company. Plan work so that duration of the interruption is kept to a minimum.

C. Cutting and Patching
See Section 15050

D. Drawings and Specifications

1. Mechanical drawings are diagrammatic and because of the small scale, it is not possible to indicate every required offset, fitting, etc. Drawings are not to be scaled for dimensions. Take all dimensions from Architectural drawings, certified equipment drawings and from the structure itself before fabricating any work. Verify all space requirements, coordinating with other trades, and install the systems in the space provided without extra charges to the Owner.
2. Examine Drawings and Specifications for other parts of the work, and if any discrepancies occur between the plans for the work of this Division and the plans for the work of others, report such discrepancies to the General Contractor and obtain written instructions for any changes necessary.
3. The precedence of mechanical construction documents is as follows:
   a. Addenda and modifications to the Drawings and Specifications take precedence over the original Drawings and Specifications.
   b. Should there be a conflict within the Specifications or within Drawings of the same scale, the more stringent or higher quality requirements shall apply.
   c. In the Drawings, the precedence shall be Drawings of larger scale over those of smaller scale, figured dimensions over scaled dimensions and noted materials over graphic indications.
   d. Should a conflict arise between the Drawings and the Specifications for products indicated on the Drawings, the Specifications shall have precedence.
   e. Should there be a conflict in dimensions or locations between Mechanical Drawings and Architectural Drawings, the Architectural Drawings shall have precedence.

E. Electrical Equipment and Wiring for Mechanical Division

1. Responsibility

   Unless otherwise indicated, all motors and controls shall be furnished, set in place and wired in accordance with the following schedule. Refer to the Mechanical/Electrical Schedule and Equipment Schedules on the drawings for additional information.

   MD: Mechanical Division, 15000
   ED: Electrical Division, 16000

ITEM	FURNISHED UNDER	SET IN PLACE OR MOUNTED UNDER	POWER WIRING	CONTROL WIRING
Equipment Motors and Thermal overloads, resistance heaters.	MD	MD	ED	-
Motor Controllers; magnetic starters, reduced voltage starters, and overload relays.	MD(4)	ED(1)	ED	-
Disconnect switches, fused or unfused, H.P. rated switches, thermal overload switches and fuses, and manual operating switches.	ED(1)	ED(1)	ED	-

Pushbutton stations, pilot lights, multi-speed switches, float switches, thermostats, control relays, time clocks, control transformers, control panels, motor valves, damper motors, solenoid valves, EP and PE switches, interlocks and boiler controls.	MD	MD(2)	ED	MD(2)
Contactors, 120V control circuit outlets for control panels and for boiler controls.	ED	ED	ED	MD
Fire Protection Controls and Switches.	MD	MD	ED	MD(3)
Smoke Detectors (Duct Mounted).	ED	MD	ED	MD(3)
Fire/Smoke Dampers, Smoke Dampers.	MD	MD	ED	MD(3)

(1) If furnished as part of factory wired equipment, power wiring and connections by ED.

(2) If float switches, line thermostats, P.E. switches, time switches, etc., carry the FULL LOAD CURRENT to any device they shall be furnished and set in place by MD, but shall be connected by ED. If they do not carry the FULL LOAD CURRENT to any device, they shall be furnished, set in place and wired by MD. Control devices carrying full load current furnished by MD and wired by ED shall be located at the device being controlled, unless shown otherwise on the drawings or mutual agreement is made between the contractors with no change in the contract price.

(3) Wiring from fire alarm electrical contacts to fire alarm system control panel by ED; all mechanical equipment control function wiring by MD. ED to coordinate locations of electrical contacts with MD. MD to coordinate locations of duct smoke detectors with ED.

2. Connections to all controls directly attached to ducts, piping and mechanical equipment shall be made with flexible connectors.

1.4 REFERENCE STANDARDS

A. For products or workmanship specified by association, trade, or Federal Standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

B. The date of the standard that is in effect at the bid date, or date of Owner/Contractor Agreement when there are no bids, except when a specific date is specified or when the standard is part of an applicable code that includes an edition date.

C. When required by individual Specifications section, obtain copy of standard. Maintain copy at job site during work until Substantial Completion.

D. Schedule of Referenced Organizations: See Division 1.

1.5 SUBMITTALS

A. Submit samples, shop drawings and product data as required by various sections of Division 15 in accordance with Division 1. Make submittals to Architect. Do not make submittals directly to the Engineer.

B. Also Refer to Shop Drawings, this Section.

1.6 QUALITY ASSURANCE

A. Preparation
Base final installation of materials and equipment on actual dimensions and conditions at the project site. Field measure for materials or equipment requiring exact fit.

B. Workmanship
Perform work in accordance with good commercial practice. The good appearance of the finished work shall be of equal importance with its mechanical efficiency. The Architect/Engineer may reject work if workmanship and appearance are not satisfactory.

C. Supervision
Be responsible for and coordinate the work of all subcontractors working under Division 15.

D. Installation Procedures
Confer and cooperate with other trades and coordinate the work in proper relation with theirs. Coordinate ceiling cavity space carefully with other trades.

E. Properly locate anchors, chases, recesses and openings required for the proper installation of the work. Arrange with the proper contractors for the building of anchors, etc. and for the leaving of the required chases, recesses and openings including required space for fire dampers and sleeves.

F. Install all work to permit removal (without damage to other parts) of coils, heat exchanger bundles, boiler tubes, fan shafts and wheels, filters, belt guards, sheaves and drives, and all other parts which might require periodic replacement or maintenance. Arrange pipes, ducts and equipment to permit ready access to valves, traps, starters, motors, control components and to clear the openings of doors and of access panels.

G. Offsets, transitions and changes in direction in pipes and ducts shall be made as required. Maintain proper head room and pitch of sloping pipes whether or not indicated on the drawings. Furnish and install all ductwork fittings, traps, air vents, sanitary vents, etc., as required to effect these offsets, transitions and changes in direction.

H. Install equipment and materials in accordance with manufacturers' recommendations unless specifically indicated otherwise, or where local codes or regulations take precedence.

I. Conceal all piping in finished areas of the building except where otherwise noted on the drawings.

J. Protection
1. Where there are existing facilities, be responsible for the protection thereof, whether or not such facility is to be removed or relocated. Moving or removing any facility must be done so as not to cause interruption of the work or Owner's operation.
2. Close ends of pipe and ductwork during construction with caps or plugs to prevent entry of foreign material. Protect insulation against dirt, water, chemical

or mechanical damage before, during and after installation. Protect fixtures and equipment against damage during mechanical work.

3. Provide protection for concrete slabs where cutting or threading of piping occurs, storage of equipment, etc.

K. Piping & Ductwork Testing: See Section 15050

1.7 REGULATORY AND CODE REQUIREMENTS

A. Apply for and pay for all permits (plan review fees), fees, licenses and inspections for this Division of work.

B. Comply with state and local code requirements and ordinances. Comply with requirements of the Utility Companies. In the case of differences between these requirements and ordinances, the most stringent shall govern. Call for inspections required by local building inspection authority.

C. Applicable Building Codes and Ordinances: Including but not limited to the following:

International Building Code, 2006 Edition
International Mechanical Code, 2006 Edition
International Plumbing Code, 2006 Edition
International Fuel Gas Code, 2006 Edition
International Fire Code, 2006 Edition
Governing Fire Department Requirements
Utility Company Requirements
State Department of Labor Requirements
State Department of Health Requirements
National Fire Protection Association Standards
State and Federal Safety and Health Laws
NFPA 70 Current Edition - National Electrical Code
NFPA 90A Current Edition - Installation of Air Conditioning and Ventilation Systems

1.8 CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

A. General

Comply with Division 1.

1.9 DELIVERY, STORAGE AND HANDLING

A. General

1. Comply with Division 1.
2. Provide for proper storage of all materials and equipment and assume responsibility for losses due to any cause. All storage shall be within the contract limit lines of the building site. Off site storage will be allowed if permitted under Division 1 requirements. Cover and store all equipment and materials out of elements and off of the ground; any rusted or weather damaged item will not be permitted to be used. Make arrangements with other contractors on the job for introduction into the building of equipment too large to pass through finished openings.

B. Acceptance

Check and sign for materials to be furnished by others for installation under Division 15 upon delivery. Assume responsibility for the storage and safekeeping of such materials from time of delivery until final acceptance.

1.10 PRODUCT OPTIONS AND SUBSTITUTIONS

A. Prior to Bidding
   1. See Instructions to Bidders.
   2. Material, equipment or service specified by name is used as a basis of standard. Equivalents to items named in the specifications may be used if accepted before bidding. Requests for acceptance shall be received at the Consulting Mechanical Engineer's office at least seven (7) calendar days before bid opening.
   3. When any product is specified only by requirement to meet an industry standard or regulating body standard (such as U.L. AGA, AWWA, ANSI, etc.) and the item proposed carries approval of that body, no prior acceptance by the Consulting Mechanical Engineer is needed.
   4. When any product or service is specified by requirement to meet a performance standard or is specified by a generic specification, (no manufacturers name listed) no prior acceptance by the Consulting Mechanical Engineer is needed except as specifically called for in these specifications.
   5. Action for substitutions specified herein will be given only after the receipt of complete data showing performance over entire range, make and project manual identification number, physical dimensions and material construction all SPECIFICALLY marked for the individual item. Letter of transmittal with at least (1) copy of all descriptive data shall be submitted to the Consulting Mechanical Engineer's office. Data may not be returned; reference addenda for approval to bid.

B. Substitutions
   1. Comply with Division 1.
   2. Materials, equipment or services listed by several identifying names are intended to be bidder's choice, and any of the listed names may be bid without soliciting prior acceptance. Where more than one name is given in the specifications, the first named manufacturer's material, equipment or services is contemplated and any changes and their costs, required to accommodate the other named material or equipment as well as space requirements for the other named materials or equipment, must be assumed by the Contractor in his bid.
   3. Material and equipment specified is used as a basis of standard, and while not specifically mentioned, material gauges, weights, appearance and space requirements must be met by any substitutions.

1.11 SHOP DRAWINGS

A. See Division 1. Furnish at least three (3) sets for review.

B. Shop Drawings are to be handled in groups, each processed in a different manner as follows:
   1. Items furnished that are specified by industry or regulating body standard and/or by performance or generic specification require no shop drawing submittals. Copies shall be included in the Operating and Maintenance Instruction Manuals.
   2. Submit shop drawings for all materials and equipment named in these specifications showing any changes required in piping, ducting, electrical wiring, space allocation etc. Be responsible to make all changes required to accommodate and to pay for these changes. Coordinate changes required with all other trades. Pay for all changes resulting from re-arranging equipment.
   3. The following items require shop drawing submittals prior to commencing work:

      a. All fixtures and equipment, including items called out by manufacturers name and model number.
      b. All substituted items.
      c. All changes from the plans or specifications.
      d. Temperature Controls.
      e. Fire Sprinkler Systems.

f. Motors, Phase Protection and Starters.

Include copies of these items in the Operating and Maintenance manuals. Submit shop drawings with one item per sheet so that a file may be set up for each specified item.

4. Where shop-drawing submittals are required, do not begin work until one (1) copy that has been approved is returned.

5. Review of shop drawings is for general conformance with the design concept of the project and does not relieve this Contractor from the responsibility of furnishing equipment and materials of proper dimension, size, quantity, quality and all performance characteristics to efficiently perform the requirements and intent of the contract documents. Review does not relieve this Contractor from responsibility for errors on the shop drawings. Approval of a specific item does not include approval of the assembly of which the item is a component. If the shop drawings deviate from the contract documents, advise the Consulting Mechanical Engineer of the deviations in writing accompanying the shop drawings, including the reasons for the deviations. Coordinate all required changes with the other trades affected. If the Contractor occasions the changes, he shall pay any costs involved.

1.12 CLEANING

A. Comply with Division 1.

B. Clean exposed surfaces of piping, hangers, ducts and other exposed items of grease, dirt or other foreign material. Remove rubbish and debris resulting from the operations and leave equipment spaces clean and ready for use. Refinish or repaint items at the discretion of the Architect.

1.13 PROJECT RECORD DRAWING

A. Comply with Division 1.

B. File at job site one copy of Drawings, Specifications, Addenda, approved shop drawings, change orders, field orders, test records, other modifications to Contract Documents.

C. Do not use Project Record Documents for construction purposes.

D. Legibly mark with red pencil field changes, such as the following, referenced to permanent and accessible features of the site or building as applicable. Do not permanently conceal any work until required information is recorded.

1. Drawings:
   a. Locations of underground work.
   b. Locations of concealed utilities.
   c. Field changes of dimension and detail.
   d. Changes resulting from change order or field order.
   e. Details not on original drawings.

2. Specifications
   Manufacturer, model number of equipment actually installed, revised construction procedures.

3. Shop Drawings
   Changes made after Architect/Engineer's approval.

E. At completion of Work, deliver completed Project Record Documents marked with field

changes to Architect/Engineer, including temperature control and fire protection "record" shop drawings.

1.14 OPERATION AND MAINTENANCE DATA

A. Comply with Division 1.

B. Submit three (3) typed and hard bound copies of Operating and Maintenance Manuals to Architect for approval prior to scheduling any system demonstration for the Owner and 15 days prior to final observation. Books shall be arranged in sequence to match the equipment schedules included in the specifications.

C. The books shall contain, but not be limited to, the following general items; each item shall be provided with a separate index tab.

1. Instructions (On Contractor's Letterhead Stationery) on who to call for service during guarantee period including name, address, and 24 hour telephone number of company responsible for servicing each piece of equipment or system.

2. Maintenance instructions (On Contractor's Letterhead Stationery) shall include: (can be referenced to manufacturer's manual with appropriate page numbers, etc.)
   a. Preventative maintenance schedule for necessary cleaning, replacement and/or adjustment of all items such as belt drives, safety controls, oil and refrigerant charges.
   b. Cleaning schedule of all strainers, traps, coils, tubes, tower pans, sprays, etc.
   c. Filter cleaning and/or replacement schedule.
   d. Lubrication charts showing type of lubricant and application methods and frequencies for each piece of equipment.
   e. Water treatment recommendations for heating water systems.

3. Manufacturer's manuals (current originals, copies are not acceptable) for each piece of equipment installed (including equipment not requiring shop drawings) identified by drawing code numbers as they appear on the drawing and in the specifications. Manuals shall include the following, as applicable:
   a. Description of unit and component parts:
      (1) Function, normal operating characteristics and limiting conditions.
      (2) Performance curves, engineering data and tests for pumps and fans. Curves shall include flow rate, pressure, HP, RPM and efficiency.
      (3) Complete nomenclature and commercial part number of replaceable parts.
      (4) Installation instruction sheets.
      (5) Complete wiring diagrams.

   b. Recommended procedures:
      (1) Start-up, break-in, routine lubrication and operating instructions and cautions.
      (2) Regulation, control, start/stop, shut-down and emergency instructions.
      (3) Special summer and winter operating cautions.

   c. Maintenance
      (1) Routine care
      (2) Guide to trouble shooting
      (3) Disassembly, repair and reassembly
      (4) Alignment, adjusting and checking

(5) Water treatment
(6) List of required lubricants and schedule
(7) Filter cleaning or replacement schedule
(8) Parts list, illustrations, assembly drawings and diagrams required for maintenance.
(9) Predicted life of parts subject to wear

4. All warranties provided by the Manufacturer on their equipment that run longer than the one-year warranty by the Contractor.

5. Valve chart(s) with schematic floor diagrams indicating valve locations with numbers labeled on valve chart.

6. All fire protection shop drawings corrected for final as-built conditions.

7. All temperature control diagrams and sequences and component descriptive literature. See Section 15900.

8. All equipment start-up logs including certification of start up by manufacturer.

9. Balance Reports: air and water. See Section 15990.

10. All pipe and ductwork pressure test certifications.

11. Domestic water sterilization certification.

D. Provide lubrication and filter maintenance charts, to be mounted adjacent to or on equipment. Charts shall provide information as noted above and shall provide a means for maintenance personnel to record when and what maintenance was accomplished.

E. These O & M books shall be considered a part of the final observation and shall be submitted for approval at least fifteen days prior to a request for a final observation.

1.15 FINAL OBSERVATION

A. Comply with Division 1.

B. Prior to notifying the Architect that the project is ready for the final observation the Contractor must submit the O & M manuals 15 days prior and the Balance Report 7 days prior and shall verify, in writing, that:
1. All systems are complete along with balancing.
2. All systems have been properly started and are operational.
3. All controls are complete, operational and sequences have been checked and are functioning properly.

C. When the Contractor notifies the Architect that the project is ready for a final observation, the Architect will visit the job site and will prepare a final observation list of all the items on the project that shall be finished or corrected before the project can be accepted.

D. When the Contractor notifies the Architect that all items on the above final observation list have been completed and corrected, the Architect will visit the project to ascertain that all the items on the final observation list have been corrected and can be accepted.

1.16 WARRANTIES

A. All materials and equipment shall be new unless otherwise specified.

B. Provide a written warranty to the Owner covering the entire mechanical work to be free

from defective materials, equipment and workmanship for a period of one year after Date of Acceptance. During this period provide labor and materials as required to repair or replace defects at no additional cost to the Owner. Provide certificates (include in O & M Manuals) for such materials or equipment which have warranties in excess of one year. Include dates of start and end of the warranty and manufacturer's representative name and telephone number.

C. This warranty will be superseded by warranty modifications resulting from use of equipment for construction heating or cooling.

1.17 DEMONSTRATIONS

A. Conduct demonstrations only after systems have been through start-up procedures, systems are complete and operating, and operating and maintenance data is complete.

B. Instruct the Owner's representatives on the proper operation and maintenance of the mechanical systems. Include seasonal concerns and operations. Provide a minimum of six (6) hours of instruction.

C. Systems: All mechanical systems listed in these specifications. See applicable sections of Division 15 for additional requirements.

D. Contractor's Representatives:
   1. Contractor's representatives shall have a thorough knowledge of the particular installation.
   2. Manufacturer's representatives shall have a thorough understanding of each particular piece of equipment.

E. Scheduling: Arrange and schedule demonstration times with Architect.

F. Location: Conduct demonstrations at project including tours of systems.

G. Operating and Maintenance Data: Arrange for data to be at demonstrations. Include review of data at demonstrations.

H. Time Allotment: Provide demonstrations of adequate time periods, except as noted elsewhere, to ensure proper understanding of systems by Owner's representative.

I. Furnish ladders, tools, etc. as required to provide access to all equipment and controls for demonstrations.

1.18 SYSTEM AND EQUIPMENT START-UP

A. General: Verify that:
   1. Building enclosure is complete.
   2. Excess building materials and debris have been removed.
   3. Building is broom clean.

B. Inspect preceding work to ensure that:
   1. Electrical: Verify with Division 16 contractor that:
      a. Temporary services are disconnected and permanent utility services are capable of full load.
      b. Connections in main switchgear and sub-panels are tight.
      c. Necessary tests and check meter readings have been made.
      d. Wiring to motors and controls required for operational smoke and fire protection code demonstrations are complete.

   2. Mechanical:

a. Specified tests on piping, ductwork and related systems have been made.
b. Operational and performance tests have been made.
c. Each piece of equipment comprising a part of system has been checked for proper lubrication, drive rotation, belt tension, proper control sequence, and any other condition that may cause damage to equipment or endanger personnel.

C. Start-Up and Testing:

1. Notify Architect at least two (2) days in advance of the start-up of mechanical systems.

2. Complete tests required by code authorities including smoke detection, fire protection and health codes.

3. Ensure that control systems are fully operational in automatic mode.

4. After test runs have been completed and systems have been demonstrated to be satisfactory and ready for permanent operation, clean or replace permanent pipeline strainers, clean and recoat permanent filters, replace throwaway air filters with new, properly adjust valve and pump packings, adjust belt tensions, secure drive guards in place, check lubrication and replenish if required.

5. If systems are not to continue in use following the start-up procedures take steps to insure against accidental operation or operation by unauthorized personnel.

6. All refrigeration equipment, boilers, rooftop units, units specified with controls, and other equipment so specified shall be started by the manufacturer or under the manufacturer's supervision. Start-up data shall be recorded in logs. If a unit or piece of equipment is specified with factory controls to accomplish a sequence, it shall be the responsibility of the manufacturer to verify that the specified sequence is being met. This verification shall be noted on the start-up log; coordinate with control contractor. Copies of start-up logs shall be forwarded to Mechanical Engineer and included in Operation and Maintenance manuals.

7. The contractor to adjust settings thru first year as required by Mechanical Engineer.

8. Balancing shall occur after the start-up procedures have been completed.

1.19 CONTRACT CLOSEOUT PROCEDURE

A. Comply with Division 1.

B. Approval for final payment will not be given until the following items have been submitted and reviewed. Refer to other sections of these specification for specific requirements:

1. Project Record Drawings.
2. Record of Piping and Ductwork Tests.
3. Sterilization Certification.
4. Operation and Maintenance Manuals.
5. Equipment Start-Up Logs.
6. Balance Report.
7. Keys for Mechanical Equipment, Panels, etc.
8. Spare Equipment or Material Parts.

PART 2 – PRODUCTS

Not Applicable

PART 3 - EXECUTION

Not Applicable

END OF SECTION 15010

SECTION 15050
BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

The General Provisions of the Contract, including General and supplementary Conditions and Division 1 - Specification Sections and Contract Documents apply to work in this section. Consult them for further instructions and be governed by the requirements thereunder.

1.2 WORK INCLUDED

A. Work Included in this Section

1. Pipe Supports, Anchors and Seals
2. Motors and Starters
3. Valves
4. Mechanical Excavation and Backfill
5. Pipe Installation
6. Welding
7. Supporting Steel
8. Vibration Isolation
9. Pipe and Ductwork Testing
10. Flushing, Cleaning and Sterilizing

B. Furnish Only

1. Access Panels: For appropriate section for installation.

C. Related Requirements

1. Mechanical and Electrical Coordination: Section 15010
2. Cutting and Patching: Division 1
3. Excavation and Backfill: Division 2
4. Concrete: Division 3
5. Access Doors: Division 8
6. Basic Mechanical Requirements: Section 15010

D. Reference Standards and Codes

1. Comply with Section 15010.
2. AWWA Standard C651-05, Disinfecting Water Mains, 2005.

1.3 RELATED WORK

A. Mechanical: Division 15 - All Sections

B. Testing, Adjusting and Balancing: Section 15990

C. Controls and Instrumentation 15900

1.4 QUALITY ASSURANCE

Welder Qualifications

Welders shall be qualified per ANSI/ASME B31.9 Building Service Piping for the type of work being performed.

PART 2 - PRODUCTS

2.1 EQUIPMENT MANUFACTURERS

A. Equipment in each of the following categories shall be of one manufacturer or available thru one manufacturer (or vendor) for each category to facilitate ease of maintenance for the Owner.

1. Motors (open drip-proof squirrel cage)
2. Starters
3. Single Suction Pumps
4. Plumbing Fixture Trim
5. Thermometers
6. Pressure Gauges
7. Gate, Plug, Globe and Check Valves
8. Butterfly Valves (Individual valves not included in piping packages listed below)
9. Ball Valves (Individual valves not included in piping packages listed below)
10. Balancing Valves
11. Equipment Connection Piping Packages
12. Dielectric Unions
13. Strainers
14. Air Filters

2.2 MOTORS, PHASE PROTECTION AND STARTERS

A. General

1. All motors, phase protection, starters and other electrical control equipment shall be listed per the requirements of the National Electric Code.
2. Submit motor, phase protection and starter shop drawing per Section 15010.
3. Motors incorporated into package equipment and defined as “definite purpose” motors are exempt from these requirements.

B. Motors

1. Furnish double shielded ball bearings in accordance with ANSI B3.16-1992 for ¾ HP motors and larger, squirrel cage, open dripproof, copper windings, Class B or F insulation, 1800 and/or 1200 rpm, normal starting torque motor of the horsepower and current characteristics specified with thermal overload protection and dustproof

and leakproof bearing rings and constructed for use at the altitude where the work is to be located. Motors 1/2 HP or less may be split capacitor single phase with sleeve bearings and a standard frame size and rpm. Motors guaranteed to operate continuously at full load with temperature rise in any part not to exceed NEMA Standards. Motors shall be commercially, dynamically balanced and tested at the factory before shipment and selected for quiet operation. Provide motors for V-belt drives with a cast iron or steel base, with slide rail and adjustable screw device and belt guard. Line up motors and drives and place motors and equipment on foundations ready for operation.

a. Inverter Duty Motors

1) Motor supplied for use with Variable Frequency Drives shall be rated for inverter duty and must include a stainless steel nameplate showing 'Inverter Duty Motor'.

2) Nameplate shall also show that motor is suitable for variable torque operation on VFD power from 6 to 60Hz, and show rated torque in lb-ft on inverter power in addition to the standard nameplate data specified in NEMA standards.

3) Motor manufacturer shall supply certification that motor includes an 'inverter grade' insulation system using not less than triple insulation layer wire and other features necessary to the voltage spike specifications of NEMA MG1-31.40.4.2. Motors shall also have a high rigidity stator core treatment.

4) Motor insulation shall be an "Inverter Grade" system designed to meet the voltage spike limits defined by NEMA MG1-1993, part 31.40.4.2. Insulation systems must use triple layer magnet wire or must use magnet wire which has a Pulse Endurance Index (PEI) greater than 50. Insulation systems utilizing heavy film and two film wire with a Pulse Endurance Index less than 50 are not acceptable. Complete insulation of the slot, cell and phase groups is required. The system shall be rated for class F rise or better.

5) Inverter Duty stator core designs shall be of high rigidity type with reinforced end turn construction to minimize mechanical fatigue of the winding, and to reduce resonant noise. Single dip and bake cycles are not acceptable.

6) Motor manufacturer shall supply certification with submittals that the motor is constructed to meet all requirements of NEMA MG1-1993, part 31.

7) Rotor cores and/or assemblies shall be of low vibration design that meets 1/2 of the NEMA MG1 recommended levels for balance.

8) Inverter duty motors shall include a normally closed winding over temperature thermostat suitable to be wired to the VFD panel for drive shutdown.

9) Refer to Section 15800 for VFD requirements.

2. Where commercially available, motors rated greater than 5 HP shall have a power factor of not less than 90 percent under rated load conditions. Where not commercially available, power factors shall be capacitor corrected by equipment manufacturer to at least 90 percent under rated load conditions. Motors shall have 1.15 service factor at altitude.

3. Motors, starters and other electrical control equipment in moist areas or special conditions, such as explosion proof, shall be designed and approved for installation in such areas. See schedules on drawings and equipment specifications for starter type.

4. Motor wiring shall terminate in a NEMA terminal box mounted on the motor case and shall be of the manufacturer's standard size. The terminal box shall have a bolt

type copper ground connector.

5. All general purpose motors shall have minimum full-load nominal efficiencies as listed in the following table:

NEMA Premium Efficiency Motors

ODP				**TEFC**		
RPM	**1200**	**1800**	**3600**	**1200**	**1800**	**3600**
Motor Horsepower						
1	**82.5**	**85.5**	**77.0**	**82.5**	**85.5**	**77.0**
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	**87.5**	**86.5**	**85.5**	**88.5**	**86.5**	**85.5**
3	88.5	89.5	85.5	89.5	89.5	86.5
5	**89.5**	**89.5**	**86.5**	**89.5**	**89.5**	**88.5**
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	**91.7**	**91.7**	**89.5**	**91.0**	**91.7**	**90.2**

C. Motor efficiencies shall be tested in accordance with procedures specified in NEMA MG1-1987 and IEEE Standard 112, Test Method B. Nominal full-load efficiency shall be listed on the electric motor's nameplate.

D. Starters

1. Provide starters of current and capacity ratings to serve the motor intended. Starters shall be built and sized in accordance with NEMA Standards for industrial control except no contactors shall be smaller than NEMA Size 1. Indoor starters shall be provided with a NEMA 1 enclosure. Outdoor starters shall be provided with a NEMA 3R (gasketed) or NEMA 4 enclosure. All three phase starters to have a trip-free, thermal overload relay in each ungrounded phase conductor. Thermal overload relays shall be block type with an adjustable dial to set to exact motor full load amps. Overloads shall be factory calibrated as a unit and shall be ambient compensated. Relays shall be manual reset type and shall meet NEMA Class 10 tripping characteristics. Differential single phasing protection shall be provided in the thermal overload relay. Starter shall have integral disconnect switch and carry U.L. listing as an assembly. Furnish hand-off-auto switches and green running pilot light (6 volt transformer type bulb) in starter cover.

2. Provide integral transformer with secondary fuse and 120 volt control circuit on all starters which are furnished with control circuits. Transformer shall be mounted and factory wired in the starter enclosure. Control circuits shall be deenergized whenever the operating power supply to the particular equipment is disconnected. Also provide auxiliary contacts required for system operation plus one spare (minimum of one normally open contact and one normally closed contact required). Installation of additional auxiliary contacts shall be accomplished without having to remove starter from its enclosure. Coordinate actual number and type of contacts required for each starter with Division 15900.

3. Size thermal overload relays for approximately 115% of full load motor current. Switch and fuse units will not be acceptable unless specifically indicated.

4. Starters to be Allen Bradley, Cerus Cutler-Hammer, Furnas, S & S or Square D.

5. Provide starters for 3/4 HP motors and larger, unless specifically noted.

2.3 BELT DRIVES

A. Provide belt drives with cast iron or steel sheaves, either companion driven sheaves (except for two groove) or fixed pitch sheaves, dynamically balanced and keyed.

B. Single groove (or greater as necessitated by torque requirements) variable and adjustable drive sheaves with a key for holding pitch adjustment shall be used for motors 15 HP and below; selected so required rpm is obtained with sheaves set at mid-position.

C. Provide matched belts sized for 150% of motor horsepower.

D. Consulting Mechanical Engineer reserves the right to direct speed changes as required (at no cost) if in his/her opinion these are warranted after final balancing. This includes fixed sheave replacement.

2.4 ACCESS DOORS

Furnish access doors where indicated and at locations where required for access to concealed valves, dampers, cleanouts, control devices, and equipment servicing. See Division 8 for access door types and finishes including, access doors for man access to pipe chases. Access panels and doors in ductwork, air-handling units, sheet metal plenums are specified in Section 15800. If installed in fire rated surfaces, access doors shall carry proper rating.

2.5 PIPE SUPPORTS AND HANGERS

A. General

1. Use adjustable pipe hangers on suspended pipe. Chain or perforated strap hangers will not be permitted. Provide hangers to support the systems without sagging, including hangers at each offset or change in direction, at ends of branches over five feet in length and at the following maximum spacing:

Pipe Type	Pipe Size	Maximum Spacing	Minimum Hanger Rod Size
Steel Pipe	1/2”	6’-9”	3/8”
	3/4” through 1-1/4”	8’-0”	3/8”
	1-1/2” and 2”	10’-0”	3/8”
	2-1/2” through 4”	10’-0:	1/2”
Copper Pipe	1/2” through 1-1/2”	6’-0”	3/8”
	2” and above	10-0”	3/8”
Cast Iron	2”	1 Each Joint	3/8”
	3” and 4”	1 Each Joint	1/2”

2. See Vibration Isolation, this section, for special hangers.

3. Hanger rods shall be continuous threaded steel. Rods may be reduced one size for double rod hangers with 3/8" as a minimum diameter.

4. Concrete inserts to be steel case and expander plug for threaded connection with lateral adjustment, two slot for reinforcing rods and lugs for attaching to forms or machine bolt expansion anchor. Size inserts to match size of threaded hanger rods.

5. Plastic pipe (PVC, CPVC. etc.) shall be supported at not to exceed 4'-0". Minimum hanger rod size shall correspond to the steel pipe criteria for various pipe sizes as noted in above table.

B. Individual Hangers

1. Individual hangers for non-insulated copper piping shall be copper plated or plastic coated steel, adjustable swivel ring hangers.

2. Individual hangers for uninsulated steel and insulated steel or copper piping (except

steam and high temperature hot water) shall be zinc plated, adjustable swivel ring hangers for pipe sizes up through 1-1/2" and wrought steel, adjustable clevis hangers for pipe sizes 2" and over.

C. Trapeze Hangers:

1. Parallel runs of piping may be supported on trapeze hangers. Trapeze shall be Unistrut P-1000 or equivalent by B-Line or Superstrut. System shall be selected to support five times the weight or thrust applied without failure. Where trapeze length exceeds four feet, provide additional hanger rod at mid span. Hangers shall be spaced for smallest pipe in group.

2. All non-insulated steel pipe shall have standard pipe clamps at each support.

3. All non-insulated copper pipe shall rest on neoprene sleeves or 3M Scotch Rap 50 applied to a 50 mil thickness extended 1/2" beyond clamp edge and have standard pipe clamps at each support.

4. All insulated pipe (steel or copper) shall have standard pipe straps over the high density insulation inserts at each support.

D. Insulated Pipe Supports

Where individual hangers are used protect all insulated pipe at point of support with a 360 or 180 degree insulation insert of high density polyurethane foam, water-proofed 140 psi calcium silicate, or expanded perlite. Adhesive shall comply with NFPA-90A, flame spread 10/smoke 0. Provide minimum G-60 galvanized shield for high density insert. Where trapeze hangers are used, protect all insulated pipe at point of support with 360 degree insulating insert. Encase insulation in a 360 degree sheet metal shield. Where insulation stops and starts for pipe clamps, ends of insulation shall be sealed with liquid mastic to provide continuous vapor barrier. Insert to be same thickness as adjoining pipe insulation and be divided into longitudinal half sections as applicable and covered with fire resistant vapor barrier jacket. Insulation insert for all cold liquid (60^0F or below) shall extend 1 inch beyond sheet metal shield on each end. Shield length and minimum sheet metal gauges shown in chart below. When pipe hanger spacing exceeds 10 ft., and for all pipe roller applications, utilize a double layer shield.

Pipe Size	Shield Length	Minimum Gauge
1/2” through 1-1/2”	4"	22"
2” through 6”	6"	20"

1. 1/2” through 3" - Cast iron hook

2. 4” and Over - Welded steel bracket and wrought steel clamp.

3. Unistrut may be used for multiple pipe runs up to 3" in size.

E. Vertical Supports

1. Provide friction riser clamps, supported and braced. Clamps for copper piping shall be plastic coated steel. Copper pipes shall be wrapped in 3M Scotch Rap 50 applied to a 50 mil thickness extended 1/2" beyond clamp edge.
   a. Cast Iron Soil Pipes: Support at not less than every story height and at its' base.
   b. Screwed Pipe: Support at 10 foot on center for 2 inch and larger and 8 foot on center for smaller than 2 inch pipe.
   c. Copper Tubing: Support at 8 foot on center for 2 inch and larger and 6 foot on center for smaller than 2 inch pipe.

2.6 SLEEVES

A. Schedule 40 steel pipe (galvanized if used below grade or in outside wall) or plastic sleeves manufactured by PSI/Thunderline sized large enough to allow for movement and for continuous insulation. Sheet metal sleeves are not allowed. Sleeves used below grade and for penetration of water proofed walls shall contain integral water stop. Seal space between pipe and sleeve with Link Seal compressible linked rubber seals.

B. In addition to schedule 40 sleeves, prefabricated fire rated Through Penetration Fire Stop Devices and Through Penetration Fire Stop Systems for each specified and particular piping or conduit material for fire rated penetrations shall be allowed. System shall be as manufactured by ProSet Systems or Approved Equivalent.

2.7 VALVES

A. General

All valves of a given type shall be of one manufacturer and shall be listed with the Manufacturers Standardization Society of the Valve and Fittings Industry.

B. Pressure Ratings

Unless otherwise indicated, use valves suitable for minimum 125 psig at 450^{o}F and 200 psig at 250^{o}F.

C. Valve Connections

1. Provide valves suitable to connect to adjoining piping as specified for pipe joints.

2. Thread pipe sizes two inches and smaller.

3. Flange pipe sizes 2-1/2 inches and larger.

4. Solder or screw to solder adaptors for copper tubing.

5. Use grooved body valves with mechanical grooved jointed piping

6. Provide butterfly valve with tapped lug body when used for isolating service.

D. Valve Operators

1. Provide suitable hand wheels for gate, globe or angle and drain valves.

2. Provide one plug cock wrench for every ten plug cocks sizes 2" and smaller, minimum of one. Provide each plug cock sizes 2-1/2" and larger with a wrench with set screw.

3. Provide adjustable memory stops for all valves used in balancing service.

2.8 VIBRATION ISOLATION

A. Neoprene Pads: Mason Spec Pads

Neoprene pads shall be either ribbed or waffle patterned in-shear pads. All pads shall be true in-shear pads using alternately higher and lower ribs to provide effective vibration isolation, and shall be molded using oil resistant compounds.

Manufacturer	
Mason Industries, Inc.	MSW
Kinetics Noise Control	NPD

B. Spring Isolation Curbs: Mason Spec N

The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating floor section. The lower member shall be designed for a flat roof. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind forces. Curb shall have internal stabilizers to provide wind resistance

with a minimum clearance of 1/4"(6mm) so as not to interfere with the spring action except in high winds. Steel springs shall be laterally stable and rest on 1/4"(6mm) thick neoprene acoustical pads. Minimum spring deflection shall be 1”**.** Hardware must be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing. All spring locations shall have access ports with removable waterproof covers.

The floating member of the roof curb shall have a perimeter angle cross members to support two layers of 5/8” waterproof sheetrock laid on with staggered joints.

Submittals shall include all curb dimensions, weight, spring deflections, spring diameters, compressed spring height and solid spring height as well as seal and wind resistance details.

20 ton and smaller use factory curb and no spring isolation curb required.

25 ton to 50 ton RTU’s: Mason Industries RCS, Kinetics Noise Control ESR with two layers of 5/8 sheetrock.

C. Flexible Pipe Connectors:
Flexible stainless steel annular hose with stainless steel braid or bronze hose and braid. Male nipples shall be used for piping size 2 inches and less. Pipe sizes 2-½ inches and larger shall be flanged (150# ASA). Copper couplings shall have sweat fittings.

Manufacturer	Screwed	Flanged	Sweat
Masons	MN-PC	FFL-PC	CPS-PC
Flex-Weld/Keflex	KSSPC-MPT	KSSPC-FLG	-
Hyspan	4505	4502	4507
Metraflex	SST	MM	BBS
Streamflo	SPCT	SPCF	-
Thermo Tech Flex/Flo	F/F/N	F/F/F	F/F/C

D. Flexible Equipment Connectors:
Flexible connectors shall be manufactured of E.P.D.M. reinforced with nylon. No steel rings or wire shall be used as pressure reinforcement. Straight connectors shall have two spheres. Connectors size 2 inch and less to have threaded ends with female unions. Connectors size 2-1/2 inch and larger shall have floating flanges recessed to lock the connector's raised face neoprene flanges. Connectors shall be rated a minimum of 150 psi at 220^{o}F. When pressures will cause the connector to extend beyond its rated elongation, control cables shall be employed with end fittings isolated by means of 1/2" thick bushings designed for a maximum of 1000 psi.

Manufacturer	Screwed	Flanged	Elbow
Mason	SFU	SFDEJ	-
C-Flex	TU	TF	-
Flex-Weld/Keflex	K500N	KTWNNF	-
Metraflex	Dbl.Sphere Union	Dbl. Sphere	EL Sphere

Steamflo	AMU	AMT	-
Thermo Tech Flex/Flo	F/F/Union	F/F/DS	-
Kinetics Noise Control	UTC	FTC Kinflex	

2.2 FLANGE GASKETS

Gasket material shall be full-faced for cast iron flanges and raised-face for steel flanges. Select materials as noted below. As applicable due to service, gaskets shall conform to ANSI A21.11, B16.20 or B16.21.

Service	Acceptable Materials (Pressure/Temperature Rating)
Domestic Water	PTFE (1200 psig @ 500°F)
Heating water (with and without glycol)	PTFE (1200 psig @ 500°F)

Gaskets shall be as manufactured by Garlock, Frenzelit, Vellumoid or approved equivalent.

PART 3 - – EXECUTION

3.1 INSPECTION

Inspect preceding work in accordance with Section 15010.

3.2 MOTORS, PHASE PROTECTION AND STARTERS

A. Motors:

Provide capacitors to correct motor power factor to at least 90 percent where motor has a power factor less than 90 percent.

3.3 PREPARATION

A. Field Measurements

Base final installation of materials and equipment on job site dimensions and conditions. Job site dimensions shall take precedence over Drawing dimensions. Field measure critical dimensions and do not fabricate or cut materials to length until such measurements are made. Be responsible for accurate location of rough-ins as required for equipment being serviced.

B. Cleaning

Ream pipes and tubes. Clean off scale and dirt, inside and outside before joining, leaving ready for painting or identification as required. All piping stored outdoors shall be flushed of debris before installation.

3.4 EXCAVATION AND BACKFILL

A. General

1. Geological Conditions
   a. Bidders may review the report on file in the Architect's office.
   b. Bidders must assume all responsibility for deductions and conclusions which they make as to the nature of the materials to be excavated for underground piping or mechanical construction.

2. Provide all excavating and backfilling required by the work in this division, all as required by the rules of the State Department of Labor and Employment and OSHA. All pipe must be laid on bedding material with bellholes provided for hubs. After pipe is laid in trench, it shall be tested, insulated if specified, and backfilled. Comply with requirements of Division 2.

3. Verify locations of existing and new underground utilities prior to trenching and, if damaged by this contractor, replace immediately in an approved manner at no

expense to the Owner.

4. For pipe laid in trenches below slabs on grade, compact bottom of trenches in accordance with Division 2 and the Geotechnical Report. Remove rock and stones from bottom of trench.

5. Do not place backfill over pipe lines until lines are properly tested and approved.

B. Compaction

1. Remove rocks and stones from backfill material. Backfill by hand around the pipe and the first 12" over the top of the pipe. Moisten, backfill and tamp in 8" layers (maximum) with air motor or gasoline driven tamper to consolidate to 90% of the maximum density obtainable at optimum moisture content. Puddling will not be allowed.

2. Trenches under road surfacing shall have the upper eighteen inch (18") layer, forming the subgrade for pavement compacted to at least 95% of the maximum density obtainable at optimum moisture content for rigid pavements.

3. Density of backfill shall be determined by the requirements of the A.A.S.H.O. in Pamphlet 57. Standard Method T-99-57.

4. Where requirements of the general conditions are more stringent than the above, the general condition requirements shall be met.

C. Pavement

Accomplish cutting of flexible pavement so that the remaining exposed edge of the pavement conforms vertically and horizontally to a straight line, preferred method is saw cutting. The width of the section of pavement removed shall be of necessary width for the proper laying of pipe, but shall not exceed thirty six inches (36"). Waste material resulting from the above operations will be disposed of in suitable waste areas. Repair pavement to satisfaction of the Architect, Owner and/or authorities having jurisdiction.

D. Shoring

Provide all shoring required to perform the excavation and to protect the project, employees, and public.

E. Surveying

Establish all lines, grades and elevations. Stake out the work and furnish all line stakes (1" x 2" x 10") and all hubs or hardwood pegs (1" x 1" x 6") to stake out the lines and structures to line and grade.

F. Maintaining and Protecting Traffic

Maintain sufficient barricades, warning signals and lights, traffic control officers to protect pedestrian and vehicular traffic. Provide and maintain such detours as may be necessary to keep traffic moving during construction.

G. Surface Drainage and Ground Water

Surface drainage shall be diverted away from open excavation and trenching before commencement of work at the location. Surface water or ground water seepage which enters or accumulates in the trenches shall be removed by pumping or subdraining, and the subgrade or pipe bed restored to original bearing value and conditions.

H. Any settling of backfilled trenches which may occur during the warranty period shall be repaired without expense to the Owner, including the complete restoration of all damaged property.

3.5 VIBRATION ISOLATION

A. Neoprene Pads

1. Install per manufacturer's recommendations. Provide on all floor mounted equipment with motors not specified for another vibration method i.e. boilers, etc.
2. Where multiple pads are stacked, steel shims must be placed between pads per manufacturer's recommendations.

B. Spring Isolation Curbs: (AHU-1)

1. Install per manufacturer's recommendations.

2. The supply and return openings in the unit shall be extended down below the upper curb and flexible connections shall be installed for connection to distribution ductwork. The ductwork prior to the flexible connection shall be secured to the roof curb assemble per the manufacturer's recommendations.

3. The electrical conduits, heating water, chilled water and refrigerant piping shall be connected to the rooftop unit as described in flexible pipe or flexible equipment connectors.

4. Contractor to insulate the curb with 2" ridged closed cell flame retardant insulation.

5. Contractor to provide sheetrock installation where specified in the curb and seal edges seams and ducts. The acoustical material must surround duct to provide a continuous sound break. This acoustical layer shall be caulked to minimize sound transmission.

C. Piping

1. Air Handling Units

a. Connect all heating water piping to equipment supported by vibration isolators with flexible equipment connectors. Hang all piping so that it does not touch any part of the structure.

3.6 SLEEVES, BOXES, AND CONCRETE CURBS

A. Major openings in the structure for mechanical work may be shown on the structural drawings, these will be done under the Architectural Division of these Specifications. It is this Contractor's responsibility to accurately set necessary sleeves and boxes for pipe and ducts (not shown on the structural drawings) before erection of structure. This Contractor is responsible for the correct size and location of all openings including coordination with the other trades. All sleeves shall be large enough to allow for continuous insulation to pass through the sleeve.

B. Sleeves and boxes shall be provided wherever pipes and ducts pass through floor, wall and roof construction.

C. Each sleeve shall be utilized for only one pipe. Blockouts for multiple pipes or individual pipes are not allowed unless indicated on the Drawings or approved by the Architect.

D. Terminate sleeves flush with walls, partitions and ceilings. In areas where pipes are concealed (i.e. in chases), terminate sleeves 1/4" above finished floor. In areas where pipes are exposed, extend sleeve 1/4" above finished floor, except in mechanical rooms and

rooms containing floor drains, where sleeves shall be extended 2" above finished floor.

E. Pipes passing through exterior wall shall be sealed water tight by using liquid sealant or compressible linked rubber seals.

3.7 CUTTING AND PATCHING

Be responsible for the cost of cutting and patching for work under Division 15 caused by improper coordination or notification. Comply with requirements of Division 1.

3.8 PIPE AND DUCTWORK PENETRATIONS

A. Where horizontal ducts and pipe pass through walls, and vertical ducts and pipes pass through floors or roofs seal off void between opening and duct, or pipe and sleeve. All penetrations of exterior wall below grade shall be sealed water tight. All penetrations of exterior walls above grade shall be sealed weather tight.

B. Wherever any pipe, duct, conduit, steel member, bracket, equipment or other material penetrates or passes through fire-resistant wall, ceiling or floor, completely seal voids in construction with non-hardening caulk or other fire resistant material as approved by all authorities having jurisdiction. Embed sealing material full thickness of material being penetrated. Sealants used at penetrations of items which can be consumed in a fire shall be intumescent and shall be installed so as to fill the void left if penetrant is consumed. Sealants to be installed in accordance with manufacturer's instructions and shall have been tested in accordance with ASTM E-814 and classified by Warlock Hersey.

3.9 FLASHINGS

A. All flashings will be done under roofing division except as noted or detailed elsewhere in these specifications.

B. See Section 15400 for vents and drains.

3.10 PUMP AND EQUIPMENT CONNECTIONS

Where the suction or discharge of any pump, inlet or outlet of terminal equipment, or inlet or outlet of heating generation equipment is smaller than the pipe size noted on the drawings, all strainers, valves, flexible connections, expansion joints, etc., shall be a minimum of the pipe size noted on the drawings.

3.11 PIPE INSTALLATION

A. Installation

1. Install piping without springing or forcing, and to clear windows, doors and other openings. Cutting or other weakening of the building structure to facilitate piping installation is not permitted.

2. Provide sufficient swing joints, anchors, expansion loops and devices necessary to permit free expansion and contraction without causing undue stresses. Also see Expansion Compensation this section. Make changes in direction with fittings. Support piping independently at equipment so its weight will not be supported by the equipment.

3. Install vertical risers plumb and straight, horizontal lines parallel with walls and partitions. Conceal piping above ceilings and within furring and walls unless otherwise indicated.

4. All piping shall be run full size as indicated on drawings. Any reductions in piping required by equipment connections shall be made at these connection points.

B. Clearance
Provide clearance for proper installation of insulation and for access to valves, air vents, drains and unions. Provide minimum 1/2 inch clearance between pipes after insulation.

C. Shut-Off Valves & Unions
1. Where indicated, provide shut-off valves and unions suitably located, to isolate each item of equipment, branch circuit or section of piping.

2. Provide dielectric unions at junctions of dissimilar metals.

D. Routes and Grades
1. Route piping in general locations indicated, in an orderly manner and to maintain required grades. Coordinate with other piping, conduits, ducts and equipment making necessary offsets to accommodate the same.

2. Install piping to conserve headroom and interfere as little as possible with use of available space. Group piping wherever possible at common elevations. Install concealed pipes close to the building structure to keep furring to a minimum.

E. Flange Installation
1. Align flange bolt locations with equipment and/or companion flange, “Two-hole” flanges with level for all horizontal applications.

2. Apply anti-seize thread compound to bolts before nuts are installed.

3. Gasket material shall be centered on the face of the flange.

4. Tighten bolts to evenly compress gasket material. A torque wrench shall be used for final tightening of the bolts. The required torque shall be determined by the gasket supplier.

5. Once system has been in operation for 24 hours, all flange bolts shall be re-torqued to prescribed level.

6. Chemicals used for water treatment shall be chemically compatible with the flange gasket material.

3.12 WELDING
A. General
1. Piping shall comply with the provisions of the latest revisions of the applicable sections of the ASME Code for Pressure Piping, ANSI/ASME B31.9 Building Service Piping.

2. Boiler external piping shall comply with the latest revision of Section 1 of the ASME Boiler and Pressure Vessel Code, ANSI/ASME BPV-1 Power Boilers.

B. Each manufacturer or contractor shall be responsible for the quality of welding done by his organization and shall repair or replace any work not in accordance with these specifications.

3.13 INSTALLATION PIPE HANGERS
A. Adequately support piping from the building structure with adjustable hangers to maintain uniform grading where required and to prevent sagging and pocketing. Provide supports between piping and building structure where necessary to prevent swaying.

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

adjacent work. Place a hanger within one foot of each horizontal elbow.

C. Use hangers that are vertically adjustable 1-1/2 inches minimum after piping is erected.

D. Support horizontal soil pipe near each hub or hubless clamp with five feet maximum between hangers, except where 10-foot lengths of pipe are installed, then, maximum spacing of hangers may be 10 feet, as long as the following requirements are met.
   1. Support adjacent to joint, not to exceed 18 inches.

   2. Brace at not more than 40-foot intervals to prevent horizontal movement.

   3. Support at each horizontal branch connection.

E. Support vertical soil pipe at each floor with riser clamps. Provide intermediate support with friction clamps tied to structure. Where practical, support riser piping independently of connected horizontal piping.

F. Insulation shall be carried full size through the hangers.

G. Concrete inserts to be used for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams, wherever practical. Set inserts in position in advance of concrete work. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.

3.14 VALVES

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

B. Provide drain valves at main shut off valves, low points of piping and equipment.

C. Control Valve Piping
   If the control valve size is smaller than the pipe size marked on the drawing, the reduction in size pertains to the valve only. Gate valves, globe valves, and strainers on either side of the automatic valve shall be a minimum of the pipe size marked on the drawings.

3.15 ACCESS DOORS

A. Furnish an access door for each pipe chase for each floor. This includes both toilet plumbing chases and pipe riser chases. Access door assembly to be minimum size of 24" x 24". Coordinate with Architectural drawings.

B. Also, furnish access doors in all non-removable ceilings and in partitions and walls where necessary to maintain access to plumbing cleanouts, shock absorbers, fire dampers, manual dampers, valves and other mechanical devices requiring access. Size these as required (minimum 24" x 24") to provide adequate access for service or replacement of components.

C. Furnish all access doors to the General Contractor for installation by trade responsible for surface in which installed. Provide instructions for location.

3.16 EQUIPMENT BASES AND SUPPORTS

A. General
   Furnish and install, as indicated on the plans and/or as may be necessary for the proper installation of all equipment furnished under this Division, all foundations, bases and supports. Be responsible for their correct location and sizes to fit all equipment. Shim and grout between the equipment and its base to align and level. Bolt equipment bases, vibration isolators, and supports to prevent relative movement.

B. Supporting Steel

Provide supporting steel not indicated on the Structural Drawings for equipment requiring same. Fabricate supports in accordance with AISC Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings. Brace and fasten with flanges bolted to structure.

C. General

Housekeeping Bases

Concrete bases for all floor mounted equipment including anchor bolts and inserts are installed under Division 3 in accordance with setting diagrams furnished by the contractor responsible for installing the equipment. Bases shall be 4 inches in height and over the complete floor area of the equipment. The bases shall be located and sizes determined by the contractor furnishing the equipment.

3.17 PAINTING

Supporting steel shall receive one coat of primer paint in the shop after fabrication welding is complete, as specified in Division 5. Paint field joints with one coat of matching primer. Finish painting under Division 9.

3.18 PIPE AND EQUIPMENT IDENTIFICATION

See Section 15190.

3.19 ESCUTCHEONS

A. Install nickel-plated floor, wall and ceiling escutcheons of adjustable type on pipes passing through walls, floor or ceiling in finished areas after painting is completed.

B. Install 20 gauge flange around ducts passing through walls, floor or ceilings in finished areas.

3.20 PIPE AND DUCTWORK TESTING

A. General

1. Test piping and ductwork systems prior to concealment. Ensure that the test pressure which might damage fixtures, existing piping or equipment does not reach such units by valving them off or otherwise isolating them during the test. Keep written field records of all tests. Each record shall contain, as a minimum, the date of the test, system or subsystem tested, test medium and pressure, duration of test, test results, name and signature of individual performing test, and the name and signature of witness to the test who is not an employee of the firm performing the test. Submit copies of all tests to Architect. All tests must be done to the satisfaction of the Owner's representative and local authorities having jurisdiction, before covering. Furnish all instruments required for testing. All hydrostatic tests to be held for a minimum of six (6) hours without loss of pressure. Any visible leakage or appreciable pressure drop during the test will be cause for rejecting the test. Additional tests will be required after corrective measures have been taken until satisfactory results are obtained. Contractor shall be responsible for furnishing all plugs, piping, valves, hoses and pumps necessary for the required tests and for proper disposal of the water upon completion of the tests.

2. Test all drain, waste and roof drain lines with standing water test of twelve feet of head, held long enough to visually inspect each joint.

3. Test all heating water piping before connecting to units, at 150 psig hydrostatic pressure.

4. Test all natural gas piping under 60 psig air pressure.

5. Test all refrigeration piping per Section 1108 of the 2006 International Mechanical Code using oil pumped, dry nitrogen and tapping of joints. If there is any loss of

pressure, soap each joint to find leaks. After system is assumed to be free of leaks, charge with refrigerant to 10 psig and then increase pressure to pressures listed in Section 9 of ASHRAE 15, using oil pumped, dry nitrogen. Check all parts of the system with a halide torch or electronic leak detector. After testing is complete and system is considered leak-free, evacuate using a vacuum pump to 500 microns and purge with oil pumped, dry nitrogen to raise pressure to atmospheric. Re-evacuate the system and re-purge with oil pumped, dry nitrogen a second time. Do not use system compressor for evacuating the system.

6. Seal all audible and visible leaks in ductwork. Smoke testing of ductwork for undetected leaks may be required by the Mechanical Engineer if air flow requirements cannot be maintained.

3.21 FLUSHING, CLEANING AND STERILIZING

A. Before final connections are made in the piping systems, all piping except as individually noted below, shall be blown out with air and then completely washed out with cleaning compounds compatible with final fluid to avoid contamination. The systems shall then be flushed for the complete removal of all foreign materials. Furnish all temporary connections, valves, etc., required for this purpose. Chemicals used in the pipe cleaning as well as all chemicals used for water treatment shall be chemically compatible with all elements of the piping system in particular the flange gasket material.

B. Clean the boilers by the same procedure.

C. After flushing, sterilize the domestic water system in accordance with AWWA Standard C651-05, Disinfecting Water Mains, and all subsequent addenda. After minimum contact period, flush the system with clean water until the residual chlorine is no greater than the city water. Submit to the Architect, written certification that sterilization has been performed. Include a copy in Operation and Maintenance Manuals. Provide a test analysis by the State Health Department of a random water sample, if requested by the Architect.

END OF SECTION 15050

SECTION 15190
MECHANICAL IDENTIFICATION

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
The General Provisions of the Contract, including General and Supplementary Conditions and Division 1 - Specification Sections and Contract Documents apply to work in this section. Consult them for further instructions and be governed by the requirements thereunder.

1.2 DESCRIPTION OF WORK
A. Furnish and Install
1. Markers, tags and labels for mechanical pipes, ducts and equipment.

2. Pipe identification and flow indications.

3. Valve tags

B. Related Requirements
1. Basic Mechanical Requirements: Section 15010

2. Basic Materials and Methods: Section 15050

1.3 REFERENCES
Comply with ANSI A13.1 - Scheme for the Identification of Piping Systems.

PART 2 – PRODUCTS

2.1 MATERIALS
A. Pipe Markers: Identify the contents of the various piping systems. Flow arrows shall clearly indicate the direction of flow. Utilize either of the following methods:
1. Pressure Sensitive Markers: Brady Type B-350 or B-946, Seton, MSI, Craftmark or equivalent flexible film identification markers and tape, with legend size, color coding, and marker length per ANSI A13.1.

2. Stenciled Markings: Of size and color per ANSI A13.1, using clear cut stencils and oil base paint.

B. Tags: Brass or color coded anodized aluminum 1-1/2 inch diameter with edges ground smooth. Punch each tag to receive tie wires. Evenly space and stamp letters (1/4 inch high) and numbers (7/16 inch high) into the metal surface, with black letters.

C. Labels: White plastic laminate with black engraving, fastened with brass screws. Pressure-sensitive embossed labels (Dymo Type) are not acceptable. Provide labels of uniform size. Label all equipment unless a manufacturer's label is firmly attached.

2.2 STENCILS
A. Stencils or Pressure Sensitive Markers
1. Conform to the following Schedule:

Outside Diameter of Pipe or Pipe Insulation	Length of Color Field	Minimum Size Letter
1/2”	8”	3/8”
3/4” through 1-1/4”	8”	1/2”
1-1/2” and 2”	8”	3/4”
2-1/2” through 6”	12”	1-1/4”

8” through 6”	24”	2-1/2”
10” and above	32”	3-1/2”
Equipment	-	2-1/2”

PART 3 – EXECUTION

3.1 PIPING IDENTIFICATION

A. General

1. Identify piping in crawlspaces, above ceilings, etc. as well as exposed to view except piping in finished areas. Provide identifying markings at valves, fittings, and equipment, at terminal points, at each branch and riser take-off, on pipes that lead to and from underground areas, and at both sides of piping passing through walls, ceilings, and floors. In addition, provide identifying markings at 30 feet o.c. for exposed piping and concealed piping.

2. All markers must be in compliance with respect to (1) proper letter color, (2) proper letter size, (3) correct background color, and (4) proper marker length.

3. Identification of all piping systems shall conform to the designations in the mechanical legend on the drawings.

4. Apply directional flow arrows adjacent to each pipe mark.

B. Pressure Sensitive Markers

Apply in accordance with manufacturer's recommendations. Marker adhesion will be tested for permanence. Replace any markers showing dogears, bubbles or other failings.

C. Stenciled Markings

Apply after completion of finished coat of paint. Wipe pipe clean. Perform stenciled on markings without overspray, drips or other imperfections. Provide dark background when using light colored stencils on light coverings (i.e. provide black background if using yellow stencil on white covering).

D. Markers and Markings

1. Use an arrow marker with each pipe content marking. The arrow shall always point away from the pipe marking and in the direction of flow; color and height of arrow to be same as content marking. If flow can be in both directions, use a double-headed arrow.
2. Apply pipe and arrow marking within three inches of each valve to show proper identification of pipe contents and direction of flow.
3. Apply the marking to the pipe so lettering is in the most legible position. For overhead piping, apply marking on the lower half of the pipe where view is unobstructed, so marking can be read from floor level.

3.2 VALVE IDENTIFICATION

A. Identify all valves and cocks including fire protection valves, in main and branch piping located inside the building. Use tags secured with brass 'S' hooks, brass jack chains or bead chains.

B. Stamp valve tags with a unique prefix to indicate system, followed by a number. (Example: CW-1; CW-2; HW-1; etc.). In general, the prefix shall match the system abbreviation used on the Drawings.

C. Provide a typewritten list of valves including: valve identification number, location, function, normal position, service and area served. Include copies in the operation and maintenance manuals.

D. Show valve tag designations on the Project Record Document Drawings and on schematic flow diagrams.

3.3 EQUIPMENT IDENTIFICATION

A. Controls: Stencil or label magnetic starters and relays to identify connecting or controlled equipment. Stencil or label manual operating switches, fused disconnect switches and thermal overload switches which have not been specified as furnished with indexed faceplates as to "connected" or "controlled" equipment. Stencil or label automatic controls, control panels, zone valves, pressure/electric and electric/ pressure switches, relays and starters.

B. Pumps: All pumps shall be identified as to service and zone(s) served. Stencil or label base mounted pumps. Tags secured by tie wire may be used on small in-line pumps.

C. Fans: Stencil or label supply and exhaust fans and air handling units and connecting ductwork supplying one or more areas from an equipment room or isolated crawl or furred space as to drawing code number, service and areas of zones served.

D. Air Conditioning Equipment: Identify air conditioning equipment such as refrigeration units, pumps, etc., by stencils or system nameplates. When more than one piece of like equipment is installed, they shall be identified as to area or space served.

E. Fire Dampers: Identify all fire dampers and their access doors by printed stencil secured to the access door or a approved location by the Architect.

END OF SECTION 15190

SECTION 15250
INSULATION

PART 1 – GENERAL

1.1 RELATED DOCUMENT

The General Provisions of the Contract, including General and Supplementary Conditions and Division 1 - Specification Sections and Contract Documents apply to work in this section. Consult them for further instructions and be governed by the requirements thereunder.

1.2 WORK INCLUDED

A. Furnish and install:

1. Piping insulation, including valves, fittings and other piping accessories

2. Equipment insulation

3. External duct wrap

B. Related Requirements:

1. Basic Mechanical Requirements: Section 15010

2. Basic Materials and Methods: Section 15050

3. Mechanical Identification: Section 15190

4. Air Distribution: Section 15800

1.3 RELATED WORK

A. Insulated pipe supports: Section 15050

B. Ductwork lining: Section 15800

1.4 QUALITY ASSURANCE

A. Requirements of regulatory agencies:

1. Flame/smoke rating: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke developed index of 50 or less as tested by ASTM E 84 (NFPA 255) method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories Inc. label or listing (UL 723), or satisfactory certified test report from an approved testing laboratory to prove that fire hazard ratings for materials proposed for use do not exceed those specified.

2. Exceptions: The following materials are exceptions to the flame/smoke rating requirements specified above:
   a. Nylon anchors for securing insulation to ducts and equipment.
   b. Cork or treated wood inserts used between shields and piping at hangers on low-temperature piping.

3. Moisture resistance: Do not provide materials with flameproofing treatments subject to deterioration due to the effects of moisture or high humidity.

B. Codes and standards. Provide insulation conforming to the following standards:

1. American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM standards, including:
   a. C 167 Test Methods for Thickness and Density of Blanket or

Batt Thermal Insulations (1998).

b. C 195 Specification for Mineral Fiber Thermal Insulating Cement (2000).
c. C 335 Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation (1995).
d. C 449 Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement (2000).
e. C 533 Specification for Calcium Silicate Block and Pipe Thermal Insulation (2001).
f. C 534 Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form (2201).
g. C 547 Specification for Mineral Fiber Preformed Pipe Insulation (2000).
h. C 552 Cellular Glass Block Thermal Insulation (2000).
i. C 553 Specification for Mineral Fiber Blanket and Felt Insulation for Commercial and Industrial Applications (2000).
j. C 592 Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal Mesh Covered) (Industrial Type) (2000).
k. C 612 Specification for Mineral Fiber Block and Board Thermal Insulation (2000).
l. C 665 Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing (1998).
m. C 921 Practice for Determining Properties of Jacketed Materials for Thermal Insulation (1996).
n. C 1045 Standard Practice for Calculating Thermal Transmission Properties Under Steady State Conditions (2001).
o. C 1338 Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings (2000).
p. D 781 Method of Test for Puncture and Stiffness of Paperboard, Corrugated and Solid Fiberboard.
q. E 84 Test Method for Surface Burning Characteristics of Building Materials (2001).
r. E 96 Water Vapor Transmission of Materials (2000).

2. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE): Provide and install pipe and duct insulation in accordance with the following ASHRAE standard:
   a. 90.1 Energy Conservation in New Building Design (Current Edition)

3. National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:
   a. 90A Installation of Air Conditioning and Ventilating Systems
   b. 255 Test Methods, Surface Burning Characteristics of Building Materials (latest edition)

4. Underwriters laboratories
   a. UL 723 Surface Burning Characteristics of Building Materials.

1.5 SUBMITTALS

Product data: Submit manufacturer's technical data for each type of mechanical insulation in accordance with Section 15010. Submit schedule showing manufacturer's product number, K-value, thickness and furnished accessories for each mechanical system requiring insulation.

1.6 DELIVERY, STORAGE AND HANDLING

A. Delivery: Deliver insulation, coverings, cements, adhesives, and coatings to the site in non-

broken factory containers with manufacturer's stamp or labels affixed showing fire hazard indexes of products and manufacturer's density and thickness rating.

B. Storage and Handling: Protect insulation against dirt, water, chemical and mechanical damage. Store in a warm, dry location. Do not install damaged or wet insulation; remove from project site.

1.7 PROJECT CONDITIONS

A. Environmental requirements: Perform work at ambient and equipment temperatures as recommended by the insulation manufacturer.

B. Protection: Protect insulation against dirt, water, chemical or mechanical damage during and after installation. Repair or replace any insulation or covering damaged prior to final acceptance of work.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

Owens Corning, Johns Manville, Mason, Knauf, Armstrong, 3M, ETS Schaefer and Imcoa insulation will considered equivalent and will be acceptable without prior approval by the Consulting Mechanical Engineer.

2.2 ACCEPTABLE PRODUCTS

Various codes are more restrictive on the use of certain products in plenums etc. This specification allows several methods of insulating valves, fittings, etc., but it is the contractor's and the manufacturer's responsibility to assure that the code authorities will approve any product to be installed on the project.

2.3 INSULATION GENERAL REQUIREMENTS

A. General: Provide insulation conforming with the referenced publications and the specified temperature ranges and densities, in pounds per cubic foot (pcf).

B. Exterior of insulation: Provide insulation with exterior surface that is cleanable, grease resistant, non-flaking and non-peeling.

C. Physical changes: Provide insulation that shows no physical changes that adversely affect its qualities under normal use at the intended use temperature.

2.4 MATERIALS

A. Pipe Insulation

1. Interior Use

a. Fiberglass: One-piece molded three pound density fiberglass pipe insulation (ASTM C547, Class 2) with factory applied all-service jacket with self-sealing lap. Jacket color shall be white and suitable for painting with latex paints. Insulation shall be suitable for pipe temperatures from 0 to 850 degrees. Maximum k-value shall be 0.24 Btu-in/hr-sq ft/degrees at 75 degrees mean temperature (ASTM C335). Jacket shall provide a vapor barrier with a permeance of less than 0.02 perms/in (as tested by Procedure A of ASTM E96). Shall be tested in conformance with ASTM E84 and not exceed 25/50, UL 723 and NFPA 255.

b. Flexible elastomeric: Flexible tubular closed-cell elastomeric tubing conforming to ASTM C 534, Type I. Insulation shall be suitable for pipe temperatures from -40 to 220 degrees. Maximum k-value shall be 0.27 Btu-in/hr-sq ft/degree at 75 degrees mean temperature (ASTM C177 or C518). Permeance shall be 0.20 perm/in or less (as tested by Procedure B of ASTM E96). Flame-spread/smoke-developed indices shall be 25/50 or

less for thickness 1 inch or less.

2. Exterior Use
   a. Fiberglass: Fiberglass pipe insulation for exterior use shall be the same as for interior use, except that the all-service jacket may be omitted where a vapor barrier is not required and replaced with a factory installed all-weather 30 mil UV resistant PVC jacket or a metal jacket installed according to Part 3 of this specification section.
   b. Flexible elastomeric: Insulation for exterior applications shall be the same as for interior use. Exterior protection shall be as recommended by the manufacturer.

3. Below Grade Use
   a. Cellular glass: Insulation for buried pipe shall be cellular glass insulation conforming to ASTM C 522 having a density of approximately 8.0 pcf. Maximum k-value shall be 0.35 at 75 degrees mean temperature. Permeance shall be zero. Compressive strength shall be 100 psi average. Insulation material shall be totally inorganic.
   b. Flexible polyolefin: Insulation for buried pipe shall be flexible polyolefin listed by manufacturer for use for below grade applications. Thickness for system applications shall be increased one size when used below grade.
   c. Pipe wrap: Pipe wrap shall be a 50 mil thick elastomeric wrap designed for below grade use, Protecto Wrap No. 200 coating or equivalent.

B. Piping Accessories (Fittings, Unions, Etc.) Insulation
1. Premolded insulation sections: Premolded insulation sections shall meet the requirements for the adjacent insulation.

2. Tape
   a. All service jacket tape: Provide tape with pressure sensitive adhesive suitable for sealing all service jacket on chilled and dual temperature piping system. Tape shall provide a vapor barrier.
   b. PVC sealing tape: Provide PVC sealing tape with pressure sensitive adhesive suitable for use with pre-molded PVC insulation covers. Tape shall provide a vapor barrier. Tape shall be white and 10 mil thick.

3. Glass cloth: Provide white 20 x 10 mesh resin-treated glass cloth.
4. Vapor barrier mastic: Mastic shall be a water-base product suitable for spraying or trowel application. Color shall be white. Water vapor permeance (ASTM E 398) shall be 3.0 perm at 1/16 in. dry film thickness new and 1.0 perm when aged. Surface temperature range shall be -20 to 180 degrees.

5. Insulating and finishing cement: Provide a high temperature mineral fiber cement with a hydraulic-setting binder (asbestos free) suitable for service to 1200 degrees, complying with ASTM C 449. Cement shall have a k-value of 0.97 Btu-in/hr-sq ft/degree at 400 degrees mean temperature. Cement shall be suitable for troweled application and set up to a smooth hard white finish. Surface shall be suitable for painting, or weatherproofing for outside service.

6. PVC jacketing and fitting covers: PVC fitting covers shall be used with fiberglass inserts or with fiberglass pipe insulation cut to the shape of the cover. Inserts shall meet the temperature requirements for fiberglass pipe insulation. Covers and jacketing shall meet the 25/50 flame and smoke developed ratings of ASTM E 84. Covers and jacketing shall be white, 20 mil thickness and be suitable for surface temperatures up to 150 degrees. Covers and jacketing used external to building shall be 30 mil thickness.

7. Metal jacket pipe and fitting covers shall be 0.016 thick aluminum or stainless steel.

8. Vapor barrier coating: Provide white, flexible, fire resistive vapor barrier coating. Permeance shall be 0.05 perm at 0.055 in. dry film thickness. Coating shall be good for temperatures at coating of 0 to 150 degrees.

C. Equipment Insulation
1. Fiberglass: For equipment having surface temperatures between 0 and 450 degrees, provide fiberglass insulation board or blanket meeting ASTM C 612, 3 pcf density with a k-value of 0.23 Btu-in/hr sq ft/degree at 75 degrees mean temperature. Supply with all service jacket if other covering is not specified. For equipment having surface temperatures between 450 degrees and 850 degrees provide fiberglass insulation board specified for these temperatures.

D. Fiberglass Duct Wrap
1. Exposed Duct
a. Rectangular duct: Fiberglass insulation board, 1-1/2" thick, 0.6 pcf density having an installed k-value of 0.23 Btu-in/hr-sq ft/degree at 75 degrees mean temperature. Supply with vapor barrier foil-scrim-kraft (FSK) jacket. Flame-spread/smoke developed indices shall be 25/50 or less.
b. Round duct: Fiberglass duct wrap conforming to ASTM C 553, Type 1, 1-1/2" thick, 3/4 pcf density having a k-value of 0.27 Btu-in/hr-sq ft/degree at 75 degrees mean temperature. Supply with vapor barrier foil-scrim-kraft (FSK) jacket. Flame-spread/smoke developed indices shall be 25/50 or less.

2. Concealed duct: Fiberglass duct wrap conforming to ASTM, C 553, Type 1, 1-1/2" thick, 1 pcf density, having a k-value of 0.27 Btu-in/hr-sq ft/degree at 75 degrees mean temperature. Supply with foil-scrim-kraft (FSK) jacket. Flame-spread/smoke developed indices shall be 25/50 or less.

3. Bonding adhesive: Provide bonding adhesive designed to adhere fiberglass insulation to metal ducts. Adhesive shall be nonflammable, fire-resistive and meet the requirements of NFPA 90A.

4. Foil-scrim-kraft (FSK) tape: Provide tape with pressure sensitive adhesive and FSK backing suitable for use on FSK jackets.

5. Vapor barrier coating: Provide solvent-based vapor barrier coating for service temperatures from -20 to 200 degrees. Coating shall meet NFPA 90A requirements.

E. Insulation Accessories
1. General: Provide insulation accessories compatible with materials to which applied and suitable for the services. Provide insulation accessories that do not corrode, soften or otherwise attack the insulation or jacket in either the wet or dry state.

2. Adhesives, coatings, sealing compounds and protective finishes: Provide adhesives, coatings, sealing compounds, and protective finishes as recommended by insulation manufacturer for applications indicated.

3. Staples: Provide outward-clinching monel-metal type staples, 3/4 in nominal width.

4. Bands: Provide bands of galvanized steel, aluminum, brass or nickel copper alloy of 3/4 in. nominal width. Provide band thickness exclusive of coating not less than

0.005 in. for steel and nickel copper alloy, 0.007 in. for aluminum and 0.01 in. for brass.

5. Wire: Provide wire of 14 ga. nickel copper alloy or copper clad steel, 16 ga. stainless steel or 18 ga. soft annealed galvanized steel.

6. Wire Netting: Provide wire netting for exposed surface of insulation to be cement finished. Provide wire netting that is 22 ga., 1 in. galvanized mesh, with continuous 26 ga. galvanized corner beads having 2-1/2 in. wings.

7. Fire stop sealant: Provide inorganic fire stop sealant having 1 hr., 2 hr. or 3 hr. rating as required by building penetration requirement.

PART 3 –EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Inspection

Inspect work in conformance with Section 15010.

B. Preparation

All piping and ductwork systems shall be tested and have all leaks repaired prior to the application of the insulation. All surfaces shall be clean and dry; all foreign materials, such as rust, scale and dirt removed; and where specified, surfaces painted, prior to installing the insulation.

C. Workmanship

1. Furnish and install piping, ductwork and equipment insulation as specified herein.

2. Insulation shall be applied by experienced coverers per best trade practice and manufacturer's printed installation instructions. Insulation shall be clean and dry when installed. Install insulation material with smooth and even surfaces. Butt edges firmly together.

3. Make insulation continuous through sleeves or openings in walls and floors, except when there is a required fire resistance rating. Where this occurs, fill the open space between the pipe or duct and the building opening with fire stop sealant. Carry insulation through hangers, including trapeze hangers. Butt insulation tight to high density inserts (Section 15050) at hanger locations and secure by taping insulation to inserts. Where pipe supports for vertical riser clamps and anchors must be rigidly secured to pipe, cut insulation around support, fill void around support with insulation cement and cover with vapor barrier mastic.

4. Make sure that covering material which is to be painted will be in satisfactory condition to receive paint.

5. Ductwork insulation shall meet the requirements of NFPA 90A, latest edition.

6. Cover all exposed and leading edges of insulation with adhesive.

7. Where new piping is connected to existing insulated pipe, new insulation shall be butted against existing insulation and sealed to provide complete thermal barrier, as well as vapor barrier where required by this specification. Existing insulation shall be trimmed as required to allow a tight continuous butt joint.

8. Repair or replace all existing insulation to meet the requirements of these specifications where the existing insulation has been damaged or requires removal

due to new construction requirements.

3.2 PIPE INSULATION INSTALLATION

A. Domestic Cold Water Piping

1. General

a. Unless otherwise specified, insulate all domestic cold water piping. Exceptions are:

(1) Piping used exclusively for fire protection.

(2) Chrome-plated tubing

b. A vapor barrier shall be provided on all insulated surfaces of the piping system.

c. Install pipe insulation of at least the minimum thickness specified in Table 15250-1.

2. Insulation Installation

a. Fiberglass Insulation

(1) Apply insulation to the pipe by opening the seam and then closing it after placement. Flap edges should be down at the 3 o'clock or 9 o'clock position. Remove release paper and seal flap. Apply butt strips at joints. Rub down all edges with a plastic squeegee.

(2) Staple flap on 6" centers starting at center. Seal staples with vapor barrier adhesive.

(3) Seal all exposed ends of pipe insulation with vapor barrier coating.

b. Flexible elastomeric insulation: Slip insulation on the pipe prior to connection wherever possible and seal the butt joints with adhesive. Where the slip-on technique is not feasible, slit the insulation and apply to the pipe. Seal the seams and butt joints with adhesive per manufacturers recommendations.

c. Valves, unions, flanges and fittings: Insulate valves, unions, flanges and fittings as specified in this section.

d. Buried pipe: Spiral wrap all buried pipe, except water service from street to buildings, with pipe wrap with 50% overlap. No insulation is required.

B. Domestic Hot Water Piping

1. General

a. Unless otherwise specified, insulate all domestic hot water supply and recirculating piping. Exceptions are:

(1) Chrome-plated tubing

b. No vapor barrier is required on this piping.

c. Install pipe insulation of at least the minimum thickness specified in Table 15250-1.

2. Insulation installation: Install fiberglass insulation as specified for domestic cold water piping.

3. Insulation of pipes under handicapped lavatories and sinks: Insulate angle stop assemblies and drain lines with foam insert covered with 1/8" minimum abrasive resistant exterior cover with fasteners located out of sight, Brocar Trap Wrap Kit 500R or 500HS, McGuire Prowrap, Truebro LavGuard, TCI Products Skal + Gard, or equivalent. Acceptance of installation quality will be by the Architect.

4. Valves, unions, flanges and fittings: Insulate valves, unions, flanges and fittings as specified in this section.

5. Buried Pipe: Insulate all buried piping with fiberglass insulation, 4-1/2 pcf minimum or flexible polyolefin. Spiral wrap insulation with pipe wrap with 50% overlap (not

required on polyolefin insulation).

C. Storm Drain Piping
Insulate horizontal storm drain piping (including overflow piping), fittings and roof drain bowls which are above ground and in the building the same as for domestic cold water piping. No insulation is required on buried piping.

D. Heating Hot Water
1. General
   a. Unless otherwise specified, insulate all heating hot water and steam piping. This includes condensate piping and boiler feed piping.
   b. No vapor barrier is required.
   c. Install pipe insulation of at least the minimum thickness specified in Table 15250-1.

2. Insulation installation
   a. Fiberglass installation:
      (1) Apply insulation to the pipe by opening the seam and then closing it after placement. Flap edges should be pointing down at the 3 o'clock or 9 o'clock position. Remove release paper and seal flap. Apply butt strips at joints. Rub down all edges with a plastic squeegee.
      (2) Staple flap on 6" centers starting at center. Seal staples with all service jacket tape.
      (3) Seal ends of pipe insulation at all valves, fittings, flanges and hangers with adhesive.

3. Valves, unions, flanges, and fittings: Insulate valves, unions, flanges and fittings as specified in this section.

4. Buried Pipe: Insulate all buried piping with fiberglass insulation, 4-1/2 pcf minimum. Spiral wrap insulation with pipe wrap with 50% overlap.

E. Refrigerant Piping
1. General
   a. Unless otherwise specified, insulate <u>all</u> refrigerant piping (inside and outside) including any buried piping.
   b. Liquid lines within the building are not required to be insulated, except where personnel protection is required.

F. Valves, Flanges, Unions, Fittings, Air Separators and Pump Casings.
Insulate valves, flanges, unions, and fittings in all types of systems, air separators in heating and chilled/dual temperature water systems, and pump casing for chilled and dual temperature water systems as follows.
1. Option 1: Insulate with pre-molded insulation sections. Secure sections in place with all service jacket tape and trim insulation to assure an even transition with adjacent pipe insulation. Apply glass cloth circumferentially around insulation sections and then apply vapor barrier mastic over the entire surface to provide a vapor seal.

2. Option 2: Apply insulating and finishing cement over surface. Smooth and finish cement to make a flush transition with adjacent pipe insulation. After cement has dried, apply glass cloth circumferentially around cement. Apply vapor barrier mastic over entire surface to provide a vapor seal.

3. Option 3: Insulate with factory precut, two layer insulation and cover with factory

pre-molded, one piece PVC fitting covers. Tuck the ends of the insulation snugly into the throat of the fitting cover and the edges adjacent to the pipe fitting. Secure the fitting cover with vapor barrier master or by taping the ends circumferentially with PVC sealing tape to the adjacent pipe covering. Tape shall overlap at least 1/4 in. and extend a minimum of 2 in. onto the pipe covering.

4. For flexible elastomeric insulation for fittings, flanges and valves shall be premolded, precut or job fabricated of the same thickness and conductivity as used on adjacent pipe.

G. Minimum Pipe Insulation

The minimum pipe insulation thickness specified in Table 15250-1 are for fiberglass pipe insulation and meet the Model Energy Code (1992) and ASHRAE Standard 90A. Thickness of other types of insulation shall be adjusted to provide equivalent resistance to heat flow.

Table 15250-1
Minimum Thickness for Pipe Insulation

Insulation Thickness in Inches for Pipe Size (2)

Piping System Types	Fluid Temperature Range	Run-outs up to 2" (1)	1" and less	1-1/4" to 2"	2-1/2" to 4"	5" to 6"
Domestic Cold Water	40-60	1/2	1/2	1/2	1	1
Domestic Hot Water	105 -160	1/2	1	1	1-1/2	1-1/2
Heating Systems: Hot Water	141-200	1/2	1-1/2	2	2	2
	105-140	1/2	1	1	1-1/2	1-1/2

(1) Runouts to individual terminal units not exceeding 4 feet in length.
(2) For piping exposed to outside air, increase thickness by 1/2 inch.

3.3 EQUIPMENT INSULATION INSTALLATION

A. High Temperature Equipment

1. General: Unless otherwise specified, insulate equipment in hot water heating and domestic hot water systems. This includes boilers and storage tanks. Care shall be taken not to insulate over any nameplates or labels. Bevel and seal insulation around such.

2. Exceptions: Do not install insulation on equipment with factory installed insulation.

3. Insulation Thickness and Material: Insulation thickness shall be as shown by manufacturer's charts to provide a surface temperature less than or equal to 120 degrees at 90 degrees ambient temperature and zero wind speed. Materials shall be suitable for equipment surface temperatures.

4. Finish: Cover insulation with 18 ga., 1" galvanized wire mesh. For equipment, finish over the galvanized wire with glass cloth and vapor barrier mastic coating with dry film thickness of 1/16 inch or use FSK jacket. For breeching, finish with 1/2 in. layer of insulating and finishing cement.

3.4 DUCT INSULATION INSTALLATION

A. Inside Duct Liner
See Section 15800, Air Distribution

B. Outside Duct Wrap
1. General
a. Reference Section 15800, Air Distribution, for description of ducts requiring insulation.
b. Supply and/or return ductwork located within conditioned spaces served by this ductwork, do not require insulation. Ductwork passing through a space that is not supplied air by this ductwork requires insulation. Mechanical rooms and ceiling plenums are not conditioned spaces and duct insulation is required.
c. Ductwork insulated inside and factory insulated ducts need not be insulated on the outside.
d. Insulation for exposed rectangular ducts shall be fiberglass board. Insulation for other ducts shall be fiberglass duct wrap.
e. Ducts for outside air intakes or ducts exposed to the weather shall have 2 in. thick insulation.

2. Installation
a. Fiberglass board: Secure board insulation tightly and smoothly with not less than 50 per cent coverage of bonding adhesive. After application of adhesive, secure the insulation tightly and smoothly with speed washers and welded pins. Space pins not over 18 inches apart each way, not over 3 inches from edges of insulation joints, and capable of supporting a load of 20 pounds per pin. Apply insulation with all joints, in close mechanical contact and all open joints, breaks, punctures and voids filled with vapor barrier coating. Where pins are welded to ducts, use a welding procedure which will not distort the duct, will not burn through, or will not mar the interior finish of the duct, but will develop the full strength of the pin. Provide pin sizes and diameters as recommended by the manufacturer for the type and thickness of the insulation specified. Joints in jacket shall be taped with 4 in. wide FSK tape.
b. Fiberglass duct wrap: Secure duct wrap tightly and smoothly with a bonding adhesive applied in 6 in. transverse strips on 12 in. centers. When the long side of the duct or the duct diameter is 24 inches or more, secure insulation also with speed washers and pins as specified for board insulation. Pins shall be spaced not more than 13 inches apart each way. Do not permit sagging of the insulation and provide sufficient bonding adhesive or fasteners to prevent this. Joints in jacket shall be taped with 4 in. wide FSK tape.
c. All cuts and tears shall be sealed with strips of 4 in. wide FSK tape.

END OF SECTION 15250

SECTION 15300
FIRE PROTECTION SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

The general provisions of the Contract, including General and supplementary Conditions and Division 1 - Specification Sections and Contract Documents apply to work in this section. Consult them for further instructions and be governed by the requirements thereunder.

1.2 DESCRIPTION

A. Work Included

1. Furnish all labor and material, and perform all operations necessary for the installation of complete and operating systems subject to the conditions of the contract. All work must be done in accordance with the applicable NFPA standards and complying with the requirements of Local Building and Fire Departments. These jurisdictional authorities and codes shall take precedence over the Drawings and Specifications, in the event of dispute or discrepancy between requirements of Contract Documents and insurance rating authority or code.

2. Furnish and Install
   a. Sprinkler equipment including inside and outside piping, sprinkler heads, valves, and accessories, necessary to provide a complete and approved fire sprinkler system(s).
   b. Replace existing sprinklers throughout all existing areas of the basement and first and second floors, whether shown on design drawings or not.

3. Wiring
   a. All wiring will be done under Electrical Division, provide supervision for proper operation.
   b. All wiring shall comply with the National Electrical Code, local codes and Electrical Division of these specifications.
   c. All wiring shall be run in metallic conduit, tubing or raceways.

B. Fees and Permits: All fees and permits specifically required for fire protection work, other than permits normally required by the Mechanical Subcontractor, shall be applied for and paid for by the Fire Protection Subcontractor, including but not limited to installation and licensing permits.

C. The position is taken that the Owner is entitled to a no penalty project; all efforts and installations shall be directed toward this end. All deficiencies as noted by local jurisdictional authorities shall be corrected. No extra charges will be allowed on this account.

D. Coordinate with other trades and arrange the work to make the work of all trades fit in the space provided. This shall include all work in the ceiling plenum, mechanical rooms and wherever else work from multiple trades occurs. Additionally, participate in the project coordination effort organized by the General Contractor. Under no conditions shall this contractor expect all work to occur at one elevation throughout the project; anticipate the need for rises and drops in the routing of all sprinkler piping to coordinate with all other trades.

1.3 QUALITY ASSURANCE

Contractor Qualifications

Work shall be performed by a contractor regularly engaged in the design and installation of fire protection systems in accordance with NFPA requirements having at least 5 years continuous experience in the type of work specified.

1.4 REGULATORY AND CODE REQUIREMENTS

Applicable codes and standards include, but are not limited to the following. The requirements of the below codes shall be considered the minimum level of performance required for the project.

NFPA 13, 2007 Edition - Installation of Sprinkler Systems
International Building Code, 2006 Edition
International Fire Code, 2006 Edition

1.5 SUBMITTALS

A. Shop Drawings: Submit for the following in accordance with Section 15010 and Division 1.
   1. Submit sprinkler system layout and hydraulic calculations design for review. (Show additional heads not indicated on design drawings, but are required for proper coverage.) Furnish additional heads that may be required for coordinated ceiling pattern, or other conditions, even though number of heads may exceed minimum code requirements. The above-mentioned additional heads shall be provided at no extra cost. Submit final shop drawings of entire system after review and approval of head locations.

      Drawings shall bear review stamp of local jurisdictional code authorities. Include hydraulic calculations. No work shall be started until all approvals are obtained.

   2. Drawing submittals shall be the same size drawing format and size as the construction document drawings.

B. Product Data: Submit for the following in accordance with Section 15010 and Division 1.
   1. All valves, auxiliary drain valves, sprinkler devices and heads, pipe and fittings, hangers, flow switches, specialties and accessories used in the system.

C. Test Reports: Submit certified test reports in accordance with Section 15050.

D. Operation and Maintenance Data: Submit in accordance with Section 15010 and Division 1.

1.6 DELIVERY, STORAGE AND HANDLING

Comply with Section 15010 and Division 1. Exercise care to prevent damage to materials during loading, transportation and unloading. Do not drop pipe, fittings or equipment. Store materials in enclosures or off the ground under protective coverings.

1.7 PROJECT CONDITIONS

A. Existing Conditions: Examine existing conditions at the job site prior to any prefabrication of piping. Modify system as required to comply with actual job conditions and work of adjacent trades.

B. Examine conditions of new building at the jobsite prior to any prefabrication of piping. Modify system as required to comply with actual job conditions and work of adjacent trades.

C. Sequencing, Scheduling: Coordinate material delivery and installation with work of other trades.

1.8 WARRANTY
Comply with Section 15010. 1-year warranty

1.9 PROJECT RECORD DRAWINGS
Comply with Section 15010.

1.10 WATER DAMAGE
The Contractor shall be responsible for any damage to the work of others, to the building and properties/materials of others caused by leaks in the sprinkler system and shall pay for necessary replacement or repair of work or items so damaged during the installation and testing period of this work.

PART 2 – PRODUCTS

2.1 GENERAL
All material shall be U.L. listed.

2.2 PIPING AND FITTINGS INSIDE THE BUILDING

A. Piping materials shall be new and designed for 175 psi working pressure, conforming to ASTM specifications. Piping shall have the manufacturer's name or brand, along with the applicable ASTM Standard, marked on each length of pipe.

1. Schedule 40, black steel pipe, ASTM A-135/A-795 and A53 joined by screwed joints (ANSI/ASME B2.1), welded joints (ANSI/ASME B31.1) or by mechanical grooved couplings or push-on (locking) couplings, joined by UL approved combination of couplings, gaskets and grooves where approved by local jurisdictional code authority. Grooves shall be rolled (cut grooves are not acceptable) and shall be dimensionally compatible with the coupling.

2. Lightweight, UL listed exterior galvanized steel pipe in accordance with ASTM A-135/A-792, where approved by local jurisdictional code authority, joined by screwed joints (ANSI/ASME B2.1), welded joints (ANSI/ASME B31.1) or by UL approved mechanical fittings. Couplings shall be of the rolled grooved type. Rolled grooves shall be dimensionally compatible with the coupling. Pipe end preparation shall be in accordance with the manufacturer's recommendations.

3. All ASTM A135 sprinkler pipe must be tested with a non-destructive electric test for continuous and uninterrupted inspection of the welded seam and tested to a critical weld, both cone and flatten test.

4. All sprinkler piping exposed to the weather or used in a corrosive atmosphere, where noted on the drawings, shall be galvanized.

5. Where system pressures are between 175 psi and 300 psi, standard wall pipe shall be used as permitted by ANSI standards.

B. Fittings shall be able to withstand the working pressures involved but not less than 175 psi cold water. Fittings shall comply to the following Standards:

1. Screwed fittings; black cast iron, 125 lb. class in accordance with ANSI B16.4 or black malleable iron, 150 lb. class in accordance with ANSI B16.3.

2. Flanged fittings; black cast iron, short body, 125 lb. class in accordance with ANSI B16.1. Gaskets shall be full-face of 1/8" minimum thickness, red sheet rubber. Flange bolts shall be hexagon head machine bolts with heavy semi-finished hexagon head nuts, cadmium plated, with dimensions in accordance with ANSI B18.2.

3. Weld fittings; Standard weight, black steel in accordance with applicable ANSI and ASTM specifications.

4. Grooved couplings and mechanical fittings; malleable iron, 175 PSI working pressure in accordance with ASTM A47. All couplings and fittings shall be from a single manufacturer. No segmentally welded fittings are allowed. Coupling gasket material shall be EPDM. Couplings and mechanical fittings shall be tested and listed by UL and in accordance with NFPA 13.

5. Fittings used in systems where pressures exceed 175 psi shall be extra heavy pattern except as follows:
   a. Standard weight cast iron fittings 2" and smaller may be used where pressure does not exceed 300 psi.
   b. Standard weight malleable iron fittings 6" and smaller may be used where pressure does not exceed 300 psi.

2.3 VALVES

General: All valves shall be UL listed.

A. Gate Valves
   1. For system operating pressure less than 175 psi: 2" and smaller; O.S. & Y., bronze, 175 lb., screwed. 2-1/2" and larger; O.S. & Y., IBBM, 175 lb., flanged.

   2. For system operating pressure greater than 175 psi: 2" and smaller; O.S. & Y., bronze, 200 lb. screwed. 2-1/2" and larger; O.S. & Y., IBBM, 250 lb., flanged.

B. Butterfly Valves:
   1. For system operating pressure less than 175 psi: Iron body, UL rated at 175 psi, lug, wafer or grooved body, position indicator and pad locking device.

   2. For system operating pressure greater than 175 psi: Use of butterfly valve is not acceptable.

C. Check Valves
   1. For system operating pressures less than 175 psi: 2" and smaller, bronze, 125 lb., screwed. 2-1/2" and larger, IBBM, 175 lb., flanged, or grooved.

   2. For system operating pressures greater than 175 psi: 2" and smaller; bronze, 200 lbs., screwed. 2-1/2" and larger, IBBM, 250 lbs., flanged.

D. Globe and Angle Valves - Drains and Flow Regulation
   1. For system operating pressures less than 175 psi: 2" and smaller; 200 lb., screwed. 2-1/2” and larger, IBBM, 125 lb. flanged.

   2. For system operating pressures greater than 175 psi: 2" and smaller; bronze, 200 lbs., screwed. 2-1/2" and larger, IBBM, 250 lb. flanged.

E. Automatic ball drip (1/2") rated at 175 psi, Potter Roemer Series 5980, Croker 6780, or equivalent.

2.4 SPRINKLER HEADS

A. UL Listed standard spray sprinkler heads, ordinary temperature ratings (155^0F) Quick Response, except where high temperature heads are required. Replace <u>all</u> old existing sprinklers in existing building as required.

B. Heads to be provided as follows:
   1. Heads in Finished Areas

Chrome Heads with chrome escutcheons

2. Heads in Unfinished Areas
Plain brass pendent or upright as required

C. Escutcheons
Provide escutcheons to be compatible with sprinkler heads where necessary.

D. Extra Heads:
Provide extra heads of each type and temperature rating installed, enclosed in a new steel cabinet. Locate cabinet on wall next to sprinkler riser and backflow assembly. Number of heads to be in accordance with NFPA No. 13 recommendations; 6 spare heads for up to 300 sprinklers, 12 spare heads for up to 1000 sprinklers and 24 spare heads for over 1000 sprinklers. Provide two head wrenches for each type of sprinkler.

E. All heads shall be color coded and installed in compliance with NFPA.

2.5 PRESSURE GAUGES
Provide new liquid filled pressure gauges as required. UL listed 4-1/2" dial type with a maximum limit of not less than twice the normal working pressure.

2.6 FIRE DEPARTMENT CONNECTION
Provide new Knox caps on existing fire department connection inlets. Also provide a Knox key to the Cheyenne Fire Department upon completion of the system.

PART 3 – EXECUTION

3.1 GENERAL
A. Inspect proceeding work, verify all dimensions before proceeding with work and coordinate all work and placement of components with other trades.

B. Be responsible for all measurements, fitting and assembly of all work. Prefabrication is done at this Contractor's risk.

3.2 SERVICE
A. The Sprinkler Contractor shall inspect the interior condition of piping during the execution of work on the existing piping systems. If evidence of corrosion, clogging or other degradation of the piping interior is found, the General Contractor, Engineer, and Architect shall be notified in writing within 24 hours.

3.3 INSTALLATION
A. Provide core drilling and piping clearance around piping passing through existing or new building walls and floors above grade. Provide sleeves of standard weight steel pipe. The annular spaces between pipe and sleeves shall be packed tight with non-hardening caulking. Pipes passing through firewalls shall have annular space packed with approved fire barrier material. Provide chrome plated escutcheon plates large enough to cover the pipe sleeve and opening through walls and floors where piping is exposed.

B. Piping shall be installed in the most direct, straight and mechanical manner as possible and as close to walls and ceilings as is consistent with good workmanship. All lines shall be run high enough to permit relocation of lights without moving ceiling grid.

C. Coordinate exact pipe locations with drawings and other trades before design approval and fabrication of piping. This contractor shall be responsible for any redesign and fabrication required to fit system into allowable space.

D. All piping in finished areas shall be concealed unless shown otherwise, all other piping can be exposed.

E. All vertical lines shall be plumb and horizontal lines shall run parallel to building lines.

F. Install horizontal piping graded to low points and in manner to make it possible to test and empty entire system. Provide valves at low points to facilitate system drainage.

G. Pipe and fittings shall be inspected for soundness and cleaned of all dirt and other foreign matter prior to being installed. All damaged pipe and fittings will be rejected.

H. Protect open pipe ends whenever work is suspended during construction, to prevent foreign bodies entering and lodging therein. Use cast iron or malleable iron caps, or other method as approved by the Architect/Engineer.

I. Chrome plated or other polished finished components shall be installed with care so that marring does not occur to the finish.

3.4 PIPE SUPPORTS

All piping shall be supported by means of U.L. listed hangers. Sizing, spacing, and installation shall be in accordance with NFPA 13, "Sprinkler Systems", except as otherwise shown on Drawings or specified within this section.

3.5 FIRE ENTRY STATION

A. Provide fire entry station(s) consisting of O.S. & Y. gate or butterfly valve, double check backflow preventer, fire department connection, ball drip, drain valve, flow switch and exterior light and horn.

B. Exterior light and horn shall be located on the exterior of the building within twenty-five (25) feet of the fire department connection.

3.6 INSPECTOR TEST LINES

Inspector test connection and line shall be installed at the existing sprinkler system riser. Test orifice and sight glass connections shall be provided on a 1" pipe and valve assembly. Test pipe shall be connected to the existing 6" main downstream of the water flow switch and shall discharge into the existing 2" main drain brass outlet, where it can easily be seen. The size of the orifice shall be the same as the minimum sprinkler head orifice on the system. Outlet shall be turned down with 45 degree elbow and locate 6" above finished grade. If fire sprinkler head is used for outlet, all projections from broken off deflector shall be ground smooth. Final discharge location will be determined and approved during shop drawing review.

3.7 SPRINKLER CONTROL ASSEMBLY

Sprinkler system control valves on existing back flow assembly shall remain unchanged unless otherwise required by the Fire Department.

3.8 SPRINKLER HEADS

A. All heads shall be centered in ceiling tile where ceilings occur, show actual location on shop drawings.

B. When sprinkler heads are installed where they may be exposed or subject to damage, head guards shall be furnished.

C. Replace all existing (old) sprinklers with new quick response type sprinklers.

3.9 WET SPRINKLER SYSTEM

A. General

1. Fire sprinklers shall be provided and/or maintained throughout the entire building.

B. Core and Shell

Existing and new sprinkler system shall be designed to protect all portions of the new and existing building, as required by NFPA 13. Core and shell system will be designed, installed and/or modified to provide for future tenant flexibility.

C. Design

The sprinkler system shall be based on the following (hydraulic) design criteria:

1. Provide wet sprinkler system(s) of pressure, flow and densities required by NFPA 13. Systems shall be calculated and of a configuration acceptable to the local jurisdictional authority.
   a. System design throughout second floor spaces for future business occupancy uses shall be Light Hazard and provide 0.10 gpm per square foot over the most hydraulically remote 1,500 square foot area, plus 100 gpm allowance for hose streams as required and/or allowed by NFPA 13.
   b. Design throughout all first floor spaces and new basement area storage, or for future mercantile occupancies (retail and restaurant kitchen areas), shall be Ordinary Hazard Group II and provide 0.20 gpm per square foot over the most hydraulically remote 1,500 square foot area, plus 250 gpm allowance for hose streams as required and/or allowed by NFPA 13.
   c. Existing basement area shall not change except as otherwise noted.

3.10 HYDRAULIC CALCULATIONS

A. General

The Fire Protection Contractor shall prepare hydraulic calculations for the design of the system and submit to local jurisdictional code authority for approval before any fabrication or installation is started. Submittals shall include but not be limited to:

1. Computer printout sheets or hand calculation sheets with all calculations.

2. Cross reference points of calculations both on the drawings and in the calculations by symbol or number.

3. Hydraulic calculations shall be used to verify all new sprinkler system piping for core and shell work.

4. Existing piping system to remain unchanged, unless noted otherwise, for core and shell work.

B. Flow Test Data

1. Flow tests shall be performed by this Contractor and verified by local fire department. Prior flow tests on file with local jurisdictional authority may be used only when this test data is only 3 months old at the start of the project.

2. Contractor shall use 85% of the flow test pressure data in his hydraulic calculations.

3.11 PROTECTION

A. Where there are existing facilities, be responsible for the protection thereof, whether or not such facility is to be removed or relocated. Moving or removing any facility must be done so as not to cause interruption of the work or Owner's operation.

B. Close ends of pipe during construction with caps or plugs to prevent entry of foreign material. Protect insulation against dirt, water, chemical or mechanical damage before, during and after installation. Protect equipment against damage during mechanical work.

C. Provide protection for concrete slabs where cutting or threading of piping occurs.

3.12 INSTRUCTION

When required approvals of this work have been obtained, and at time designated by the Owner, demonstrate to the Owner's personnel the operation and maintenance and demonstrate the contents of the approved manual.

3.13 IDENTIFICATION

A. Comply with Section 15190.

B. The drain, alarm test valves, etc. shall have standard identification signs, painted fire red with white lettering. The signs shall be attached to the valves in a conspicuous position.

3.14 TESTING

A. Comply with Section 15050 and NFPA 25.

B. Retest piping failing initial tests following correction of defective work. Requirements of initial tests shall apply.

3.15 COMPLETION

A. This Subcontractor shall call for inspection and obtain certificate of completion and test from the Fire Inspection Bureau under whose jurisdiction this installation occurs. After the system has been inspected and tested, provide and sign a certificate, "Contractor's Material and Test Certificates". Certificate shall also be signed by a representative of the Fire Inspection Bureau. Sufficient copies shall be prepared to ensure that inspecting authorities and the Contractor will have a copy for their files. Also provide a copy of NFPA #25, "Inspection, Testing and Maintenance of water-based fire protection systems for each O & M Manual.

B. Provide Operation and Maintenance Manual per Section 15010.

C. This Subcontractor shall remove from the building, all rubbish and unused materials due to or connected with this installation.

D. The surface of all exposed piping shall be cleaned and left ready for painting done by painting subcontractor.

END OF SECTION 15300

SECTION 15400
PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The General Provisions of the Contract, including General and Supplementary Conditions and Division 1 - Specification Sections and Contract Documents apply to work in this section. Consult them for further instructions and be governed by the requirements thereunder.

1.2 WORK INCLUDED (but not limited to)

A. Domestic Hot and Cold Water Piping

B. Waste and Vent Piping

C. Natural Gas Piping

D. Piping Material, Valves and Specialties

E. Plumbing Fixtures, Carriers and Trim

F. Domestic Water Heaters

G. Rough-Ins for Equipment and Fixtures

H. Sewage Ejector Systems

I. Interceptors

1.3 RELATED REQUIREMENTS

A. Basic Mechanical Requirements: Section 15010

B. Basic Materials and Methods: Section 15050

C. Mechanical Identification: Section 15190

D. Controls and Instrumentation: Section 15900

PART 2 - PRODUCTS

2.1 WATER PIPING MATERIALS

A. Piping Outside Building

All pipe outside the building to the service termination inside the building, 4" and larger; Class 250, cement lined, cast iron, or ductile iron of manufacturer's recommended thickness class, mechanical joint or push on joint, 3" and smaller; Type "K", hard drawn copper using BCuP2 classification brazing alloy.

B. Piping Inside Building

Piping from the service termination throughout the rest of the building, for buried lines; Type "K", hard drawn copper, wrought copper fittings using BCuP2 classification brazing alloy, for non-buried lines; Type "L", hard drawn copper, wrought copper fittings and lead free solder: 96-4 (tin/silver), Silvabrite 100 or Canfield 100% Watersafe (silver-tin copper). Where copper tube is joined to brass or bronze, use BCuP2 classification brazing alloy.

C. Valves and Specialty Schedule

1. Gate Valves
   2" and smaller: Bronze, Class 150, 300 psi W.O.G. screwed or solder; 2-1/2" and larger: iron or cast steel body, bronze trim, Class 125, 200 psi W.O.G. flanged.

2. Ball Valves
   2-1/2" and smaller: Bronze, two piece or uni-body full port with chrome plated ball, reinforced TFE seats and stuffing box, lever handle and screwed or solder ends. 400 psi W.O.G., 150 psi saturated steam. 3" and larger: Carbon steel, uni-body, full port with chrome plated ball valve, reinforced TFE seats and seals, lever handle and ANSI Class 150 flanged ends. 285 psi W.O.G., 150 psi saturated steam.

3. Butterfly Valves
   2" and smaller: Cast iron or ductile iron, stainless steel disc and stem, VITRON seal, 200 psi working pressure, 350 psi W.O.G., screwed or solder.

4. Globe Valves
   2" and smaller: Bronze, Class 150, 300 psi W.O.G. screwed or solder; 2-1/2" and larger: iron or cast steel body, bronze trim, Class 125, 200 psi W.O.G. flanged.

5. Check Valves
   2" and smaller: Bronze, Class 150, 300 psi W.O.G. screwed or solder; 2-1/2" and larger: iron body, brass trim, Class 125, 200 psi W.O.G., flanged.

6. Pressure Gauges
   3" dial, bronze bourdon tube with 1/4" pipe thread bottom mount, steel case, white face with black lettering, screwdriver calibration. Accuracy to be 1% of full scale. Pressure ranges to be approximately double the expected working pressure of the service. Brass lever handled cock or needle valve, and pigtail. U.S. Gauge Figure 5801, Danton 101, Weiss or equivalent by Ashcroft, Dwyer, Foxboro, Marsh, Marshalltown, Miljoco, Mueller Brass, Wika or Meriam.

7. Thermometers
   Multi-angle, solar powered with digital readout. Accuracy to be 1% of scale or better. Display shall have minimum 1/2" tall numbers. Unit shall be able to be switched in the field between Fahrenheit and Centigrade. Miljoco CDX, Weiss DVB or equivalent by Wikes, Weksler or Wika.

8. Dielectric Unions or Couplings and Flanges
   Union rated for 250 psi with galvanized or plated steel threaded end, copper solder end and impervious isolation gasket approved for use on gas, oil, air and water lines. Couplings approved for use on water lines and able to withstand hydrostatic test pressures of 1000 psi at 250°F with an inert, nonconductive laminate material and threaded to NPS standards. Flanges to be complete with insulated bolt sheaves, washers and gaskets.

7. Strainers
   2" and smaller: 250 lb. bronze or cast iron "Y" type screwed with stainless steel screen. 2-1/2" and larger: 250 lb. cast iron "Y" type flanged with stainless steel screen.

8. Press. Temp. Taps
   1/2" NPT, nordel or EPDM Core, Peterson Equipment Company #710, Sisco BNO-500, or Hydro-Temp, MGP/T or equivalent.

9. Trap Primer
ASSE Standard 1018 approved with integral air gap. Primer shall be pressure drop activated and all brass construction. Provide distribution unit as required for multiple drain connections.

PPP Prime-rite, Watts Series T20 or equivalent.

2.2 SANITARY WASTE AND VENT AND STORM DRAIN MATERIALS (to 5 feet outside bldg.)

A. Piping Material

1. Sanitary Waste and Vent Lines

a. Below grade to a distance of 5 feet from the building: Coated service weight cast iron with bell and spigot fittings with elastomeric joints (ASTM C564 gaskets) or coated hubless cast iron with gasket (ASTM C564) type 304 stainless steel shield and worm drive and clamp fittings or cast iron couplings with type 304 steel bolts and gaskets (ASTM C564) approved for below grade applications and installed per manufacturer's installation instructions. From this point on, material shall be as specified under "Building Sanitary Sewer."

b. Above grade: Service weight cast iron with bell and spigot fittings with elastomeric joints (ASTM C564 gaskets), hubless cast iron with gasket (ASTM C564) and stainless steel shield and worm drive clamp fittings installed per manufacturer's recommendations, or DWV copper with wrought copper or cast brass fittings using 95-5 (tin/antimony) solder joints.

c. Below grade waste and vent piping may be Schedule 40 ABSDWV plastic pipe and fitting (ASTM D2661) or Schedule 40 PVC-DWV plastic pipe and fittings (ASTM D2665) except where used in return air plenums. All pipe and fittings shall bear NFS-DWV mark and shall be joined with solvent weld joints as recommended by the manufacturer.

2.3 GAS PIPING MATERIALS

E. Pipe and Fittings: Schedule 40, ASTM-A53 Type E, Grade B black steel pipe.

1. Above grade piping; 2 inches and smaller, use 150 lb. malleable iron fittings and threaded joints in exposed locations and standard weight socket weld fittings and welded joints in inaccessible locations and return plenums. Over 2 inches, use seamless steel butt weld fittings and welded joints in exposed locations and standard weight socket weld fittings, same thickness as pipe, and welded joints in inaccessible locations and return plenums.

2. Below grade piping;

a. 150 lb. forged steel fittings and welded joints. Provide cathodic protection as required. Piping shall be provided with a factory applied coating of either fusion bonded epoxy or tape wrap (15 mil. minimum). Factory coating must be acceptable to the utility company.

3. Service line piping:
Piping and Fittings: Polyethylene plastic PE 2306, ASTM D-2513, no more than 2 years old. Dupont, Nipak, Phillips, or Plexco.

Joints to be heat fusion type.

F. Valves

1. Lubricated Plug Valves
Class 125, 175 lb. W.O.G. cast iron, screwed or flanged with low friction coated plug.

2. Non Lubricated Plug Valves
Class 150, 175 lb. W.O.G. semi steel, screwed or flanged, Keyport 425, RS49 or, Resun Fig. R-1430 or R-1431.

3. Gas Cocks
125 psi working pressure, CSA listed, ground joint, flat head, 3/4" & 1" only. Crane, Anderson Metals Corp., or approved equivalent.

4. Ball Valves
150 psi working pressure at 366°F, brass body and ball, PTFE seats. CSA approved, UL listed, FM approved, Apollo 64-200 series.

2.4 FIXTURES AND EQUIPMENT

A. General
See Section 15010 for other acceptable manufacturers, substitutions and approvals.

B. Schedule

BACKFLOW PREVENTER BFP-1

State Health Department, AWWA IAMPO (2" and below), ASSE, and USC approved double check backflow preventer assembly, consisting of two resilient seated isolation valves, two independently operating, spring loaded check valves, and resilient seated test cocks for field testing. Working pressure of 175 psi, temperature to 140°F maximum. Preventer assembly to be line size or size as called for on drawings.

Up through 2"	2-1/2" and Larger
Watts Model 007 QT	707
Or approved equivalent	

FLOOR DRAIN FD-1

Cast iron drain with double drainage flange, adjustable (utilizing multiple thread interconnections) Nickel Bronze strainer and top, deep seal "P" trap. Drain outlet size to be the same as connecting pipe size shown on drawings. Provide strainers with a minimum free area of 1.5 times the free area of the connecting pipe. Provide flashing clamp device where pans or waterproof membranes occur.

Josam	30000-A
Smith	2010-A
Wade	W-1100-Std.
Zurn	Z-415-B
Ancon	FD-100

EQUIPMENT ROOM DRAIN ERD-1

Cast iron drain with double drainage flange and loose set recessed secondary strainer, deep seal "P" trap. Provide 1/2" primer tapping. Drain outlet size to be the same as connecting pipe size shown on drawings. Provide brass rim and 1/2 and full grate for each drain as required. Provide flashing clamp device where pans or waterproof membranes occur.

Josam	35440
Smith	2632-F

Wade	W-2370-24
Zurn	Z-610-S-LY
Ancon	FS-600-F-46-56A-Pol.BRZ

HOSE BIBB HB-1

Hose bibb with integral vacuum breaker, 1/2" inlet, 3/4" hose end.

	BRASS FINISH	ROUGH FINISH
Chicago Faucet	952	998
Woodford	-	24P-1/2
Speakman	SC-5911-IS	-
T & S Brass	B-720	-
Water Saver Faucet Co.	H-12706	-

INSTANTANEOUS WATER HEATER IWH-1

Instantaneous, electric water heater. Unit shall have an ABS-UL rated cover. Element shall be replaceable cartridge insert. Element shall be iron free, nickel chrome material. Heater shall have a minimum operating pressure of 25 PSI and a maximum operating pressure of 150 PSI. Top water connections to be ½" compression fittings.

240V, 6.5 KW, 27A, 1.0 GPM capacity at 44°F rise.

Eemax SP65DL
or approved equivalent

SUMP PUMP SP-1 (Submersible)

Submersible duplex non-clog pumping units. Watertight cast iron shell with single mechanical seal system and bronze impeller. Double sealed ball bearings. Each impeller to be statically and dynamically balanced. Pump and motor to be removable (quick-disconnect) on guide bars with automatic discharge connection and lifting chain. Each pump to have 2" discharge and be able to pass 2" diameter solid.

U.L. listed control panel containing magnetic starters, fusible disconnect(s), pilot light(s), test-off automatic switch(es), low voltage transformer, and high water alarm switch and bell. Automatic alternator selection of lead pump, simultaneous operation of both pumps if one cannot carry the load, automatic operation of lag pump if lead pump fails, all factory wired. Mercury float switches for each motor. See Section 15050 for motor, phase protection and starter requirements.

Provide 42" diameter x 48" deep fiberglass sump with gas tight steel cover with manhole, vent connection and pump removal plate.

Capacity of 20 gpm at 20 feet head. 0.75 HP, 1750 RPM, 115V for each pump.

Weil 2422
Or Approved equivalent by:
Flygt
Federal

SUMP PUMP SP-2 (For Elevator Pit)

Single-stage, suction centrifugal pump. Heavy-duty cast iron bronze fitted pump precision machined to close tolerances for consistent performance. Cast iron body with enclosed bronze impeller, stainless steel hardware.

Mechanical seal with ceramic stationary element and carbon rotating element, close-coupled to a 0.75 HP, 1750 RPM, 208V-30

Rated duty 50 GPM @ 18' TDH

Provide with factory provided float for control.

Scot model 17
Or approved equivalent by:
Federal
Weil
Zoeller

WALL HYDRANT WH-1

Anti-freeze, cast brass, 3/4" hose end wall hydrant with renewable seat washer, integral vacuum breaker, loose T handle key, cast brass or stainless steel box with polished bronze box face. Provide the owner with 1 key for each hydrant installed (minimum of 2).

	w/Box
Josam	71000
Smith	5509-PB
Wade	W-8625-2
Woodford	B65
Zurn	Z-1300-6
Ancon	HY-725-2

ROOF DRAIN RD-1

Cast iron drain with cast iron removable dome, flashing clamp device and gravel stop. Provide deck clamp and sump receiver or Zurn Deck Plate for all drains except when drain is installed in poured in place concrete roof. Provide drain extensions as required.

Josam	21500
Smith	1010
Wade	W-3000
Zurn	ZC-100
Ancon	RD-100

OVERFLOW ROOF DRAIN ORD-1

Cast iron drain with cast iron removable dome, plastic standpipe, flushing clamp device and gravel stop. Provide deck clamp and sump receiver or Zurn Deck Plate for all drains except when drain is installed in poured in place concrete roof. Provide drain extensions as required.

Josam	21500-AE-16
Smith	1070
Wade	W-300-SD
Zurn	ZC-100-W
Ancon	RD-100-W

DOWNSPOUT NOZZLE DSN-1

Cast bronze downspout nozzle with loose bronze wall flange anchored to wall.

Josam	25010
Smith	1770
Zurn	Z-199

GAS PIPING SUPPORT

Gas piping support to be adjustable height roller type designed to support gas lines up to 3-1/2" OD, not exceeding 16" in height. Support to be designed for installation without roof penetrations, flashings, or damage to roofing material. Space supports per manufacturer recommendations.

Base material to be injection molded high density/high impact polypropylene with UV inhibitors and antioxidants, density 55.8 lb/cu ft. Rod type to be ½" diameter, 10" long hot dip galvanized or stainless steel. Hardware to be hot dip galvanized or stainless steel.

PHP Systems PP10 with Channel or prior approved equivalent.

PART 3 - EXECUTION

3.1 WATER PIPING

A. Inside Building

1. Run piping as direct as possible to required connections, and slope to drain valves at low points for complete system draindown. Locate drain valves at accessible points within the system. Extend existing system as required for remodel.

2. Install new water entry, including main isolation valves. Double-check backflow preventer.

B. Valves and Specialties.

1. Gate valves, plug valves, ball valves or butterfly valves may be used for shut-off service. Valves utilizing lever handles shall be installed to allow complete open to close valve operation without interference of structure, insulation, etc.

2. Ball, butterfly or globe valves shall be used for balancing service. All valves used for balancing service shall have adjustable memory stops.

3. Valves used in insulated piping systems shall have extended necks as required for proper and easy operation after valve is insulated.

4. Provide isolation valves on all lines before they leave the mechanical room and at each floor level.

5. Globe valves, where shown, are the only suitable valve.

6. Provide unions at connections to fixtures and equipment including valves when union trim is not furnished as a standard part of the equipment trim or where items cannot be removed from line without unions.

7. Dielectric unions shall be used at all connections of ferrous material to non-ferrous material. Couplings can be used wherever unions are not required.

8. Pressure gauges, thermometers, and press/temp. taps are to be used wherever shown on drawings. Press/temp. taps and pressure gauges shall be located in an accessible position and immediately before and after equipment with no valve or fitting between tap or gauge and equipment. Install pressure gauge with isolation valve and drain valve between gauge and isolation valve and install pressure snubber or needle valve in services with rapid pressure pulses. Use thermal wells with heat transfer enhancement compound for thermometers.

9. Vibration isolation, see Section 15050.

10. All valves and specialties in grooved piping systems shall be attached to adjacent pipe using rigid couplings.

11. Pressure Testing
See Section 15050.

3.2 SOIL, WASTE, AND VENT (to five feet outside building)

A. General

1. Connect to existing waste piping. Provide adaptors as required to connect into existing conditions.

2. Main waste lines within the building; provide a uniform fall of not less than one inch in eight feet.

3. Branches; provide a uniform fall of not less than one inch in four feet for 3" and smaller and one inch in eight feet for sizes 4" and larger.

4. Horizontal lines suspended from structure; provide hangers at five feet intervals or wherever necessary to insure proper grading.
5. Vertical lines; anchor at each floor level.
6. Fixtures; vent in accordance with sound plumbing practice and applicable codes. Do not install vents within two feet of roof edge, parapet or wall line of an "on the roof" structure.

B. Cleanouts

Install full size brass cleanout plugs on pipes up to 4" in size and 4" cleanouts on 4" and larger pipes, wherever pipes change direction 45 degrees or more or otherwise require cleanouts for proper cleaning of entire drainage systems. All wall cleanouts shall be located 4" to 6" above floor unless cleanout would fall behind permanent casework, then locate at 4'-6" above floor. Provide cleanouts at 50 feet maximum intervals for pipe 4" and less in size, 100 feet intervals for 5" pipe and larger. Cleanouts to have brass plugs with chrome plated cover plates for walls, scoriated brass cover for floor installed flush with floor and brass cover with carpet ring for carpeted area, flush with carpet. Submit proposed locations of all cleanouts for approval prior to installation.

C. Pressure Testing
See Section 15050.

3.3 GAS PIPING

A. General

All underground pipe shall be buried 24 inches minimum and surrounded with 4" clean sand before backfilling. All buried steel joints shall be welded; all joints shall left exposed until testing has been completed. Provide an electrically continuous insulated number 18 copper

tracer wire, installed with and attached to all underground non-metallic piping. Terminate each end above grade, identify and protect.

Gas meter bank and service from the main to the meter will be furnished and installed by the utility company, paid for by the Owner. Coordinate with CLF-P for meter bank configuration. Furnish and install all gas piping from the meter throughout the building and connect to all equipment required.

1. Provide "Tee" with 1/2 inch valve and plug in the gas line on house side of meter and at each piece of mechanical equipment (prior to gas train) for measuring pressures and flows.

2. Install an accessible wrench operated plug valve on the gas main before it enters the building. Provide wrench to Owner.

3. Buried Pipe Coating
   Buried pipe tape wrap shall be machine wrapped using a 50% overlap wrap minimum. Pipe shall be coated with primer before wrapping. Pipe may be wrapped prior to testing. Fittings and joints shall be double wrapped. Extend fitting and joint wrapping not less then 6 inches past the end of the fitting or joint onto the pipe section. Test pipe, joints and fitting prior to wrapping joints and fittings. The type of wrap used shall be as recommended by the manufacturer for the ambient temperature during installation.

4. Provide lubricated plug valves, six inch long condensate dirt pockets and unions at equipment connections.

5. Provide isolation valves on all lines before they leave the first floor.

6. Take branches from top or sides of horizontal pipes, not from bottom.

7. Installation, materials and/or equipment not indicated on the Drawings, specified or covered by the requirements of utility of agency having jurisdiction shall be in accordance with NFPA 54 "National Fuel Gas Code" (Latest edition).

8. Prepare pipe, fittings, supports and accessories not pre-finished, ready for finish painting.

B. Pressure Testing
   1. See Section 15050.

   2. After test, purge lines per NFPA 54 instructions.

3.4 FIXTURES AND EQUIPMENT

A. Fixtures
   1. Install all fixtures and rough in according to the fixtures accepted.

   2. All fixtures shall be secured to walls and floor or countertops in accordance with manufacturer's roughing in and setting requirements to form a rigid installation.
   3. All pipe at the fixtures, which may be exposed to view, shall be brass chrome finish, finished with chrome escutcheons where they project from walls and floors.

   4. Stop valves shall be furnished and installed at all fixtures and at rough in locations. Stop valves shall be furnished and installed at all equipment locations.

   5. Securely anchor flush valves behind or within walls to be rigid and not subject to movement due to push or pull action on the valve.

6. Integral vacuum breakers shall be provided at all outlets with hose connections.

7. Contractor shall fill gap between wall and all fixtures located against the wall with white silicon sealant with "Coved" finish.

B. Valving
Provide valves on all water lines before they leave the basement or mechanical room. Install shut off valves for all plumbing groups of more than 4 fixtures. Provide isolation valves at each branch take-off from the main.

C. Hose Bibbs and Wall Hydrants
Provide and install hose bibb in each equipment room where there is a cold water line present. Install accessible stop and drain valve in branch line ahead of each wall hydrant. Provide chrome plated hose bibbs in all finished areas and rough brass in all mechanical areas.

D. Water Heater
Make connections between existing water heater and domestic water piping system with dielectric unions, if required.

E. Shock Absorbers
Isolate each absorber with a ball valve. Place in accessible location not more than 6" from access door. Provide access doors as required; re: Section 23 0050. Selection of shock absorber size shall be based on fixture units shown on the drawings.

F. Trap Primers
1. Install per manufacturer's recommendations.

2. System must be flushed prior to installation of trap primers.
3. All primers shall be cycled 6 times to assure proper operation. Include certification of primer cycling in O & M manuals.

4. Install pipe at a 1 foot in 20 feet slope towards floor drain.

G. Backflow Preventer
1. Backflow preventer is to be retested 90 days after initial test and acceptance.

2. Backflow preventer is to be warranteed by this Contractor for period of one (1) year from the date of acceptance.

3.5 FLASHINGS
A. Provide flashing as recommended by roofing manufacturer for each vent or stack and for each roof drain. Clamp flashing into roof drain.

B. Flash all drains (i.e. roof, floor, etc.) not installed in slab on grade with 36-inch square, 4 lb/sq.ft. sheet lead, or chlorinated polyethylene factory laminated to 15 lb. felt. Clamp flashing into drain.

3.6 ADJUSTING AND CLEANING
A. Make final adjustment of tempering valves under maximum flow conditions to discharge temperature called for in these specifications.

B. Clean strainers, traps, aerators, and valves of debris, sand and dirt.

C. At completion, thoroughly clean plumbing fixtures and equipment.

D. Adjust flush valves, faucets, showers, bubblers for proper flow, after cleaning and flushing operations are accomplished.

E. Upon completion of water heater installation, verify satisfactory control operation under maximum demand operation as recommended by manufacturer. Adjust discharge water temperature. Make control adjustments required.

F. Adjust balancing valves in domestic hot water recirculation lines to insure quick delivery of hot water to fixtures. Set memory stops.

3.7 PROTECTION

Protect fixtures and related components from damage before, during and after installation to date of final acceptance or owner move-in. Provide protective coverings or other protection as required.

END OF SECTION 15400

SECTION 15600
HEAT GENERATION, REFRIGERATION AND LIQUID HEAT TRANSFER

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
The General Provisions of the Contract, including General and Supplementary Conditions and Division 1 - Specification Sections and Contract Documents apply to work in this Section. Consult them for further instructions and be governed by the requirements thereunder.

1.2 WORK INCLUDED (But Not Limited To)
A. Heating water piping.

B. Refrigeration piping.

C. Pre-insulated pre-fabricated pipe.

D. Valves and specialties.

E. Pumps.

F. Boilers.

G. Coils-heating and cooling.

H. Heat release equipment.

I. Air control assemblies.

J. Water treatment.

K. Glycol feeders.

1.3 RELATED REQUIREMENTS
A. Basic Mechanical Requirements - Section 15010.

B. Basic Materials and Methods - Section 15050.

C. Mechanical Identification - Section 15190.

D. Controls and Instrumentation - Section 15900.

E. Testing, Adjusting & Balancing - Section 15990.

PART 2 – PRODUCTS

2.1 MATERIALS AND EQUIPMENT (See Section 15010 for other acceptable manufacturers.)
A. Piping Materials
1. Low Pressure (124 psi and less)
Low Temperature (249^{0}F and less)
Contractor's option, either steel or copper for water pipe as outlined below. All fittings to be long radius pattern.
a. Steel Pipe
(1) Hot water heating piping; Schedule 40, ASTM-A53, Type E Grade B black steel.

(2) Fittings on exposed pipe 2" and under may be 125 lb. cast iron screwed, or for any water lines, 150 lb. malleable iron screwed. Fittings on concealed pipe, use forged steel, standard weight, butt weld or socket welded. Fittings on pipe 2-1/2" and over, use forged steel, standard weight, butt weld. Fittings for condensate piping shall be extra strong. Where flanging to valves, equipment, etc., use 150 lb. forged steel flanges or 125 lb. cast iron flanges. For branch lines on welded installation, welding tees, thread-o-lets or weld-o-lets shall be used. No stub-in branches will be approved.

b. Copper Pipe

Hot water heating piping, including those filled with glycol solutions; wrapped type "K" hard drawn copper ASTM B88 with wrought copper fittings and BCuP2 classification brazing alloy for all buried lines. For non-buried lines; type "L" hard drawn copper ASTM B88 with wrought copper fittings and 95-5 (tin/antimony), 96-4 tin/silver) or Canfield 100% Watersafe (silver-tin-copper) solder. Where copper pipe is jointed to brass use BCuP2 classification brazing alloy. As an alternative to soldering joints, copper press fittings conforming to the requirements of ASME B16.18 or ASME B16.22 with EPDM O-rings may be used. As an alternative to the use of pre-formed tees, the Contractor may use the T-DRILL method for branch connections to mains where the branch pipe is at least one pipe size smaller than the main pipe size.

(1) Drain pan piping; type "M" copper with wrought copper fittings and 95-5 (tin/antimony) solder on all lines not buried. Type "L" copper with wrought copper fittings and 95-5 (tin/antimony) solder for all buried lines.

(2) Refrigeration piping; ACR grade per ASTM B280 copper, cleaned, dehydrated and capped at the factory. Use wrought copper, long radius type or forged-brass sweat type (no cast sweat-type) fittings brazed with AWS A5.8 BCuP2 classification filler metal, or standard SAE forged brass short shank flared fittings.

2. Grooved Pipe System (Contractor's Option for heating water at pressures of 124 psi and less and temperatures of 230^0F and less).

a. Couplings

(1) Grooved pipe couplings may be used to connect mechanical equipment to piping system and may be used in lieu of unions or welded, flanged, or screwed pipe connections for joining heating, chilled and condenser water pipe and fittings.

(2) Couplings shall be self-centered and shall engage and lock in place the grooved pipe and pipe fitting ends in a positive watertight couple. Some degree of angular pipe deflection, contraction and expansion should be allowed.

(3) Coupling housing clamps shall be cast in two or more parts of ductile iron castings, in accordance with Federal Specifications. Housing clamps shall hold in place a composition water sealing gasket designed so, that internal water pressure serves to increase the seals water tightness. Water sealing gasket shall be a Grade "E" EPDM compound with green color code, molded of materials conforming to ASTM D-2000, recommended for temperature ranges of -30^0F to 230^0F. Coupling assembly shall be securely held together by two or more tackhead, oval neck, steel bolts. Bolts and nuts shall be heat treated carbon steel and shall be in accordance with ASTM-A-183.

(4) All pipe fittings used in connection with pipe couplings shall have grooved ends and shall be cast of ductile iron castings in accordance with Federal Specification, QQ-I-666 D. Grade II.

(5) Before assembling couplings, lightly coat pipe ends and outside of gaskets with water soluble lubricant to facilitate installation.

(6) Pipes, fittings and valves shall be provided with grooved ends in accordance with pipe coupling manufacturer's latest published literature. Flanged or threaded end valves may be used with grooved adapters.

(7) Couplings and fittings shall withstand a system pressure of not less than 150 pounds per square inch.

(8) Entire coupling installation shall be done in accordance with manufacturer's latest published literature.

B. Valve and Specialty Schedule

1. Steel, Low Pressure (124 psi and less)
   Low Temperature (249^{o}F and less)

   a. Gate Valves (Rising Stem)

      (1) Class 150, 300 lb. W.O.G. bronze screwed for 2 inch and less; Class 125, 200 lb. W.O.G. iron or cast steel body, bronze mounted, flanged for 2-1/2 inch and greater.

      (2) Lockshield and Key: Nibco Option "L" with key, Powell Figure 344 or equivalent.

   b. Ball Valves

      Up to and including 2-1/2 inches: Bronze, two piece or uni-body full port with solid chrome plated ball, reinforced TFE seats and stuffing box, lever handle, and threaded ends. 400 psi WOG, 150 psi saturated steam. 3 inches and above: Carbon steel, uni-body full port with solid chrome plated ball, reinforced TFE seats and seals, lever handle and ANSI Class 150 flanged ends. 285 psi WOG, 150 psi saturated steam.

   c. Butterfly Valves

      150 psi W.P. for 250^{0}F service, positive tight shut off for flow in either direction. Provide lever handle for sizes through 6", totally enclosed gear actuator 8" and larger. Full or semi lug (no wafer type) iron body to permit retention of valve to one flange only. Field replaceable resilient seat and bronze or aluminum bronze disc. Extended neck to allow for 2" of insulation when used in insulated lines. Centerline Series 200, Demco NEI, DeZurik BGS, Anvil Series 8000, Keystone AR2, Appollo, Stockham LD-700 Series, Bray 31, FNW 732, Victaulic Style 700 or 708, or equivalent.

   d. Plug Valves

      175 psi W.O.G., 150 psi W.P. for 250^{o}F service. Eccentric, positive tight shut off valve with permanently lubricated stem bearing surfaces in upper and lower journals. Provide adjustable position stop for all valves used in balancing service. Lever actuated on sizes 5"-8" where pressures do not exceed 100 psi. Gear actuated on higher pressures and on all sizes 10" and larger. Gears to have adjustable position stop. DeZurik Figure #118, Keystone Series 500 or equivalent.

   e. Globe Valves (Rising Stem)

      Class 150, 300 psi W.O.G. bronze screwed for 2" and smaller; Class 125, 200 psi W.O.G. iron or Class 150, 300 psi cast steel, bronze mounted, flanged for 2-1/2" and above.

   f. Check Valves

      (1) Class 150, 300 psi W.O.G. bronze screwed for 2" and smaller; Class 125, 300 psi iron, bronze trim, flanged for 2-1/2" and above.

      (2) 125 psi W.P. iron noiseless check valve for pump discharges, Gulf Valve MB12, Metraflex CHEXX Model C125/150, Clow 329,

"Muessco" 101-AP, "Streamflow" 153, Techno 5050, Shurjoint SJ900 or equivalent.

(3) Where grooved piping systems are used, Victaulic Series 716 or 779 check valve with Vic-300 butterfly valve may be used.

g. Flo-Control Valve

Bell & Gossett Flo-Control, Taco Flo-Chek or Hoffman Flo-Control Valve.

h. Calibrated Balancing/Shut Off Valve (Contractor option)

(1) 250 psig at 250°F, bronze body/brass ball construction with glass and carbon filled TFE seat rings for 125 psig at 250°F, cast iron body/brass vane construction. Valves to have differential pressure read ports (Schrader type), drain/purge ports, memory stop feature and calibrated name plates. Valves to be leaktight at full rated working pressure. Provide premolded insulation to permit access.

Bell and Gossett Model CB (1/2"-3"), Armstrong Model CBV (1/2"-12"), Tour and Anderson (1/2" - 12"), Taco Accu-Flo (1/2" – 4") or approved equivalent.

i. Unions

300 lb. W.O.G. malleable iron screwed or 125 lb. cast iron flanged union.

j. Pressure Gauges

3" minimum dial, bronze bourdon tube with 1/4" pipe thread bottom mount, steel case, white face with black lettering, screw driver calibration. Accuracy to be 1% of full scale or better. Pressure ranges to be approximately double the expected working pressure of the service. Brass lever handled cock rated to 200 psi and bronze siphon.

(1) For water temperatures up to 150°F: wet gauge – Winters 100 Series, or equivalent by Ashcroft, Danton, Dwyer, Foxboro, Marsh, Marshalltown, Meriam, Miljoco, Mueller, U.S. Gauge, Weiss or Wika.

(2) For water temperatures over 150°F: dry gauge – Winters 100 Series or equivalent by Ashcroft, Danton, Dwyer, Foxboro, Marsh, Marshalltown, Meriam, Miljoco, Mueller, U.S. Gauge or Weiss.

k. Pressure Temperature Taps

1/2" NPT, or EPDM core, Peterson Equipment Company #710, Sisco, or Hydro-Temp BNO-500, MG P/T, or equivalent.

l. Thermometers

Multi-angle, solar powered with digital readout. Accuracy to be 1% of scale or better. Display shall have minimum ½" tall numbers. Unit shall be able to be switched in the field between Fahrenheit and Centigrade. Miljoco CDX, Weiss DVB or equivalent by Wikes, Weksler or Wika.

m. Dielectric Unions, Couplings (waterways) and Flanges

Unions rated for 250 psi with galvanized or plated steel threaded end, copper solder end and impervious isolation gasket approved for use on gas, oil, air, water and steam lines. Couplings (waterways) approved for use on gas, oil and water lines and shall have rated working pressure and temperature of 300 psi and 225ºF with an inert, non-conductive laminate material and threaded to NPS standards. Flanges to be complete with insulated bolt sleeves, washers and gaskets.

2. Copper, Low Pressure (124 psi and less)
Low Temperature (249°F and less)

a. Gate Valves (Rising Stem)

(1) Class 150, 300 lb. W.O.G. bronze, screwed or solder ends.

(2) Lockshield and Key: Nibco Option "L" with key, Powell Figure 344 or equivalent.

b. Ball Valves
3" and smaller: bronze, two piece, full port, solid chrome plated bronze ball with reinforced teflon seats and packing, 400 psi W.O.G. screwed or solder.

c. Butterfly Valves
2" and smaller: bronze, stainless steel disc and stem, VITON seal, 175 psi working pressure, 350 psi W.O.G., screwed or solder.

d. Globe Valves (Rising Stem)
Class 150, 300 lb. W.O.G. bronze, screwed or solder ends.

e. Check Valves
Class 150, 300 lb. W.O.G. bronze, screwed or solder ends, or Class 150, 300 lb. WOG, iron or cast steel, flanged or **<**grooved**>**.

f. Unions
Cast brass type

g. Flo-Control Valves, Calibrated Balancing/Shut-Off Valve, Radiator Valves, Strainers, Pump Suction Diffuser, Pressure Gauges, Pressure Temperature Taps, Thermometers, Dielectric Unions, Couplings and Flanges. Same as specified for steel, suitable for use in copper pipe.

3. Refrigerant
a. Valves: standard brass or bronze for refrigerant service.

b. Filter-dryers: 1500 psi minimum burst pressure conforming to ARI Standard 710 with full flow replaceable core in sizes 1/2" and larger and sealed type in sizes smaller than 1/2". Desiccant cores shall not cake, plug, channel or break down, but remove water, acid and foreign material from refrigerant. Desiccant shall not pass into refrigerant lines. Provide in all liquid lines to each evaporator.

c. Strainers: brass or cast iron body with no less than 60-mesh non-corrodible screen of a free area not less than 10 times the pipe diameter.

d. Sight Glass: Locate in liquid line proceeding each expansion valve.

e. Discharge Line Oil Separator: Separator shall be complete with an oil-float valve assembly or needle valve and orifice assembly, drain line shut-off valve, and sight glass. Rated capacity to be equal to or greater than the compressor. Connect oil-return line to the compressor.

f. Charging Valves: General purpose type with brass body, solder or flared ends and removable valve core. Provide quick coupling connection at valve inlet.

C. Equipment Schedule

AIR CONTROL AND EXPANSION TANK ASSEMBLY ET-1,2 (Diaphragm Tank)

Assembly shall consist of air separator, air vent, and pressurized diaphragm type expansion tank.

Air Vent: Cast iron body and cover, stainless steel bolts and stainless steel and brass control portion, 150 psi maximum working pressure and 250°F maximum operating temperature; Thrush #720, B & G #107, Armstrong #750.

Expansion Tank: Welded steel, designed and constructed per ASME Section VIII with heavy duty butyl rubber diaphragm compatible with propylene and ethylene glycol and water mixtures. Maximum working pressure of 125 psi and operating temperature of 240°F. Tank shall be provided with a ring base (vertical units), lifting rings, NPT system and drain connection. Provide an air charging valve (standard tire valve) to facilitate onsite pressure adjustments.

Air Separator: See separate Equipment Spec.

See schedule on drawings for capacities.

Acceptable Manufacturers: Taco, Bell & Gossett, John Wood, Amtrol, Wessels, Armstrong, or Wheatley

AIR SEPARATOR AS-1,2

Furnish and install as shown on the drawings a coalescing type air eliminator on the hot and chilled water systems. All eliminators shall be fabricated steel, rated for 150 psig working pressure with entering velocities not to exceed 4 feet per second at specified GPM. Units shall include an internal bundle filling the entire vessel to suppress turbulence. The bundle must consist of a copper core tube with continuous wound copper medium permanently affixed to the core. A separate copper medium is to be wound completely around and permanently affixed to each internal element. Each eliminator shall have a separate venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism. Units shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Eliminators shall include a bottom connection for use as a blow down connection. Air Eliminators shall be capable of removing 100% of the free air, 100% of the entrained air, and up to 99.6% of the dissolved air in the system fluid.

See schedule on drawings.

Acceptable Manufacturers: Spirotherm Spirovent or approved equivalent

CHEMICAL POT FEEDER ASSEMBLY

Furnish and install pot feeder assembly where shown on drawings. Feeder shall have a five (5) gallon capacity and have a working pressure of at least 175 psi. Feeder shall be equipped with a 3-1/2 inch fill opening with quick opening cap and 3/4 inch inlet and outlet tappings.
Chemical feeder shall be constructed to allow the installation of a particulate filter. Media shall be 20 micron pleated paper filters.

Acceptable Manufacturers: Vector Industries VF-1000, Neptune DBFC-5, or J.L. Wingert, Model F-5HD

GLYCOL FEEDER ASSEMBLY GF-1,2

System shall consist of a 50 gallon polyethylene tank with a sealed polyethylene tank cover, low level control, pressure switch, pump, tank stand, gallon level markings, adjustable pressure relief valve, suction and drain valves. Provide a bung for relief valve discharge connection. Coordinate size with relief valve discharge. Provide a hose bibb, for tank draining and a pump shut off valve. The tank shall be supported by a steel tank stand with footpads. Pump shall be mounted on a steel platform under the tank. Provide a 0-60 psi system pressure gauge.

Low Level Control: The controller shall be a NEMA 3 enclosure mounted on the tank stand. The following face mounted components: Low liquid level alarm light, pump test switch, and a pump operating indicating light.

Provide normally open dry contacts for remote alarm indication. The low level controller

shall prevent pump operation when the liquid level is 3" or less (adjustable) in the tank. Low liquid level light shall operate under low liquid level condition.

Pressure Switch: Pressure switch to be corrosion resistant and rust proof construction, visible double break contacts which are silver-cadmium oxide, reinforced neoprene diaphragm, no-drift adjustable pressure setting, pilot duty NEMA-A600.
Furnas Model 69WB3 or equivalent

INLINE PUMP HWP-1,2; HP-1,2; BP-1,2

Horizontal shaft, single stage, flexible coupled drive with guard, factory painted pump and resiliently mounted motor for in-line mounting and rated for a minimum of 175 psi working pressure. Cast iron casing with suction and discharge flanges with companion flanges and gauge ports. Bronze fitted construction complete with bronze impeller keyed to shaft. Stainless or alloy steel shaft with integral thrust collar. Bearings to be oil lubricated bronze sleeves or permanently lubricated ball bearings. Mechanical shaft seal with ceramic seal seat rated to 250°F at 150 psi. Rotating parts to be statically and dynamically balanced. Construction shall allow for complete servicing without breaking piping or motor connections.

Coordinate pump HWP-1,2 (snowmelt) to meet the requirements of the snowmelt system.

Pump motors shall be 1750 rpm unless specified otherwise.

Motor and starter as detailed in schedule. Refer to Section 15050 for required motor, phase protection and starter characteristics.

Pump impeller curve shall not cross HP curve at ANY point. Impeller selection shall NOT be maximum size for casing. When pumps are used in parallel applications, pump curve shall cross the system curve for both single pump operation and combined pump operation. Submit curves.

Provide one bearing assembly and seal kit for each pump.

SEQUENCE OF CONTROL

HWP-1,2: See sequence of controls for snowmelt system for pump operation.
HP-1,2: See B-2 sequence on drawings.
BP-1,2: Interlock with boiler. Refer to boiler manufacturer requirements.

See schedule on drawings for capacities.

Acceptable Manufacturers:
B & G Series 60, or Taco Series 1600.

CONDENSING BOILER B-1,2

Boiler shall be CSD-1 approved and ASME coded and stamped. This specification is for a complete boiler system that shall include but not be limited to the boiler, individual boiler controls, Boiler Management System (BMS) controls, fully compatible with the building DDC system. Interface utilizing BACNET open protocol fully compatible with the Section 15900 Contractor.

Boiler shall be natural gas fired; condensing design with a modulating forced draft power burner and positive pressure vent discharge. The boiler shall be capable of handling

return water temperatures down to 40°F without any failure due to thermal shock or fireside condensation. The boiler shall be designed so that the thermal efficiency increases as the boiler firing rate decreases. The boiler manufacturer must publish independent testing agency part load efficiency values. The boiler control panel shall be of a modular component design with the hotter flame safeguard control, temperature controller and enunciator board field replaceable. The heat exchanger shall be constructed of cast aluminum. The heat exchanger shal be cast sectional construction. The boiler shall have ASME approved relief valve setting of 150 psig.

The boiler burner shall be capable of 23 to 1 turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves.

The UL listed gas train shall consist of a safety shut-off valve with proof of closure switch, a differential pressure regulator, a manual isolation valve, a modulating fuel valve (listed above) as well as all interconnecting piping and appurtenances required for a complete installation.

Boiler shall incorporate an electric type low water level cut-off with test and manual reset and dual over-temperature protection with manual reset in accordance with ASME Section IV and CSD-1. Remote fault alarm contacts, sensor failure detection and boiler status and failure enunciator shall be standard equipment.

Connection between central BMS system and module shall be twisted pair low voltage wring.

Provide BMS Panel boiler to be BACNET compatible. Boiler controls shall be pre-wired complete with operating control with 10°F differential and limit control (with manual reset). A pre-wired control panel with manual or automatic operation of the boilers, supply water sensors, panel mounted alarm, a contact for boiler for remote monitoring, manual reset high limit temperature controllers, differential switch to sense air flow to burner and a manual reset low gas pressure switch, digital readout of supply water temperature. Provide factory mounted boiler proof of operation contacts for each boiler.

SEQUENCE OF CONTROL

B-1 (Snowmelt)

B-2 (Second Floor Tenant)
A temperature sensor sensing leaving water temperature in the heating water supply main downstream of the boiler piping shall, through the BMS control system, provide modulation of the boilers. The designated reset temperature shall be received from the building automation system (4-20 m.a.).

The building automation system (Section 15900) shall control the main building heating pumps and shall provide this control panel with a signal to start. It shall also provide a desired water temperature to this control panel. This BMS control panel shall start the lead boiler circulating pump and enable the boiler to start on low fire (using its own controls). As the load increases (water temperature drops) the boiler shall switch to high fire.

Coordinate with the Section 15900 Contractor to provide a complete operating system.

Provide manufacturer's authorized check-out, start-up, and control setup and check. Provide Owner training of boiler operation, control, and maintenance. Provide documentation and records of start-up and training to Owner.

See schedule on drawings for capacities.

Acceptable Manufacturers:
AERCO Modulex or approved equivalent

SNOWMELT SYSTEM

The snow melt system including all piping layout of grids/loops, piping from manifolds to outside, finalizing of all pumps, boilers, controls shall be provided by an experienced snow melt system contractor. Contractor shall have a minimum of 5 continuous years' experience of designing, installing, start-up service and maintenance of such systems. Full layout and equipment shop drawings shall be provided for review.

3/4" O.D., 5/8" I.D. tubing shall be cross-linked polyethylene with a maximum working pressure of 100 psi at 180°F. The tubing shall be manufactured in accordance with ASTM F876. The tubing shall have an oxygen diffusion barrier limiting oxygen diffusion through tubing to a maximum of 0.10g/m³/day at 104°F water temperature. The tubing minimum cold bend radius shall not be less than six times the O.D. Bend radius less than six times the O.D. shall be required to use bend supports.

Provide cast brass manifolds with integral circuit balancing valves. Construction manifold shall prevent dezincification. Manifolds shall have a means of purging or venting air from the system. Isolate manifolds from supply and return tubing with valves and provide balancing valves for each loop.

All fittings to be manufactured of brass.

Provide motorized mixing valve.

Coordinate pump requirements with the HWP-1,2 supplier.

Manufacturer to provide all components for a complete and operating system. Manufacturer to include all components to install piping, mount manifolds, and control snow melt system.

Include a ten year not prorated warranty for tubing and 48 mo. warranty for the manifolds and other equipment.

Provide detailed Shop Drawings of complete system, piping layout, manifolds, mixing valves, controls, etc.

Acceptable Manufacturers: Wirsbo or approved equivalent

CONTROLS

Provide a microprocessor based control panel that activates the snow melt system based on signals from a snow/ice sensor and an outdoor air sensor. Provide all sensors.

Control panel features shall include :

1. A selectable LCD display of slab surface temperature, surface temperature setting, melt sequence time remaining, accumulated hours of use, and percent heat output.

2. Status lights for power on, remote enable signal present, warm weather cutoff, melt mode activated, water detected, cold weather cutoff, idling mode, pump activated, system melting, and sensor fault.

3. Slab surface melt temperature setpoint (adj.). Slab surface idling temperature setpoint (adj.).

4. Control of the motorized mixing valve and provide water temperature indication.

5. Water sensor sensitivity setpoint (adj.).

6. Melt system minimum on time (adj.).

7. Cold weather cutoff temperature setpoint (adj.).

8. Test button to initiate a test sequence.

SEQUENCE OF CONTROL

Snowmelt System Control

1. The snowmelt system shall be controlled by a microprocessor based control panel furnished by the snowmelt system manufacturer. The outdoor temperature sensor and snow/ice sensor shall also be furnished by the snowmelt system manufacturer.

2. The control panel shall continuously monitor the snow/ice sensor located in the slab. When snow, ice, or water are detected the melting mode shall be initiated, unless the warm weather or cold weather cut-off controls have been activated.

3. If the outdoor air temperature is above the melting temperature setpoint, the snowmelt system shall enter the warm weather cut-off mode. It shall remain there until the outdoor air temperature drops below the melting temperature setpoint. The warm weather cut-off mode shall deactivate the snowmelt system.

4. If the outdoor air temperature falls below the cold weather cut-off setpoint, the snowmelt system shall enter the cold weather cut-off mode. It shall remain there until the outdoor air temperature rises above the cold weather cut-off setting. The cold weather cut-off mode shall deactivate the snowmelt system.

5. The melting mode shall be capable of being activated either through the snow/ice sensor for through a remote signal. When the melting mode is activated, the pump shall be energized and the heat relay shall cycle the pump on and off, using pulse width modulation (PWM) control, to maintain the slab surface at the melting temperature setpoint.

6. The slab shall be maintained at an idling temperature when the snowmelt system is not in the melting mode. Control operation is similar to the melting mode except the slab is maintained at a higher idling temperature setpoint.

7. If a sensor fault occurs, a warning light shall be activated at the control panel.

8. Control panel shall modulate the mixing valve to maintain the desired water temperature. Provide signal, wired to the boiler control panel to start the boiler and boiler circulating pump on a call for heat.

9. The snowmelt system control panel shall energize the pump for 20 seconds after every 3 days of no system operation.

10. Desired slab surface melting temperature, slab surface idling temperature, and cold weather cut-off temperature setpoints shall be adjustable at the control panel.

Provide shop drawings and controls sequence diagrams.

Approved Manufacturers: Tekmar D662 or approved equivalent.

SENSORS

Provide an outdoor air temperature sensor consisting of a thermostat protected within a UV resistant PVC plastic enclosure.

Provide a snow/ice sensor which sets flush with slab surface mounted in a sensor socket. The sensor shall measure slab surface temperature, sensor core temperature, and detect water on the sensor surface. The sensor socket shall be constructed of die cast brass.

PART 3 – EXECUTION

3.1 PIPEWORK

A. Piping

1. Grade and valve all water piping systems with 3/4" hose end valves to permit complete drainage of the system. All high points in equipment rooms shall be vented with automatic air vents piped to convenient drain. All high points in system outside of equipment rooms to be vented with combination automatic/manual air vents to relieve air in the system.

   All branch lines and runouts shall be taken off of the top of mains and branch lines, wherever possible.

2. All buried pipe to be insulated as per Insulation Section of these Specifications. All buried pipe shall be surrounded by 4" clean sand.

3. Valve off each individual piece of radiation or equipment with valve for shut off service on supply, valve for balancing and shut-off service on return. Provide isolation valves at each pipe branch take-off from the main.

4. Expansion Compensation: Furnish and install expansion loops where indicated or required in accordance with Section 15050. When grooved piping systems are installed, expansion loops and associated items may be eliminated if the system is installed in accordance with the manufacturer's information on expansion compensation. Contractor shall verify compliance in shop drawing submittal.

5. All branch connections created with the T-DRILL method shall be installed by T-DRILL trained and certified craftsmen. The collar shall be formed in a continuous operation consisting of drilling a pilot hole and drawing out the tube surface. The collaring device shall be fully adjustable to ensure proper tolerance and complete uniformity of the joint. The branch tube shall be notched to conform with the inner curve of the run tube and have two dimple stops in line with the run of the tube. All joints shall be brazed using BcuP series filler metals.

6. Press Fit Fittings

   a. Press connections shall be made in accordance with the manufacturer’s written installation instructions. The installing contractor shall be factory trained and certified by a designed factory representative. Documentation of each individuals certification shall be kept on file at the job site and be made available to the engineer or Owner upon request.

b. Tubing shall be fully inserted into the fittings and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing if fully engaged in the fitting. The joints shall be pressed using the tool approved by the manufacture of the fittings.

7. Pressure Testing: See Section 15050.

8. Cleaning: See Section 15050.

9. Refrigerant:
   a. Pitch suction lines 1" in 15'-0" towards compressor. Install oil traps, consisting of short radius fittings, at the base of vertical suction lines.
   b. Provide shop drawings of all piping with sizes, layout and accessories shown. Piping layouts are based on equipment specified in schedules on drawing. Any changes to piping layout required due to different equipment shall be shown in shop drawings along with explanation as to reason for change. Provide equipment cut sheets and capacity curves with shop drawings.

10. Provide Rectorseal Products as recommended by the manufacturer for glycol systems with threaded pipe.

B. Valves and Specialties.

1. Ball valves, plug valves or butterfly valves may be used in lieu of gate valves on all water services for shut off service wherever the pressure and temperature ratings are satisfactory. Valves utilizing lever handles shall be installed to allow complete open to close valve operation.

2. Calibrated balancing/shut-off valves shall be used for balancing service on all lines. Plug or butterfly valves may be used for balancing service on lines 4" and larger provided there is an accurate means for determining flow rates when using these valves. Provide adjustable memory stops on all valves used for balancing service. Plug valve symbols are used on drawings.

   Calibrated balancing/shut-off valves shall be installed with a minimum of 5 pipe diameter in and 2 pipe diameters out of valve assemblies. Inlet shall be increased to 10 pipe diameters if installed downstream of pumps, tees or regulating valves.

3. Globe valves, where shown, are the only suitable valve.

4. Check valves on all base mounted pump discharges are to be "noiseless check valves", other check valves to be horizontal swing check valves.

5. Tee type strainers are not acceptable. Basket type strainers shall only be used where indicated.

6. Unions, flanges or grooved piping are to be used wherever necessary and in piping at all equipment so that piping may be conveniently broken and moved to facilitate equipment maintenance.

7. Dielectric unions are to be used at <u>all</u> connections where ferrous material is connected to non-ferrous material and where ferrous material is connected to domestic water piping. Couplings (waterways) can be used wherever unions are not required.

8. Pressure Gauges and Press.-Temp. Taps are to be used wherever shown on drawings. Gauges and taps shall be installed in pipe immediately before and after equipment with no valve or fitting between gauge or tap and equipment. Taps shall be located in an accessible position. On pipe sizes 4" and larger where 1/2" or 3/4" taps are required, Vic-Lets and Vic-Wells may be used in lieu of weld or thread-o-lets. Coil syphons (pigtails) shall be used on steam service gauges. Snubbers shall be provided on all services where pulsating of gauge needle occurs. Install pressure gauges with isolation valve and drain valve between the gauge and the isolation valve.

9. Thermometers or Press.-Temp. Taps are to be used on each side of each pump and piece of equipment where a change in temperature takes place. This does not include distribution equipment located in finished rooms such as radiation, fan coils or unit ventilators. Use thermal wells with heat transfer enhancement compound for thermometers.

10. Install automatic valves, thermals wells, pressure taps, water, drains, etc. as furnished and specified under Section 15900.

11. Air separator(s) shall be supported from floor with angle iron legs or hung from structure with threaded rods and angle iron clips welded to tank. Valve and pipe blowdown full size to floor drain.

12. Chemical pot feeder(s) shall be mounted with fill opening no higher than 3'-0" above finished floor.

13. All valves and specialties in grooved piping systems shall be attached to adjacent pipe using rigid couplings.

14. Vibration Isolation, see Section 15050.

C. Valving of Branches
Valve all lines at the chase on each floor level.

D. Equipment Room Drains
Grating of drains shall be notched as required by discharge piping at drain so that all water from drain lines enter the drains.

3.2 BOILER EMERGENCY POWER OFF

Provide emergency power off push button(s) to disconnect power to boiler burner controls. Regardless of the number of boilers, each push button shall stop all boilers. Push button shall be a maintained (push-pull) red mushroom type operator with clear-hinged cover. Mount switch at 5’-0” above finished floor so that it is not confused with other switches. Pushbutton(s) shall be labeled “EMERGENCY BOILER SHUTDOWN” and located just inside each boiler room door. Switch shall be wired into the boiler limit circuit and shall break the 120 V power at the boiler.

3.3 CHEMICAL FEEDERS

A. Install feeders in accordance with manufacturer's recommendations. Feeders shall be installed at no greater than 3'-0" above the finished floor and secured or attached to wall or structure. Provide 3/4" ball valves on inlet and outlet tappings, 1/2" ball valve for drain and 1/4" petcock.

B. Provide access space around chemical feeders to allow chemicals to be added to the feeder. Provide no less space than minimum as recommended by manufacturers.

C. Once the system has been filled and the chemical levels adjusted for the system, leave the valves to the feeder open.

D. Install filter media once system has been chemically treated. System shall be cleaned by Contractor during start-up and balancing phase of the work. Install one clean filter upon turn-over to Owner and provide one spare filter.

3.4 GLYCOL FEEDER ASSEMBLY

A. Clean and flush glycol system prior to adding glycol solution. RE: Section 15050.

B. Fill system and storage drum with a mixture of glycol and water solution as noted on drawings by volume suitable for operating temperatures. Propylene glycol shall be industrial quality heat transfer fluid. Dowfrost or Intercool NFP.

C. Perform tests to determine the strength of glycol and water solution. Submit written test results and include in O & M manuals. Provide test prior to end of first year of operation and replenish as required.

D. Set pressure switch to start feed pump at 10 psi and stop feed pump at 12 psi.

E. Run full size discharge line from system relief valve to storage tank.

F. Adjust setting on glycol feeder pressure relief valve to be 10 psi greater than the pump shutoff pressure noted above.

3.5 INLINE PUMPS

A. Install pumps in accordance with manufacturer's recommendations.

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

C. Install pumps to allow complete removal without dismantling connecting piping.

D. Provide line sized shut-off valve and strainer on pump suction and line sized silent check valve (installed minimum 5 pipe diameters downstream of pump discharge) and balancing valve on pump discharge. Decrease from line size using reducers. Provide pressure gauges, etc. as shown. Pipe strainer discharge through shut-off valve to floor drain. Lubricate pumps in accordance with manufacturer's recommendations after completion of system installation and prior to start-up.

3.6 SNOWMELT SYSTEM INSTALLATION, TESTING, STARTUP

A. Hydronic radiant heat tubing loops shall be installed in accordance with the manufacturer’s recommendations and the details as shown on the drawings.

B. All fittings and manifolds should be accessible through access covers for maintenance. Tubing loops shall be installed without splices, as a minimum, from the point at which the tubing enters the manifold to the point at which it exits the manifold. Tubing shall exit the basement garage through PVC sleeves for supply and return tubes or as detailed or directed by the Architect. Carefully rack and support exposed tubing.

C. Install the mixing valve and control interlocks per manufacturer’s recommendations.

D. Installation shall follow the manufacturer’s shop drawings for tubing layout, tube spacing, manifold configuration, manifold location, and controls. All notes on the shop drawings shall be followed.

E. Mains shall be hydraulically balanced.

F. Distribution manifolds shall be attached to supply and return mains at access cover locations. A minimum of one supply and one return manifold is required and for alternate expansion/construction joints.

G. Wire mesh in sheets (not rolls) or rebar shall be provided as required over the entire area to be snowmelted.

H. Piping shall be attached to reinforcing steel using wire ties. All loops shall be a maximum of 250 feet in length and form a continuous conduit without joints from supply to return manifolds.

I. No pipe shall extend through expansion, construction or working joints in concrete slab. Expansion joints installed during or cut after concrete pour shall be carefully coordinated with the tubing layout and snowmelt manufacturer.

J. All pipe connections, fittings, and distribution manifolds shall be free of concrete and arranged to be easily serviced by removal of poured-in-place concrete access covers.

K. The tubing system shall be pressurized with water or air to a pressure of 60 psig 24 hours prior to encasement in the concrete slab. The tubing system shall remain at this pressure during the slab installation and for a minimum of 24 hours thereafter to ensure system integrity.

L. Install all sensor, controls and controller. Coordinate locations with Architect and show on shop drawings. All wiring shall be in conduit. See Section 15900 and Division 16000 for more requirements.

M. At startup time, the Contractor shall follow the manufacturer's recommendations for system water and temperature balancing, record balance settings at each manifold location, and include a complete record of these settings in the operation and maintenance manuals and provide complete owner training. Verify control operation is in accordance with the sequence specified.

3.7 CONTROL SYSTEMS

A. Some equipment specified in this section have control devices specified with the equipment. This contractor is responsible to have all controls properly installed, wired, and make operational. This contractor shall provide all necessary control transformers, relays, or other devices required shall be provided and required.

B. All exposed wiring shall be run in conduit. See section 15010 for wiring requirements.

C. Provide complete shop drawings for control systems. (See Section 15010)

D. Specific Systems

1. Provide complete control systems, integrating multiple pieces of equipment as required to provide complete operation systems. Provide all necessary control transformers, relays, or other devices as required. Mount all devices in a control panel, located in the mechanical room or other designated location.

2. Boiler / Snowmelt System

a) Each of these systems is specified with a package control system. The controller shall coordinate with both system suppliers and provide a

complete integrated system. Develop a detailed control diagram for the total system. System shall include all pumps and control valves.

b) Contractor shall install all sensors required for systems. All exposed wring shall be in conduit.

END OF SECTION 15600

SECTION 15800
AIR DISTRIBUTION

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

The General Provisions of the Contract, including General and Supplementary Conditions and Division 1 - Specification Sections and Contract Documents apply to work in this section. Consult them for further instructions and be governed by the requirements thereunder.

1.2 WORK INCLUDED (BUT NOT LIMITED TO)

A. Ductwork

B. Flexible Ducts

C. Dampers, Turning Devices and Ductwork Accessories

D. Fire Dampers, Fire/Smoke Dampers and Smoke Dampers

E. Duct Liner

F. Filters and Air Filtering Systems

G. Exhaust Fans

H. Supply and Return Fans

I. Louvers

J. Intake and Relief Hoods

K. Grilles, Registers and Diffusers

L. Gas Fired Air Handling Units

M. Rooftop Air Handling Units

N. Electrical Resistance Heating

O. Refrigerant Direct Expansion Evaporator Coils

P. Direct Expansion Condensing Units

1.3 RELATED REQUIREMENTS

A. Basic Mechanical Requirements - Section 15010

B. Basic Materials and Methods - Section 15050

C. Mechanical Identification - Section 15190

D. Controls and Instrumentation - Section 15900

E. Testing, Adjusting & Balancing – Section 15990

PART 2 – PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. General

See Section 15010 for other acceptable manufacturers, substitutions and approvals.

B. Ductwork

1. Sheet metal duct systems to be ASTM A924 and ASTM A653 galvanized steel sheet, lock forming quality, having G-90 zinc coating in conformance with ASTM A90. Contractor shall furnish certification form from mill or supplier as to coating thickness upon request. Gauges of ductwork shall be in accordance with SMACNA HVAC Duct Construction Standards Manual or Uniform Mechanical Code, whichever is more stringent.

2. Glass Fiber Duct System (Temporary Ductwork)

Glass fiber duct board, UL 181, 1" thick rigid glass fiber with integral aluminum foil vapor barrier and surface for velocities up to 2400 fpm, maximum 0.23 K factor at 75°F.

4. Spiral Seam Ducts.

Round and oval spiral seam galvanized steel ducts and fittings shall meet requirements of Paragraph 2.1.A. United McGill Corp., Chavez Sheet Metal, Cobb Mechanical, Hercules Industries, Metco Inc., Sheet Metal Products Company, Semco, Superior, Spir-L-ok (ductwork only) or Spiral Pipe of Texas. Minimum galvanized gauges listed.

Diameter	Minimum Galvanized Gauge (to meet UMC 97 Table 6-B)
3" through 14"	26 ga.
15" through 23"	24 ga.

5. Flexible Ductwork

a. General

UL-181 listed, Class I factory pre-insulated duct with solid inner liner formed by a reinforced aluminum laminate or other reinforced material mechanically bonded or locked together with a corrosive resistant galvanized or coated steel helix and covered with a minimum 1-1/2" thick fiberglass blanket sheathed in a polyethylene vapor barrier. Insulation to have a 0.23 "C" factor maximum, shall meet FHA/HUD requirements and have a vapor barrier permeability of 0.10 perms (ASTM E96-Procedure A). Duct shall comply with the latest NFPA 90A and 90B Standards. Pressure ratings based on test with temperature and velocity applied. Flame spread less than 25/smoke development less than 50. Duct must be approved by code authority for specific application.

b. Low Pressure

Duct (all sizes) shall have a positive working pressure rating of not less than 6" w.g., and a negative working pressure rating of not less than 0.5" w.g. Pressure ratings shall be at a maximum operating temperature of 180°F.

Flexmaster Type 5, Wiremold WC, Genflex SFR-25A, Omniaire 1100, Hercules IFM, ATCO UPC #30, Thermaflex G-KM.

c. High Pressure

Duct (all sizes) shall have a positive working pressure rating of not less than 12" w.g., and a negative working pressure rating of not less than -1" w.g. Pressure ratings shall be at a maximum operating temperature of

180°F.

Flexmaster Type 3, Thermaflex MKC, Genflex IGE.

6. Duct Sealant.
Non-hardening, water resistant, non-combustible, liquid or mastic or with tape as recommended by manufacturer. All sealants shall have approved fire rating for plenum application as required by code authority.

C. Duct Pressure Classes (SMACNA)
1. Unless indicated on drawings or elsewhere in this specification, the following shall be used to determine duct construction pressure class:
a. Variable Air Volume (VAV) systems; upstream of terminal control units to the fan outlet, ductwork pressure class shall be not less than the blocked off static pressure of 4" when the fan is at its minimum cfm setting. Downstream of terminal control units, pressure class shall be 1" w.g.

b. Constant Air Volume Supply systems; from the supply diffuser or register to the supply fan inlet, ductwork pressure class shall be not less than 2" total static pressure.

c. Return Air Ductwork; -1/2" w.g. pressure class.

Relief Air Ductwork; +1/2" w.g. pressure class

d. Exhaust systems; from the exhaust grille or register to the exhaust fan inlet, ductwork pressure class shall be at least 100% of the total static pressure specified for the fan. Ductwork downstream of exhaust fans shall be 1/2" w.g. pressure class.

D. Duct Accessories
1. Round Duct Take-off Fittings.
a. Spin-in Fitting
Factory fabricated 26 gauge (all diameters) G-90 galvanized sheet metal for insulated ducts duct board. Butterfly damper with quadrant operator and lock nut on all applications.
b. Lateral Take-off Fitting
Factory fabricated 26 gauge G-90 galvanized sheet metal fittings with 45 degree angle take-off, adhesive coated gasket, 1" mounting flange and butterfly damper with quadrant operator and lock nut on all applications.

2. Flexible Connections.
For indoor applications, 24 oz. per yard, fire-retardant neoprene coated, U.L. approved material. Flame spread: 25 maximum and Smoke development: 50 maximum, maximum length = 10". For outdoor applications, 24 oz. per yard, UV resistant Hypalon, U.L. approved material. For high temperature applications (+200°F), Teflon, U.L. approved material.

3. Turning Vanes.
Non-adjustable 90° turning vanes, 22 gauge galvanized steel runners, per SMACNA Standards with:
a. Double Wall Vanes
2" radius and smaller to be 26 gauge galvanized steel minimum Radius above 2" to be 24 gauge galvanized steel minimum.
b. Single Wall Vanes
2" radius and smaller to be 24 gauge galvanized steel minimum. Radius

above 2" to be 22 gauge galvanized steel minimum.

4. Volume Dampers.

a. Rectangular and Square

22 gauge galvanized steel blades and frame up to 18" width and 12" height; above to be 16 gauge galvanized steel frames with 16 gauge galvanized steel opposed blades. Blades to be brake formed at edges for stiffness. Galvanized steel shaft (1/2" diameter minimum on dampers wider than 36", 3/8" diameter on dampers less than 36" width, 3/8" minimum control arms) with molded synthetic plastic or oil impregnated sintered bronze bushings. No blade end seals. Maximum blade width of 8 inches.

Ruskin MD15 or MD35 or equivalent.

b. Round and Oval

Dampers to have blade stops and be fitted with locking type hand quadrant control solid steel rod (1/4" diameter minimum) welded to blade, and molded synthetic plastic, stainless steel or oil impregnated sintered bronze sleeve shaft bearings.

Damper blades and collars to be galvanized steel sheet of the following minimum gauges.

Diameter	Collar	Blade
3” through 20”	20	20
20” through 40”	14	10

Manufacturer	3” through 20”	20” through 40”
Ruskin	MDRS25	CDR25
AES	WM-VCD	HDR-50
Louvers & Dampers or equivalent	RBD	-

5. Access Doors (in ductwork)

Doors shall be constructed of same gauge as ductwork being installed in, 24 gauge (minimum), galvanized sheet metal provided with 22 gauge minimum flat iron or angle iron stiffening frame and so constructed that they can be operated without twisting or distortion. Provide duct opening at each door with a continuous reinforcing galvanized bar or angle against which the door will close, 1/8" neoprene gasket. Doors shall be provided with no less than two galvanized iron hinges and sash-lock latches sized to suit door size with each hinge having a bronze pin. Doors shall be double skin with 1" insulation between sheet metal where ducts are insulated.

Pre-manufactured access doors can be used provided they are submitted for review per Section 15010 prior to project bidding.

6. Duct Liner (inside the duct).

One inch thick, resin bonded glass fiber, black coating on air stream surface, rated by manufacturer for at least 4000 FPM and meeting the requirements of ASTM C1071 Type I. Fire resistance shall meet requirements of NFPA 90A. Flame spread rating not to exceed 25. Fuel contribution and smoke development not to exceed 50. Noise reduction coefficient (NRC) of not less than 0.60 when tested in accordance with ASTM C423 using an "A" mounting or a minimum of 0.70 using an "F" mounting. K value not more than 0.26 Btuh per square foot per ºF at 75ºF or an "R" value of 4. Maximum absolute roughness factor per foot of .004 ft.

a. Manville "Linacoustic"
b. Certainteed "Toughgard"
c. Owens Corning "Aeroflex"
d. Knuaf
e. or prior approved equivalent

E. Fire Dampers, Combination Fire/Smoke Dampers, and Smoke Dampers
1. Fire Dampers, U.L. Label.
a. Vertical or Horizontal
(1) Static Type
1-1/2 hr. fire rating, with sleeve where construction fire rating requires. To meet NFPA 90A requirements. Shutter, curtain type blades and replaceable fusible link. Frame type CR for round ducts, frame type B for rectangular ducts unless indicated otherwise. Frame Type A may only be used where specifically indicated.
(2) Dynamic Type 1-1/2 hr., fire rating, dynamic rated, with sleeve where construction fire rating requires. To meet U.L. Safety Standard 555 for Fire Dampers-Fourth Edition and NFPA 90 A requirements. Each damper shall include a UL-approved label verifying its classification as a dynamic rated fire damper: a static damper is not acceptable. Submittal literature shall include performance data showing compliance with UL-555. Shutter, curtain type blades and replaceable fusible link. Frame type CR for round ducts, frame type B for rectangular ducts unless indicated otherwise. Frame Type A may only be used where specifically indicated.

F. Filter Gauges
Differential pressure gauges, Dwyer Series 2000 ASF magnehelic or equivalent with scale range approximately twice the pressure drop recommended for filter change and adjustable signal flag.

G. Smoke Detectors
1. Smoke Detectors to be provided under Electrical Division.

H. Equipment Schedule
ELECTRIC UNIT HEATER EUH-#

U.L. listed and approved assembly.
Horizontal Model with individually adjustable horizontal louvers. Metal sheathed fin tube heating element. 18 ga. cabinet with baked enamel finish. Direct drive propeller fan with safety fan guard. Motor shall be totally enclosed, sleeve or ball bearing and shall have built in overloads. Automatic reset thermal overload protection; all heaters drawing more than 48 amps to have built in branch circuit fusing. Motor HP etc. and starter as detailed in schedule. Supply with integral disconnect.

Wall mounted 24V thermostat.
Qmark Model MUH Horizontal, Erincraft Series HD, Markel Series 5100, Redd-i Series UH

See schedule on drawings for capacities.

EXHAUST FAN EF-1

Aluminum, water tight, removable housing with galvanized steel or aluminum bird screen and aluminum blade, self acting, sound dampened, backdraft damper. B.I. centrifugal type

fan wheel statically and dynamically balanced. V-belt drive with adjustable motor sheave. Motor and fan mounted on vibration isolators. Motor and starter as detailed in schedule. Refer to Section 15050 for additional motor, phase protection and starter requirements. Bearings shall be heavy duty, grease lubricated, ball or roller type and selected for Basic Rating Life (L_{10}) of 80,000 hours at maximum speed and horsepower per ABMA Std 9 or 11. Sone level in accordance with AMCA Standards. Furnish Factory fabricated curb to G.C. for installation.

See schedule on drawings for capacities.

ROOF MOUNT:
Belt Drive
Cook ACE-B or equivalent by
Greenheck GB
Jenn Air BCR
Acme Model PV
Carnes VEBK
Ammerman BRX
ILG CRB
Breidert CX

EXHAUST FAN EF-2

Centrifugal FC fan in sound insulated cabinet bearing the AMCA label for air performance and UL listed. Integral backdraft damper. Motor mounted in rubber mountings or other suitable method of vibration isolation. Steel Face grille with 85% free area included with unit. Provide in-line configuration for ducted inlet and outlet.

See schedule on drawings for capacities.

Acceptable Manufacturers: Cook Gemini, Carnes Model VCDB, Pace DD, Acme Master-Ette, Penn Zephyr, ILG QA, Greenheck Model SP or CSP, Jenn Air J Series, or Twin City TL.

ROOFTOP HVAC UNIT RTU- #

Self contained, air cooled air conditioning unit with natural gas heating. Factory pre-wired, assembled, tested and complete with refrigerant and oil charges. U.L. & CSA certified and labeled.

1/2" thick, coated, glassfiber, insulated galvanized steel casings, baked enamel finish, removable for access to all components. All joints gasketed to form a weathertight fit. Provide hail guards.

Factory furnished, 14“ tall insulated roof curb, gasketed to provide a weather tight seal between unit and curb.

Factory furnished economizer section compatible with the main unit and roof curb, complete with return air and fully gasketed outside air dampers, ¼” air inlet screen and hood and counter-balanced barometric relief damper to provide tight closure during the off cycle, and all controls to allow the operation of an "economizer cycle" capable of 100% outside air. Contractor to set outdoor air damper for outside air quantity shown on drawings.

Aluminized steel heat exchanger with 5 year warranty. Aluminized steel or stainless steel

burner. Intermittent spark pilot ignition system. Fan time delay relay, interlocked with induced draft fan by centrifugal switch and flame rollout switch. Induced draft combustion. 100% safety shut off electronic flame sensing controls. Visual inspection of burner flame shall be possible without removing casing panels. All controls tested and listed for operation down to -30^{o}F outdoor air temperature.

2" disposable filters in rack within unit. Access door for changing filters from outside of the unit.

Vibration isolator mounted hermetic compressor(s) with forced feed lubrication,
thermostatic high temperature protection, crankcase heaters, freezestat, anti-recycle timer, high pressure cutout, low pressure cutout, pressure relief plug and service valves. Anti-cycle circuit to prevent compressor from restarting for at least 5 minutes after shutdown. Compressors shall have a 5 year warranty.

Evaporator and condenser coils with aluminum fins mechanically bonded to seamless copper tubes.

Belt drive, FC, centrifugal evaporator fan with adjustable motor sheave. Direct drive propeller type condenser fan. Permanently lubricated type motors and bearings. Electrical data detailed in schedule. Refer to Section 15050 for additional motor, phase protection and starter requirements.

Induced draft motor is energized with a call for heat from thermostat. When induced draft motor reaches a predetermined speed the centrifugal switch closes, pilot solenoid shall energize and pilot valve open, a spark is generated and the pilot is lit.

See schedule on drawings for capacities.

McQuay MPS Series, Carrier 48 TF Series, Trane Y Series, or approved equivalent.

PACKAGED ROOFTOP AIR CONDITIONING UNIT AHU-1

GENERAL
Unit furnished and installed shall be direct expansion cooling with hot water heating packaged rooftops. Cooling capacity ratings shall be based upon ARI Standard 360. Unit shall consist of insulated weathertight casing with compressors, air cooled condenser coil, condenser fans, evaporator coil, hot water coil filters, supply/exhaust fan motors and drives, and unit controls.

Unit(s) shall be single piece construction as manufactured at the factory. Package units shall be constructed for installation on a roof curb providing complete support for the unit which meets all applicable building codes. Unit shall be flashed water tight to the soundroof curb.

Unit(s) shall be factory run tested to include the operation of all fans, compressors, heat exchangers, and control sequences; shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas; shall conform to UL 1995/CSA 22.2 #236 for construction of
packaged air conditioner and shall have UL/CSA label.

Refer to Section 15050 for all motor, phase protection and starter requirements.

UNIT CASING
Cabinet shall be constructed of a double wall of galvanized steel, phosphatized, and finished with an air-dry paint coating durable enough to withstand 750 consecutive-hour

salt spray application in accordance with standard ASTM B 117. Structural members shall be minimum 14 gauge with access doors and removable panels of minimum 18 gauge steel. Roof panels shall be sloped to provide positive drainage of water away from the cabinet.

Fully gasketed piano hinged access doors with friction latching hand tighten fasteners and tie-backs to provide access to filters, heating section, mixed air section, exhaust air fan section, supply air fan section and evaporator coil section. Provide access doors on both sides of the unit.

The unit control panel section shall be compartmented to separate high and low voltage components. The control panels shall also be fully gasketed, hinged and provided with quick release latches for easy access.

Provide a minimum of 1/2 inch thick matfaced fiberglass internal liner on all exterior panels in contact with the conditioned air stream.

AIR FILTERS
Filters shall mount integral within unit casing and be accessible via hinged access doors. Filters shall be 2" disposable pleated media with a minimum performance of MERV 6.

FANS - SUPPLY AND EXHAUST
Provide single width, single inlet airfoil centrifugal supply. The fan assembly shall have fixed pitch drives with a minimum of two belts. Dynamically balance all fans and the unit's operating fan assembly (fan mounted on actual shaft, bearings and in scroll housing). Balancing of the fan wheel only shall not be acceptable.

Exhaust fan to be direct drive axial. Blades shall be constructed of fabricated steel and shall be securely attached to fan shaft. Fan assembly shall be statically and dynamically balanced. Unit DDC controller shall provide building static pressure control. A factory mounted exhaust fan VFD shall provide proportional control of the exhaust fans from 25% to 80% of the supply air designed airflow. The field shall mount the required sensing tubing

Mount fan motor(s) and fan on a common base assembly and isolated from unit with spring isolators. Provide thrust restraint isolation on the fan housing/fan base to assure smooth fan startup transition and operation. Provide flexible duct connector between fan discharge and downstream section.

Solid steel fan shaft shall be mounted on heavy duty grease lubricated ball bearings. Bearings shall be selected for Basic Rating Life (L_{50}) of 200,000 hours at maximum speed and horsepower per ABMA standard 9 or 11.

Provide VFD for variable air volume application. See VFD specification elsewhere herein.

HOT WATER HEATING SECTION
Provide factory assembled and installed non-freeze coil, ARI certified with three-way hot water modulating valve and actuator. Coil shall be constructed of minimum of 0.006" aluminum fins with minimum of 0.016" copper tubes and copper or cast iron headers. Coil performance shall be ARI standard 410 certified. Headers shall have drain and vent connections. Coils shall be proof tested at 300 psig and leak tested to a minimum 200 psig air pressure under water. Coil U-bends shall not be exposed outside of casing. Coil frame shall be independent of casing. Coils shall be removable from the top or side. Provide sealing strips between coil frame and casing to prevent bypass.

Factory shall provide a field piping vestibule. The control valve shall be field supplied and

installed in the unit heater vestibule. The control valve shall be capable of receiving a 2-10 VDC signal. Connection holes through the base of the unit in the field piping vestibule shall be cut and sealed in the field.

EVAPORATOR COIL SECTION
Provide minimum of 0.0055" aluminum fins mechanically bonded to seamless copper tubes of ½" minimum. Evaporator coil shall be inter-circuited to maintain active coil face area at part load conditions. Coil shall also utilize internally enhanced tubing for maximum efficiency. Manufacturer shall guarantee coil face velocities against moisture carryover at the scheduled conditions.

Provide an adjustable thermostatic expansion valve for each refrigerant circuit. Factory pressure and leak test coil at 300 psig.

Provide sloped drain pan to assure positive drainage of condensate from the unit casing. Coils which are greater than 45 inches in height shall have intermediate drain pan which shall be piped down to the primary drain pan.

CONDENSER SECTION
Provide a minimum of 0.0055" aluminum fins mechanically bonded to seamless minimum 3/8" copper tubes. Factory leak test coil under 450 psig pressure.

Provide subcooling circuit(s) integral with condenser coils to maximize efficiency and prevent premature flashing of liquid refrigerant, to a gaseous state, ahead of the expansion valve.

Provide vertical discharge, direct drive fans with steel blades, and three phase motors. Fans shall be statically and dynamically balanced. Motors shall be permanently lubricated, with built-in current and thermal overload protection in a weathertight slingers over motor bearings.

Provide factory made for field installation louvered steel or hooded coil guards around perimeter of condensing section to protect the condenser coils, refrigerant piping and control components. Louvered panels shall be fabricated from minimum 20 gauge galvanized steel and be rigid enough to provide permanent protection for shipping and pre-/post- installation. Course wire mesh is not an acceptable material for coil guards.

Condenser coils shall be V-banked for cleaning ease. The coils shall not exceed 14 fins per inch density in order to permit routine cleaning, and prevent excessive air pressure drop across the condenser coil.

REFRIGERATION SYSTEM
Compressor shall be industrial grade, energy efficient direct drive 3600 RPM maximum speed reciprocating or scroll type. The motor shall be of a suction gas cooled hermetic design. Compressor shall have centrifugal oil pump with dirt separator, oil sight glass, oil charging valve and shall be mounted on spring isolators or rubber-in-shear isolators.

If semi-hermetic reciprocating industrial grade compressors are utilized, provide single piece crankshafts, connecting rods, aluminum pistons, rings to prevent gas leakage, high strength non-flexing ring type suction and discharge valves, spring loaded heads, replaceable cylinder liners, and sealing service immersed in oil. Provide removable discharge heads and hand hole covers, and discharge service valves.

Provide compressor with automatic capacity reduction equipment consisting of suction valve unloaders, Use electric solenoid actuated lifting mechanism operated by oil

pressure. Provide for unloaded compressor start.

Provide with thermostatic motor winding temperature control to protect against excessive motor temperatures resulting from over-/under-voltage or loss of charge. Provide high and low pressure cutouts, and reset relay.

Provide factory-installed compressor lockout thermostat to prevent compressor operation at low ambient conditions below 45 degrees F.

Provide coil frost protection compressor unloading based on refrigerant circuit suction temperature to prevent coil frosting with minimum energy usage. As an alternate, factory-installed hot gas bypass shall be required on all VAV units to prevent coil frosting.

EXHAUST/RETURN SECTION
Provide 100% modulating exhaust air capabilities integral to unit. Unit shall control building pressurization by the operation of exhaust/return fans and modulation of relief dampers. Controller shall compare actual building interior pressure with outside ambient air pressure and supply duct pressure. Pressurization setpoint shall be field adjustable at the control interface to positive, neutral or negative values.

OUTDOOR AIR SECTION
Provide 100% modulating economizer system fully integrated with unit return and exhaust air dampers. Unit operation is through primary temperature controls that automatically modulate dampers to maintain desired space temperature conditions and maintain a fixed minimum amount of outdoor air.
Provide automatic outdoor enthalpy lockout sensor.

Provide adjustable minimum position control through the standard rooftop control panel.

Provide spring-return motor for outside air damper closure during unit shutdown or power interruption.

A CO_2 sensor system which shall calculate the required amount of outdoor air as allowed by ASHRAE ventilation standard. Carbon dioxide sensor shall be located in return air path.

Moisture entrainment in the outdoor air stream shall be limited by employing moisture eliminators, an intake hood, insect or snow screens or another method of the manufacturers standard design which will not allow snow or rain into the unit under any conditions.

DAMPERS
Provide totally gasketed low leak dampers with a leakage rate not to exceed 2.5% of nominal airflow at one inch W.C. static pressure.

Leakage rate shall be determined in accordance with AMCA Standard 575.

ELECTRICAL POWER CONNECTION
Unit shall be provided with a single point power connection at a non-fused disconnect. Provide unit mounted service receptacle.

DDC MICROPROCESSOR CONTROLS
General - Each unit shall be provided with a factory-installed, programmed and run-tested, stand-alone, microprocessor control system suitable for variable air volume control. This system shall consist of temperature and pressure (thermistor and transducer) sensors, rinted circuit boards, and a unit-mounted control panel. The

microprocessor shall be equipped with on-board diagnostics to indicate that all hardware, software, and all interconnected wiring and sensors are in proper operating condition. The microprocessor's memory shall be non-volatile EEPROM type, thus requiring no battery or capacitive backup to maintain all data during a power loss.

The interface portion of the control panel shall be readily accessible for service diagnosis and programming without having to open the main control panel on the rooftop unit. Alphanumeric coded displays shall not be acceptable.

The interface portion of the control panel shall be a 16 key touch-sensitive membrane key switch panel, password protected to prevent use by unauthorized personnel; display shall consist of a 2 line by 40 characters per line clear English display.

The DDC control system shall permit starting and stopping of the unit locally or remotely. The control system shall be capable of providing a remote alarm indication. The unit control system shall provide for outside air damper actuation, emergency shutdown, remote heat enable/disable, remote cool enable/disable, heat indication, cool indication, and fan operation.

Anti-recycle Protection - shall be provided to prevent excessive cycling, and premature wear, of the compressors, contactors and related components.

A. The unit control system shall have the ability to communicate to an independent Building Automation System (BAS) via a direct BACnet\IP communications network. BACnet Communications shall conform to the BACnet protocol (ANSI/ASHRAE135-2001). Only standard BACnet objects shall be allowed, proprietary BACnet objects will not be accepted. A protocol implementation conformance statement (PICS) shall be provided. Multiple units may be connected in a common communications network.

B. Through communications, the BAS System Integration (SI) Contractor shall be capable of interacting with the individual rooftop unit controllers. The commissioning of each rooftop unit will require the field installation of the BAS communication card kit by the SI Contractor

C. The unit DDC controller shall communicate the unit status of the equipment with the BAS as follows:

    1. Off Unoccupied, BACnet AV object, read only

    2. Off alarm, BACnet AV object, read only

    3. Startup mode of operation, BACnet AV object, read only

    4. Fan only mode of operation, BACnet AV object, read only.

    5. Cooling mode of operation, BACnet AV object, read only

    6. Heating mode of operation, BACnet AV object, read only

    7. Unoccupied cooling, BACnet AV object, read only

    8. Operating cooling capacity percentage, BACnet AV object, read only

    9. Building Occupancy, BACnet AV object, read only

D. The BAS shall be capable of controlling the unit status by the following control points. All

daily schedules and holiday schedules shall be performed by the BAS.

1. Building occupancy, BACnet BV object, read/write

E. The unit DDC controller shall communicate the status of the following cooling parameters to the BAS:

1. OA temperature, BACnet AI object, read only
2. Return air temperature, BACnet AI object, read only
3. Discharge air temperature, BACnet AI object, read only
4. Discharge air temperature setpoint, BACnet AV point, read only
5. Cooling capacity, BACnet AV point, read only
6. Space temperature, BACnet AI object, read only
7. Space temperature setpoint, BACnet AV object, read only

F. The unit DDC controller shall communicate the following supply air fan parameters to the BAS:

1. Supply fan status, BACnet AV point, read only
2. Supply fan capacity, BACnet AV point, read only
3. Duct static pressure, BACnet AV point, read only
4. Duct static pressure setpoint, BACnet AV point, read only

G. The unit DDC controller shall communicate the following economizer parameters to the BAS:

1. Economizer status, BACnet AV point, read only
2. OA damper position, BACnet AV point, read only
3. OA damper minimum position setpoint, BACnet AV point, read only
4. OA temperature, BACnet AV point, read only
5. RA temperature, BACnet AV point, read only
6. Discharge Temperature, BACnet AV point, read only
7. Discharge air temperature setpoint, BACnet AV point, read only

H. The unit DDC controller shall communicate the following exhaust fan parameters to the BAS

1. Building static pressure setpoint, BACnet AV point, read only
2. Building static pressure, BACnet AV point, read only

3. Exhaust fan status, BACnet AV point, read only

4. Exhaust fan capacity, BACnet AV point, read only

I. The BAS shall be capable of controlling the cooling system through the unit DDC controller by the following control points:

1. Discharge air temperature setpoint, BACnet AV object, read/write

2. Minimum discharge air temperature setpoint, BACnet AV object, read/write

3. Maximum discharge air temperature setpoint, BACnet AV object, read/write

4. Space temperature setpoint, BACnet AV object, read/write

5. Unoccupied space temperature setpoint, BACnet AV object, read/write

J. The BAS shall be capable of controlling the supply air fan through the unit DDC controller by the following control points:

1. Duct static pressure, BACnet AV object, read/write

2. Duct static pressure setpoint, BACnet AV object, read/write

K. The BAS shall be capable of controlling the economizer system through the unit DDC controller by the following control points:

1. Outdoor air damper minimum position, BACnet AV object, read/write

2. Economizer change over method, BACnet AV object, read/write

L. The BAS shall be capable of controlling the exhaust system through the unit DDC controller by the following control points:

1. Building static pressure setpoint, BACnet AV object, read/write

M. For the convenience of the end user, alarm indications shall be divided into faults, problems and warnings. “Faults” shall shut down the entire unit, provide alarm information, and are the highest priority. The “problems” shall shut down only the affected component(s), provide alarm information and have a middle priority. The “warnings” shall provide alarm information, take no action, and have the lowest priority. The unit keypad shall display the following alarms:

1. Emergency Stop – fault

2. High RA temperature - fault

3. High discharge temperature - fault

4. Low discharge temperature – fault

5. Duct high limit - fault

6. Airflow - fault

7. Sensor failure – problem or fault

8. High pressure (by circuit) - problem

9. Low pressure/frost (by circuit) - problem

10. Dirty filter - warning

N. The unit DDC controller shall communicate the highest priority alarm for each of the alarm classifications to the BAS. As an alarm condition is resolved and cleared, the next highest priority alarm condition shall be transmitted to the BAS. The alarms are classified as shown below in order of descending priority.

O. The unit DDC controller shall communicate the following individual fault alarms to the BAS:

1. Emergency Stop, BACnet AV object, read o

2. Outdoor Air Sensor Fail, BACnet AV object, read only

3. Space Sensor Fail, BACnet AV object, read only

4. Return Sensor Fail, BACnet AV object, read only

5. Discharge Sensor Fail, BACnet AV object, read only

6. High Return Air Temp, BACnet AV object, read only

7. High Discharge Air Temp , BACnet AV object, read only

8. Low Discharge Air Temp, BACnet AV object, read only

9. Airflow, BACnet AV object, read only

10. No Active Faults, BACnet AV object, read only

P. The unit DDC controller shall communicate the following individual problem alarms to the BAS:

1. OAT Sensor Problem, BACnet AV object, read only

2. Space Sensor Problem, BACnet AV object, read only

3. Return Air Sensor Problem, BACnet AV object, read only

4. High Pressure (by circuit), BACnet AV object, read only

5. Low Pressure/Frost (by circuit), BACnet AV object, read only

6. No Active Problems, BACnet AV object, read only

Q. The unit DDC controller shall communicate the following individual warning alarms to the BAS:

1. Dirty Filter, BACnet AV object, read only

2. No Active Warnings, BACnet AV object, read only

R. The BAS shall be capable of clearing the alarms of the unit DDC controller in either of two ways, each individual alarm or all active alarms

S. It will be the responsibility of the SI Contractor to integrate the rooftop unit data into the BAS to affect the integrated building control logic and centralized system workstation interface. It will be the unit manufacturer's responsibility to assist the SI Contractor by providing all necessary documentation.

T. If the unit manufacturer cannot provide all of the above points through direct communication with the BAS, then the unit manufacturer shall pay for all costs associated with the Temperature Controls company providing these points

ROOF CURB
Roof Curb provided under Section 15050 Vibration Isolation. Rooftop manufacturer to coordinate unit with curb manufacturer.

See schedule for capacities.

Acceptable Manufacturers:

McQuay
Trane
Carrier
York
or approved equivalent

ELECTRIC CABINET HEATER ECUH-#

U.L. listed and approved assembly for surface mounting. Baked enamel glass fiber insulated cabinet, color to be picked by the Architect. 18 ga. Casing top and front panels. Corrosion resistant, helical coiled fin electric heating elements, individually removable. Blow through model. 1-inch glass fiber throwaway type filter. 2-speed permanent split capacitor or shaded pole motor with build-in automatic reset motor overload protection. HP, etc., detailed in schedule. Forward curved, DWDI fan wheels. Automatic reset snap-action type thermal protection shall be furnished through holding coil circuit of the control system relay(s) for protection in the event of overheating due to air blockage from any cause. Thermal protector shall be linear type to sense temperatures the entire length of heating elements, to detect localized overheating from partial air blockages. Integral thermostat control shall be standard on floor and wall mounted units, and shall consist of factory build-in thermostat of bulb and capillary type, fully enclosed snap-acting. The thermostat shall have a temperature adjustment range between 45°F and 95°F, with tamper-resistant adjustment through the discharge grille by means of an Allen key or slotted screwdriver. Ceiling and inverted mounted units shall use a wall mounted 120V thermostat (Qmark MHT-4015E-1007 or equivalent) and internal power supply. Thermostat operates the single-phase holding coil circuit of the integrally mounted power control relay(s). An integral fan delay switch shall prevent discharge of cold air, by delaying fan start-up of the fan motor until heating elements have warmed up. This same fan delay switch shall maintain motor operation after heating elements have been de-energized to dissipate any residual heat. Cabinet unit heaters to be provided with factory installed integral disconnect.

Vertical cabinet: TRANE, or Qmark Model CUF or equivalent by Berko, FPE, Markel or Redd-i.

See schedule on drawings for capacities.

FLUE

Factory built pre-fabricated assembly (UL 1738/ULC S636 listed). Positive pressure rated. Double wall construction with inner wall of type AL 29-4C stainless steel only and outer wall of type 430 stainless steel or aluminized steel.

Originate at all boilers.

Provide all elbows, fittings, adapters, thimbles and flue cap for a complete system. Provide offsets to provide required clearances to adjoining walls and parapets.

Counterflash through roof and terminate two feet above roof parapet or air intake duct (whichever is higher) with approved exit cap.

Provide complete detailed shop drawings.

Acceptable Manufacturers: Metal-Fab, Heat-Fab Saf-T Vent CI Plus, or approved equivalent

VARIABLE FREQUENCY DRIVE

Variable Frequency Drives for motors shall control motor speed through a 6 pulse fully digital Pulse Width Modulated (PMW) inverter. VFD shall use microprocessor suitable for interfacing with building Direct Digital Control (DDC) system and Programmable Logic Controllers (PLC's) complete with analog/digital, input/output and serial communications. VFD shall comply with all applicable standards of UL, UL 508C, IEEE, IEEE-519-1992, NEMA, ICS-7.0, ETL and IEC (801-2, 801-4 & 255-4.) VFD shall be rated for operation at 6,200 feet above sea level without derate of drive. Refer to Section 23 0050 for inverter duty motors.

VFD shall be housed in a NEMA 3 enclosure with circuit breaker and shall have current ratings at minimum VFD base design carrier frequency.

Main input disconnect shall disconnect all power within the VFD including controls. Operator control command center shall allow manual stop/start, speed control, local/remote starter indication, manual or automatic speed control selection, and run or preset speed selection. VFD will include a slip compensation circuit for constant torque loads only. For HVAC fans and pumps, slip compensation is not necessary. Provide an electronic overload circuit to protect A-C motor operated by the VFD output. Digital display shall indicate frequency output, voltage output, current output, motor RPM, output kW, elapse time, time stamped fault indication, DC bus volts, and analog signal input values. VFD will also include the capability of starting into a rotating load regardless of direction without the need for a time delay upon a start command, an automatic restart circuit which is able to be set by number of restart attempts and time interval between starts, ability to ride through power dips up to 10 seconds without a controller trip depending on load and operating condition, multiple volts/Hz patterns, and an isolated electrical follower capable of enabling the VFD to follow a 0-20mA, 4-20mA or 0-4, 0-8, 0-10 volt D-C grounded or ungrounded speed signal.

VFD shall have the following protective circuits and features: output phase to phase short circuit condition, total ground fault under any operating condition, high input line voltage, low input line voltage, loss of input or output phase, and external fault relay to shut down VFD upon signal from external source.

VFD shall be capable of operating continuously at an ambient temperate of 0°C to 40°C with relative humidity of 95% noncondensing, A-C line variation of -10% to +10% voltage and ±5Hz frequency, and a minimum bus-bracing of 30,000 amps RMS symmetrical. Full output shall be available at 10% low voltage mains input, or the drive shall be over-sized (derated) to provide full output at 10% low voltage input.

Provide line reactors sized for 2.5% of drive size, reactor shall be integrally Factory mounted in VFD assembly. VFDs without built-in line reactors shall add a minimum 3% AC line reactors to the input of the VFD.

A certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the Owner as part of the operating and maintenance manual, and a copy kept on file at the manufacturer.

Acceptable Manufacturers:

ABB	Square D
Danfoss Graham	Motor Drives International
AC Tech	Reliance Electric
Cutler Hammer	Robicon
Mitsubishi	Toshiba

or approved equivalent

STATIONARY LOUVER SL-#

18 gauge minimum galvanized steel 4" blades on 4" centers at 45° with return bends. Set in 18 gauge minimum galvanized steel frame. Secured and caulked into opening. Removable galvanized steel 1/4 inch 19 gauge wire mesh behind louver. Performance in accordance with AMCA Publication 511.

See schedule on drawings for capacities.

Ruskin	L811
Airstream Model	C-45
American Warming	LF-47
Arrow	FS-400
Cesco	SLS4
Dowco	LFC-4
Greenheck	FSJ-402
Louvers & Dampers Company	FL-41-C
United Air	F-445-S

INTAKE HOOD IH-1

Galvanized steel with prime coat finish (color selection by Architect) or aluminum intake hood with removable or hinged hood. Inlet area to have 1/4" 19 ga. wire mesh bird screen. Installation to be on flat roof. Hood size to be as shown in manufacturer's catalog for listed throat size.

See schedule on drawings for capacities.

Penn Airette Ventilator Intake Hood
Cook Type VI
Greenheck Fabra-Hood Model FHI
Carnes Air Intake Hood Model GI

Louvers and Dampers Intake Hood AGV-200/SGV-100
ILG Intake Hood MRV-S
Exit Aire Inlet Ventilator Type RS
Acme Model IV
Cesco GVS-I
Western Vents Series AV-200

RELIEF HOOD RH-1

Galvanized steel with prime coat finish (color selection by Architect) or aluminum relief hood with fully insulated removable or hinged hood. Outlet area to have 1/2" 19 ga. wire mesh bird screen. Installation to be on flat roof. Hood size to be as shown in manufacturer's catalog for listed throat size.

Relief hood to include the following accessories: backdraft damper with linked blades with extruded vinyl or felt strip blade stops and adjustable counter weights, insect or snow screen, and insulated prefab roof curb.

See schedule on drawings for capacities.

Acceptable Manufacturers: Cook Type GR, Penn Airette Ventilator Outlet Hood, Greenheck Air Cap Relief Hood Model FRH, Carnes Relief Vent Model GE, Louvers and Dampers Exhaust Hood AGV-200, ILG Relief Vent M-RVE, Exit Aire Relief Ventilator Type RS, Acme Model TEV, Cesco GVS-E, or Western Vents Series AV-100

GRILLES, REGISTERS AND DIFFUSERS

All grilles, registers and diffusers shall be performance tested and rated in accordance with ADC 1062 and ASHRAE 70.

Provide square to round adaptor for louver face diffusers where required. All perforated face and louver face diffusers, registers and grilles to have off white baked enamel finish and removable face or core. When these diffusers, registers or grilles are used in grid ceilings, frame to be suitable for type ceiling in which they are installed. For concealed grid systems, face size shall match size of tile. For exposed grid systems, face size shall fit into grid. On perforated face diffusers, registers or grilles, where face size is smaller than ceiling grid (i.e., 12" x 12" face in 24" x 48" grid) an insulated panel 12" x 24" or 24" x 24" shall be furnished with diffuser shell size as required for air volume. All other ceilings frame shall be flanged type.

All round diffusers to be recessed or flush type with fully adjustable pattern, white prime coat finish.

All register and grille numbers are for steel construction unless the manufacturer makes only aluminum. Aluminum registers and grilles are acceptable, providing they come with a finish suitable for painting. Steel registers and grilles to have prime coat finish. Sidewall exhaust and return grilles and registers to have blades fixed at approximately 35 to 45 degrees.

All diffusers and registers shall be equipped with opposed blade dampers unless supplied from an accessible twist-in fitting with damper.

Registers for side wall or floor applications shall be provided with gasketing between the register and the finished surface.

Size and CFM as shown on plans. All ceiling diffusers to be 4-way throw unless noted otherwise on plans.

Air Terminal Type

Manufacture Name Model Number	RG-1, EG-1,Return Exhaust Register Grille Perforated Face Ceiling	SG-1, SR-1 Supply Register Grille Sidewall	RG-2 Return Exhaust Register Grille Wall Floor Ceiling
Titus	PAR	272-RL	23-RL
Barb Aire	or equivalent	BDDH	BDG
Tuttle & Bailey	or equivalent	T50	T70D
Carnes	or equivalent	RTDAH	RSAAH
Krueger	or equivalent	880H	S80H
Anemostat	or equivalent	S2H	S3HD
Grillmaster	or equivalent	S4H	RAH
J & J	or equivalent	990H	S90H
Metalaire	or equivalent	H4004	RH
Agitair	or equivalent	DDH	DG
Nailor	or equivalent	7100	6145H
Legend:	16 x 16	24 x 4	6 x 24
	Nominal Neck Size	Nominal Neck Size	Nominal Neck Size

Where no number is listed for particular manufacturer, the model cataloged was not considered equivalent to the others listed and cannot be bid.

Air Terminal Drawing Symbol Legend

SD - Supply Diffuser	RG - Return Grille
TG - Transfer Grille	EG - Exhaust Grille
SR – Supply Register	SG – Supply Grille

ELECTRIC WALL FIN RADIATION EBB-1

All units shall be UL approved. Electric resistance element shall be a metal sheathed element with aluminum or steel fins mechanically bonded to the tubes.

A factory installed junction box and wireway shall be installed on 20 gauge reinforced back panel. An automatic reset thermal high limit capillary shall be installed the full length

of the element. Provide integral disconnect and unit mounted transformer and relay for remote 24V thermostat.

Enclosure shall be 18 gauge steel or aluminum front cover, baked enamel finish. Color to be selected by Architect.

Include: Connecting strips, slide cradle hangers, end with removable by Architect. Enclosure brackets spaced at not more than four feet apart and corner caps and all components required for normal installation.

Enclosure to be: Top outlet extruded grille.

See schedule on drawings for capacities.

Qmark or equivalent by
Trane, Markel or FPE

PART 3 – EXECUTION

3.1 DUCTWORK

A. General

Duct sizes shown on the drawings are outside (sheet metal) duct dimensions. As a minimum ductwork shall be furnished, constructed and installed in accordance with SMACNA HVAC Duct Construction Standards Manual, also comply with more rigid requirements specified herein.

B. Duct Sealing

1. Static pressure construction class 2" w.g. and less when ducts are not located in the conditioned room (e.g. return air plenums are not conditioned rooms) itself, these ducts shall be sealed by using duct sealant as recommended by manufacturer. This includes the sealing of all transverse joint and fitting connections and snap lock seams. Not more than one unsealed longitudinal seam on the perimeter shall be allowed.

2. Static pressure construction class over 2" w.g. Seal all seams, joints, connections and ductwork penetrations by welding or with duct sealant to provide an air tight system.

C. Ductwork Testing

1. See Section 15050 for testing of ductwork.

2. Ductwork required to be pressure tested shall be tested to its pressure class.

D. Ductwork Application

1. All ductwork to be galvanized steel meeting ASTM A-527-71 except as otherwise called for.

2. If glass fiber supply and return duct system is used for temporary ducts only, furnish and install in accordance with SMACNA Fibrous Glass Construction Manual and the recommendations of the manufacturer. Only heat sealing (not pressure sealing) of joint tape is acceptable. All ducts in equipment rooms or otherwise in view shall be metal with lining as specified.

3. All round and oval ducts exposed to view shall be spiral seam. Concealed round and oval ducts may be fabricated with lock type or welded longitudinal seams. All

elbows to be pressed steel elbows or five piece welded elbows.

E. Takeoffs

Do not install takeoffs on elbows or other points of the system where air velocity is not uniform.

F. Ductwork Hangers, Connections and Construction

1. Suspend ducts from structure with proper hangers at a maximum of 8'-0" intervals, at each floor, change of direction and wherever necessary.

2. Make all duct connections to motor driven equipment with flexible connections, unless specifically indicated otherwise.

3. Make all radius elbows with radius of one and one half times the diameter or width of duct and an inside throat radius of one times the diameter or width. Radius elbows is the preferred method for 90^{o} duct turns. Where space limitation will not permit radius elbows, provide 90^{o} square elbows with turning vanes. All 90^{o} square elbows are to have turning vanes except where specifically noted otherwise on plans.

4. Install opposed blade dampers in all low velocity duct divisions and splits where shown or required to allow system balance. Install opposed blade dampers in all 45^{o} takeoffs unless specifically noted on the drawing.

5. All diffusers to be equipped with opposed blade dampers unless supplied from a spin-in fitting with damper. All registers to be equipped with opposed blade dampers. Where noted as grille on plans, opposed blade dampers not required. (Damper to be adjustable through face of diffuser or register.)

6. Spin-in fitting final locations shall be determined after location of lighting and other possible obstructions within the ceiling space are known so that sharp bends and excessive lengths of flexible duct are minimized.

7. Provide adjustable volume extractors at all rectangular take offs to sidewall registers and wherever indicated on plans.

8. Provide 45^{o} takeoffs with opposed blade dampers at all rectangular duct takeoffs except as indicated on drawings.

9. Make all duct offsets with 15 degree transitions. Sharper transitions can be made only when space does not allow 15 degree offsets, 30 degree offsets maximum.

10. Install all automatic control dampers, blank off plates or transitions as required by Division 15900. Provide required access doors for service to control equipment. Install smoke detectors, provided by Division 16000 where indicated on drawings.

11. All connections between ducts, hangers, hanger rods and appurtances of dissimilar metals shall be made with dielectric separation.

G. Access Doors

Provide sheet metal access doors; 18" x 16” hand access, 24" x 42" minimum personnel access where size of duct permits, as noted or as required for proper access to the equipment. Access doors shall occur on each side of each coil and filter bank, inlet to each fan, at all fire dampers, at all automatic control dampers and wherever else shown. Access doors shall open against air pressure, wherever practical. Openings in ductwork for access doors shall have folded edges, if exposed, for protection.

3.2 FIRE DAMPERS, FIRE/SMOKE DAMPERS, SMOKE DAMPERS

A. Fire Dampers

1. Vertical or Horizontal Install fire damper with code approved sleeves in all duct openings where shown on drawings. Install in accordance with the U.L. requirements and manufacturer's recommendations with access door located on downstream side of damper in duct. Use frame CR for all round ducts. Use frame B for rectangular and square ducts. Where fire dampers are required at sidewall grilles or registers frame A may be used. Openings through partitions <or floors> shall be 1/8 inch per foot larger than damper dimensions to allow for thermal expansion. Dynamic type dampers are required in all ducted applications. Static type dampers are only allowed in non-ducted applications and where approved by local jurisdictions.

2. All fire dampers shall be operated, prior to building occupancy, to determine that they function properly. Contractor shall prepare list of all dampers and include who performed test and date of test for each damper; list shall be included in O and M manual.

3.3 DUCTWORK INSULATION

A. Insulate all supply and return ducts, and outside air ducts and wherever else called for on the plans. Exhaust ducts do not require insulation unless specifically called for. Supply and/or return ductwork located within the conditioned spaces served by this ductwork, do not require insulation. Ductwork passing through a space that is not supplied air by this ductwork requires insulation. Ceiling plenums and mechanical rooms are <u>not</u> conditioned spaces and duct insulation is required.

B. Rectangular and square supply and return ductwork shall be lined on the inside of the ductwork using duct liner.

1. The liner shall be applied to the inside of the duct (with the spray face to the air stream) with non-flammable, sprayable, duct liner adhesive complying with ASTM C916 and with 90% (min) adhesive coverage coating the clean sheet metal. Liner shall be installed per NAIMA “Duct Liner Installation Standard”. The liner shall further be fastened with stud weld or impact-driven type pins and clips which shall compress the liner to hold it firmly in place.
Maximum spacing of mechanical fasteners shall be as follows:

<u>Velocity (fpm)</u>	<u>0-2500</u>	<u>2501-4000</u>
From transverse end of liner	3”	3”
Across width of duct	12” O.C.	6” O.C.
From corners of duct	4”	4”
Along length of duct	18” O.C.	16” O.C.

The upstream transverse edges and clips shall be sealed with vapor barrier adhesive.

2. All corner joints in the liner shall be lapped tightly butted or folded.

3. Leading edges of liner at fan discharge, where lined duct is proceeded by unlined duct, and where air velocities exceed 4000 fpm shall be provided with galvanized sheet metal nosing.

C. Round supply, round return and outside air ductwork shall be wrapped with insulation on

the outside unless otherwise noted. Round duct exposed below ceilings in occupied areas shall not be insulated. See Section 15250, Insulation.

3.4 FLEXIBLE DUCTS

A. Attach all flexible ducts inner liner to duct connectors, diffuser necks, or ductwork with stainless steel worm driven clamp. Tape outer vapor barrier securely over clamp with vapor barrier tape.

B. Low pressure flexible duct to be used only in systems with a maximum of 2" static pressure available.

C. Maximum length of any section of flexible duct to be eight feet. Provide rigid round duct on takeoffs as required to maintain maximum length.

D. Maximum length of any section of flexible duct to be eight feet. Provide rigid round duct on takeoffs as required to maintain maximum length.

3.5 GRILLES, REGISTERS AND DIFFUSERS (GRD)

A. Install all GRD's to ductwork with airtight connections.

B. Paint ductwork visible behind GRD's matte black.

C. Install all GRD's in general location indicated on the drawings. Coordinate exact location with Architectural reflected ceiling plan.

D. Install and support all GRD's per manufacturer's recommendations and per UBC Standards.

1. GRD's weighing less than 20 pounds shall be positively attached to ceiling suspension main runners or to cross runners with the same carrying capacity as the main runners.

2. GRD's weighing greater than 20 pounds, but not more than 56 pounds, in addition to the above, shall have two No. 12 gauge hangers connected from the terminal or service to the ceiling hangers or to the structure above. These wires may be slack.

3. GRD's weighing greater than 56 pounds shall be supported directly from the structure above by approved hangers.

E. Forward GRD A_k factors to Test and Balance Contractor.

3.6 AIR FILTERS

A. Provide extra set of air filters for all air handling units and built-up filter banks.

B. Specified filters along with extra sets should not be used during construction. Contractor should provide temporary filters as required to protect system from construction dust, dirt and debris.

3.7 SMOKE DETECTORS

A. Location of smoke detectors shall be as shown on drawings, provided by Division 15000, installed by Division 15000.

B. Wiring of detectors to fire alarm panel by Division 16000. Control wiring of detectors (i.e. fan shut down, etc.) by this Division.

C. Wire smoke detectors to protect the unit in both hand and automatic operation.

D. On signal from smoke detector, supply fan shall be shut off.

3.8 ROOF TOP HVAC UNIT

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

B. Install unit(s) roof curb.

C. Pipe coil drain pan and drain pans of other sections, with independent traps, full size, through a 4" deep "P" trap to nearest roof drain. Fill "P" trap with water before starting up unit.

D. McQuay unit is drawn on plans. Other manufacturers may vary slightly in dimensions, coil placement, etc. Changes to accommodate other manufacturers shall be made at no extra cost.

E. Provide a clean second set of filters to Owner for installation after substantial completion.

F. Provide start-up from factory certified technician.

G. Install duct mounted smoke detector in unit return ductwork as shown on drawings.

3.9 SPLIT SYSTEM AC UNITS

A. Mount and install evaporators and condensing units dead level. See plumbing drawings for condensate lines. Condensing unit to have the discharge air side of unit facing east.

3.2 VARIABLE FREQUENCY DRIVES

A. Factory Certified Start-up: Provide Factory start-up for each drive by a factory authorized service center. A certified start-up form shall be completed for each drive with a copy provided to the Owner as part of the operating and maintenance manual and a copy kept on file by the manufacturer.

B. Provide interlock between VFD and motor disconnect on units, if disconnect is switched off, VFD to shut off and vice versa.

3.1 AIR HANDLING UNIT INSTALLATION

A. EXAMINATION

1. Verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings.

2. Verify that proper power supply is available.

B. INSTALLATION

1. Install in accordance with manufacturer's instructions.

2. Install roof mounting curb level.

3. Pipe coil drain pan through a full size 4” deep “P” trap to roofdeck. Fill “P” trap with water prior to starting unit.

4. Install three-way heating valve with piping arrangement indicated. Provide wiring of control valve as required for controls system.

C. MANUFACTURER'S FIELD SERVICES

1. Manufacturer shall furnish a factory trained service engineer without additional charge to start the unit(s).

D. A McQuay unit is shown on the drawings. Other units by other manufacturers may vary slightly in dimensions, coil placement, weight, etc. Changes to accommodate other manufacturers shall be made at no extra cost.

END OF SECTION 15800

SECTION 15900
CONTROLS AND INSTRUMENTATION

PART 1 - CONTROLS

1.1 RELATED DOCUMENTS

A. The General Provisions of the Contract, including General and Supplementary Conditions and Division 1 - Specification Sections and Contract Documents apply to work in this section. Consult them for further instructions and be governed by the requirements thereunder.

1.2 DESCRIPTION

A. Work Included

1. Provide an automatic temperature control (ATC) system of direct digital controls and/or solid state electronic and components to comprise a complete system, furnished and installed by the Temperature Control Manufacturer or by the Manufacturer's representative as approved under paragraph 2.1 "Acceptable Manufacturers." The complete ATC system shall include all requirements set forth in this Section, and the Related Requirements in Division 15 and Division 16 documents.

2. The DDC system shall consist of independent, stand alone, control units and VAV box terminal control units. The control units shall contain their own microprocessors complete with all necessary software logic functions to perform all specified control sequences in a completely independent manner. Include all software packages detailed in this specification for current or future use. Provide all necessary wiring, hardware, software and accessories to tie all control units and VAV box terminal control units together through a communication network system for programming, data gathering, setpoint adjustment, alarming, and system checkout at a single point in the building. The system shall be capable of communications through a telephone modem and standard telephone line to a remote terminal. The DDC system must meet current FCC requirements.

3. The system shall be complete in all respects, put in operation and calibrated under occupied conditions. This contractor is responsible for providing all sequences of operations specified in this section or on drawings even if equipment and controls are furnished by others. For sequences specified in other sections, if equipment and controls are furnished by others, the temperature control contractor shall be responsible for verifying sequences of controls and coordination.

4. All temperature controls shall be of the approved manufacturers provided by a single source responsibility.

B. General: All automatic control valves shall be furnished by the Temperature Control Contractor and installed under his supervision under the Mechanical Division, Section 15600. All automatic control dampers and air monitor stations unless otherwise specified, shall be furnished by the Temperature Control

Contractor and installed under his supervision under the Air Distribution Section 15800.

1.3 WIRING

A. All wiring shall comply with the National Electric Code (latest edition), local codes and the Electrical Division of these specifications.

B. All control interlocks and wiring done at the factory, and 120 V power circuits to each control panel or control panels shall be wired by the Temperature Control Contractor, except control junction box shown on the plans and schedules. Power circuits shall be provided under the Electrical Division.

C. If more 120 volt power circuits are required than shown on the drawings due to additional equipment required by the ATC Contractor, the cost of additional power circuits shall be the responsibility of the ATC Contractor.

1.4 CONCEALMENT

A. Conceal wiring in all finished areas.

1.5 SUBMITTALS

A. The ATC Contractor shall submit shop drawings of all components of the ATC System including all equipment, control panels, and wiring diagrams in accordance with Section 15010. Work shall not begin until acceptance of submittals has been obtained from the Architect/Engineer. Field wiring and installation of control components may begin prior to completion of the DDC System software, provided this portion has been accepted by the Architect/Engineer. Upon review and acceptance of the submittals, the ATC Contractor shall disperse the required information to all other trades involved in the work managed by the ATC system.

B. Shop drawings paper copies shall be submitted for review. These shall be corrected to "record" conditions at the end of the job and included with the mechanical "record" drawings as described in Section 15010 and Division 1. Also include an electronic copy of all record drawings.

C. Shop drawing shall consist of engineering data on each control system component, control diagrams, wiring diagrams, damper schedule, automatic valve schedule with CVs, flows and pressure drop, sequence of control, piping diagrams for all valves, control panels and panel layouts, installation and calibration instructions. Shop drawings shall include sufficient product information to determine compliance to these specifications. Control diagrams shall include:

1. Schematic representation of system under control with field devices located, piped and wired.

2. Control panel layout showing instruments fully piped or wired to numbered terminal strips.

3. Front panel face layout with nameplate schedule, and location in building, for each panel.

4. Bill of Material; scheduling all items by using code abbreviation indicating quantity, manufacturer, manufacturer's code number, and full equipment descriptive literature, i.e., dampers, valves, relays, controllers, sensors and miscellaneous devices.

5. Written sequence of control incorporating into the written sequence all functional devices using device code abbreviation or point number.

6. Calibration Schedule and set point for every device.

D. Final DDC programming will be developed as part of the system shop drawing review, during system startup and during final evaluation and set up of the project. The ATC Contractor must anticipate some software changes required by the Architect/Engineer or Owner to bring the control system in line with optimum performance and energy efficiency.

E. Programming Manual

Provide a Programming Manual describing programming and testing, system starting, a system overview, and a detailed description of each software feature. The manual shall instruct the user on programming or reprogramming any portion of the system and include all control programs, variables, set points, time periods, messages, passwords and other information necessary to load, alter, test, and execute the system. The manual shall also include:

1. Complete descriptions of the programming language including commands, editing and writing control programs; the printouts and logs; and mathematical calculations.

2. Instructions on modifying any control point, verifying error status, changing passwords, and initiating or disabling control programs.

3. An operator's reference table listing the addresses of all connected input points and output points. Initial settings shall be shown where applicable.

F. Operational and Maintenance Data

Submit the following in accordance with Section 15010.

1. General instruction sheets for all products and devices furnished under the ATC specifications.

2. Parts lists, availability (supplier name, telephone number and location), and guarantee of local stock for all products and devices furnished under the ATC specifications.
3. List of recommended spare equipment, along with quantities, the Owner should maintain on site.

4. Two copies of Operators Manuals.

5. Final approved set of all shop drawing submittals, corrected for As-Built conditions.

6. Two copies of the final version of software on disc format of the owners choosing.

7. As built drawings (paper and electronic).

8. Point validation certification.

G. Submittal shall be provided in six (6) copies as a minimum.

1.6 ADJUSTABILITY

A. All control components shall be completely adjustable, so that setpoints may be easily changed. All setpoints in the temperature control system shall be adjustable without the addition or modification of controls.

1.7 DEMONSTRATION, TRAINING AND COMPLETION

A. Upon completion of the installation the ATC Contractor shall provide a minimum of 16 hours of complete system instruction and training to the owner's operating personnel. The training session(s) shall be conducted at the building. Two copies of the as-built shop drawings and operation and maintenance manuals hall be provided at the training session. See Section 3.13, paragraph B, demonstrations for additional requirements.

B. In accordance with Section 15010 the ATC Contractor shall submit a letter certifying completion of all temperature control work including training prior to final payment.

1.8 WARRANTY

A. In accordance with Section 15010 the control system shall be warranted to be free from defects in workmanship and material for the period indicated in Section 15010. The ATC contractor shall make all necessary repairs, adjustments and replacement at no cost to the owner during the warranty period.

B. ATC contractor shall provide a verification check of all controls within a few weeks of the end of the warrantee period. Recalibrate, readjust (after discussing any new setpoints with the Owner) and repair all faulty equipment.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS AND INSTALLERS

A. All controls shall be of the approved manufacturers. It is recognized that packaged equipment comes with other names or controls and that some functions are accomplished with other named components. This specification does not intend to prohibit this practice.

The ATC contractor is responsible for pre-assembling and installing panels and all hardware with his own employees, proving the system and training the owner's people in its proper function and maintenance. ATC contractor may subcontract wiring, conduit placement, but shall make all wiring terminations and be responsible for his subcontractor's work.

Acceptable manufacturers and installers are listed below.

Manufacturer	Installer
Automatic Logic	Integrated Control Systems, Inc.
CSI	Western Building Services, Inc.
Johnson Controls Company	Manufacturer
Lon Works Systems	Long & Associates, Casper WY
CW Industries	CW Industries

2.2 LOW VOLTAGE POWER AND WIRING

A. All control devices and panels containing low voltage power sources shall inherently comply with NEC Class 2 requirements (current limiting), or shall be supplied with branch circuit fusing to limit control circuit current to NEC Class 2. All control transformers shall be of the inherent current limiting type, or shall be installed with primary disconnect and overload protection.

B. Shielded Cable: Twisted shielded cable shall be used where called for and where required to properly protect the DDC system from false signals and electrical noise. Shielding shall be fine braided tinned copper (90% coverage) or aluminum foil (100% coverage).

C. Minimum Requirements
Communication Cable: Twisted shielded pair, 18 gauge
Analog Input: Twisted shielded two, three, or four wire as required, 18 gauge
Binary Input: 18 gauge
Analog Output: Twisted shielded, 18 gauge
Binary Output: 18 gauge

2.3 SENSORS

A. Temperature

1. Electronic temperature sensors shall be platinum or nickel-iron RTD, thin film integrated circuit, or aged thermistors. Resistance change versus temperature shall be linear over the range of the application.

SENSOR ACCURACY

SENSOR FUNCTION	ACCURACY	RANGE
Outside Air Temperature	±2°F	-20°F to 110°F
Space Temperature	±1.5°F	55°F to 90°F
Duct Temperature	±1.0°F	40°F to 120°F
Heating Water Temperature	±2.0°F	80°F to 230°F

2. Where called for, room temperature sensors shall have adjustable setpoint potentiometer.

3. Averaging Temperature Sensors shall be provided in all duct applications with cross section of over 10 sq. ft. Sensor shall be an averaging type capillary of not less than 15 feet. Capillary shall be serpentined across the duct for an average of one linear foot of capillary per one square foot

of cross sectional duct area. Where multiple coil sections exist, separate capillaries shall be provided for each section.

4. Outside air sensors shall be suitable for outdoor use. Install sensors with shield and located where unaffected by the sun.

5. Liquid sensors shall be provided with separable wells.

B. Pressure: Pressure sensors shall be temperature compensated for the expected temperatures of the application.

1. Duct Pressure Sensor shall have a range of 0 to 3" W.C., 0 to 0.5" W.C., or as required for application, repeatability of ±1.5% of range, accuracy of ±3% of range.

2. Building Static Pressure Sensor shall have a maximum range of -0.5 to 0.5" W.C., repeatability of ±1% of span and accuracy ±2% of span.

3. Air Differential Pressure Switches shall be single contact for actuation on decreasing pressure (normally closed), 0.5" to 2.0" range. Relay rating of 15 amps at 120-480 VAC.

Dwyer 1823-2 or approved equivalent

2.4 TRANSMITTERS

A. Transmitter output signal shall be directly proportional and linearized over the full range of the transmitter. The output shall be industry standard 3-15 psi, 0-10V, or 4-20ma. The transmitter shall be selected to match the applied control loop such that the setpoint falls approximately in the center of its range. Pneumatic and electronic transmitters shall comply with the accuracy and repeatability requirements specified for sensors.

2.5 CONTROLLERS

A. Thermostats

1. General

All thermostats shall have a temperature range suitable for the application and shall have adjustable setpoints. All room thermostats shall have concealed adjustment and locking cover. All room thermostats that control both heating and cooling shall have a separate setpoint for heating and cooling (can be accomplished by individual thermostats located under one cover) or have separate heating and cooling control points provided through thermostat's adjustable throttling range.

2. Two position thermostats shall be line or low voltage as indicated. Contacts shall be rated for the application. Two position thermostats used for occupied rooms shall have heat anticipator.

3. Duct sensing elements and liquid immersion elements shall be as described under sensors.

2.6 ACTUATORS

A. Electronic Actuator (for dampers and valves)

1. Electronic direct-coupled actuation shall be provided on all dampers. The fastening clamp shall attach to the damper shaft for maximum strength and eliminate slippage. Single bolt or setscrew type fasteners are not acceptable.

2. Actuators shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.

3. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe are not acceptable. All spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation. All spring return actuators with greater than 60 in-lbs. of torque shall have an assembly of sufficient size to be directly mounted to an integral damper jackshaft of up to 1.05 inches when the damper is constructed in this manner.

4. Proportional actuators shall be positive positioning and accept a 0-10 VDC or 0-20 mA control signal and provide a 2-10 VDC or 4-20 mA operating range. An actuator capable of accepting a pulse width modulation control signal and providing full proportional operation of the damper is acceptable. All proportional actuators shall be able to provide a 2-10 VDC-position feedback signal as required by control specification.

5. All 24V AC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC or more than 8 watts for DC applications.

6. Actuators with greater than 35 in-lb. of torque shall be provided with a conduit fitting and a minimum three-foot electrical cable that is pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.

7. All actuators shall have a visual position indicator to indicate control position of the actuator.

8. Actuators shall be applied according to the valve or damper manufacturer's specifications.

9. Actuators shall be Underwriters Laboratories Standard 873 listed as meeting correct safety requirements and recognized industry standards. Actuators shall have a 2-year manufacturer's warranty, starting from the date of substantial completion.

10. Torque Requirements:
    a. Damper actuators shall be sized with enough torque to provide a minimum of 5 inch-pounds of torque per square foot of damper face area.

b. Valve actuators shall be sized to provide the minimum torque required for proper valve close-off for the required application.

11. Actuator Housings: Actuators shall be provided with proper weather, corrosive, or explosion-proof type housings as required by application.

B. VAV control unit electronic actuators: rotary or linear drive type capable of continuous stall without damage. Rotary drive actuators shall have adjustable stop pins and shall fit directly over the damper shaft. Gears and bearings shall be oil impregnated steel.

C. When multiple damper sections are used, use one operator per section (at least one operator for each 30 square feet of damper or for each length greater than 48"). "Ganging" sections together through linkages and one actuator is not acceptable.

D. Size all damper actuators to be used in air handling systems for 3000 fpm damper velocity and maximum static pressure difference producible by system. Fan inlet vane actuators shall be sized for a minimum of 30% over torque required to open vanes from the fully closed position with fan on and/or steel and/or phenolic. Units shall be factory only serviceable and shall carry a 2-year unconditional warranty.

E. When application (see Sequence of Control) requires normally open or normally closed damper position, actuator must have spring return. Non-mechanical forms of fail-safe operation are not acceptable.

F. Actuators providing control by temperature change of media within actuator are not acceptable.

G. Direct coupled actuators are permitted.

H. Size all valve actuators to be able to close valve tight against 150% of maximum available pumping head or steam operating pressure.

I. Actual actuator position as a percentage of full travel shall be known and controlled by the DDC system. If the signal output actuator configuration is such that the actuator position is not directly known, then a position feedback device and an input signal to the DDC system must be provided. Note this possible input requirement is not listed in the input/output summary table at the end of this section. System knowledge of actual actuator position not required for VAV control unit applications.

2.7 DAMPERS

A. Damper frames shall be 13 gauge galvanized steel channel or 1/8" extruded aluminum with reinforced corner bracing. Damper bearings shall be nylon, Teflon or oil impregnated bronze. Damper blades shall not exceed (8) inches in width. Maximum damper section width to be 48 inches. Blades are to be suitable for high velocity performance. All edges of the blades and top, bottom and sides of the frame shall be provided with replaceable, butyl rubber or neoprene seals. Side seals may be spring loaded stainless steel. The seals shall provide a

maximum of 1% leakage when sized at a wide open face velocity of 1500 fpm, 4" static pressure. The damper linkage shall provide a linear flow of equal percentage characteristic as required.

B. Dampers to be Reed National TC-62, Johnson "Proportion/Air," Honeywell "Moduflow low leakage," Ruskin "RCD45 low leakage," or equivalent.

2.8 VALVES

A. General: All valves to heating coils which are part of an air handling system which takes in outside air shall open for full supply water flow from heating generation plant whenever a loss of power or air supply to the valves occurs or as described in the sequence of operations. All valves shall close against flow. All control valves shall be single seat type, tight shut-off, unless otherwise indicated. All control valves shall conform to the pressure class requirements of globe valves as specified in Section 15600, unless listed differently below.

B. Water System Valves

1. Characterized Control Ball Valves

a. Valves 1/2 inch - 2 inches shall be forged brass body with nickel plating, NPT screw type. The operating temperature range shall be 0°F to 212°F (-18°C to 100°C).

b. The valves shall have an ISO type 4-bolt flange for mounting actuator in any orientation parallel or perpendicular to the pipe. A non-metallic thermal isolation adapter shall separate flange from actuator with high temperature materials rated for continual use at greater than the application temperature. Valve assemblies without thermal isolation as described are not acceptable.

c. The isolation adapter shall also provide stable direct coupled mechanical connection between the valve body and actuator and prevent all lateral or rotational forces from affecting the stem and its packing O-rings.

d. All control ball valves shall be furnished with a stainless steel ball and stem and fiberglass reinforced Teflon seats and seals. The valves shall have a blow out proof stem design.

e. Flow type for modulating two-way valves shall be equal percentage. All control ball valves shall have a flow-characterizing disk in the inlet of the valve to provide this true equal percentage flow response.

f. Three-way valves shall have equal percentage control port. They shall have a modified linear bypass port which will yield 70% of the flow of the A port. The total flow remains near constant. Three-way valve shall be applicable for both mixing and diverting.

g. The characterizing disk shall be held securely by a keyed ring.

h. The stem packing shall consist of 2 O-rings designed for on-off or modulating service and requiring no maintenance.

2. Actuated Globe Valves

Two and Three-Way Screwed Valves 1/2" through 2"

Two and Three-Way Screwed Flanges 2-1/2" through 6"

a. Valves 1/2 inch – 2 inches shall be bronze body, NPT screw type, and shall be rated for ANSI Class 250 working pressure. The

operating temperature range shall be 20°F to 280°F (-7°C to 138°C). Spring loaded TFE packing shall protect against leakage at the stem.

b. Valves 2-1/2 inch - 6 inches shall be iron body, flanged type, and shall be rated for ANSI Class 125 working pressure. The operation temperature shall be 32°F to 250°F. TFE V-ring packing shall protect against leakage at the stem.

c. The valves shall be provided with a metallic linkage. A thermal isolation adapter shall separate the valve bonnet from the linkage. Valve assemblies without thermal isolation as described are not acceptable.

d. Flow type for two-way valves 1/2 inch – 6 inches shall be equal percentage.

e. Flow type for modulating three-way mixing and diverting valves 1/2 inch – 6 inches shall be linear.

3. Electronic Butterfly Valves
Two-Way and Three-Way Valves 1/2 inch – 12 inches

a. Valves 2 inches –12 inches shall be fully lugged cast iron body.

b. Flanges shall meet all ANSI 125 and ANSI 150 standards.

c. The operating range shall be -22°F to 150°F.

d. The stem shall be one piece stainless.

e. The 416 stainless shaft shall be supported at three locations with PTFE bushings for positive shaft alignment.

f. The seat shall be EPDM; Phenolic backed, non-collapsible, and easy to replace.

4. Valves (two way) shall be rated as follows:
Body static pressure rating: 250 psi
Close-off rating: 1.5 times pump design operating head
Dynamic rating: 1.5 times pump design operating head

5. For system scheduling valves, in lieu of three way valves, linked butterfly valves may be used for valves larger than 3 inch. Butterfly valve materials shall be as specified in Section 15600.

6. Valves shall be sized for pressure drops (in ft.) as follows:

a. Heating water radiation and coil control, 10 ft.

b. Heating water coil control with coil pump, 10 ft.

c. Heating water system scheduling, 10 ft.

d. Two position valves, 10 ft.

2.9 INDICATORS

A. Interface each indicator with remote sensor/controller to display measured value.

B. Supply selector switches for multiple indicators that show which variable is being measured.

C. Electro mechanical device or panel mounted back screen display.

D. Accurate to ±0.5% of the measured variable's maximum value.

2.10 LOW TEMPERATURE DETECTION THERMOSTATS

A. Low temperature detection thermostats shall be of adjustable electric contact type silver plated, having manual reset with 20' flexible sensing bulb of increment type with any section (16 inches maximum) capable of actuating mechanism on temperature drop below set point. They shall have an isolated set of contacts when required to be connected to alarm system.

2.11 TRANSDUCERS AND INTERFACES

A. Electronic transducers shall be of the one or two input/output type suitable for interfacing a sensor or a recorder. Start point and steepness shall be fully adjustable (not fixed) for various ranges. Accuracy shall be ±1% of maximum value.

2.12 WELLS

A. Metal to be compatible with the pipe it is to be installed in (generally brass or bronze).

2.13 CURRENT SENSOR

A. Current sensor of the induction type shall be located between the motor starter and the motor on one leg of the motor wiring. Power for the sensor shall be induced from the monitored load. Sensor shall be capable of detecting belt, bearing or coupling loss. An adjustable trip set point of ±1% on a range suitable for the monitored load shall be provided along with an LED for sensor output status. The sensor shall be a normally open switch and shall produce a 0.1 amp signal when closed. Provide with an adjustable mounting bracket for installation in motor starter cabinet.

MAMAC, Hawkeye, or approved equivalent

2.14 SMOKE DETECTORS

A. Smoke detectors to be provided under Electric Division.

2.15 FLOW SWITCHES

A. Shall be paddle or pressure differential type with SPDT contacts, zinc plated inside a vapor proof enclosure. Maximum temperature and pressure ratings of 300°F/150 psi. Brass wetted primary parts with monel adjustable vane. Field adjustable sensitivity screw.

McDonnell Miller Model FS4-3 or approved equivalent

2.16 CONTROL UNITS

A. General

The control units shall be direct digital, microprocessor based with plug in type boards and designed to monitor the HVAC equipment and through the proper control mode maintain the desired environmental conditions. The network of control units shall be capable of stand alone operation. Additionally, each control unit shall be capable of networking for single point programming and data gathering. Each control unit shall include its own microprocessor controller(s),

input/output modules, terminal modules and back-up batteries.

The system of control units shall have the capability of supporting an operator's terminal. The control units shall include a 24 hour time of day clock with Julian calendar. Each control unit shall be able to operate in the ambient environment it is located in; as a minimum, units shall be able to operate in temperatures of 40°F to 120°F and 10% RH to 90% RH. Locate units where they are not under water pipes or provide water tight enclosures. Be responsible to insure that each control unit will operate properly in the operating environment it is in.

B. Location

Locate control units in mechanical rooms, locations shown on drawings or other approved locations.

C. Controllers

Controllers shall be mounted and wired in a grounded steel NEMA-1 enclosure complete with all relays, digital to analog converters, and wired to properly identified terminal strips. Enclosures shall be lockable, all keyed the same. Provide the owner's representative with six sets of keys.

D. Input/Output Modules

1. These modules shall be mounted and wired in the same steel enclosure as the controllers. The microprocessor based I/O modules shall interface the controllers with specified sensors and output devices to accomplish the specified sequences.
2. The input/output modules shall isolate the controllers from the field points and wiring. Additional isolation relays shall be included as necessary so that continuous line voltage (120/240V) shorting to any input or output line will not damage the controllers in any way.

3. Input points to include sensors and contact closures. Outputs to include SPDT relays and analog 4-20 ma current loop signals. Digital to analog conversion shall have a minimum resolution of 12 bits. See also sensor accuracy requirements. All relays used shall have, as a minimum, 24 volt coils and contact ratings of 1.5 times the operating amperage and rated mechanical operations rating exceeding 1 million.

E. Communication

1. Communication to remote terminals shall be through EIA RS232C or RS485 ASCII Serial Codes, minimum 9600 baud rate or EIA 709.1 ConTalk protocol.

2. The DDC System shall include an auto dialer phone modem. Modem shall be able to perform automatic dialing and continuous redial of up to 4 specific phone numbers, automatic answering pulse or touch tone dialing. The system shall be a standard office grade phone line. The modem shall be Hayes compatible 9600 baud, utilizing Bell 212A and 103A protocol.

3. Each communication cable shall be provided with lightning arresters where cables exit or enter buildings. Fiber optic cable may be used as a communication cable in lieu of lightning arrestors.

F. Capacity

1. The DDC System shall be furnished with sufficient internal memory to provide at least the capabilities listed under software requirements and the expansion capabilities listed below.

2. In addition to the required input/output points called for in the Sequence of Control, the system shall have the additional control units (as required), the terminal strips and all necessary hardware and software set up for the future addition of a minimum of

    4 Temperature sensor inputs
    2 Contact Closure Inputs
    2 On/Off Outputs
    2 Analog Outputs

G. Power

1. Connect the control units to the power circuit(s) provided under Division 16. If more 120 volt power circuit(s) are not shown at the chosen control unit location(s) or if more 120 volt power circuits are required than shown on the drawings, the cost of the relocation or additional power circuits shall be the responsibility of the ATC Contractor.

2. The control units shall operate from 120 volt, 60 hertz power and continue to operate from line voltages as low as 105 volts or as high as 127 volts.

3. A power-on indicator light, power switch, power line filter, surge protection, and power fuse shall be provided.

4. When a power failure occurs the DDC System shall shut itself down in an orderly manner without loss of any data. On return from power failure the DDC System shall check its own memory and clock for any corruption of memory. If found to be correct, a warm start shall be accomplished; a warm start shall not require initialization from the central terminal. If memory or clock is corrupted, a cold start (including initialization from the central terminal) shall be accomplished.

H. EEPROM

EEPROM shall be used for storage of data and control strategy changes.

I. Lightning and Static Protection

Lightning arresters or optical couplers shall be provided to prevent induced voltages in the transmission lines from damaging any of the electronic circuits.

J. Labeling

All input/output terminals and adjustable devices shall be clearly labeled as to function and settings.

K. Control Unit(s) Failure

In the event of a control unit failure the following shall occur:

System shall fail to the last commanded position condition or fail to heating and night mode. An alarm indicating control unit failure shall appear on the control unit and at the central terminal.

2.17 TERMINAL CONTROL UNITS

A. General

1. Each VAV control unit (see Section 15800) shall be locally controlled by a terminal control unit (TCU). Each TCU shall be remotely addressable over the Centralized Facility Network System using a multidrop pair of wires by the DDC System higher level control units.

2. Each TCU shall be based on a minimum 8 bit microprocessor with control algorithms and default set points embedded in non- volatile memory. They shall regulate zone (room) temperature by regulating the volume of air supplied to the zone and modulating heating valves. This shall be accomplished by controlling zone air velocity at an appropriate setpoint which is reset by the space temperature. A PID type control algorithm shall reduce offset and overshoot. Proportional only control is not acceptable. Each controller shall be stand-alone and have the following independently adjustable setpoints:

   Heating temperature
   Cooling temperature
   Maximum cooling velocity (for VAV boxes)
   Minimum cooling velocity (for VAV boxes)

3. Room sensors shall have the following items available at sensor:
   Adjustable setpoint potentiometer.

   LCD display showing current temperature and heating and cooling setpoints.
   Exposed pushbutton to allow occupant to reset to occupied mode.

B. Isolation: Control, communication, and power circuits for each controller shall be electrically isolated to protect against transients and steady state pick-up, spikes and power surges.

C. Communication: Each TCU shall be able to communicate to a hand held digital readout service tool. Connection point shall be either at the TCU or at the room temperature sensor. In addition to being able to read and adjust the setpoints mentioned above, the hand held service tool shall be able to read:

   Supply air velocity
   Space temperature
   Operating mode

   Provide one (1) hand-held service tool to the Owner's representative.

D. Air Velocity Sensor (VAV units)

1. Velocity sensor shall be either hot wire anemometer or multipoint flow sensor with differential pressure transmitter which transmits velocity

pressure to the TCU. Range shall be 50 to 2500 FPM accurate to ±25 FPM. It is the ATC contractor's responsibility to verify and supervise that the velocity sensor location and type, along with the actual VAV control unit inlet configuration for all VAV control units, will function satisfactorily to provide accurate pressure independent control.

2. The ATC contractor shall instruct and supervise the balancing contractor on how to set minimum and maximum air volume settings.

E. Power: Each TCU shall incorporate a single point electrical power connection. Power shall be from either the fan powered VAV unit or unit ventilator or fan coil fan circuit or from junction boxes as shown on drawings.

F. All setpoints shall reside in EEPROM.

G. All VAV box control components, including TCU's are to meet UL and local jurisdictional requirements for environmental air plenum applications.

H. Responsibility: The ATC contractor shall provide and be responsible for the complete temperature control system, including VAV control unit, fan coil units or unit ventilator controls. By agreement the VAV control unit, fan coil or unit ventilator mounted controls may be installed at the factory, under ATC contractor's supervision.

2.18 OPERATOR INTERFACE

A. General

1. The system shall be capable of incorporating an Owner-furnished local computer or a portable laptop computer to interface with all control units for the purpose of setting, changing, or commanding parameters, displaying all information available to the control units, annunciating alarms and checking out the system. Provide Owner with computer minimum requirements.

2. Each system with control units shall have an operator interface display mounted on the face of one of the control units, provided this terminal can access all other control units in the system.

3. The operator interface display shall include complete descriptive alarm and point descriptions plus engineering units.

2.19 SOFTWARE

A. General

1. All control of the DDC system analog outputs shall be performed in a digital manner using the digital signal from the web-based microprocessor based controllers converted through electronic circuitry for modulation of electric actuators or through transducers to produce the pneumatic signal for operation of pneumatic actuators.

2. Each control unit shall contain self-diagnostics that will continuously monitor the proper operation of the control unit. A malfunction within control unit will be reported and will inform the operator of the nature of the malfunction and which control unit is affected.

B. Controller Software

1. General

a. All temperature control functions shall be executed within the web-based stand-alone control unit(s) and not rely on any higher level microprocessor for operation. Loop control shall be executed via direct digital control algorithms. Controller software shall include a complete operating system, control application packages as described herein, standard control algorithm application packages, and an operator custom control and calculation application package complete with interpreter. It shall be possible to change any setpoint value within a control unit while it is operating and performing other functions. Input for these changes shall be made via the communications network. Commanding shall be done in English language without codes.

b. If reprogramming is to be done by a reloading process, then all output points must remain at their last commanded position during reloading and a computer must be provided for editing of the program.

c. The local controller operating system software shall operate independently of any central computer. The operating system shall control communications between the centralized facility operator station, controllers and the I/O modules, accept analog and digital inputs, produce analog and digital outputs, provide alarm monitoring, control application packages, and interface the necessary sensor and actuator types. The controller operating system shall also contain built in diagnostic routines as described herein.

d. The controller software shall allow for scaling and for calibration of sensor lead length variations to ensure instrumentation accuracy's. The software shall provide for staggered automatic restart of equipment based on current program time without operator intervention.

e. All setpoints shall reside in EEPROM.

2. Control loops shall support any of the following control modes:
Two position control, proportional control (P), proportional plus integral control (PI), proportional plus integral plus derivative control (PID), time proportioning control and floating control algorithms. All of these modes shall be in its memory and available for use by the Operator. The analog output of P, PI, and PID control shall be continuously updated. Between cycles the analog output shall retain its last value. Each control loop shall be fully operator definable in terms of sensors, actuators, control mode, gain, control action and sampling time.

3. Sampling Time
As a minimum the time between sampling (system check for change) of

input points shall be 2 seconds.

4. Point Limits
Each analog point shall have a user defined high and low limit. If the measured or calculated value falls out of the limit range, that point shall be considered in alarm. Any analog point shall be disabled from alarm reporting if it is turned off.

5. Alarms
Whenever a field point status exceeds preset limits, or there are other indications of system exceptions, alarms, error failures, the following indications shall be provided.
   a. Audible tone: The system shall have an audible tone. The audio tone shall be capable of being enabled or disabled on operator command and a manual silencer switch. A red warning light shall remain on at silencer switch until alarm is satisfied. If another alarm occurs before the last one is resolved, then the audible tone shall again sound.
   b. Display: The alarm point identification shall appear on the CRT and printer along with individual point alarm messages. Upon operator command, all alarms resident in the CPU shall be printed along with individual point alarm messages.

C. Control Application Software
The following control application programs, as a minimum, shall be callable through the centralized facility operator station. Parameters shall be capable of being modified through an operator's terminal.
1. Time Program
   a. This program shall provide for independent automatic start up and shut down of selected equipment. The program shall allow for the assignment of independent start and stop times to any equipment connected to the controller. All remote equipment which operates on a preset time basis can be assigned to this program.
   b. The time program shall operate in accordance with a yearly calendar with automatic adjustments for daylight savings time and leap year.
   c. Holiday routine; software shall include a calendar for each time clock or zone that will allow the user to program the days and hours of the year that building is occupied or unoccupied. The calendar shall be initially set by the ATC contractor as dictated by the owner representative.
   d. See sequence of control and point requirements for zoning and zone override switches.

2. Discharge Reset
For VAV air handling systems, the DDC system shall be able to maintain a constant discharge temperature, or reset it as indicated below. Provide a software "switch" on the unit equipment page so that the operator may select either method.
   a. After the system comes out of morning warm-up, the discharge

temperature shall be set at 65°F. As the zone calling for most cooling approaches its cooling setpoint the discharge temperature shall be reset downward to a minimum of 55°F to maintain the zone calling for the most cooling at its cooling setpoint.

3. Custom Software
An operator programmable custom control application package shall be provided to permit nonstandard control algorithms to be developed by the operator to create customized control strategies. This application package shall allow the operator to program custom control sequences directly into the unit controller's memory. The package shall permit interlocks, calculations of Btus, flows, outputs, provide hysteresis, scaling, offset, average, minimum, maximum, linearization, square root, subtraction, summation, multiplication, division, etc. Default modes, start up and check out tests, interlocks, demand control, etc. shall be accomplished utilizing this package.

4. History Log
The system shall have a history logging routine which shall record user definable values on an incremental basis (1-60 minutes) for the past 24 hours. Provide storage capacity for a minimum of 8 variable values to be logged for 24 hours.

5. Operating Hours
The number of operating hours shall be accumulated for each piece of equipment that requires periodic maintenance. Include a zero reset.

6. Equipment Pages
   a. Software shall be written so all pertinent information regarding a piece of equipment will appear on a screen (page) with one queue. Line by line queuing is not acceptable. The information to appear shall include: calendar date, all necessary information for equipment algorithm(s) including associated I/O values. Each page shall be menu driven.
   b. Changing all setpoints and times shall be menu driven.
   c. Software must be written so that referencing a manual or training is not required for accessing and changing setpoints or times.

7. System Security
Provide a minimum of three levels of system security. Each level shall have at least one programmable security code.

Levels shall be as follows:

Level 1: Be able to read but not change system values.

Level 2: In addition to Level 1, be able to change setpoint and time values.

Level 3: In addition to Level 2, be able to reprogram the system

PART 3 - EXECUTION

3.1 ACCESSIBILITY

A. Install all control devices in "Readily Accessible" locations as defined by Chapter 1, Article 100, Part A of the National Electric Code.

3.2 CONTROL PANELS

A. Provide and install local control panels for each Mechanical System. Group these together into one panel when multiple systems are located in one equipment room.

B. The panels shall be totally enclosed with hinged door and containing associated control components such as controllers, relays, switches, gauges, microprocessor, modem, communication interface, override timers, etc. Panel to meet NEMA one requirements with proper bracing for rigid wall or floor mounting.

C. Unless indicated otherwise all controlling devices (including duct and immersion controllers, relays, selectors, networks, and switches) shall be panel mounted. Only when the controlling device must be mounted at the equipment or it is not practical due to distance (e.g. limits to capillary length) may components be field mounted.

D. Mark each control device on the panel with engraved plastic laminate nameplates describing its function and cross-referencing it to control diagrams. Mark items within panel plainly and permanently as to its identification on the control drawings.

E. Each electrical wire shall be labeled at each end and terminate at a bulkhead, terminal strips, or control instrument. All wires and tubes shall be organized in a bundle or wire mold rack and tied. Terminal shall be numbered to match control diagrams.

3.3 WIRING OF CONTROL DEVICES BY OTHERS

A. Control devices carrying full load current furnished by Mechanical and wired by Electrical shall be located at the device being controlled, unless shown on the drawings or mutual agreement is made between the contractors with no change in the contract price.

3.4 WIRING

A. Installation of wiring, cable, conduit, etc. shall conform to Division 16. In case of conflict between this Division and Division 16, the most stringent requirements shall be met.

B. All wiring shall be installed in a neat and workmanlike manner, parallel to building lines and suspended neatly from the overhead structure (do not lay wiring on top of ceiling tiles).

C. All wiring shall be run in metallic conduit (flexible conduit shall be limited to 3 foot lengths maximum), tubing or raceways.

Exceptions:

1. NEC Class 2 low voltage wiring where not exposed to view such as above suspended ceilings, in shafts, etc., may be run in cable tested in accordance with test methods of NFPA 262 for installation in environmental air plenums or standard cable when not exposed in environmental air plenums.
2. Wiring enclosed in Temperature Control panels.

D. Communication Circuits: Cable shall not be installed closer than six feet from high power transformers or run parallel within six feet of electrical high power cables. Care shall be taken to route the cable as far from interference generating devices as possible.

E. Splices: Splices in shielded cables shall consist of terminations and the use of shielded cable couplers which maintain the integrity of the shielding. Terminations shall be in accessible locations.

F. Grounding

1. All communication cable shall be grounded at one point only, to eliminate ground loops. Earth grounding shall be single point to main water piping. All non-current caring metallic parts (for example, lightning arresters, metallic raceways, equipment enclosures) of the DDC system shall be grounded in this way.

2. Analog shields shall be ground to internal analog (nonearth) ground.

G. Temperature control wiring shall not be run in conduit with power wiring. Analog or communication wiring shall not be run in the same conduit which has highly inductive loads such as contactors or coils.

3.5 IDENTIFICATION AND DIAGRAMS

A. Identification: Tag or color-code all tubing and wiring at each end and necessary junction points and match the tagging numbers or color- coding shown on the control drawings.

B. Provide control diagrams laminated between rigid plastic mounted on a supporting back board for each system control panel. Mount the diagrams near the control panels or where directed. Identify all devices on the diagrams with the same terminology used for the nameplates. Diagram shall be a permanent as-built drawing.

3.6 SENSORS

A. Sensors shall be installed to be readily accessible and to permit quick and easy replacement. Flush mount with metal cover.

B. Duct sensors shall be installed to sense the correct temperature of the air only, within the vibration and velocity limits of the sensing element. Thermally isolate elements from brackets and supports to respond to air temperature only. Seal all duct penetrations air tight.

C. Where space sensors are mounted on an outside wall, provide insulating base.

D. Install liquid temperature sensors inside of pipe wells with an appropriate heat transfer compound inside the well.

E. Provide wind dampening "Weatherhead" on each atmospheric pressure sensing point. Locate above wind eddies carried by the building structure and roof equipment.

3.7 PRESSURE CONTROLS

A. Static and differential pressure controllers and indicators shall be transmitter and panel mounted receiver controller type, unless specified otherwise. Provide gauge on panel face to read pressure being controlled. Duct static pressure sensors shall be located in a section of ductwork with minimum turbulence.

3.8 ACTUATORS

A. Valve actuators shall be electric or electronic for all valve sizes.

B. Damper actuators shall be electric or electronic for all dampers. Provide multiple actuator on dampers greater than 16 sq. ft.

3.9 THERMOSTATS

A. Low Temperature Detection Thermostats: Each supply AHU/MUA system with water coils taking outside air shall have a low temperature detection thermostat (set at 35°F) located on the downstream side of the coil. Where multiple coil sections are used, provide one thermostat for each coil section. Wire thermostats to protect unit in both hand and automatic operation. When temperature drops below setpoint, thermostat shall stop fan(s), open heating valve and close outside air damper(s).

B. Mixed Air Low Limit Thermostats: Each supply system with outside air and return air dampers, shall have a mixed air low limit thermostat. The thermostat shall limit the outside air and return air dampers to keep the mixed air from going below 45°F. The thermostat shall override all other controls and modulate the outside air dampers to 100% closed if the mixed air temperature falls below its setting.

C. Duct or Immersion Thermostats: Duct or immersion thermostats may only be used as limit controllers, unless specified otherwise.

D. Room Thermostats

1. Provide guards on any electric or electronic thermostats serving cabinet heaters or unit heaters or other public spaces. Coordinate with Owner and Architect, except where they will be concealed or in equipment rooms. Guards to have clear plastic cover, solid type mounting base, tumble lock and two keys per cover.
   Honeywell TG501A, or Beko BTG-UK1, or equivalent

2. Mount thermostats 48” AFF where they will be unaffected by the sun. Avoid mounting on outside walls. Where thermostats must be mounted on an outside wall, provide an insulating base.

3.10 SMOKE DETECTORS

A. Location of smoke detectors shall be as shown on drawings, provided by Division 16000, installed by Division 15000.

B. Wiring of detectors to fire alarm panel by Division 16000. Control wiring of detectors (i.e., fan shut down, etc.) by this Division.

C. Wire smoke detectors to protect the unit in both hand and automatic operation.

D. On signal from smoke detector, supply fan and return fan shall be shut off and outside air and return air dampers shall close.

3.11 CURRENT SENSOR

Current sensor shall be mounted in the starter cabinet of the controlled equipment. After controlled equipment has received factory start-up, provide adjustment on current sensor set point. For controlled equipment which operates with varying current draw (e.g. heating water pumps in systems with two-and three-way valves and fans with inlet guide vanes) set point shall be made so that the full operating range of the current draw does not cause spurious trips of the status point. If necessary, install the sensor with multiple wraps of power wiring through the sensor to amplify the change in current in order to detect belt, bearing or coupling loss.

3.12 RELATED WORK IN OTHER SECTIONS

A. Coordinate all work performed under Division 15 Mechanical including:

1. Piping
   a. Install automatic valves and separable wells that are supplied under this Section.
   b. Furnish and install necessary pressure taps, water, drain and overflow connections and piping.
   c. Furnish and install necessary piping connections required for flow devices.

2. Sheet Metal
   a. Install automatic dampers and provide necessary blank-off plates or transitions required to install dampers that are smaller than duct size.
   b. Provide access doors or other approved means of access through ducts for service to control equipment.

3.13 LIMIT AND SAFETY CONTROLS

A. Temperature controls for limit and safety controls must function independently of the DDC system controls. This includes controls for mixed air low limit, coil low temperature detection and smoke detection.

3.14 COMPLETION SERVICES

A. Point Validation: Upon the completion of the installation, using walkie-talkies (as required) completely validate the proper operation and labeling of all input and output points. Validation shall be done by physically effecting the I/O points while the person on the other end observes for proper response. Contractor shall include validation certification in O & M manuals. Adjust all thermostats, valves,

dampers, etc. provided. Final adjustment shall be performed dynamically on operating system(s).

B. Demonstrations: At the completion of the work, instruct the Owner's operating personnel and demonstrate to the Architect/Engineer the proper operation of the control systems. The ATC Contractor shall provide a minimum 16 hours of system instruction to the owner. The first eight (8) hours of instruction shall be scheduled after the system is fully adjusted and operational. The last eight (8) hours shall be scheduled for approximately 60 days later. Explain the operation of the control system, the function of each component, the programming procedure, maintenance procedures and cautions, and be prepared to answer questions from the operating staff. In addition, be available for telephone consultation during the warranty period to answer questions from the operating staff concerning the control equipment, such consultation shall be at no cost to the Owner. Conduct class work and instruction to the extent that all attending personnel can reprogram the system should it prove necessary at a later date. Include a full and detailed explanation on how the system is programmed initially so all parties fully understand the form and function of the control system. Prior to the instruction period, the Owner will furnish the names of those individuals for whom training will be provided.

3.15 SEQUENCE OF CONTROL AND SYSTEM POINT REQUIREMENTS

A. See drawings for Control Sequences and minimum point requirements. If more points are required to provide the sequences specified, it is the ATC Contractor's responsibility to furnish the additional equipment necessary to perform these sequences.

B. Zoning: Day and night cycle control shall be grouped together in zones. Each night setback zone shall have a separate push button override switch located as directed by the Architect/Engineer, clearly labeled as to area. When enabled each switch shall bring its zone thru software, into the occupied mode for a selectable amount of time (set initially at two hours). This input can be enabled only one time per day.

C. Room Setpoints: Initial room setpoints are included with the sequence of control. The ATC Contractor shall discuss with the owner setting desired for all setpoints and make settings as directed.

END OF SECTION 15900

SECTION 15990
TESTING, ADJUSTING AND BALANCING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

The General Provisions of the Contract, including General and Supplementary Conditions and Division 1 - Specification Sections and Contract Documents apply to work in this section. Consult them for further instructions and be governed by the requirements thereunder.

1.2 WORK INCLUDED

This section covers testing and balancing of environmental systems including but not limited to air distribution systems, hydronic distribution systems, and the equipment and apparatus connected thereto . The testing and balancing of all environmental systems shall be the responsibility of one testing, balancing and adjusting firm.

1.3 RELATED WORK

A. Related work includes, but is not necessarily limited to the following:

1. Basic Mechanical Requirements: Section 15010

2. Basic Materials and Methods: Section 15050

3. Plumbing (Pumps): Section 15400

4. Heat Generation, Refrigeration and Liquid Heat Transfer: Section 15600

5. Air Distribution: Section 15800

6. Controls and Instrumentation: Section 15900

1.4 REFERENCES

A. ASHRAE - 1987 Systems Handbook: Chapter 57, Testing, Adjusting and Balancing.

B. ASHRAE - Standard 111 - 1988 Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air Conditioning and Refrigeration Systems.

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

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

E. SMACNA - HVAC Systems Testing, Adjusting and Balancing.

F. Sheet Metal Industry - Certification of Testing, Adjusting and Balancing Technicians.

1.5 QUALIFICATIONS OF CONTRACTOR

The Mechanical Contractor shall procure the services of an independent testing and balancing firm specializing in this work. The firm must have a Registered Professional Engineer, an AABC Certified Test and Balance Engineer, or a NEBB Certified Testing, Balancing and Adjusting Supervisor, who is an employee or principal of the firm, in charge of the work and must have a local office with resident personnel in the greater Denver area or within 100 miles of the project. Submit qualifications of above listed person prior to bidding. The firm must have experience and qualifications satisfactory to the Consulting Mechanical Engineer and must be accepted by him prior to bidding. All work must be done under the direct supervision of and the results attested by the person listed above. This person

shall be available to interpret all material found in the balance report and shall represent the testing and balancing firm at all requested meetings.

1.6 SEQUENCING AND SCHEDULING

A. Sequence work to commence after completion of systems and start-up procedures as described in Section 15010 and schedule completion of work before Substantial Completion of Project.

PART 2 – PRODUCTS

2.1 ACCEPTABLE AGENCIES

A. Firms acceptable to do the work are:

Jedi Balancing

Finn & Associates

B. Other firms desiring to bid the testing and balancing work shall submit a booklet of qualifications (showing procedure, data forms, list of previous experience, reference list and professional engineer's name) prior to bidding and in compliance with Section 15010 for review by the Consulting Mechanical Engineer. The Mechanical Contractor shall submit the name of the testing and balancing firm to the Engineer within 30 days of contract award.

PART 3 – EXECUTION

3.1 COORDINATION

A. Testing and Balancing Contractor shall visit the site and coordinate with Mechanical Contractor to make sure all items such as: thermometer wells, pressure test cocks, access doors, etc., are furnished and installed as required to allow tests and adjustments to be made as described in this Section.

B. The Mechanical Contractor shall provide all such devices required to allow the balancing to be accomplished.

3.2 STATUS OF SYSTEMS

A. Air and water testing and balancing shall not begin until the systems have been completed and are in full working order.

B. Put all heating, ventilating and air conditioning systems and equipment into full operation and continue operation of same during each working day of testing and balancing. Preliminary testing, adjusting and balancing requirements shall be ascertained prior to the commencement of work through a review of available plans and specifications for the project. In addition, visual observations at the site during construction shall be made to determine the location of required balancing devices and that they are being installed properly for the need.

C. Before any air or hydronic balance work is done, the system(s) shall be checked for the following:

1. Equipment is operable and in a safe and normal condition.

2. Proper thermal overload protection is in place for electrical equipment.

3. Duct system leakage has been minimized.

4. Final filters are clean and in place. (Verify that the filters are changed by the Mechanical Contractor if they are dirty.)

5. Ductwork systems are clean of debris.

6. Proper fan rotation.

7. Excessive equipment vibration.

8. All volume, fire and smoke dampers are in place and wide opened.

9. All return air paths are not obstructed (i.e. walls to structure).

10. Coil fins are cleaned and combed.

11. Access doors are closed and duct end caps are in place.

12. Air outlets are installed and connected.

13. Hydronic systems have been flushed, filled and vented.

14. Proper pump rotation.

15. Strainer baskets are clean and in place.

16. Service and balance valves are open.

17. Proper control valve installation and operation.

18. Proper system static pressure to assure a full system.

19. Proper flow meter and check valve installation.

D. All throttling devices and control valves shall be open at this time.

E. Promptly report defects or deficiencies noted during balance or abnormal conditions in the mechanical system which prevent system balance to the appropriate responsible person. Make special note of any discrepancy between tabulated conditions and specified conditions including, but not limited to, missing items, non-functioning items, items without final connections, etc., and call to the pertinent Contractor's and the Consulting Mechanical Engineer's attention. Rebalance and retabulate information as required by the Consulting Mechanical Engineer to provide a properly performing building.

F. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

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

B. Provide additional balancing devices as required.

3.4 ADJUSTING AND BALANCING

A. Adjust and balance all air and water systems within +10% to -5% of design flow rates. Check, adjust and balance all systems to meet the design conditions and tabulate all information on acceptable forms. All systems shall be checked for proper performance during design conditions, both heating and cooling.

B. Recorded data shall represent actual measured, or observed condition. Affinity or fan law conversion to obtain readings is not allowable.

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

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

E. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors or covers to electrical switch boxes, plugging test holes in ductwork where readings were taken and restoring thermostats to specified settings.

3.5 TEMPERATURE CONTROLS

A. Inspect all temperature control systems for proper sequence of operation, completeness and approximate calibration. Report any deficiencies to the responsible contractor immediately.

B. VAV Boxes (Pinch Down)

Verify the following and report any discrepancies to the responsible contractor:

1. Velocity pressure sensor is receiving the proper signal and is then sending that signal to the regulator.
2. Primary air damper will allow design flows without going to end point settings.
3. Thermostat is calibrated.
4. Control pressure is compatible with the primary damper motor range, dead band range and heating electric P.E. or valve motor range.
5. Direct acting or reverse acting controls are properly installed.

3.6 AIR BALANCE

A. Adjust air handling and distribution systems to provide required or design supply, return and exhaust air quantities at site altitude. Measure air quantities at inlets and outlets.

B. Vary total system air quantities by adjustment of fan speeds.

1. Adjust RPM on Belt Drive Fans:

   Include sheave and belt exchange to deliver air flow within limits of installed motor horsepower and mechanical stress limits of the fan. Determine the limiting fan tip speed before increasing RPM. Final fan speed setting shall allow for predicted filter loading and shall establish proper duct pressures for operation of zone CFM regulators.

2. Adjust RPM on Direct Drive Fans:
   a. For motors with speed taps, set fan speed on tap which most closely approaches design CFM. Report tap setting on equipment data sheet as high, medium or low.
   b. For motors with speed control rheostat, set output of fan at the design CFM by adjusting the rheostat. After adjustment, check the fan's ability to restart after shutdown. Increase setting as required for proper starting. Mark rheostat to indicate final setting position.

C. Vary branch air quantities by damper regulation. Effect volume control by duct internal devices such as dampers.

D. Make air quantity measurements for all mechanical air moving equipment in ducts by pitot tube traverse of entire cross sectional area of duct to verify outlet readings and as a check for ductwork leakage. Pitot tube traverse shall be provided at all ducted exhaust fan inlets. If pitot tube traverse is not practical, an explanation of why a traverse was not made must appear on the appropriate data sheet.

E. Adjust air diffusion patterns to obtain uniform space temperatures and to minimize objectionable drafts and noise. Use volume control devices to regulate air quantities.

F. Measure static pressure conditions on air supply units, including filter, coil and other equipment pressure drops, and total pressure across the fan. Make allowances for loading of filters and indicate this on the final report.

G. The supply fan static pressure shall be set by the balancing firm and the control contractor if the systems have fan volume control dampers or variable frequency drives (VFD). The duct static shall be confirmed both through the instrumentation installed on the job and by the balancing contractor. The fan speed resulting in satisfactory system performance shall be determined at full design delivery. Inlet or outlet fan volume control dampers shall be in the wide open position and one path presenting the greatest resistance to flow shall be fully open and unobstructed. For VFD installations, the fan speed (by sheaves) shall be set so that the VFD can increase fan speed to account for filter loading.

H. Adjust outside air, return air and exhaust air automatic dampers for design conditions. Adjust and record percent outside air under minimum damper position. (Adjustment of minimum outside air on percent of damper actuator position is not acceptable.)

I. Systems with economizer dampers shall have data recorded during 100% open outside air mode, 100% return air mode, and 50% open outside and return air mode.

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

K. Measure building static pressure and adjust outside, return and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries. Coordinate with Temperature Control Contractor to make system adjustments if pressure is controlled through temperature control system.

L. Adjust all terminal variable volume boxes as follows:
   1. For shutoff VAV boxes, constant volume boxes, or double duct boxes, set the regulators to provide design minimum and maximum CFM. Adjust thermostat to assure proper damper operation.

   2. For VAV or constant volume boxes with reheat, set the regulators to provide design minimum and maximum CFM. Check control sequence operation to assure proper sequencing. Reset PE switches as required.

3.7 HYDRONIC BALANCE

A. Adjust water systems to provide required or design quantities.

B. Hydronic Systems without meters (thermal or terminal rated pressure balance). The system shall be balanced proportionally to the terminal ratings. On completion of the balance the following information shall be recorded in the report: Design entering and leaving water temperature/pressure drop, final balance entering and leaving water temperature/pressure drop.

C. The hydronic system(s) shall be balanced being certain that the path to one terminal is fully open. Total system flow shall be adjusted at pump by restricting the discharge balance valve. Indicate final valve position on report.

D. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

E. Balance system with automatic control valves fully open to heat transfer elements. Control valve bypass loops shall be set with the balancing valve to provide equal flow in either mode. Confirm in writing.

F. Adjustment of hydronic systems shall be by means of balancing valves or fittings. Do not use service or shut-off valves for balancing.

G. Where available pump capacity is less than the total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to the other parts.

H. If after final balance has been completed, the system is noisy due to final valve settings, noisy valves shall be opened to decrease their noise to an acceptable level. Circuit which was left open, per Paragraph D above, shall be rechecked and recorded once system has been quieted down to determine if an adequate flow rate still remains.

3.8 ELECTRIC HEATERS

This Contractor shall check staging of heating devices and reset if required for proper operation.

3.9 MOTOR STARTERS AND THERMAL OVERLOAD RELAYS

Furnish, exchange and adjust thermals as required for proper motor protection on Mechanical Contractor furnished magnetic and manual starters. Check for correct sizing and notify Electrical Contractor of discrepancies.

3.10 REPORT OF WORK

A. This Contractor shall submit a minimum of four (4) bound copies of the final testing and balancing report at least 7 days prior to the Mechanical Contractor's request for final inspection. All data shall be recorded on applicable reporting forms. The report shall include all operating data, a list of all equipment used in the testing and balancing work, and shall be signed by the supervising engineer and affixed with his certification seal. Also include project altitude and any correction factors used in the calculations. Final acceptance of this project will not take place until a satisfactory report is received.

B. A reduced set of contract document drawing indicating 'as-built' conditions shall be included in the report with all terminals (VAV boxes, outlets, inlets, coils, unit heaters, etc.) and thermostat locations clearly marked and all equipment designated.

C. After all balancing is complete and all coordination with the contractor and the engineer is complete, the balancing firm shall furnish bound reports which contain the following information. All information listed below shall be included in report unless written approval for deletion of items is agreed to by Mechanical Engineer prior to start of balancing.

1. Title Page including company name, address and telephone number; project name and location; project Architect; project Engineer; project Contractor; project altitude.

2. Instrument list including instrument, manufacturer, model, serial number, range, calibration date.

3. Electric Motor data including manufacturer, HP, voltage, phase, amperage (name plate, actual (in all operating modes), no load), service factor, efficiency, power factor, starter size (brand, model, enclosure type, installed thermal heaters and the rating of the heaters, required thermal heaters and the rating of the heaters if different than installed).

4. V-Belt Drive data including identification/location, required driven RPM; driven sheave (diameter and RPM), belt (size and quality), motor sheave (diameter and RPM), center to center distance (maximum, minimum and final).

5. Air Moving Equipment data including location, manufacturer, model, supply air flow (specified and actual), return air flow (specified and actual), outside air flow (specified and actual), total static pressure (specified and actual), inlet pressure, discharge pressure, fan RPM, motor and V-belt drive information as previously mentioned.

6. Static pressure across each individual component of the system and the total system.

7. Exhaust Fan data including location, manufacturer, model, air flow (specified and actual), total static pressure (specified and actual), inlet pressure, discharge pressure, fan RPM, motor and V- belt drive information as previously mentioned, duct pitot tube traverse near inlet of all ducted fans.

8. Outside/Return Air data including identification/location, supply air flow (specified and actual), return air flow (specified and actual), minimum outside air flow (specified and actual), return air temperature, outside air temperature, mixed air temperature (specified and actual).

9. Air Terminal Device data including air terminal number, room number/location, terminal type, terminal size, area factor, design velocity, design air flow, test (final) velocity, test (final) air flow, percent of design air flow. Include summary sheet for each system showing total terminal air flow by outlet and required total system air flow.

10. Terminal Unit data including manufacturer, type (constant, variable, dual duct, reheat, fan powered parallel, fan powered-series), identification/number, location, model, size, minimum static pressure, minimum air flow (specified and actual), maximum air flow (specified and actual), inlet static pressure, fan air quantity (specified and actual) on fan powered terminal units, motor data as previously mentioned on fan powered terminal units.

11. Duct Traverse data including system zone/branch, duct size, area, design velocity, design air flow, test velocity, test air flow, duct static pressure, air temperature, air correction factor. Reduced drawings included with balance report shall indicate all duct traverse locations.

12. Total CFM (required and final) for each fan system, including ducted cabinet heaters, unit heaters, fan coils, etc. Compare equipment air volumes measured by duct traverse readings to air terminal summary sheets for each piece of equipment.

13. Pump data including identification/number, manufacturer, size/model, impeller, service, flow rate (specified and actual), pressure rise (specified and actual), discharge pressure (full-flow and no-flow), suction pressure (full-flow and no-flow), total operating head pressure, motor data as previously mentioned. Include manufacturer's pump curves in report. For installations where pumps are sequenced for lead/lag, operation provide lead pump (each pump) and lag pump (all pumps) operational information. This shall include flow rate, pressure rise, discharge pressure, total operating head, and all operating motor data for both pumps at all operating conditions.

14. Air Cooled Condenser data including identification/number, location, manufacturer, model, entering DB air temperature (specified and actual), leaving DB air temperature (specified and actual), number of compressors, motor data as previously mentioned.

15. Boiler data including water flow rate (specified and actual), entering and leaving water temperature, steam pressure leaving boiler, gas flow rate, flue gas analysis (copy of manufacturer's analysis report), entering and leaving water pressures, motor data as previously mentioned (if applicable). Temperature readings are not required if flow rate measurements can be obtained. Mechanical Engineer may request these temperature readings if required for trouble shooting system.

16. Heating Coil data including identification/number, location, service, manufacturer, air flow (specified and actual), water flow (specified and actual), water pressure drop (specified and actual), entering and leaving water temperatures (specified and actual), entering and leaving air temperatures (specified and actual), air pressure drop (specified and actual). Temperature readings are not required if flow rate measurements can be obtained. Mechanical Engineer may request these temperature readings if required for trouble shooting system.

17. Flow Measuring Station and Calibrated Balancing Valve data including identification, location, size, manufacturer, model, flow rate (specified and actual), pressure drop (specified and actual), station or valve calibrated setting.

18. Gas flow and pressure to each piece of mechanical equipment and gas pressure at meter under full flow.

3.11 COMPLETION SERVICES

A. The balancing firm shall make any changes of fan belts and sheaves to obtain the required cfm and make other corrections to the systems for proper performance as requested by the Consulting Mechanical Engineer or Owner.

B. Final acceptance of the project will not be made until a satisfactory report is received. When deemed necessary by the Owner or Engineer, the balancing firm shall run temperature and/or humidity recordings and shall read any of the report quantities in the presence of the Owner or Engineer for verification purposes.

END OF SECTION 15990