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SECTION 21 0000

FIRE PROTECTION

PART 1 - GENERAL

1.1 GENERAL

A. Division 0 and Division 1 of these specifications are hereby made a part of this section.

1.2 WORK INCLUDED

A. The intention of the specifications and plans is to provide finished systems, properly tested and ready for operation, including necessary minor details and accessories required to make the work complete, even though such items may not be expressly shown or specified for all systems herein specified and shown on the drawings.

B. The scope shall include, but not be limited to, the following:

1. Complete wet pipe sprinkler system.
2. Modification of existing sprinkler system.
3. Preparation of complete and detailed working plans in accordance with NFPA 13 including hydraulic calculations.
4. Fire department connection.
5. Inspector's test stations, drain valves and piping.
6. Testing.
7. Flush existing sprinkler system per NFPA 25.
8. Alternate – Complete Fire Pump System.

C. The work covered by this section of the specifications includes the furnishing of all labor and materials and in performing all operations in connection with the installation of the fire protection work shown on the drawings and as described herein and shall be interpreted as work to be performed by other trades will always be specifically referenced to a particular Contractor and/or section.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. The following items of labor and material incidental to or related to the installation of the Fire Protection work shall be provided by others at no cost to this Contractor.

1. Cutting and patching shall be as provided under General Conditions.
2. Flashing and counterflashing shall be provided under Division 7.
3. All finished field painting shall be provided under Division 9.
4. Electrical work shall be provided under Section 260000.
5. All electric interlock wiring and remote control wiring required for the fire protection systems shall be furnished and installed under the Electrical Section to the extent shown on the electrical drawings. All interlock and control wiring not specifically shown on the Electrical drawings but required for correct operation of the fire protection systems shall be included as work under the fire protection section of these specifications.

1.4 DEFINITIONS

A. "This Contractor" or "F.P.C." means specifically the Fire Protection Contractor working under this respective section of the specifications.

B. "Furnish and install" and "provide" means to supply, erect, install and connect in readiness for regular operation, the particular work referred to, unless otherwise specified.

C. "Concealed" shall mean hidden from sight in walls, in chases, furred spaces, above ceilings, within enclosed cabinets, underground, in trenches or otherwise enclosed.

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

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

1.5 CODES, ORDINANCES AND PERMITS

A. All work performed under this section of the specifications shall be done in accordance with the applicable National, State and local codes, laws and ordinances.

B. All materials and work provided shall be in accordance with, but not limited to, the following:

1. American National Standards Institute (ANSI).
2. American Society for Testing and Materials (ASTM).
3. Building Officials and Code Administrators (BOCA).
4. National and State Electrical Code (NEC).
5. National Electrical Manufacturer's Association (NEMA).
6. National Fire Protection Association Codes and Standards (NFPA).
7. Occupational Safety and Health Act (OSHA).
8. State Building Codes
9. Standards of Underwriters Laboratories (UL)
10. NFPA Pamphlets:
    a. No. 13 – Installation of Sprinkler Systems
    b. No. 20 – Electric Fire Pump Systems
    c. No. 25 – Inspection, testing and maintenance of water based fire protection systems.
11. State Department of Public Safety
12. Local Fire Department requirements.
13. Local Water Department requirements.
14. Owner's insurance company.
15. Insurance Service Organization (ISO).
16. Factory Mutual (FM)

C. Where code references are given, the latest issue of that code in effect at the time of bidding shall be used. Code references given to indicate the minimum quality and performance acceptable. Where specifications and/or drawings indicate more stringent requirements, the specification shall govern.

D. Permits: Be responsible for filing all documents, payment of all fees and securing of all inspections and approvals necessary for the installation and operation of all systems furnished under this section.

E. Where the contract documents indicate more stringent requirements than the above codes and ordinances, the contract documents shall take precedence.

F. Include in the work, without extra cost to the Owner, any labor, materials, services, apparatus, drawings, in addition to contract drawings and documents in order to comply with all applicable local ordinances and regulations, whether or not shown on drawings and/or specified.

G. It shall be the responsibility of this Contractor to prepare drawings showing complete and fully coordinated sprinkler head and piping layouts in accordance with the requirements of NFPA and those authorities having jurisdiction over this project. It shall also be the responsibility of the Sprinkler Subcontractor to obtain all approvals from local authorities and the Owner's Insurance Underwriter prior to submission to the Architect.

1.6 WORKING PLANS

A. Submit working plans and hydraulic calculations signed and sealed by a Professional Fire Protection Engineer registered in the state in which the project is located, to authorities that have jurisdiction, including:

1. Architect/Engineer
2. Insurance Underwriter – Factory Mutual Global Guidelines
3. Fire Department
4. State Fire Marshals Office

B. Working plans and computerized hydraulic calculations shall be prepared by a minimum Level 3 N.I.C.E.T. certified sprinkler layout designer. Drawings shall be signed and the N.I.C.E.T. certificate number indicated on the plan.

C. Working plans shall be at least 1/8 inch = 1'0" scale on sheets of uniform size. Working plans shall show all data required by NFPA Nos. 13 and 14. Submit working plans in one complete package.

D. Working plans will be subject to the Architect's final approval. Submit these plans to the Architect after review by other authorities. If necessary to submit plans to the Architect before review by other authorities, identify authorities that have not reviewed plans and resubmit for final approval when review by all parties is complete.

1.7 DRAWINGS AND SPECIFICATIONS

A. Drawings:

1. The drawings are generally diagrammatic and are intended to convey the scope of work and are to indicate the general arrangement of equipment, and piping. The drawings are not intended to show each and every detail of construction.
2. This Contractor shall refer to the drawings showing the work to be done under this section of the specifications and also all other drawings related to the work to be done under other sections so that he has full comprehension of the scope of his work and its relationship to the other sections of the work.
3. Certain details indicated on the drawings are general in nature and specific labeled detail references to each and every occurrence of use are not indicated; however, such details by their titles shall be applicable to every occurrence on the drawings.
4. The Architect reserves the right to make reasonable modification to the arrangement of outlets, apparatus and equipment up to the time of roughing piping without incurring extra cost to the Owner.

B. Specifications:

1. Specifications are intended to complement the drawings; however, work detailed and/or noted only on the drawings or work described only in the specifications shall also be considered as part of the scope of work.

2. Work shall be performed as described above in the specifications, except where specific deviations are indicated and/or noted on the drawings.

1.8 SHOP DRAWINGS, PRODUCT DATA AND SAMPLES

A. Refer to General Conditions, Shop Drawings, Product Data and Samples and add the following:

1. All submittals shall be complete and shall be in three-ring loose-leaf binders. No consideration will be given to partial submittals, except with prior approval of the Architect. Each item shall have a cover page stating project, specification and paragraph reference number, or drawing reference number, and scheduled equipment identification number, if applicable.

2. The review of submittals does not relieve this Contractor from the responsibility of shop drawing errors in details, sizes, quantities, wiring diagram arrangements and dimensions which deviate from the specifications, contract drawings, and/or job conditions as they exist.

3. Changes to work already performed made necessary by delays in shop drawing review are the responsibility of this Contractor.

4. Copies of equipment and system guarantees shall be submitted with shop drawing package.

B. Refer to General Conditions for substitution of equipment.

C. If apparatus or materials are substituted for those specified under this section, and such substitutions necessitate changes in or additional connections, supports or construction, same shall be provided at no additional cost to the Owner. This Contractor shall assume cost and entire responsibility thereof. Architect's permission to make such substitution shall not relieve this Contractor from full responsibility for work.

1.9 EXAMINATION OF SITE AND CONTRACT DOCUMENTS

A. Refer to General Conditions and add the following:

1. Bidders are advised to visit the site and inform themselves as to conditions under which this work will be performed prior to submitting prices. Failure to do so, will, in no way relieve the successful bidder from the responsibility of furnishing any materials or performing any work in accordance with the true intent and meaning of the drawings and specifications.

2. No claim for extra compensation will be recognized if difficulties are encountered which an examination of the site conditions and contract documents prior to executing the contract would have revealed.

3. This Contractor shall be responsible for ordering and furnishing the correct quantity of material required. Routing and equipment arrangements shown on the drawings are approximate only and are not warranted to be accurate.

4. Arrangements shall be made with the Owner prior to the visit for inspection of the existing buildings.

1.10 RECORD DRAWINGS

A. The General Contractor shall provide two (2) sets of blackline on white record drawings to this Contractor, one set of which shall be maintained at the site and which shall, at all

times, be accurate, clear and complete, showing the actual location of all equipment and piping. The record drawings shall be available to the Architect's/Engineer's field representative at all times.

B. Any addenda sketches, supplementary drawings and change orders issued during the course of construction shall be transferred to the record drawings.

C. At the completion of this contract, this Contractor shall submit through the General Contractor an accurate checked set of record drawings.

D. Non-availability of record drawings or inaccuracies therein shall postpone the final inspection until they are available.

E. After approval of these record drawings, photo reproductions of the original tracings shall be revised to incorporate all the changes on the record drawings. These photo reproductions shall be certified by this Contractor as correct and delivered to the Architect together with two (2) sets of blackline prints.

F. All costs related to the foregoing requirements shall be paid for this Contractor.

G. All valves shown on these drawings shall be numbered with numbers corresponding to those on the valve charts.

1.11 USE OF ELECTRONIC DRAWING FILES

A. If requested, the Engineer will provide electronic copies of selected CAD (Computer Aided Design) drawing files for the Contractor's use in the preparation of shop drawings, coordination drawings, or as-built drawings related to this project, subject to the terms and conditions in the following paragraphs.

B. The Engineer's electronic files are prepared on AutoCad Release 2007. The Engineer will provide drawing files through Release 2007.

C. Data contained on these electronic files is part of the Engineer's instruments of service and shall not be used by the Contractor or anyone else receiving this data through or from the Contractor for any purpose other than as a convenience in the preparation of shop drawings, coordination drawings, or as-built drawings for the referenced project. Any other use or reuse by the Contractor or by others will be at the Contractor's sole risk and without liability or legal exposure to the Engineer. In accepting these files, the Contractor shall agree to make no claim and shall waive, to the fullest extent permitted by law, any claim or cause of action of any nature against the Engineer, its officers, directors, employees, agents of the Engineer, which may arise out of or in connection with the Contractor's use of the electronic files.

D. Furthermore, the Contractor shall to the fullest extent permitted by law, indemnify and hold harmless the Engineer from all claims, damages, losses and expenses, including attorney's fees arising out of or resulting from the Contractor's use of these electronic files.

E. These electronic files are not contract documents. Significant differences may exist between these electronic files and corresponding hard copy contract documents due to software incompatibility, software translation, addenda, change orders or other revisions. The Engineer makes no representation regarding the accuracy or completeness of these electronic files. In the event that a conflict arises between the hard copy contract documents prepared by the Engineer and the electronic files, the hard copy contract documents shall govern. The Contractor is responsible for determining if any conflict exists. By use of these electronic files, the Contractor is not relieved of his duty to fully comply with the contract documents, including and without limitation, the need to check, confirm and coordinate all dimensions and details, take field measurements, verify field conditions and coordinate all work with that of other contractors for the project.

F. Because of the potential that the information presented on the electronic files can be modified, unintentionally or otherwise, the Engineer reserves the right to remove all indication of their respective ownership and/or involvement from each electronic file provided.

G. A service fee of $65.00 per sheet shall be remitted directly to the Engineer prior to delivery of the electronic files. Arrangements shall be made directly with the Engineer for files prepared by them. Electronic files will not be released until payment is received. A written release to be prepared by the Engineer will be required as well.

H. Under no circumstances shall delivery of the electronic files for use by the Contractor be deemed a sale by the Engineer, who make no warranties, either expressed or implied, of merchantability and fitness for any particular purpose. In no event shall the Engineer or its consultant(s) be liable for any loss of profit or any consequential damages arising out of the use of these electronic files.

1.12 WARRANTY

A. Refer to General Conditions and add the following:

1. Standard equipment guarantees offered by the manufacturer for one (1) year or greater shall be in addition to that as required by this contract.

2. Copy of manufacturer's equipment guarantees shall be submitted with this Contractor's written guarantee.

1.13 ALTERNATE

A. Provide an add alternate for a complete electric sprinkler booster pump system with an estimated capacity of 500 gpm. The alternate shall include a new 8" fire service from the site, double check valve, controls combustion air and ventilation with 2 hour egress to the exterior and appurtenances. The system shall be in accordance with NFPA pamphlet No. 20.

PART 2 – PRODUCTS

2.1 HANGERS

A. Hangers and hanging methods shall be per NFPA 13 Standards or more stringent requirements as specified herein. All hangers, clamps, rods, shields, etc., shall be UL listed and FM approved.

B. Piping 3” and smaller shall be supported using standard adjustable flat iron hangers.

C. Sprinkler piping shall be substantially supported from the building structure and must support the load of the water filled pipe plus a minimum of 250 lb. applied at the point of hanging.

D. The use of toggle type hangers of any kind or wall and ceiling plates will not be allowed.

E. Hangers shall be manufactured by Grinnell Company, F&S Central, Fee and Mason or equal.

F. Hangers shall be in accordance with provisions of NFPA Pamphlets #13 and #13R and/or FM requirements.

2.2 PIPE AND FITTINGS

A. Pipe shall be new, designed for 175 PSI working pressure, conform to NFPA, ANSI and ASTM Standards, manufactured in the United States, and have the manufacturer’s name or brand, along with the applicable ANSI or ASTM Standard, marked on each length of pipe. All piping systems shall be FM approved.

B. Above ground wet pipe sprinkler systems. Pipe material shall be welded and seamless steel pipe, Schedule 40, threaded ASTM A53, for sizes 2" and smaller, larger than 2" shall be Schedule 10 rolled groove, steel piping.

C. Screwed fittings for Schedule 40 pipe shall be cast iron, 125/250 pound. Malleable iron screwed fittings shall not be permitted.

D. Piping and fittings of the plain end type with gasket and locking device will not be considered for use on this project.

E. Pipe fittings and couplings used in sprinkler systems shall be of the materials indicated within this section and shall be designed to withstand a working pressure of not less than 175 psi.

2.3 PIPING ACCESSORIES

A. Pressure gauges shall be Marsh Type JR4000 Standard Gauge, 4½ inch dial, recalibrator bushed, copper alloy bourdon tube, 2 percent accuracy, 304 stainless steel case, 1/4 inch national pipe thread bottom connection and brass gauge cock.

B. Gauges shall be mounted in a position readable from the floor.

2.4 SPRINKLER HEADS

A. Furnish and install sprinkler heads of the type indicated and where shown on the drawings or as required for the particular area in accordance with NFPA guideline. Temperature ratings shall be as required for the area protected. Sprinkler heads shall be UL listed and FM approved.

B. Sprinklers shall be glass-bulb type. Body shall be die-cast brass with wrench-shaped hex boss cast into the body to facilitate installation and reduce the risk of damage during installation.

C. Concealed pendant and sidewall sprinkler heads with white cover plates. Pendants shall be adjustable height design. Victaulic Model V38.

D. Upright sprinkler heads of conventional design shall be installed in unfinished area such as basements. Victaulic Model V27.

E. Sprinkler heads shall be quick response, concealed, 155°F rating, low profile, glass bulb, in the living spaces,.

F. All sprinkler heads and piping shall be located within soffit enclosures, where indicated.

2.5 SPARE HEADS

A. This Contractor shall furnish spare heads equal to the following:

1. For systems having less than 300 sprinklers, not fewer than 10 sprinklers.

2. For systems with 300 to 1000 sprinklers, and not fewer than 15 sprinklers.

3. For systems with over 1000 sprinklers, not fewer than 24 sprinklers.

B. Heads shall be packed in a suitable container and shall be representative of, and in proportion to, the number of each type and temperature rating heads installed. In addition, two (2) sprinkler head wrenches shall be provided.

2.6 ALARM SWITCHES

A. Furnish and install all tamper and flow switches required to supervise all valves and alarm all fire zones. All devices shall be UL listed and FM approved. Wiring shall be under Section 260000.

B. Tamper switches include red tamper-proof switch housing and shall be Potter OSYS style, Gem Model F640, or Simplex #OSYS-U.

C. Flow switches shall include red tamper-proof switch housings, flow paddle, adjustable pneumatic retard setting 0-70 seconds, voltage compatible with the fire alarm system. This Contractor shall set the retard as directed by the local fire department or 45 seconds if no preference. Potter VSR-D, Gem Model WFD, or Simplex VSR-F.

2.7 TEST AND DRAIN CONNECTIONS

A. Drains and test connections shall be provided in the systems as required. Drains shall be provided at all low points in the piping, at base of all risers and wherever necessary to insure that all portions of the sprinkler piping may be completely drained.

B. Test connections shall consist of drain piping with globe valve piped to the sump pit in the Basement. Pipes through outside walls shall be IPS brass or copper pipe with sleeve caulked watertight. All test connections through outside walls shall exit at Ground Floor level in a location and manner approved by the Architect and Engineer.

2.8 VALVES

A. All valves shall be free from defects and shall be stamped or marked with the manufacturer's name, and FM and UL approved. All isolation valves shall be provided with tamper switches. Valves shall be by a U.S. manufacturer and be rated for 175 PSI working pressure.

B. Ball valves 2" and smaller shall be bronze, standard port, chrome-plated brass ball, stainless steel stem, TFE seats, brass gearbox with pre-wired supervisory switches, rated for 350 PSI working pressure, with grooved or threaded ends. Victaulic FireLock® Series 728.

C. Gate valves shall be of the 175 PSI standard class. Valves two inches and smaller shall be all bronze, with rising stem and screwed ends. Over two inch sizes shall be bronze mounted, ductile iron body, outside screw and yoke type, grooved or flanged. The interior main service valve and fire pump suction valves must be OS&Y gate type valves. Grooved end OS&Y gate valves shall be Victaulic Series 771.

D. Butterfly valves 2½" and smaller shall be slow closing with visual position indicator, built-in supervisory tamper switch, ASTM 584 bronze body and housing, brass or cast iron handle, Type 304 stainless steel disc, EPDM elastomer seal, cast aluminum switch housing, grooved or threaded ends, Milwaukee Butterball BB SC Series or equal as manufactured by Central or Viking. The supervisory switch shall be SPDT rated for 10 amps, 115 VAC, .5 amps, 28 VDC. The entire assembly shall be UL listed, FM approved and rated for 175 PSI working pressure. Butterfly valves shall not be used on the suction of the fire pump or as the main fire service valve.

E. Check valves shall be installed horizontally and be iron body, bronze mounted, swing type, flanged ends, automatic ball drip, with manufacturer's name, pressure rating and year of manufacturer cast on body.

2.9 FIRE SAFING

A. Where piping passes through fire rated walls, floors and ceilings, provide a fire safing system so as to maintain the integrity of the rated assemblies to the satisfaction of the Architect and the Building Inspector. The fire safing system shall be as manufactured by 3M, Dow, Bio-Fire Shield or Nelson. Provide manufacturer's details or custom details when there are no manufacturer's details for each condition with a UL listing referenced. Where piping is insulated, pipe insulation shall run continuous through the rated opening. Details shall show the required depth and annular space width requirements and limitations and any packing requirements.

B. Refer to architectural drawings for rated walls and partitions. When there are no architectural drawings or they do not indicate rated walls and partitions, the following guidelines shall be used. All floors, corridor walls, party walls, mechanical room walls, duct and pipe chase walls, stairwells, trash room and chute walls shall be considered minimum two hour fire rated walls.

2.10 FIRE PUMP (VERTICAL – ELECTRIC) ADD ALTERNATE NO. 3

A. Furnish and install where shown on drawings one (1) Aurora Fire Pump System complete with pump, driver, automatic controller and necessary accessories. The fire pump shall be designed to deliver 500 GPM when operating against a total dynamic head of 100 PSIG. The pump shall also deliver not less than 150 percent of rated capacity at a pressure not less than 65 percent of rated pressure. The shut-off (no flow) head shall not exceed 120 percent of rated head. Suction pressure is 30 PSIG. These conditions include 10 psi FM allowance. Pump systems manufactured by Aurora or Patterson are acceptable equals.

B. The fire pump shall be a Aurora, Compact Fire Pump system, 4-383-78, or equal system as manufactured by Patterson Pump. Series of in-line construction specifically labeled for fire service and shall be connected to the underground fire main system. The pump casing shall be cast iron with 4 - inch 125 pound rating suction and 4 inch (125) pound rating discharge flanges machined to American National Standards Institution (ANSI) dimensions. The pumping unit shall be listed by Underwriters Laboratories, Inc., and approved by (Factory Mutual Research Corporation (FM). The unit shall meet all the requirements of the National Fire Protection Association (NFPA) Pamphlet #20, Standard for the Installation of Fire Pumps, and be acceptable to the authority having jurisdiction. Where conflicts arise between the NFPA and the approving authority, the authority's requirements shall take precedence.

C. The pump manufacturer shall furnish piping accessory items for the pump installation which will adapt the pump connections to the fire protection system and test connection as follows. Fittings subjected to pump discharge pressure shall be ANSI (125) (250) pound rating. Fittings subjected to suction pressure shall be ANSI 125 pound rating. Accessories include, but are not limited to:

1. 4" x 6" eccentric suction reducer.

2. 4” x 6” concentric discharge increaser.
3. Suction and discharge pressure gauges.
4. Pump casing relief valve.
5. Automatic air relief valve.
6. Main relief valve, direct acting with discharge to the exterior.
7. (2) 2-1/2” hose valves test header with caps and chains.
8. Relief cone.
9. Discharge fitting.
10. Coupling guard.
11. Splash shield.
12. Ball drip guard.
13. Capacity plate and approval stamps.

D. The pump driver shall be motor rated 40 HP, 3500 RPM, 3 phase, 60 hertz with open drip-proof NEMA enclosure for operation on 480 volt service. The motor shall be of such capacity that 115 percent of the full load ampere rating shall not be exceeded at any condition of pump load for UL listed fire pump systems and 110 percent of full load for FM approved fire pump systems. The motor locked rotor current shall not exceed the values stated in NFPA Pamphlet #20.

E. The pump and motor shall be mounted on a common steel baseplate connected by a flexible coupling protected by a suitable guard. The fire pump manufacturer shall accurately align the pump and motor shafts prior to shipment. After field installation, but prior to grouting the base, a millwright or similarly qualified person shall check and verify or correct the shaft alignment.

F. All pumps where the suction pressure is expected to average 40 psi or below shall be provided with a lantern ring connected to the pressure side of the pump by a cored passage in the parting flange of the pump. Stuffing boxes shall be equipped with split bronze packing glands designed for easy removal for packing inspection and maintenance.

G. The automatic electric motor controller shall be UL listed and FM approved specifically for fire pump service with all circuit breakers, inter-connecting wiring, etc.. The controller shall be completely assembled, wired and tested by the manufacturer prior to shipment from the factory, and shall be labeled “Fire Pump Controller”. (The controller shall be located as close as practical to and within sight of the motor. It shall also be so located and protected to avoid being damaged from water escaping from the pump or connections.) (The controller shall be mounted on a common base with the pump and motor, and wired to the motor by the pump manufacturer.) The controller shall be combined manual and automatic, designed for across-the-line type starting, rated for the horsepower specified within this specification and shall be complete with the following:

1. Disconnect Switch – Externally operable, quick-break type.
2. Motor Starter – Across-the-line type capable of being energized automatically through the pressure switch or manually by means of an externally operable handle.
3. Pressure switch set to cut in at 30 psig and out at 100 psig (total discharge pressure).

4. Running Period Timer: Set to keep motor in operation, when started automatically, for a minimum period of one minute for each 10 HP motor rating, but not to exceed 7 minutes.

5. Pilot Lamp: To indicate circuit breaker closed and power available.

6. Ammeter test link and volt meter test studs.

7. Alarm Relay: To energize an audible or visible alarm through an independent source of power to indicate circuit breaker open or power failure.

8. Manual Selection Station: A two position station shall be provided on the enclosure marked “Automatic” and “Non-Automatic”.

9. Means shall be provided on the controller to operate an alarm signal continuously while the pump is running.

Control equipment shall meet all requirements of NFPA Pamphlet #20.

H. The pump shall be hydrostatically tested and run tested prior to shipment. The hydrostatic test shall be conducted at a pressure not less than 150 percent of the no flow (shut-off) head of the pump’s maximum diameter impeller plus the maximum allowable suction head, but in no case less than 250 psig.

I. A field acceptance performance test shall be conducted upon completion of pump installation. The test shall be made by flowing water through calibrated nozzles, approved flow meters or other such accurate devices as may be selected by the authority having jurisdiction. The test shall be conducted as recommended in NFPA Pamphlet #20 by (the installing contractor) (the Owner) (the Owner’s representative) in the presence of the authority having jurisdiction and with that authority’s final approval and acceptance. Failure to submit documentation of factory and field tests will be just cause for equipment rejection.

J. Furnish a jockey pump having a capacity of 5 GPM at 70 feet TDH at 3500 RPM with 30 PSIG suction pressure.

K. Pump shall be coupled to 1HP, 3500 RPM, 3 phase, 60 cycle, 480 volt, open-drip-proof motor. For control of pump, furnish an adjustable pressure switch, an air circuit breaker, a magnetic across-the-line starter, a selector switch and a minimum run period timer, all in a single NEMA 1 enclosure.

L. The pump and electric motor shall be thoroughly shop-tested by the respective manufacturers as required by NFPA Pamphlet No. 20. The control panel shall also be tested as a unit. All such tests shall be conducted prior to shipment.

M. The pumps, driver, controller and all accessories shall be purchased under a unit contract. The pump shall be given a complete performance test with POSITIVE SUCTION PRESSURE. A certified performance curve shall be prepared and submitted. Pumps shall also be hydrostatically tested to twice the shut-off pressure, but in no case less than 250 pounds per square inch.

N. The pump manufacturer shall assume unit responsibility and shall provide the services of a factory trained representative to supervise and/or be available to conduct final field acceptance tests.

O. This Contractor shall furnish an additional alarm panel for mounting the front desk and a point to the building automation system.

PART 3 – EXECUTION

3.1 MATERIALS AND WORKMANSHIP

A. All materials installed in this work shall be new, unless noted otherwise, without damaged functional or aesthetic components. All equipment finishes shall be touched up with matching finishes where slight scratches occur. Equipment or material subject to severe deterioration shall be completely refinished or replaced as directed by the Architect.

B. All labor utilized in the installation of the work shall be experienced in the respective trade required. Installation of exposed finished materials shall be neatly done flush, straight and/or plumb, without distortion, meeting the building finished surfaces.

C. Where labor to be furnished must meet specific code requirements, only individuals certified to do such shall be used.

3.2 COORDINATION

A. This Contractor shall give full cooperation to all other trades and shall furnish any information necessary to permit the work of all trades to be installed satisfactorily and with least possible interference or delay. If this Contractor installs his work before coordinating with other trades or so as to cause interferences with work of other trades, he shall make necessary changes in the work to correct the condition without extra charge. In areas, if due to construction conditions, more than one trade is required to use common openings in beams, chases, shafts, etc., this Contractor must plan and locate the positions of items of piping, etc., which are under the scope of his contract with that of items under the scope of other contractors, in order that all items may be accommodated within the space available. Location and positioning shall be done prior to installation and to the satisfaction of the Architect and/or Engineer.

B. This Contractor shall obtain detailed printed information from the manufacturer of equipment which he is to provide for the proper methods of installation. He shall also obtain all information from the General Work Contractor and others which may be necessary to facilitate his work and the completion of the whole project. All equipment shall be installed in strict accordance with the manufacturer's recommendations.

C. This Contractor shall include under coordination work, the installation of all systems in conformance with governing codes. This Contractor is advised that no piping, ducts or equipment foreign to the electrical equipment shall be permitted to be installed in, enter or pass through such spaces or rooms provided for switchboards and panelboards in accordance with Article 384 of the National Electrical Code.

3.3 PROTECTION AND CLEAN-UP

A. Refer to General Conditions and add the following:

1. This Contractor shall be responsible for maintenance and protection of all materials and equipment, furnished by him, during the construction period from loss, damage or deterioration until final acceptance by the Owner. All materials and equipment on the job site shall be suitably stored and unprotected from the weather. All piping and equipment openings shall be temporarily closed during construction to prevent obstruction and damage.

2. This Contractor shall, at all times, keep the site clear from the accumulation of waste materials and rubbish caused by his operations. At the conclusion of work, all materials and equipment used in the work shall be removed from the site. All equipment and systems shall be thoroughly cleaned of construction debris. All equipment with finished damaged surfaces shall be cleaned and repainted with the same paints as were factory applied.

B. All equipment with damaged finished surfaces shall be cleaned and repainted with the same paints as was factory applied.

3.4 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

A. This Contractor shall instruct, to the Owner's satisfaction, such persons as the Owner designates, in the proper operation and maintenance of the systems and their parts. Submit to the Architect a letter naming the person or persons so instructed and the date of such instruction.

B. Furnish operating and maintenance manuals in accordance with General Conditions and forward same to the Architect for transmittal to the Owner.

C. The operating instructions shall be specific for each system and shall include copies of posted specific instructions.

D. For maintenance purposes, provide shop drawings, parts lists, specifications and manufacturer's maintenance bulletins for each piece of equipment.

E. Provide names, addresses and telephone numbers of the manufacturer's representative and service company for each piece of equipment so that service or spare parts can be readily attainable.

F. At the conclusion of the operating instructions, this Contractor shall have the Owner's personnel sign off stating they have received the required instruction. Separate statements shall be required for each piece of equipment and system. These statements shall include date, names of Owner's representatives, name of instructor and brief description of equipment or system.

3.5 SYSTEM START-UP AND OPERATION

A. This Contractor shall provide all labor and materials and services necessary for the initial start-up and operation of all systems and equipment furnished and installed under this section of the specifications.

B. This Contractor shall provide the services of a qualified representative for all major equipment pre-start set-up, start-up and initial operation. Such periods shall be sufficient to insure proper operation of systems and equipment.

C. This Contractor shall check all equipment during initial start-up to insure correct rotation, proper lubrication, adequate fluid flows, non-overloading electrical characteristics, proper alignment and minimal vibration. Systems shall be checked for water flows throughout without blockages.

D. During operation of the systems qualified licensed personnel shall be provided and designated for maintenance of equipment and systems in good running order. Items such as strainer cleanouts, bearing lubrication, packing replacement and other consumables shall be provided without cost to the owner. Failure of equipment during this period due to lack of proper supervision is the responsibility of this Contractor, and continued failures shall be grounds for the Owner to provide such services with back-charges to this Contractor.

3.6 SYSTEMS IDENTIFICATION

A. All Equipment furnished shall be marked with screwed-on nameplates. Nameplates to be of black phenolic with white engraving.

B. Equipment identification designations shall be taken from equipment schedules as indicated on the drawings.

C. All service piping which is accessible for maintenance operations (except piping in finished spaces) will be identified with Seton "SETMARK" semi-rigid plastic (not pressure sensitive) identification pipe markers or equal. Direction of flow arrows are to be included on each marker, unless otherwise specified.

D. In conformance with "Scheme for the Identification of Piping Systems" (ANSI A13.1-1996) each marker must show approved color-coded background, proper color of legend in relation to background color, approved legend letter size and approved marker length.

SETMARK snap-in-place markers for all pipe sizes.

E. Locations for pipe markers to be as follows:

1. Adjacent to each valve and fitting.
2. At each pipe passage through wall, floor and ceiling construction.

SETMARK pipe markers as manufactured by Seton Nameplate Company, Bradford, CT.

3.7 EXISTING WORK AND DEMOLITION

A. This Contractor shall participate in the survey of the existing fire protection systems. He shall disconnect and cap all service lines to be disconnected for those services which normally are included in his field of work. Particular care shall be taken to avoid creating hazard or causing disruption of services in adjoining areas.

B. The demolition, including the dismantling and removal of existing equipment and/or materials therein, shall be performed by the individual contractors.

C. Disconnect and cap all piping back to the nearest concealed joint from all walls or partitions which are removed, as shown on the drawings.

D. Reroute all concealed piping which passes through or extend beyond the walls or partitions to be removed.

E. All equipment removed shall be turned over to the Owner unless indicated to be reused or scrapped.

F. Materials shall be disposed of off site in a legal and proper manner by this Contractor.

3.8 CUTTING AND PATCHING

A. This Contractor shall be responsible for all required cutting and drilling associated with his work.

B. All cutting and drilling involving structural elements shall be provided by the General Contractor.

C. All rough patching and finish patching shall be provided by the General Contractor.

3.9 SAFETY REQUIREMENTS

A. This Contractor shall comply with the provisions of the "Construction Safety Act" and the "Occupational Safety and Health Act of 1970", as well as all other applicable Federal, State and local requirements.

B. This Contractor shall be responsible for the safety, efficiency an adequacy of his plant, appliances and methods, and for any damage which may result from their failure or their improper construction, maintenance or operation.

C. This Contractor shall notify the General Contractor of any flammable, combustible and/or toxic materials intended for use on this project and shall furnish the General Contractor literature pertinent to the use and control of such materials.

D. This Contractor shall delegate one (1) representative to act as Safety Engineer, who shall be responsible to maintain all safety requirements of the Trade Contractor and shall attend all project safety meetings scheduled by the General Contractor.

3.10 SPRINKLER SYSTEM

A. Furnish and install a complete wet sprinkler system as indicated on the drawings. The system shall include piping, valves, fire department connection, heads, flow switches and any appurtenances and incidentals required to make a complete and operable system.

B. This Contractor shall submit sprinkler layouts and hydraulic calculations to Owner's Insurance Company and local Fire and Building Department for approval before submitting to Architect/Engineer prior to start of installation.

C. Sprinkler heads shall be installed only after piping has been tested and accepted, and after all ceilings are installed. Do not use sprinkler heads as caps/plugs during testing.

D. Sprinklers shall be installed in accordance with following schedule:

1.	Public areas with ceilings	Concealed Type
2.	Mechanical Rooms with ceilings	Recessed Type
3.	Exercise, Weight Room areas	Concealed Type
4.	Field House	Upright
5.	Pool area	Corrosion-Resistant, Recessed Type

3.11 SYSTEM DESIGN

A. Furnish and install a complete combined automatic wet pipe sprinkler system within the building hydraulically designed.

B. The drawings indicate preferred riser and main sprinkler pipe locations.

C. Design density shall be as follows:

D. The general sprinkler system shall be hydraulically designed utilizing a density of .10 over 1,500 square feet. Maximum sprinkler head spacing shall be 200 square feet per head. Provide an allowance of 250 GPM for hose stream at the base of the riser.

E. The complete fire protection system shall be flushed, fully tested, accepted by the local Fire Department and in operation prior to final acceptance by the Engineer. Flush existing fire service and fire protection piping prior to connecting to new piping and equipment.

F. The base system calculation shall be based on the Fire Department enhancement of 500 gpm at 150 psi delivered to the fire department connection. When complete, hydraulic calculations shall indicate minimum 10 PSI remaining pressure.

3.12 INSTALLATION

A. Fasten items to building construction as detailed or as otherwise required to provide a secure and permanent installation.

B. Where fastening spacing or sizes are not shown, this Contractor shall use spacing and sizes of bolts, screws, welds, etc. which will develop the full strength of the member being fastened. Thus, failure due to overstressing must occur in the member before occurring in the fastenings.

C. Fastenings to plaster or drywall construction shall be into wood or metal blocking, securely bolted, nailed or wired into framing or support system. Toggle bolts permitted only where detailed and where specific requests are approved.

3.13 CORE DRILLING/DRILLING

A. This Contractor shall provide all core drilling necessary to install new piping through existing building walls.

B. Core drilled holes shall be sized to provide a total of not less than 1/2 inch clearance around the piping.

C. Core drilled holes shall not be used as support points for any piping.

D. All openings within the building shall be sealed airtight using fire barrier caulking with a UL classification for use as a fire penetration seal for floors and walls with two to three hour fire rating, expanded and tamped into place for the full depth of the opening. Openings through exterior walls and floors shall also be sealed outside using waterproof mastic.

3.14 TESTING

A. Upon completion and prior to acceptance of the installation of the new sprinkler system, work shall be tested as required by the National Fire Protection Association Pamphlet #13 and arrangements made for approval. Piping shall be tested to a hydrostatic test pressure of 200 PSI for a period of two (2) hours. Drain tests and alarm tests shall be made as required.

3.15 WATER SUPPLY

A. The most recent flow test data available once the system has been upgraded to the building.

B. The model results, (calculated), once the modifications and new supply is installed are estimated as follows:

1. 500 GPM @ 38.5 PSI.

2. 750 GPM @ 36.8 PSI.

C. Calculated information provided by The Pare Corporation in conjunction with Rhode Island College.

3.16 DISCONNECTION OF FIRE PROTECTION SYSTEMS

A. This Contractor shall notify the local Fire Department, insurance company and building owner of any shut down of sprinklers and standpipes that do not affect any alarm. This Contractor to bear cost of local Fire Department fire watch.

B. This Contractor shall notify the Electrical Contractor of any shut down of sprinklers and standpipes that affect the fire alarm system. This Contractor to bear cost of the local Fire Department fire watch.

C. This Contractor shall be responsible for providing the services of an individual, factory trained, for the specific fire alarm zones as required to accomplish the work of this contract at no additional cost to the Owner.

3.17 PHASING OF WORK

A. Fire protection work will be phased in coordination with all other portions of the work of this project as directed by the Architect. Refer to the Architect's design documents for details of the phasing of the work and provide all labor, equipment and materials necessary whether permanent or temporary to phase of work.

3.18 FIRE SAFING

A. Where piping passes through fire rated walls, floors and ceilings, provide a fire safing system so as to maintain the integrity of the rated assemblies to the satisfaction of the Architect and the Building Inspector. The fire safing system shall be as manufactured by 3M, Dow, Bio-Fire Shield or Nelson. Provide manufacturer's details or custom details when there are no manufacturer's details for each condition with a UL listing referenced. Where piping is insulated, pipe insulation shall run continuous through the

rated opening. Details shall show the required depth and annular space width requirements and limitations and any packing requirements.

B. Refer to architectural drawings for rated walls and partitions. When there are no architectural drawings or they do not indicate rated walls and partitions, the following guidelines shall be used. All floors, corridor walls, party walls, mechanical room walls, duct and pipe chase walls, stairwells, trash room and chute walls shall be considered minimum two hour fire rated walls.

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SECTION 22 0000

PLUMBING

PART 1 – GENERAL

1.1 GENERAL

A. Division 0 and Division 1 of these specifications are hereby made a part of this section.

1.2 WORK INCLUDED

A. The intention of the specifications and plans is to provide for finished systems, properly tested and ready for operation, including necessary minor details and accessories required to make the work complete, even though such items may not be expressly shown or specified for all system herein specified and shown on the drawings.

B. The scope shall include, but not be limited to, the following:

1. Sanitary and storm systems.
2. Hot and cold water systems
3. Natural gas system
4. Insulation
5. Fixtures and equipment
6. Coring drilling
7. Gas- fired water heaters
8. Backflow preventers
9. Temperature maintenance cable system
10. Owner equipment connections for ice machines, refrigerators, whirlpool and therapy tubs.

C. The work covered by this section of the specifications includes the furnishing of all labor and materials and in performing all operations in connection with the installation of the plumbing work shown on the drawings and as described herein and shall be interpreted as work to be done by the Plumbing Contractor. Work to be performed by other trades will always be specifically referenced to a particular Contractor and/or section.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. The following items of labor and material incidental to or related to the installation of the Plumbing work shall be provided by others at no cost to this Contractor.

1. Cutting and patching shall be as provided under General Conditions.
2. The provision of temporary water, light and power for construction and costs for usage shall be provided under Division 1 (or appropriate section).
3. All finish field painting shall be provided under Division 10.
4. Toilet accessories shall be provided under Division 7.
5. Heating and ventilating systems shall be provided under Section 230000
6. Electrical work shall be provided under Section 260000.

1.4 DEFINITIONS

A. “This Contractor” or “P.C.” means specifically the Plumbing Contractor working under this respective section of the specifications.

B. “Furnish and install” and “Provide” means to supply, erect, install and connect in readiness for regular operation, the particular work referred to, unless otherwise specified.

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

1.5 CODES, ORDINANCES AND PERMITS

A. All work performed under this section of the specifications shall be done in accordance with the applicable National, State and local codes, laws and ordinances and Rhode Island Fuel Gas and Plumbing Codes.

B. All materials and work provided shall be in accordance with, but not limited to, the following:

1. American National Standards Institute (ANSI).
2. American Society for Testing and Materials (ASTM).
3. Building Officials and Code Administrators (BOCA)
4. National and State Electrical Code (NEC)
5. National Electrical Manufacturer's Association (NEMA)
6. National Fire Protection Association Codes and Standards (NFPA)
7. Occupational Safety and Health Act (OSHA)
8. State Building Code
9. Standards of Underwriters Laboratories (UL)

C. Where code references are given, the latest issue of that code in effect at the time of bidding shall be used. Code references given to indicate the minimum quality and performance acceptable. Where specifications and/or drawings indicate more stringent requirements, the specification shall govern.

D. Permits: Be responsible for filing all documents, payment of all fees and securing of all inspections and approvals necessary for the installation and operation of all systems furnished under this section.

1.6 DRAWINGS AND SPECIFICATIONS

A. Drawings:

1. The drawings are generally diagrammatic and are intended to convey the scope of work and are to indicate the general arrangement of equipment, piping and fixtures. The drawings are not intended to show each and every detail of construction.
2. This Contractor shall refer to the drawings showing the work to be done under this section of the specifications and also all other drawings related to the work to be done under other sections so that he has full comprehension of the scope of his work and its relationship to the other sections of the work.
3. Certain details indicated on the drawings are general in nature and specific labeled detail references to each and every occurrence of use are not indicated; however, such details by their titles shall be applicable to every occurrence on the drawings.
4. The Architect reserves the right to make reasonable modification to the arrangement of outlets, apparatus and equipment up to the time of roughing piping without incurring extra cost to the Owner.

B. Specifications:

1. Specifications are intended to complement the drawings; however, work detailed and/or noted only on the drawings or work described only in the specifications shall also be considered as part of the scope of work.
2. Work shall be performed as described above in the specifications, except where specific deviations are indicated and/or noted on the drawings.

1.7 SHOP DRAWINGS, PRODUCT DATA AND SAMPLES

A. Refer to General Conditions, Shop Drawings, Product Data and Samples and add the following:

1. All submittals shall be complete and shall be in three-ring loose-leaf binders. No consideration will be given to partial submittals, except with prior approval of the Architect. Each item shall have a cover page stating project, specification and paragraph reference number, or drawing reference number, and scheduled equipment identification number, if applicable.

2. The review of submittals does not relieve this Contractor from the responsibility of shop drawing errors in details, sizes, quantities, wiring diagram arrangements and dimensions which deviate from the specifications, contract drawings, and/or job conditions as they exist.

3. Changes to work already performed made necessary by delays in shop drawing review are the responsibility of this Contractor.

4. Copies of equipment and system guarantees shall be submitted with shop drawing package.

B. Refer to General Conditions for substitution of equipment.

C. If apparatus or materials are substituted for those specified under this section, and such substitutions necessitate changes in or additional connections, supports or construction, same shall be provided at no additional cost to the Owner. This Contractor shall assume cost and entire responsibility thereof. Architect's permission to make such substitution shall not relieve this Contractor from full responsibility for work.

1.8 EXAMINATION OF SITE AND CONTRACT DOCUMENTS

A. Refer to General Conditions and add the following:

1. Bidders are advised to visit the site and inform themselves as to conditions under which this work will be performed prior to submitting prices. Failure to do so, will, in no way relieve the successful bidder from the responsibility of furnishing any materials or performing any work in accordance with the true intent and meaning of the drawings and specifications.

2. No claim for extra compensation will be recognized if difficulties are encountered which an examination of the site conditions and contract documents prior to executing the contract would have revealed.

3. This Contractor shall be responsible for ordering and furnishing the correct quantity of material required. Routing and equipment arrangements shown on the drawings are approximate only and are not warranted to be accurate.

4. Arrangements shall be made with the Owner prior to the visit for inspection of the existing buildings.

1.9 RECORD DRAWINGS

A. The General Contractor shall provide two (2) sets of blackline on white record drawings to this Contractor, one set of which shall be maintained at the site and which shall, at all times, be accurate, clear and complete, showing the actual location of all equipment and piping. The record drawings shall be available to the Architect's/Engineer's field representative at all times.

B. Any addenda sketches, supplementary drawings and change orders issued during the course of construction shall be transferred to the record drawings.

C. At the completion of this contract, this Contractor shall submit through the General Contractor an accurate checked set of record drawings.

D. Non-availability of record drawings or inaccuracies therein shall postpone the final inspection until they are available.

E. After approval of these record drawings, photo reproductions of the original tracings shall be revised to incorporate all the changes on the record drawings. These photo reproductions shall be certified by this Contractor as correct and delivered to the Architect together with two (2) sets of blackline prints.

F. All costs related to the foregoing requirements shall be paid for this Contractor.

G. All valves shown on these drawings shall be numbered with numbers corresponding to those on the valve charts.

1.10 USE OF ELECTRONIC DRAWING FILES

A. If requested, the Engineer will provide electronic copies of selected CAD (Computer Aided Design) drawing files for the Contractor's use in the preparation of shop drawings, coordination drawings, or as-built drawings related to this project, subject to the terms and conditions in the following paragraphs.

B. The Engineer's electronic files are prepared on AutoCad Release 2007. The Engineer will provide drawing files through Release 2007.

C. Data contained on these electronic files is part of the Engineer's instruments of service and shall not be used by the Contractor or anyone else receiving this data through or from the Contractor for any purpose other than as a convenience in the preparation of shop drawings, coordination drawings, or as-built drawings for the referenced project. Any other use or reuse by the Contractor or by others will be at the Contractor's sole risk and without liability or legal exposure to the Engineer. In accepting these files, the Contractor shall agree to make no claim and shall waive, to the fullest extent permitted by law, any claim or cause of action of any nature against the Engineer, its officers, directors, employees, agents of the Engineer, which may arise out of or in connection with the Contractor's use of the electronic files.

D. Furthermore, the Contractor shall to the fullest extent permitted by law, indemnify and hold harmless the Engineer from all claims, damages, losses and expenses, including attorney's fees arising out of or resulting from the Contractor's use of these electronic files.

E. These electronic files are not contract documents. Significant differences may exist between these electronic files and corresponding hard copy contract documents due to software incompatibility, software translation, addenda, change orders or other revisions. The Engineer makes no representation regarding the accuracy or completeness of these electronic files. In the event that a conflict arises between the hard copy contract documents prepared by the Engineer and the electronic files, the hard copy contract documents shall govern. The Contractor is responsible for determining if any conflict exists. By use of these electronic files, the Contractor is not relieved of his duty to fully comply with the contract documents, including and without limitation, the need to check, confirm and coordinate all dimensions and details, take field measurements, verify field conditions and coordinate all work with that of other contractors for the project.

F. Because of the potential that the information presented on the electronic files can be modified, unintentionally or otherwise, the Engineer reserves the right to remove all indication of their respective ownership and/or involvement from each electronic file provided.

G. A service fee of $65.00 per sheet shall be remitted directly to the Engineer prior to delivery of the electronic files. Arrangements shall be made directly with the Engineer for files prepared by them. Electronic files will not be released until payment is received. A written release to be prepared by the Engineer will be required as well.

H. Under no circumstances shall delivery of the electronic files for use by the Contractor be deemed a sale by the Engineer, who make no warranties, either expressed or implied, of merchantability and fitness for any particular purpose. In no event shall the Engineer or its

consultant(s) be liable for any loss of profit or any consequential damages arising out of the use of these electronic files.

1.11 WARRANTY

A. Refer to General Conditions and add the following:

1. Standard equipment guarantees offered by the manufacturer for one (1) year or greater shall be in addition to that as required by this contract.

2. Copy of manufacturer's equipment guarantees shall be submitted with this Contractor's written guarantee.

PART 2 – PRODUCTS

2.1 HANGERS, ANCHORS, GUIDES AND PIERS

A. All piping shall be supported from the building structure by means of approved hangers and supports. Piping shall be supported to maintain required grading and pitching of lines to prevent vibration and to secure piping in place and shall be so arranged as to provide for expansion and contraction.

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

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

C. Vertical lines may be supported at each floor level if the floor-to-floor dimension is greater than 10 feet, provided that the Architect gives his approval.

D. All hangers shall be adjustable clevis hangers, hanger rods shall have machine threads. Malleable iron brackets of approved type shall be used along walls.

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

F. Hangers shall be manufactured by Grinnell Company, F&S Central or Fee and Mason.

G. Wire and strap hangers will not be permitted in this installation.

H. Install a 12 inch long, 16 gauge metal pipe shield between pipe insulation and all pipe hangers for all piping 1½ inches and larger. Hangers shall be around insulation so insulation will be between pipe and hanger. Shields shall be tach welded to the hangers.

2.2 INSULATION

A. Pipe and equipment installed under this contract shall be covered as follows:

1. All rain water piping, cold and hot water piping above ground. Both horizontal and vertical, concealed and exposed: 1 inch glass fiber 4 pound density snap-on insulation with vapor barrier.

2. All Valves and Fittings: PVC fitting jackets and fiberglass insulation. The PVC jacket shall overlap pipe insulation and all joints and throats shall be continuously sealed with 1" wide white vinyl tape and pop riveted in accordance with manufacturer's recommendations.

B. All piping, fittings and valves on factory assembled equipment shall be insulated same as for field installed piping.

C. All pipe insulation shall be covered with fire retardant vapor jacket in accordance with NFPA. Jacket shall be constructed of outer layers of white kraft paper and 1 mil aluminum foil with glass fiber reinforcing between, laminated together with fire retardant adhesive. Jacket shall have water vapor permeability of .02 perms.

D. Joints: The end joints of insulation shall be tightly butted and covered with factory furnished end joint sealing tapes. The jacket overlap shall be sealed with an approved sealer which shall not mar the jacket finish. End joints on cold piping shall be sealed with vapor barrier mastic.

E. Fittings on cold water lines, roof drain underbodies and roof drainage piping shall be vapor sealed with 1/8 inch wet coat fire retardant vapor barrier mastic. The insulation on fittings, valves and flanges shall be finished with the same type of fire retardant vapor barrier jacket as the piping.

F. All sealers, solvents, tapes, adhesives and mastics used in conjunction with the installation of all insulation specified under this section shall pass the maximum possible fire safe qualities available and shall be of a type approved under NFPA or NBFU No. 90A or 90B standards. The flame spread rating shall not exceed 24. Smoke development rating shall not exceed 50.

G. The PVC fitting jackets and fiberglass insulation may be used in lieu of standard jacket specified above; however the PVC jacket shall overlap pipe insulation and joint taped and pop riveted in accordance with manufacturer's recommendations.

H. Covering shall not be applied until the piping has passed all tests as required by the Architect.

I. Staples shall not be used in any part of this installation.

J. All covering shall be recognized manufacture equal to Fiberglass Company, Certainteed, Johns Manville or Armstrong Company and shall be installed by reputable firms regularly engaged in this work and employing men particularly skilled therein.

K. Refer to paragraph on sleeves for safing of sleeves and openings.

L. Accessible: All exposed water piping (hot and cold water) and waste piping, including traps under all accessible fixtures, shall be protected with preformed plastic kits as manufactured by McGuire "ProWrap", TrueBro, Inc. or Trap-Wrap.

2.3 PIPING ACCESSORIES

A. Furnish and install pressure and temperature relief valves, ASME rated, temperature relief 210 degrees F. double BTU rated, self-closing as manufactured by Watts Regulator Company, Taco or Bell & Gossett.

B. Furnish and install vacuum reliefs – Watts Regulator Company Model #36A or approved equal.

C. Furnish and install 4½ inch diameter dial thermometers, any angle and range 40 degrees F. to 240 degrees F. as manufactured by Albert A. Weiss & Son, Inc. Include separate thermometer well. Power Regulator and Triece are approved equals.

D. Furnish and install 4 inch diameter pressure gauges with range of 0 to 150 PSI as manufactured by US Gauge, Powers Regulator or Triece.

E. Furnish and install where shown on plans vacuum breaker as manufactured by Watts Regulator Company Model #228A or approved equal by Febco.

F. In general, all piping shall be installed with unions properly spaced to permit alterations and repairs. Where union connections are installed on brass pipe 2 inches in diameter and smaller, they shall be of brass Composition "E" in strict accordance with Federal Specification WW-U-516. All connections between copper tubing and galvanized tanks, fittings or piping shall be made with dielectric unions. Unions shall be provided at all equipment connections.

2.4 PIPE AND FITTINGS

A. Pipe and fittings shall be of U.S. manufacture and shall conform to the latest ANSI, ASTM, CS and/or FS standards.

B. All pipe installed under this section shall be in accordance with the following:

1. Service cast iron, hubless fittings and couplings, Pipe and Drainage Fittings: All above ground, rainwater, soil, waste and vent piping systems.

2. Service weight hub and spigot cast iron piping with neoprene gasket shall be used on all under slab rainwater, soil, waste and vent piping systems.

3. Type "L" Hard Tempered Copper Tubing: All hot and cold water, except exposed pipes at fixtures and owner's equipment.

4. Standard Weight Red Brass Pipe IPS: Under counter and exposed piping at fixtures and owner's equipment. This piping shall be chromium plated.

5. Schedule 40 Steel Pipe: Gas supply vent and distribution piping system.

6. Fittings for copper tubing shall be cast bronze or wrought copper sweat type.

7. Fittings for screwed gas piping above ground shall be threaded malleable iron, size 3 inches and smaller. Provide union connections at all equipment.

8. Fittings and joints on gas piping larger than 3 inch shall be welded. Valves and equipment shall be flanged.

9. Fittings for piping not specifically mentioned shall be of the same material and type as the piping they are installed in.

2.5 PIPE JOINTS

A. All threaded pipe joints shall be made with teflon tape wrapped on male threads only.

B. Type "L" copper tubing and sweat fittings shall be assembled with 95-5 tin and antimony solder, 450 degrees F. melting point and a non-corrosive flux or 96-4 tin and silver at 430 degrees F. (95.5/.5/4 copper).

2.6 PLUMBING FIXTURES

A. Plumbing fixtures shall be of the best quality as fabricated by a manufacturer of established reputation.

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

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

D. Where escutcheons are not furnished with plumbing fixtures, this Contractor shall supply them.

E. Each fixture shall be separately trapped, using type and size of trap required by the Plumbing Code except as specified otherwise. Unless otherwise specified, faucets and all exposed fittings and pipe shall be chromium plated.

F. Manufacture: Fixtures shall be manufactured by Eljer, American Standard, Kohler or approved equal. Toilet seats shall be manufactured by Church, Beneke, Bemis or equal. Plate numbers and manufacturer's names are used only to establish the type of equipment, fixture and quality desired.

G. Dimensions locating plumbing fixtures shall be as shown on the architectural drawings.

2.7 FIXTURE SCHEDULE

WC-1 Water Closet - Wall Hung
American Standard 3355.128 Afwall, 1.28 gallon toilet, vitreous china, siphon jet, elongated bowl, 2¼ inch passageway, 1½" top spud.
523 Beneke white solid plastic seat, open front, check hinge.
Sloan Optima 8111, CP flush valve, non hold open handle, 1 inch screwdriver angle stop, vacuum breaker, 1½ inch top spud connection, sweat solder adapter and cast wall flange with set screw, 1.28 gallon flush.
JR Smith combination closet carrier and drainage fitting to suit building construction.

WC-2 Water Closet - Wall Hung, Accessible
American Standard 3355.128 Afwall, 1.28 gallon toilet, vitreous china, siphon jet, elongated bowl, 2¼ inch passageway, 1½ inch top spud.
523 Beneke white solid plastic seat, open front, check hinge.
Sloan Optima 8111, CP flush valve, non hold open handle, 1 inch screwdriver angle stop, vacuum breaker, 1½ inch top spud connection, sweat solder adapter and cast wall flange with set screw, 1.28 gallon flush.
JR Smith combination closet carrier and drainage fitting to suit building construction.
Flush valve handle shall face the wide side space of the wall or stall.

U-1 Urinal (Siphon Jet)
American Standard 6561.017 Trimbrook 1 gallon vitreous china wall hung siphon jet urinal with 3/4" top spud, 2" IPS outlet and wall hangers.
Sloan Optima 8180-1.0 CP flush valve, 3/4" screwdriver angle stop, vacuum breaker, cast brass set screw flange. CP IPS nipple to wall.
Concealed chair carrier with foot support as required to suit.

U-2 Urinal (Accessible) (Siphon Jet)
American Standard 6561.017 Trimbrook 1 gallon vitreous china wall hung siphon jet urinal with 3/4" top spud, 2" IPS outlet and wall hangers.
Sloan Optima 8180-1.0 CP flush valve, 3/4" screwdriver angle stop, vacuum breaker, cast brass set screw flange. CP IPS nipple to wall.
Concealed chair carrier with foot support as required to suit.

L-1 Lavatory - Wall Hung (Accessible)
American Standard 0954.000 “Murro” vitreous china wall hung lavatory, punched for concealed arms.
Symmons Scot S-60-GH metering faucet with blade type handle. Set faucet flow time at ten (10) seconds.
McGuire 165H (pair) CP 3/8" angle supply with stop and flex riser.
McGuire 8090 CP 1¼” x 1½” cast brass adjustable P-trap with cleanout, tubing outlet to wall, and ground joint connection.
JR Smith concealed arm carrier to suit building conditions.
Trap and supplies under each lavatory to be covered with TrueBro Lav Guard insulation kit Model 102 insulator color white.

SH-1 Shower
Built-up shower base and surround by others, 2" floor drain set in floor.
Symmons #1-803S-60-285, HydaPipe heavy duty, Showeroff valve with screwdriver service stop, all brass vandal resistant institutional Fre-Flo head with rigid connection, attached soap dish, and 18 gauge #4 brush finish, stainless steel covering with ceiling flange to conceal supplies.

SH-2 Shower (Accessible)
Built-up shower base and surround by others, 2" floor drain set in floor.
Symmons #1-803S-FSB Hydapipe pressure balancing mixing valve with screwdriver service stops and adjustable stop screw, wall/hand shower with flexible 5' hose and inline vacuum breaker attached to institutional type head bracket, 30 inch slide bar, attached soap dish and 18 gauge #4 brush finish, stainless steel extension to ceiling.
2" bronze body P-trap (sweat).
JR Smith #2005A shower drain with nickel bronze strainer.

MSB-1 Mop Service Basin
Stern/Williams #SB-302L/R 36" x 24" x 12" deep mop receptor with 20 gauge stainless steel cap on all sides with tiling flange on sides adjacent to walls and 3" integral drain.
Chicago #897 with vacuum breaker, loose key stops and hose end.

WM-1 Clothes Washer
Guy Gray SSWB-1TM (washer by owner) assembly fabricated of 16 gauge steel cabinet with 1/2" hot and cold water combination washing machine valve and 2" drain.

WT-1 Whirlpool Tub (Tub by Owner)

Leonard TM-177A, Hydro therapy control unit, complete with thermostatic, vacuum breaker, adjustable high temperature limit stop, 6 gpm unit, stainless steel cabinet. Drain to floor drain.

EWC-1 Bi-Level Electric Water Cooler (Accessible)
Halsey Taylor Model HRFSER-Q, dual height, stainless steel, wall mounted, electric water cooler. Fountain shall deliver 7.5 gph of 50°F. water at 90°F ambient and 80°F. inlet water. Fountain shall include pushbutton front valve, contour formed basin to eliminate splashing and standing water and rounded corners and edges.

S-1 Hand washing Sink (Accessible)
Just SL-ADA-1921-A-GR self rimming, stainless steel, single compartment sink, 18 gauge, Type 304, 14" x 18" x 6" deep bowl with under coating and punched for three (3) holes.
Just J-ADA-35-FS perforated grid strainer with 1½" offset tailpiece.
Chicago Faucet #786-317 hi-lite combination lavatory faucet with #317 4" wristblade handles, GN2B rigid/swing convertible gooseneck spout with E29 laminar stream aerator.
McGuire H165 (pair) CP 3/8" angle supply with stop and flex riser.
McGuire 8089 CP 1½" cast brass adjustable P-trap with cleanout, tubing outlet to wall and ground joint connection.
All exposed trim under sink to be insulated and trap mounted parallel to wall.

S-3 Utility Sink
Just SL 2019-A-GR self rimming, stainless steel, single compartment sink, 18 gauge, Type 304, 14" x 16" x 7½" deep bowl with under coating and punched for three (3) holes.
Just J-35 crumb cup strainer with 1½" offset tailpiece.
Chicago Faucet #786-317 hi-lite combination lavatory faucet with #317 4" wristblade handles, GN2B rigid/swing convertible gooseneck spout with E29 laminar stream aerator.
McGuire H165 (pair) CP 3/8" angle supply with stop and flex riser.
McGuire 8089 CP 1½" cast brass adjustable P-trap with cleanout, tubing outlet to wall and ground joint connection.

S-2 Kitchen Sink (Accessible)
Just SL-ADA-1921-A-GR, 18 gauge Type 304 self rimming stainless steel single compartment sink, 14" x 18" x 6" deep bowl with undercoating and punched for three (3) holes.
Just J-ADA-35 crumb cup strainer with 1½" offset tailpiece, 4" long.
Chicago Faucet #786 Hi-lite combination lavatory faucet with #317 4" wristblade handles, GN2B rigid/swing convertible gooseneck spout with E29 laminar stream aerator.
McGuire H165 (pair) CP 3/8" angle supply with stop and flex riser.
McGuire 8089 CP 1½" cast brass adjustable P-trap with cleanout, tubing outlet to wall, and ground joint connection.
All exposed trim under sink to be insulated and trap mounted parallel to wall.

2.8 TRAPS

A. Furnish and install traps with cleanouts on all fixtures and equipment requiring connection to the sanitary system of the same size and material as the pipe on which they occur.

B. All floor drain traps shall be provided with an elastomatic trap-guard fitting as manufactured by Pro-set.

2.9 VALVES

A. Furnish and install valves where indicated on drawings or specified so located that they may be operated, repaired or replaced with a minimum effort and repacked under pressure. All valves shall be installed with stem above the horizontal.

B. The following list of valves is intended only as a guide for type and quality to this contractor.

1. Ball Valves 3 Inches and Smaller: Apollo 70-140or 70-240 with solid stainless steel ball for use on hot and cold water piping.
2. Natural gas valves:
    a. Threaded systems – ball valves, Appolo 70-140 or equal.
    b. Flanged systems – Nibco-F-510-S6-R—66-FS, stainless steel, flanged ball valves.

C. Valves shall be as manufactured by Nibco Apollo, Hammond, Stockman or Watts.

D. All valves shall be installed with handles installed above the horizontal plane.

2.10 WATER HEATING SYSTEM

A. Furnish and install the following Power VT gas water heater(s) as manufactured by PVI Industries, Inc of For Worth, Texas. The system shall be comprised of (2) 250 gallon units, model 1400N250-APV each with a natural gas input of 1,000,000 BTUH, capable of delivering 1130 gph at a 100 degree rise. Each water heat will operate at a thermal efficiency of 94% when tested to ANSI Z21.10.3. The water heaters will comply with paragraph 7.2.4.4, the thermal efficiency and the standby loss requirements of ASHRAE 90.1-1999.

B. The water heaters will be a vertical fire tube design that is constructed and stamped in accordance with Section IV, Part HLW of the ASME code. Both the storage and heating sections of the water heater will be National Board Registered for a working pressure of 150 psi and will be pressure tested at 1 ½" times working pressure. The fireside of the heating surfaces will be of boiler-grade steel. The waterside of the heating tubes will be sealed in copper. The heating tubes will be rolled, beaded, and seal welded into the tube sheets. The combustion side of the tube sheet will be insulated by a layer of ceramic fiber that will protect the tube sheet from both thermal stresses and failure that can result from the accumulation of scale and precipitants.

C. The tank will be a plated with electroless nickel (EN). Plating will occur after the pressure vessel is completely fabricated and all welding is completed. The EN plating will be a high-phosphorus (10%) and nonporous composition suitable for submersion service (ATSM B733 standard may be used as a guideline). The finished lining will not require sacrificial anode rods. For additional protection against galvanic corrosion, which may occur within the potable water system, the EN plating may have a high-dielectric-strength polymer overcoat.

D. Combustion will be provided by an induced-draft power burner that can operate with a little as 2 inches water column of gas pressure. The water heater will be UL listed for use with plastic venting materials. The heater will be capable of directly venting both inlet and exhaust air for a combined length of 100 equivalent feet. (50 equivalent feet on 1 million Btu/h model). The burner will be equipped with a gas train meeting the specification of Underwriters Laboratories and Factory Mutual.

E. The heater will be equipped with the following:

1. A solid-state flame safeguard with pre-purge, programmable post-purge, and flame status indicating lights.
2. Two immersion operating thermostats
3. An immersion temperature limiting device
4. A AGA-rated temperature and pressure relief valve
5. Tank temperature and pressure gauges
6. Electronic low water cut off
7. Manual reset temperature limiting device
8. Condensate neutralization system

F. The burner and all heater parts will have a one-year warranty. Storage tank will have a ten-year warranty covering manufacturing or materials defects, and/or the production of rusty water. Tank and heating surfaces will have a non-prorated, three-year warranty against failure due to scale buildup with no provisions for periodic cleaning for warranty coverage. If indicated here, the heater will also have a first year or long life service policy, which will cover replacement labor and freight costs under certain conditions. This summary is not a warranty. Consult warranty and policies for full details. Complete copies of all warranties and service policies, including all exclusions and conditions, will be presented to the owner as part of the submittal package.

G. The storage and heating sections will be completely factory packaged and plumbed, requiring only job site hookup to utilities, venting, and potable water inlet and outlet. The heater will be insulate dot meet current ASHRAE standards, jacketed with powder-coated steel panels, and mounted on heavy-duty channel skids. The heater will fit properly in the space provided and installation will conform to all local, state and national codes.

H. Start up on the unit will be performed by factory trained and authorized personnel. A copy of the start up report will be provided to the owner.

I. The water heaters will be manufactured by a company that has achieved certification to the ISO 9001 International Quality System, which requires external auditing of any order entry, engineering design, and product manufacturing processes. The heater will be U.L. listed and ULC listed to safety standard UL 795 “Commercial – Industrial Gas Heating Equipment” or AGA listed to ANSI Z21.10.3 “Gas Water Heaters.” The heater will satisfy current Federal Energy Policy Act (EPACT) standards for both thermal efficiency and standby heat losses as established for gas-fired water heaters incorporating storage tanks.

2.11 REDUCED PRESSURE BACKFLOW PREVENTER

A. Furnish and install reduced pressure zone backflow preventers at each cross-connection to prevent back siphonage and back pressure backflow of hazardous materials into the potable water supply system. The assembly shall consist of a differential relief valve located in a zone between two positive seating, center stem guided check assemblies. Each check module shall have a captured spring and shall be accessible through a bolted cover plate. Seats shall be replaceable without the need for special tools. The valve body shall be cast iron and have applied fusion bonded epoxy coating inside and out and shall have bronze replaceable seats. Back siphonage protection shall include provision to admit air into the reduced pressure zone via a separate channel from the water discharge channel. The valve shall be Watts Series 009QT.

1. Each unit shall be installed horizontally with ball or gate valves on each side of RPBP and ℄ 4’0” above floor. Relief valve shall be piped to floor drain.

2. Provide one (1) set of spare parts for repair and one set of special tools for each and every RPBP installed.

3. This Contractor shall obtain all required permits for each and every RPBP. Each RPBP shall be tested by DEP, or their agent, and certified reports of acceptance submitted to the Architect and Engineer.

2.12 TEMPERATURE MAINTENANCE CABLE SYSTEM

A. Furnish and install - where indicated on the drawings - a complete UL listed system of heaters, specifically approved for maintaining hot water at selected temperatures. The heating cable shall consist of two 14 awg bus wires embedded in parallel in a radiation cross-linked self-regulating conductive polymer core, specifically designed for hot water temperature maintenance. The cables will be temperature specific, noted on the piping on the drawings.

B. System shall be installed with applicable power connectors, splice kits and accessories. No thermostats shall be used to control temperatures. Cables shall be installed in parallel passes - NO spiral wrapping.

C. Refer to the manufacturer's D & I guide for proper installation procedures. Cable and related accessories shall be manufactured by Thermon Commercial Products Division. Cable shall be HSX 2100 series.

2.13 FIRE SAFING

A. Where piping passes through fire rated walls, floors and ceilings, provide a fire safing system so as to maintain the integrity of the rated assemblies to the satisfaction of the Architect and the Building Inspector. The fire safing system shall be as manufactured by 3M, Dow, Biofire Shield or Nelson. Provide manufacturer's details or custom details when there are no manufacturer's details for each condition with a UL listing referenced. Where piping is insulated, pipe insulation shall run continuous through the rated opening. Details shall show the required depth and annular space width requirements and limitations and any packing requirements.

B. Refer to architectural drawings for rated walls and partitions. When there are no architectural drawings or they do not indicate rated walls and partitions, the following guidelines shall be used. All floors, corridor walls, party walls, mechanical room walls, duct and pipe chase walls, stairwells, trash room and chute walls shall be considered minimum two hour fire rated walls.

PART 3 – EXECUTION

3.1 MATERIALS AND WORKMANSHIP

A. All materials installed in this work shall be new without damaged functional or aesthetic components. All equipment finishes shall be touched up with matching finishes where slight scratches occur. Equipment or material subject to severe deterioration shall be completely refinished or replaced as directed by the Architect.

B. All labor utilized in the installation of the work shall be experienced in the respective trade required. The installation of exposed finished materials shall be neatly done flush, straight and/or plumb, without distortion, meeting the building finished surfaces.

C. All plumbing materials and equipment shall conform to the Standards listed within this section of the specifications and wherever such standards have been established, items shall bear its respective label.

D. Where labor to be furnished must meet specific code requirements, only individuals certified to do such shall be used.

E. All equipment shall be installed in accordance with the manufacturer's instructions and recommendations with adequate clearance for access for maintenance.

3.2 COORDINATION

A. This Contractor shall give full cooperation to all other trades and to the General Contractor and shall furnish any information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay. If this Contractor installs his work before coordinating with other trades or so as to cause interference with work of other trades, he shall make necessary changes in the work to correct the condition without extra charge. In areas, if due to construction conditions, more than one trade is required to use common openings in beams, chases, shafts, etc., for the passage of ductwork, piping, conduit, etc. this Contractor must plan and locate the positions of items of piping, etc. which are under the scope of his contract with those items under the scope of other Contractors in order that all items are properly located and may be accommodated within the space available. Location and positioning shall be done prior to installation and to the satisfaction of the Architect.

B. This Contractor shall obtain detailed printed information from the manufacturer of equipment, which he is to provide for the proper methods of installation. He shall also obtain all information from the Construction Manager and others which may be necessary to facilitate his work and the completion of the whole project. All equipment shall be installed in strict accordance with the manufacturer's recommendations.

C. The work to be accomplished under this section includes work within existing areas adjacent to the site of new construction. Continuity of services within the existing areas shall be maintained. Any interruption of services necessary to accomplish the work shall be made only with the consent of the Owner.

D. This Contractor shall not unnecessarily disturb or interfere with the Owner's use of the facilities associated with or adjacent to this contract. When interference is necessary, permission shall be obtained from the General Contractor before any operation or service line is disturbed or disconnected.

3.3 PROTECTION AND CLEAN-UP

A. Refer to General Conditions and add the following:

1. This Contractor shall be responsible for the maintenance and protection of all materials and equipment furnished by him during the construction period from loss, damage or deterioration until final acceptance by the Owner. All materials and equipment on the job site shall be suitably stored and protected from the weather. All piping, duct and

equipment openings shall be temporarily closed during construction to prevent obstruction and damage.

B. All equipment with damaged finished surfaces shall be cleaned and repainted with the same paints as was factory applied.

3.4 OPERATING AND MAINTENANCE MANUALS

A. This Contractor shall provide three (3) complete sets of operating and maintenance manuals to the Owner prior to the operating instruction period. Maintenance manuals shall be submitted to the Architect for review. The receipt of reviewed maintenance manuals by the Owner shall be a prerequisite to system acceptance. Each manual shall include the following:

1. A complete set of shop drawings/equipment arranged in accordance with their appearance in the specifications. Drawings shall be folded and included in envelopes and bound into the manual.

2. A complete set of operational and servicing instructions for each piece of equipment, bound into the manual adjacent to the corresponding shop drawing.

3. A complete listing of all equipment suppliers, together with local agent's names, addresses and telephone numbers.

4. A complete set of valve listings.

5. Copies of all service contracts provided for the guarantee period.

6. Copies of all equipment and system warranties shall be included.

3.5 SYSTEM START-UP AND OPERATION

A. This Contractor shall provide all labor and materials and services necessary for the initial start-up and operation of all systems and equipment furnished and installed under this section of the specifications.

B. This Contractor shall provide the services of a qualified representative for all major equipment pre-start set-up, start-up and initial operation. Such periods shall be sufficient to insure proper operation of systems and equipment.

C. During operation of the systems qualified licensed personnel shall be provided and designated for maintenance of equipment and systems in good running order. Items such as strainer cleanouts, bearing lubrication, packing replacement and other consumables shall be provided without cost to the Owner. Failure of equipment during this period due to lack of proper supervision is the responsibility of this Contractor, and continued failures shall be grounds for the Owner to provide such services with back-charges to this Contractor.

3.6 EXISTING WORK AND DEMOLITION

A. This Contractor shall participate in the survey of the existing plumbing systems. He shall disconnect and cap all service lines to be disconnected for those services which normally are included in his field of work. Particular care shall be taken to avoid creating hazard or causing disruption of services in adjoining areas.

B. The demolition, including the dismantling and removal of existing equipment and/or materials therein, shall be performed by the individual Contractors.

C. Disconnect and cap all piping back to the nearest concealed joint from all floors, walls, partitions or ceilings which are removed, as shown on the drawings.

D. Sanitary, waste and vent piping shall be cut and capped within 24 inches of an active line. No dead end runs of piping longer than 24 inches will be allowed to exist at the completion of demolition.

E. Reroute all concealed piping which passes through or extends beyond the floors, walls, partitions and ceilings to be removed.

F. All equipment removed shall be turned over to the Owner unless indicated to be re-used or scrapped.

G. Material shall be disposed off site in a legal and proper manner by this Contractor.

3.7 VALVE TAGS, NAMEPLATES AND CHARTS

A. All valves on pipes of every description shall have neat circular brass valve tags of at least 1½ inches in diameter, attached with brass hook to each valve stem. Stamp on these valve tags in letters as large as practical the number of the valve and the service, such as “HW”, “CW”, for hot water and cold water respectively. The numbers of each service shall be consecutive.

B. All valves on tanks and pumps shall be numbered by 3 inch red metal discs with white numbers 2 inches high secured to stem of valves by means of brass hooks or small solid link brass chain.

3.8 RAINWATER, SANITARY AND VENT SYSTEMS

A. Furnish and install a complete system of gravity building drains to take wastes from all soil and waste stacks, fixtures, drain outlets and equipment as indicated and/or described in these plans and specifications.

B. Unless specifically noted otherwise on the drawings, all horizontal rainwater and sanitary piping 4 inches and larger shall be pitched at a rate of 1/8 inch per foot in direction of flow. Horizontal rainwater and sanitary piping 3 inches and smaller shall be pitched at rate of 1/4 inch per foot in the direction of flow.

C. Vent System: Furnish and install a complete system of vent piping to vent all stacks, fixtures, traps and appliances as indicated on the drawings and/or require to meet the plumbing code. All vent piping shall be concealed where possible with horizontal pipe pitching back toward fixtures to allow condensation to drain.

3.9 COLD AND HOT WATER SYSTEMS

A. Furnish and install complete cold, hot and temperature maintenance for water systems to service all fixtures and equipment indicated on the drawings, or specified as requiring cold or hot water. Cold water piping shall connect to existing cold water mains and extend to all fixtures and equipment including piping, fittings, and valves. Hot water piping shall extend from the new water heaters to all fixtures and equipment, including piping, fittings and valves. In general, piping shall pitch upward in direction of flow with each branch and riser separately valved and with 1/2 inch hose end drains on the outlet side of the valve and at all low points in the system. Install ball valves for each battery of fixtures and other valves as necessary to isolate all parts of these systems. Temperature maintenance cabling shall be complete from the heaters up to each piece of equipment, fixture, and/or outlet.

B. All valves shall be installed with handles above the horizontal plane.

3.10 GAS SYSTEM

A. Furnish and install pipe, fitting, valves and connections to all gas-fired equipment and all accessories and incidentals as indicated or specified to maintain a complete gas system. Installations shall be made in accordance with the State Gas Code requirements. All horizontal gas piping shall be pitched not less than 1/4” in 15’ to prevent traps. Pitch piping to risers. Install an 8” long sediment leg at the base of all risers. All changes in direction shall be made with plugged tees for cleaning and piping out. All horizontal branch outlet mains and not from the bottom. Coordinate the installation of the gas system with the utility company and General Contractor, and gas-fired equipment layouts from related trades.

3.11 CHLORINATION OF PIPE LINES

A. Sterilization: All water lines shall be thoroughly flushed and chlorinated before being put into service.

B. Methods: Chlorine may be applied by the following methods, subject to approval: Liquid chlorine gas-water mixture, direct chlorine gas feed or calcium hypochlorite and water mixture.

C. Point of Application: The chlorinating agent shall be applied at the beginning of the reach, adjacent to the source of supply for filling. The chlorine shall be applied through a corporation cock or other approved connection to the newly installed pipe.

D. Rate of Application: The water from the source of supply shall be controlled to flow very slowly in the newly installed pipe during the application of the chlorine which shall be applied in amounts such as will produce a dosage of at least 40 to 50 parts per million. In the event that the pipe line is already filled, the dose shall be increased to such concentration and shall be applied for a sufficient period to produce a residual not less than 25 parts per million at all of the outlets within the reach being chlorinated, including the terminus of the reach.

E. Retention Period: Treated water shall be retained in the pipe long enough to destroy all non-spore containing bacteria. The period shall be at least twenty-four (24) hours and preferably longer, as may be directed. After the chlorine treated water has been retained for the time required, the chlorine residual at pipe extremities and other intermediate points shall be at least twenty-five (25) parts per million.

F. Back Pressure to be Prevented: Back pressure causing reversal of flow from the section being chlorinated to the supply shall be prevented.

G. Chlorinating Valves and Accessories: In the process of chlorinating newly installed pipe, all valves and other pipe line accessories shall be operated while the pipe is filled with the chlorinating agent.

H. Final Flushing and Dose: Following chlorination, and after the entire length of line is ready for operation, all treated water shall be flushed thoroughly from the newly installed pipe line, at its extremities, until the replacement water throughout its length will, upon test, both chemical and bacteriological, be provided equal to the quality introduced at the permanent source of supply.

I. Repetition of Procedure: Should the initial treatment prove ineffective, the chlorination procedure shall be repeated as directed until confirmed tests show that water from the newly installed pipe conforms to the requirements of the preceding section.

J. Liquid Chlorine: Chlorine gas-water mixture shall be applied by the means of a solution feed chlorinating device. Chlorine gas shall be fed directly from a chlorine cylinder equipped with suitable device for regulating the rate of flow and the effective diffusion of gas within the pipe. Calcium hypochlorite shall be comparable to commercial products known as “HTH”, “Perchloren” and “Maxochlor”. A solution consisting of 5 percent powder to 95 percent water by weight should be prepared. The calcium hypochlorite and water mixture, first made into a paste and then thinned to a slurry, shall be injected or pumped into the newly installed line under the conditions specified hereinbefore.

K. At the conclusion of chlorination, have an approved lab analyze the water for acceptability and submit a certified report to the Architect.

L. The final report shall indicate each and every water outlet, 25 PPM at each outlet, and date and time of initial test. Final list with same data after the 24 hour retention time.

3.12 TESTING PIPING SYSTEMS

A. Test all work in the presence of the Architect and/or Engineer and the Plumbing Inspector, as called for in local codes and in the following manner:

1. After soil, waste and vent and storm piping is in place, and before being furred in, plug lower ends and fill. The system shall be left tight under these conditions and water level shall be maintained intact for a period of at least two (2) hours.

2. Test domestic water piping by applying a hydrostatic pressure of 200 PSI using a pump for this purpose. Make sure that all lines are properly plugged or capped and that air has been vented before applying pressure which shall remain constant without pumping for at least one (1) hour.

3. Any leaks in joints or evidence of defective pipe or fittings disclosed by tests shall be immediately corrected by replacing defective parts with new joints or material. No makeshift repairs effected by caulking threaded pipe with lead wool, application of wicking or patented compounds being permitted. Perform smoke tests if required by local code or by the Architect.

4. Gas (natural) system piping shall be tested to a pressure of 50 PSIG and pressure shall be held for two (2) hours minimum. A mercury gauge shall be used for test.

5. As the systems or portion of systems are tested, submit certified reports stating results of testing. In addition, copies of these certified reports shall be included with the maintenance instructions.

3.13 INSTALLATION OF TOILET ROOM AND LOCKER ROOM ACCESSORIES

A. Install all accessories where shown and as detailed on the Architect's drawings. Accessories shall be provided to this Contractor under Section 10800, at a location agreeable to all parties.

B. All accessories shall be fastened by approved means to the building structure. Supports shall be capable of withstanding a force of 300 pounds. Accessories mounted on masonry walls shall be supported by anchor bolts, on stud walls supported with fishplates welded to metal studs. Submit to the Architect a schedule of proposed mounting methods for each individual room and accessory. Wood blocking for the mounting of these accessories shall be provided by this Contractor.

3.14 CORE DRILLING/DRILLING

A. This Contractor shall be responsible for all his own required core drilling and drilling. Included shall be all required rentals, water and other accessory costs.

SECTION 23 0000

HEATING, VENTILATING AND AIR CONDITIONING INDEX

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SECTION 23 0000

HEATING, VENTILATING AND AIR CONDITIONING

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. Division 0 and Division 1 of these specifications are hereby made a part of this section.

B. Include all labor, materials, equipment, appliances and services necessary to furnish, fabricate and install all work specified herein. Refer to the drawings for further definition of location, extent and details of the work.

C. Where the specifications refer to three (3) products, by name, catalog number and/or manufacturer, it is the intent of the specification that the Contractor shall submit one (1) to the Architect for approval.

D. Where the specifications refer to less than three (3) products by name, catalog number and/or manufacturer, unless otherwise specified, the intent is to establish a standard of quality and not be construed as limiting competition; in such cases, the Contractor may, with the permission of the Architect, submit detailed information to the Architect for his review. If, in the judgment of the Architect, the submission is acceptable, the Architect will transmit his approval in writing to the Contractor.

1.2 WORK INCLUDED

A. The intention of the specifications and plans is to provide for finished systems, properly tested, balanced and ready for operation, including necessary minor details and accessories required to make the work complete, even though such items may not be expressly shown or specified.

B. The scope shall include, but not be limited to, the following:

1. Boilers.
2. Pumps and piping systems.
3. Heating systems.
4. Exhaust systems.
5. Sheet metal.
6. Balancing.

C. The work covered by this section of the specification includes the furnishing of all labor and materials and in performing all operations in connection with the installation of the HVAC work shown on the drawings and as described herein and shall be interpreted as work to be done by this Contractor. Work to be performed by other trades will always be specifically referenced to a particular Contractor and/or Section.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. The following items of labor and material incidental to, or related to the installation of the HVAC work shall be provided by others at no cost to this Contractor.

1. Cutting and patching shall be provided under Division 1.
2. The provision of temporary light, power, water and heat and costs for usage shall be provided under Division 1.
3. Concrete work for equipment bases, housekeeping pads, vibration isolation frames, inertia blocks, boxed openings, perimeter curbs, fuel oil tank hold-down mats and chimney bases shall be provided under Division 3.
4. Undercut doors and door louvers shall be provided under Division 6.

5. Flashing and counterflashing shall be provided under Section 07600.
6. All finish field painting shall be provided under Section 09900.
7. Water, natural gas, and compressed air sources shall be provided under Section 220000.
8. All power wiring, motor starters and interlocking, except as indicated or specified otherwise, shall be provided under Section 260000.

1.4 DEFINITIONS

A. "This Contractor" – shall mean specifically the HVAC Contractor providing work under this respective section of the specifications.

B. "Provide" – Shall mean the furnishing and installing of materials and/or equipment.

C. "Underground" – Shall mean pipe that is buried exterior to or within the building.

D. "Finished grade" – As used herein, means the final grade elevations indicated on the drawings.

E. "Concealed" – Shall mean in walls, in chases, above ceilings, within enclosed cabinets, underground, in trenches or otherwise enclosed.

F. "Exposed" – Shall mean in closets, in finished rooms, under counters, behind and/or under equipment and/or otherwise visible.

G. "HVAC" – Shall mean heating, ventilating and air conditioning.

H. "Piping" – Shall mean pipe, fittings, hangers and valves.

I. "General Contractor" – Shall mean Contractor or Contractors as designated by the Contract Documents as responsible to perform work as referred under this section, as well as other sections of the specifications.

1.5 CODES, ORDINANCES AND PERMITS

A. All work performed under this section of the specifications shall be done in accordance with the applicable National, State and local codes, laws and ordinances.

1. American Society for Testing and Materials (ASTM)

B. All materials and work provided shall be in accordance with, but not limited to, the following:

1. Associated Air Balance Council (AABC)
2. American Moving and Conditioning Association (AMCA)
3. American National Standards Institute (ANSI)
4. Air Conditioning and Refrigeration Institute (ARI)
5. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
6. American Society of Mechanical Engineers (ASME)
7. American Society Building Officials and Code Administrators (BOCA)
8. Factory Mutual (FM)
9. Health, Education and Welfare Resource Administration HEW (HRA)
10. National Electrical Code (NEC)
11. National Electrical Manufacturer's Association (NEMA)
12. National Environmental Balancing Bureau (NEBB)
13. National Fire Protection Association (NFPA)
14. Occupational Safety and Health Act (OSHA)
15. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
16. Underwriters Laboratories, Inc. (UL)

C. Where code references are given, the latest issue of that code in effect at the time of bidding shall be used.

D. This Contractor shall be responsible for providing and filing all plans, specifications and other documents, pay all requisite fees and secure all permits, inspections and approvals necessary for the legal installation and operation of the system and/or equipment furnished under this section of the specifications.

E. This Contractor shall frame under glass all permits, secured by him, adjacent to the respective system and/or equipment and required to be displayed by code, law and ordinance. Those permits secured but not required to be displayed shall be included in the Owner's maintenance manual.

1.6 SHOP DRAWINGS, PRODUCT DATA AND SAMPLES

A. All submittals shall be complete and shall be in three-ring, loose-leaf binders. No consideration will be given to partial submittals, except with prior approval of the Architect. Each item shall have a cover page stating project, specification and paragraph reference number, or drawing reference number, and scheduled equipment identification number, if applicable.

B. The review of submittals does not relieve this Contractor from the responsibility of shop drawing errors in details, sizes, quantities, wiring diagram arrangements and dimensions which deviate from the specifications, Contract drawings, and/or job conditions as they exist.

C. Refer to General Conditions for substitution of equipment.

D. If apparatus or materials are substituted for those specified under this section, and such substitutions necessitate changes in or additional connections, piping supports or construction, same shall be provided at no additional cost to the Owner. This Contractor shall assume cost and entire responsibility thereof. Architect's permission to make such substitution shall not relieve this Contractor from full responsibility for work.

E. Changes to work already performed made necessary by delays in shop drawing review are the responsibility of this Contractor.

F. All pump and fan equipment must be submitted with complete operating curves.

1.7 EXAMINATION OF SITE AND CONTRACT DOCUMENTS

A. Refer to Paragraph 1.2.2 of General Conditions and add the following:

1. Bidders are advised to visit the site and inform themselves as to conditions under which this work will be performed. Failure to do so will, in no way, relieve the successful bidder from the responsibility of furnishing any materials or performing any work in accordance with the true intent and meaning of the drawings and specifications.

2. No claim for extra compensation will be recognized if difficulties are encountered which an examination of the site conditions and contract documents prior to executing the contract would have revealed.

3. This Contractor shall be responsible for ordering and furnishing the correct quantity of material required. Routing and equipment arrangements shown on the drawings are approximate only and are not warranted to be accurate.

4. Arrangements shall be made with the Owner prior to the visit for inspection of the existing buildings.

1.8 RECORD DRAWINGS

A. The General Contractor shall provide two (2) sets of blackline on white record drawings to this Contractor, one set of which shall be maintained at the site and which shall, at all times, be accurate, clear and complete, showing the actual location of all equipment and piping. The record drawings shall be available to the Architect's Engineer's field representative at all times.

Any addenda sketches and supplementary drawings issued during the course of construction shall be transferred to the record drawings.

B. At the completion of the contract, the General Contractor shall submit an accurate checked set of as-built drawings. Non-availability of record drawings or inaccuracies therein will postpone the final inspection until they are available.

C. After approval of these as built drawings, photo reproductions of the original tracings shall be revised to incorporate all the changes on the as-built drawings. These photo reproductions shall be certified as correct and delivered to the Architect together with two (2) sets of blackline prints. Sepia reproducibles shall not be accepted as record drawings.

D. All valves shown on these drawings shall be numbered with numbers corresponding to those on the valve charts.

E. All costs related to the foregoing requirements shall be paid for by this Contractor.

1.9 USE OF ELECTRONIC DRAWING FILES

A. If requested, the Engineer will provide electronic copies of selected CAD (Computer Aided Design) drawing files for the Contractor's use in the preparation of shop drawings, coordination drawings, or as-built drawings related to this project, subject to the terms and conditions in the following paragraphs.

B. The Engineer's electronic files are prepared on AutoCad Version 2007. The Engineer will provide drawing files through Release 2007.

C. Data contained on these electronic files is part of the Engineer's instruments of service and shall not be used by the Contractor or anyone else receiving this data through or from the Contractor for any purpose other than as a convenience in the preparation of shop drawings, coordination drawings, or as-built drawings for the referenced project. Any other use or reuse by the Contractor or by others will be at the Contractor's sole risk and without liability or legal exposure to the Engineer. In accepting these files, the Contractor shall agree to make no claim and shall waive, to the fullest extent permitted by law, any claim or cause of action of any nature against the Engineer, which may arise out of or in connection with the Contractor's use of the electronic files.

D. Furthermore, the Contractor shall to the fullest extent permitted by law, indemnify and hold harmless the Engineer from all claims, damages, losses and expenses, including attorney's fees arising out of or resulting from the Contractor's use of these electronic files.

E. These electronic files are not contract documents. Significant differences may exist between these electronic files and corresponding hard copy contract documents due to software incompatibility, software translation, addenda, change orders or other revisions. The Engineer makes no representation regarding the accuracy or completeness of these electronic files. In the event that a conflict arises between the hard copy contract documents prepared by the Engineer and the electronic files, the hard copy contract documents shall govern. The Contractor is responsible for determining if any conflict exists. By use of these electronic files, the Contractor is not relieved of his duty to fully comply with the contract documents, including and without limitation, the need to check, confirm and coordinate all dimensions and details, take field measurements, verify field conditions and coordinate all work with that of other contractors for the project.

F. Because of the potential that the information presented on the electronic files can be modified, unintentionally or otherwise, the Engineer reserves the right to remove all indication of their respective ownership and/or involvement from each electronic file provided.

G. A service fee of $65.00 per sheet shall be remitted directly to the Engineer prior to delivery of the electronic files. Arrangements shall be made directly with the Engineer for files prepared by them. Electronic files will not be released until payment is received. A written release to be prepared by the Engineer will be required as well.

H. Under no circumstances shall delivery of the electronic files for use by the Contractor be deemed a sale by the Engineer, who make no warranties, either expressed or implied, of merchantability and fitness for any particular purpose. In no event, shall the Engineer or its consultant(s) be liable for any loss of profit or any consequential damages arising out of the use of these electronic files.

1.10 ELECTRICAL CHARACTERISTICS

A. In general, and unless specifically indicated otherwise in the specifications, or noted on the drawings, all building service, heating, ventilating, air conditioning and miscellaneous equipment shall be of the following characteristics:

1. Motors up to an including 1/3 HP shall be suitable for 120 volt, one phase operation.

2. Motors larger than 1/3 HP shall be suitable for 208 volt, three phase operation.

3. All motors shall be furnished with power factor correction capacitors to achieve a minimum power factor of .9.

B. All motors shall be premium efficiency (energy efficient motors) with 95 percent minimum efficiency.

1.11 SCHEDULE OF VALUES

A. This Contractor shall, within thirty (30) days of the Contract award, submit to the Architect a complete breakdown of the contract price to aid in determining the value of the installed work during the construction period. The cost breakdown shall be presented in two (2) forms. The first form shall correspond to the construction schedule with percentage or progress to complete breakdown with progress description by month. The second form shall be a more detailed form. Each building block shall be listed individually with breakdown expressed in terms of major equipment and systems. In addition, each system cost shall be totalized.

B. This Contractor's requisitions shall not be paid until the breakdown has been received by the Architect and its form approved.

1.12 WARRANTY

A. Refer to General Conditions of the specifications and, in addition, all work under this section shall be guaranteed free from defects in workmanship or materials for a period of one (1) year from the date of final acceptance of the system installed. Any such defective work developing during this period, unless such defects are clearly the result of misuse of equipment by persons not under the control of this Contractor shall be replaced by this Contractor without cost to the Owner. Where such defective work results in damage to work of other sections of the specifications, all such work shall be restored to its original condition by mechanics skilled in the affected trade, at the expense of this Contractor. This Contractor shall submit a separate written guarantee stipulating the aforesaid conditions.

B. Standard equipment guarantees offered by the manufacturer for one year or greater shall be in addition to that as required by this Contractor. Copy of manufacturer's equipment guarantees shall be submitted with this Contractor's written guarantee.

1.13 GUARANTEE

A. Attention is directed to provisions of the General Conditions and Supplementary General Conditions regarding guarantees and warranties for work under this Contract.

B. Manufacturer shall provide their standard guarantees for work under this Section; however, such guarantees shall be in addition to and not in lieu of all other liabilities which the manufacturer and Subcontractor may have by law or by other provisions of the Contract Documents.

C. All materials, items of equipment and workmanship furnished under this Section shall carry the standard warranty against all defects in material and workmanship for a period of not less than one (1) year. Any fault due to defective or improper material, equipment, workmanship or

design which may develop within that period shall be made good, forthwith, by and at the expense of the HVAC Contractor, including all other damage done to areas, material and other systems resulting from this failure.

D. Contractor shall guarantee that all elements of the systems are of sufficient capacity to meet the specified performance requirements as set forth herein, or as indicated.

E. Upon receipt of notice from the Owner of failure of any part of the systems or equipment during the guarantee period, the affected part or parts shall be replaced by the Contractor within a reasonable period of time.

F. Furnish before the final payment is made a written guarantee covering the above requirements.

1.14 PROTECTION

A. The Contractor shall be responsible for the maintenance and protection of all materials and equipment furnished by him during the construction period from loss, damage or deterioration until final acceptance by the Owner. All materials and equipment on the job site shall be stored and protected from the weather. All piping, duct and equipment openings shall be temporarily closed during construction to prevent obstruction and damage.

B. The Contractor shall, at all times, keep the site clear from accumulation of waste materials and rubbish caused by his operations. At the conclusion of the work, all materials and equipment used in the work shall be thoroughly cleaned of construction debris. All equipment with damaged finished surfaces shall be cleaned and repainted with the same paints as was factory applied.

1.15 TESTS

A. Furnish all labor, materials, instruments, supplies and services and bear all costs for the accomplishment of the tests herein specified. Correct all defects appearing under tests and repeat the tests until no defects are disclosed; leave the equipment clean and ready for use.

B. All leaks, loose fittings, air, etc., must be eliminated from the systems. Test out all equipment together with valves and controls, test the operation of all valves, controls and other devices. Each piece of equipment, including equipment, piping and valves, shall be operated continuously for a period of not less than eight (8) hours in the presence of the Architect or his authorized representative and Owner's representative before acceptance.

C. The following systems shall be tested in the presence of the Architect, users and CNY Building 149 Buildings and Grounds representative.

1. All new supply air systems.
2. All new exhaust air systems.
3. Fancoil units and controls (new and existing).
4. All new process chilled water systems.

D. Any equipment and/or controls which fail to meet any test shall be modified and/or replaced until satisfactory test results are achieved, at no cost to the Owner.

E. The Contractor shall perform all tests other than herein specified which may be required by legal authorities or the agencies to whose requirements this work is to conform.

1.16 ABBREVIATIONS

A. UL Underwriters Laboratories, Inc.

B. NFPA National Fire Protection Association

C. IEEE Institute of Electrical & Electronic Engineers

D. ASTM American Society for Testing and Materials

E.	NEMA	National Electrical Manufacturer's Association
F.	ANSI	American National Standards Institute
G.	AABC	Associated Air Balance Council
H.	AMCA	Air Moving and Conditioning Association
I.	ARI	Air Conditioning and Refrigeration Institute
J.	ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
K.	ASME	American Society of Mechanical Engineers
L.	BOCA	Building Officials and Code Administrators
M.	NBFU	National Board of Fire Underwriters
N.	NEC	National Electrical Code
O.	OSHA	Occupational Safety and Health Act
P.	SMACNA	Sheet Metal and Air Conditioning Contractors National Association

1.17 TEMPORARY HEATING

A. Provided by the Contractor, utilizing the existing building heating system in accordance with the Architect's requirements.

1.18 ACCEPTANCE OF INSTALLATION CONDITIONS

A. This Contractor shall be fully responsible for the proper execution and performance of the work described herein. It shall be his responsibility to inspect all installation conditions and request the Contractor to correct any conditions which may affect his work adversely.

1.19 DRAWINGS

A. The HVAC Drawings are diagrammatic only and are not intended to show every detail of existing conditions, construction or arbitrary location of HVAC work. Each system shall be complete with minor parts not specifically noted on the Drawings, but each required for a properly functioning system conforming to State and local Codes. Where building construction makes it advisable or necessary to change location of piping, ductwork or equipment without increasing the cost of the work, such changes shall be made with the consent of the Architect, Engineer and Owner and at no additional cost to the Owner.

B. In case of conflict with building parts or the work of other trades, the Architect shall be notified immediately and requested to render a decision so that there will be no delay in the building construction.

1.20 SPECIFICATIONS

A. The Specifications are intended to complement the Drawings; however, work detailed and/or noted only on the Drawings or work described only in the Specifications shall also be considered as part of the scope of work.

B. Work shall be performed as described in the Specifications except where specific deviations are indicated and/or noted on the Drawings.

1.21 EXISTING EQUIPMENT SHUT-DOWN

A. Contractor shall not make any equipment or system shut-downs without the strict consent and supervision of Charlestown Navy Yard Building 149 Buildings and Grounds Department. Coordinate time frame for notification seven (7) days, plus or minus, with Architect and Buildings and Grounds Department.

1.22 PHASES

A. See Division 1 for phasing. There are significant phases in scope which this Contractor will be required to price per Division 1 language.

PART 2 – PRODUCTS

2.1 ACCESS PANELS

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

B. For all work by this trade, furnish access panels for installation in walls and ceilings, at locations indicated on the drawings or as required to permit access.

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

D. Access panels shall be as specified in Section 08305 Access Doors, but shall be provided by this trade.

E. All access panels shall be shown on the coordination drawings.

2.2 AIR SEPARATORS

A. Furnish and install as shown on the drawings a spirotherm, Bell & Gossett, or Taco air separation fitting on the hot water heating system, chilled water system and condenser water system.

B. All fittings shall be fabricated steel, rated for 150 psig design pressure and be selected for less than 1 foot of water pressure drop and velocity not to exceed 4 feet per second through the unit at specified GPM. Performance curves specifying air collection efficiency and pressure drop at rated flow shall be furnished by the unit manufacturer as part of the submittal for each unit.

C. All units shall include an integral spirally wound three dimensional copper grid to act as a turbulence suppressive coalescing medium which must completely fill the fitting's internal area. Units are to remove free and entrained air during system start up and continue to eliminate dissolved air through continual circulation and the coalescing action of the spirally wound grid.

1. Alternate units shall have an internal stainless steel air collector tube with 5/32" diameter perforations and 63% open area designed to direct accumulated air to the compression tank via an NPT connection at top of unit.

D. Each fitting is to have a separate air and 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 float actuated brass air vent. There shall be no restriction in the connection from the venting chamber to the vent.

E. The fittings are to 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. Units shall include a bottom connection for use as a blow down connection for periodic cleaning.

F. Provide integral high capacity float actuated air vent at top fitting of tank.

1. Alternates must include bronze or cast iron float actuated air vent rated at 150 psig which shall be threaded to the top of the fitting.

2. Unit shall have bottom blow down connection.

2.3 BOILERS (NATURAL GAS FIRED)

A. There shall be provided and installed a quantity of 2 Buderus SB615 Series condensing gas-fired boilers, suitable for firing with natural gas utilizing a forced draft combustion system.

B. The boiler(s) shall have a full three pass fire tube design to allow complete combustion of the fuel in the main combustion chamber. All flue side surfaces, including the main combustion

chamber, second and third flue passages shall be constructed of 316 stainless steel designed to maximize the condensate formation. All flue passages shall be fully water-backed to minimize thermal stresses on the boiler vessel.

C. Boiler(s) shall be constructed with dual return water connections where the lower connection shall be aligned with the lowest (coldest) return water temperature for maximum efficiency.

D. Boiler(s) shall be suitable to operate under any return water temperature, any boiler water flow rate and without any restrictions on temperature rise through the boiler vessel. Boiler(s) shall be able to operate at efficiencies up to 98% at suitably low return water temperatures.

E. The condensing secondary and tertiary fire tube flue passages shall be fabricated from 316 stainless steel with a reduced cross section in the direction of flue products flow to maintain a near constant velocity of combustion products and to enhance micro turbulences for maximum heat transfer.

F. Boiler(s) shall have an internal water baffle plate separating return water between second and third flue passages for maximum efficiency.

G. Boiler(s) shall be fully serviceable from the front by means of a reversible swing burner door and removable access cover.

H. The boiler vessel shall be wrapped with a full 4” thermal insulation blanket for minimal stand-by loss.

I. The control system for the boiler shall consist of the Buderus Logamatic 2107 furnished with supply and outdoor air sensors for reset control of the heating system. The control shall have night setback capability, display and easy adjustment of the heating schedule with indicator symbols for circulators, burner and with modulating control.

J. The control shall have a dynamic burner differential, built-in boiler protection for low return water temperatures and an adjustable responsiveness to outdoor temperature variations. Manufacturer shall provide only factory authorized technician for startup.

2.4 BREECHING & CHIMNEY (DOUBLE WALL PIPING SYSTEMS)

A. This factory-built system shall be laboratory tested and listed by the Underwriters Laboratories, Inc., for use with building heating equipment burning gas, solid or liquid fuels as described in NFPA 211, which produce exhausted flue gases at a temperature not exceeding 1400 degrees F. under continuous operation conditions.

B. The manufacturer shall provide all component parts as necessary for a complete installation between the equipment served and the point of termination, as indicated on the Drawings or specified herein.

C. The double wall insulated stack shall have an outer jacket of stainless steel. There shall be a minimum 1 inch insulated space between the walls. The inner gas-carrying pipe shall be Type 304 stainless steel. The inner liner shall be .035 inch nominal thickness for all diameters.

D. When the breeching and chimney is installed according to the manufacturer's installation instructions and the limits of its listing, it will comply with National Safety Standards and Building Codes.

E. Inner pipe joints shall be sealed by use of V bands and RTV silicone sealant for flue gas temperatures up to 600 degrees F.; above this temperature, joints shall be sealed with V bands and high temperature joint cement as outlined in the installation instructions and supplied by the manufacturer.

F. Stacks extending above roof surfaces must terminate as required by local Code or as required by NFPA 211.

G. Outer jacket shall be 316 Type stainless jacket with nominal thickness of .025 inch for all sizes through 24 inches.

2.5 CHEMICAL TREATMENT

A. Provide where shown on drawings and as specified herein the equipment necessary for chemical treatment and service as provided by New England Systems and Supply, Inc., Nutmeg, Metropolitan Refinery Company, Inc., Barclay Chemical Company, Inc., Betz Company or Water Services Laboratories, Inc., or approved equal.

B. The contract agreement satisfactory in form and substance to the Owner – executed between this Contractor and the chemical treatment company to furnish supervisory service to assure the use of proper chemical treatment to and for systems, installed under this contract, hot water, chilled water and condenser water, for a period of one (1) year from date of initial treatment thereof. The Contract: Assigned by this Contractor to the Owner on the date that the building is accepted by the Owner, so that chemical treatment will continue uninterrupted during the one year life of the contract. If the building is not accepted by the Owner prior to the expiration of the one year contract, arrangements shall be made by this Contractor to extend this contract until the building is accepted by the Owner.

C. Chemical treatment company shall perform the following through its agents:

1. Supervise initial cleaning of systems and equipment.
2. Supervise initial introduction of chemical treatment.
3. Furnish service calls by its agents at a frequency of not less than one (1) per thirty (30) days thereafter, during the one (1) year life of the contract.
4. Furnish all required chemicals for proper treatment of all systems hereinafter described, together with all necessary testing equipment and reagents for field analysis of the water during the aforementioned one year contract.
5. The chemical treatment company shall assume responsibility for field testing and control and regular addition of chemical treatment in whatever amounts are necessary on each of the systems hereinafter described, as provided by the chemical treatment company until the date of acceptance of the building by the Owner.
6. Some water circulating pumps shall have mechanical seals as specified in this section. It shall be the responsibility of the chemical treatment company to coordinate with the pump manufacturer and adjust the formulation of the water treatment chemicals to be assured that the normal life of the mechanical seals is not affected.
7. The chemical treatment supplier shall provide chemicals which are non-pollutants and meet Federal Water Quality criteria.
8. The chemical treatment company shall establish, document and submit to the Architect volumes of each system or sub-system for which treatment is provided.

D. Hot Water Systems: Provide for each system one liquid chemical bypass type feeder of approximately 5 gallon capacity, complete with valves and fittings which shall be connected across each hot water heating system pump set.

E. Chemical cleaning solutions used shall not be harmful to materials of construction. After systems have been drained, flushed and refilled, a chemical test shall be made by the chemical treatment company to determine that cleaning solution remaining in system does not impart alkalinity to water in excess of 300 ppm. A written report to this affect shall be submitted to the Architect.

F. Initial Cleaning of Hot Water Piping System: Cutting oil, excess pipe joint compound, finely divided solids and other similar foreign materials shall be removed from all circulating water and steam piping systems before they are placed in operation. The cleaning materials used shall be supplied and applied by the chemical treatment company and all circulation, draining, flushing and refilling work shall be done by this Contractor, as directed by the chemical treatment company.

G. Refer to Piping Systems Flushing and Cleaning for additional requirements.

2.6 CABINET HEATERS

A. Cabinet unit heaters shall be of the size, type and capacity indicated on drawings. Equipment shall be as manufactured by Airtherm, Sterling or Vulcan.

B. Cabinet unit heaters shall consist of a heating element with centrifugal fans driven by an electrical motor, filter, and where semi or fully recessed, they shall be flanged on four sides. They shall be capable of delivering the indicated heat emission with entering air at 60 degrees F. Each unit shall be provided with manual on-off switch and two-speed selector switch.

2.7 DOUBLE WALL GAS FIRED APPLIANCE VENTING SYSTEMS (FOR DHW HEATER)

A. This factory-built system shall be laboratory tested and listed by the Underwriters Laboratories, Inc., for use with building heating equipment burning gas fuel as described in NFPA 211, which produce exhausted flue gases at a temperature not exceeding 1400 degrees F. under continuous operation conditions.

B. The manufacturer shall provide all component parts as necessary for a complete installation between the equipment served and the point of termination, as indicated on the Drawings or specified herein.

C. The double wall stack shall have an outer jacket of 316 stainless steel, .025 inch thick. There shall be a minimum 1 inch air space between the walls. The inner gas-carrying pipe shall be Type 304 stainless steel. The inner liner shall be .035 inch nominal thickness.

D. When the gas vent system is installed according to the manufacturer's installation instructions and the limits of its listing, it will comply with National Safety Standards and Building Codes.

E. Inner pipe joints shall be sealed by use of V bands and RTV silicone sealant.

F. Vents extending above roof surfaces must terminate as required by local Code or as required by NFPA 211.

2.8 DUCTLESS SPLIT FANCOIL SYSTEM

A. Provide a complete split system type ductless fancoil air conditioning system consisting of compact mounted packaged evaporator sections with matching air cooled outdoor condensing unit. The units shall be listed by the Electrical Testing Laboratories (ETL) and bear the ETL label. All wiring to be in accordance with the National Electrical Code (NEC). The units shall be rated in accordance with ARI Standard 210 and bear the ARI label. A full charge of R-140A for 40 feet of refrigerant tubing shall be provided in the condensing unit. System SEER shall meet or exceed 1992 Federal Standards.

1. The system components shall be provided by a single manufacturer to provide for an integrated, 100% compatible installation. System shall be as manufactured by Mitsubishi Company, Sanyo Company or Trane.

B. The units shall have a manufacturer’s warranty for a period of one (1) year from date of installation. The compressor shall have a warranty of six (6) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the site of installation.

C. The indoor unit shall provide a total minimum cooling capacity as scheduled on the drawings with an SEER of 16.0 at ARI Standard conditions. The system net minimum total cooling capacity shall be rated at 67 degrees FDB indoor and 95 degrees FDB air entering the outdoor coil.

D. The indoor unit shall be completely factory assembled and wired. The casing shall be of galvanized sheet steel, phosphatized, bonderized and finished in a baked enamel white finish.

1. The evaporator fan shall be a high performance forward curve line flow fan direct driven by a single motor. The fan shall be statically and dynamically balanced and shall run on

permanently lubricated bearings.

2. An adjustable change vane shall be provided with the ability to direct the air flow from horizontal to vertical. An adjustable guide vane shall be provided to manually change the air direction from left to right.

3. The evaporator coil shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phoscopper or silver alloy. The coils shall be pressure tested to 450 psig at the factory.

4. An insulated condensate pan with drain shall be provided under the coil.

E. The control system shall consist of multiple microprocessor sections. One microprocessor shall be factory wired and located within each indoor unit. It shall have the capability of sensing room temperature and indoor coil temperature; receive and process commands from the remote controller; and control the outdoor unit. The Contractor shall be responsible for required interlock wiring.

1. The microprocessor within the wall mounted remote controller shall display setpoint; provide two (2) manually selected modes of cooling, normal and economy operation at 2 degrees above setpoint; night set back operation of 4 degrees above setpoint; and manual or automatic fan speed control.

2. The optimum temperature shall be memorized for immediate recall as the system default setpoint whenever the system is used again.

3. The system shall be capable of automatic restart when power is restored after power interruption.

4. Automatic fan speed control shall be based upon the temperature difference between setpoint and room temperature maintaining lowest speed possible.

5. A remote control unit shall be wireless, using infrared, line of sight for control of system and shall include automatic ON/OFF timer; liquid crystal display, and temperature reset capability. Furnish and install, in the field, on the wall, a remote control unit holder.

F. The outdoor unit shall be completely factory assembled, piped and wired. The casing shall be fabricated of galvanized steel, phosphatized, bonderized and finished with baked enamel. The unit shall be furnished with direct drive, propeller type fans arranged for horizontal discharge.

1. The motor shall have inherent protection, be of the permanently lubricated type and resiliently mounted for quiet operation.

2. The fans shall be provided with a raised guard to prevent contact with moving parts.

3. Multiple compressors shall be provided, one for each indoor evaporator fancoil unit. The compressors shall be of the high performance rotary type with accumulator and internal thermal overloads. The compressors shall be mounted so as to avoid the transmission of vibration.

4. The refrigeration system shall have the capability to operate with maximum height difference of 40 feet and overall refrigerant tubing length of 160 linear feet between indoor and outdoor sections without the need for line size changes, traps, or additional oil. Refrigerant flow from the condenser to be controlled by means of capillary tubes.

5. The condenser coil shall be non-ferrous construction with smooth plate fins bonded to copper tubing. The coil shall be protected with an internal metal guard finish to match unit panels.

6. The unit shall be controlled by the microprocessor located in the matching indoor units.

2.9 ENERGY RECOVERY VENTILATION UNITS

A. General

1. Energy Recovery Ventilator shall be as manufactured by Aaon, Semco or Venmar.
2. Units shall be listed per UL1812 and bear the UL label. Energy transfer ratings of the energy recovery wheel shall be ARI Certified.
3. Performance shall be as scheduled on plans.
4. Exhaust discharge and outside air intake shall not be located on the same side on roof top units.

B. Unit Casing and Frames

1. Unit shall be double wall, frame type construction of galvanized steel. Frame and panels shall be G90 galvanized steel.
2. All panels exposed to the weather shall be a minimum of 18 gauge galvanized steel.
3. Unit shall be internally lined with galvanized sheet metal creating a double wall.
4. Where top panels are joined there shall be an overlapping, standing seam to insure positive weather protection.
5. All metal-to-metal seams shall be factory sealed, requiring no caulking at job site.
6. Provide with Permatector (or approved equal) exterior finish for outdoor units.
7. Unit base to be designed for curb mounting. Unit base shall overhang the curb for a positive seal against water run-off.

C. Weatherhoods

1. Weatherhoods shall be the same finish as the unit, Outdoor air weatherhood shall incorporate a louvered design and moisture eliminator.
2. Weatherhoods shall be tested in accordance with AMCA Standard 500-L to prevent water penetration up to 3 in/hr at 29 mph.

D. Insulation

1. Unit casing to be insulated with 1 inch fiberglass.
2. Insulation shall meet requirements of NFPA 90A and tested to meet UL 181 erosion requirements.
3. Insulation to be enclosed in double wall construction.

E. Evaporator Coil Section

1. Provide heavy-duty aluminum fins mechanically bonded to copper tubes. 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. Staggered coils are not acceptable.
2. Evaporator coils shall have galvanized steel end casings.
3. Evaporator coils shall have equalizing type vertical tube headers.
4. Provide a thermostatic expansion valve (TXV) for each refrigerant circuit.
5. Factory pressure and leak test coil at 300 psi.
6. Provide pitched stainless steel drain pan to assure positive drainage of condensate from the unit casing.

F. Refrigeration Components

1. Provide factory assembled, integral to the unit or remote outdoor mounted, air-cooled condensing section or unit suitable for rooftop installation.
2. Include compressors, air cooled condenser, refrigerant, lubrication system, interconnecting wiring, safety and operating controls, motor starting components and additional features as specified herein or required for safe, automatic operation.
3. Capacities, number of refrigeration circuits, steps of unloading and minimum capacity shall be as indicated in the equipment schedule.
4. The contractor may provide multiple separate units in lieu of a single unit in order to provide the required number of steps of unloading. This contractor is responsible for all additional costs, including electrical and controls costs, associated with multiple units.
5. Refrigerant is to be R-410A.
6. Provide hot gas bypass feature with associated accessories for low load operation.
7. Remote air-cooled condensing unit shall be manufactured and/or provided by the same manufacturer as the ERV unit. Unit shall be manufactured in accordance with ARI 365.
8. Cabinet
    a. Construct cabinet of heavy gauge, galvanized steel coated with paint.
    b. Cabinet must meet the 500-hour salt spray exposure test in accordance with ASTM B117.
    c. Provide lifting holes to facilitate rigging and access panels to facilitate access to all-internal areas of unit that require service or repair.
9. Compressors
    a. Provide scroll hermetic type or reciprocating type compressors.
        (1) Scroll compressors: Direct drive suction cooled motor with built in motor temperature and current protection.
        (2) Provide oil pump with dirt separator and oil level sight glass.
        (3) Provide with crankcase heater.
        (4) Provide with suction service valve and liquid line shut off valve with charging and gauge ports for each compressor circuit.
        (5) Provide discharge line service valves with gage ports.
        (6) Provide with liquid line filter drier, sight glass.
        (7) Mount compressors on vibration isolators.
    b. Reciprocating Compressors:
        (1) Hermetic or semi-hermetic compressors with built in temperature and current protection.
        (2) Provide with suction service valve and liquid line shut off valve with charging and gauge ports for each compressor circuit.
        (3) Provide discharge line service valves with gage ports.
        (4) Provide with liquid line filter drier, sight glass.
        (5) Provide with crankcase heater.
        (6) Provide oil level site glass on semi-hermetic units.
        (7) Mount compressors on vibration isolators.

10. Condensers

    a. Provide condenser coils with aluminum alloy plate fins mechanically fastened to seamless copper tubing with integral subcooler.

    b. Construct coils with design working pressure suitable for the refrigerant.

    c. Condenser Fans - Provide direct-drive statically and dynamically balanced propeller type fans with vertical discharge and guards constructed of heavy gage PVC coated wire or galvanized steel.

11. Power Wiring

    a. Provide factory installed 24-volt control circuit with fusing, control power transformer and all associated internal wiring.

    b. Provide a single point power connection to the unit(s).

    c. Provide factory installed magnetic contactors for compressor and condenser motors.

    d. Electrical characteristics shall be as indicated in the equipment schedule.

12. Controls

    a. Provide high/low refrigerant pressure cutouts with manual reset and anti-shortcycle compressor timer.

    b. Unit must be capable of operating down to ambient temperature of 40 deg F. Provide low ambient lockout to prevent compressor from operating below 40 degrees.

    c. Provide a terminal strip for external control of compressor stages for field provided controls.

G. Energy Recovery Wheel

1. Wheel shall be of the enthalpy type for both sensible and latent heat recovery and be designed to insure laminar flow.

2. Energy transfer ratings must be ARI Certified to Standard 1060 and bear the ARI certification symbol for ARI Air-to-Air Energy Recovery Ventilation Equipment Certification Program based on ARI 1060. Ratings "in accordance with 1060" without certification are not acceptable.

3. Desiccant shall be silica gel for maximum latent energy transfer. Wheel shall be constructed of lightweight polymer media to minimize shaft and bearing loads. Polymer media shall be mounted in a stainless steel rotor for corrosion resistance.

4. Wheel design shall consist of removable segments for ease of service and/or cleaning. Silica gel desiccant shall be permanently bonded to wheel media to retain latent heat capability after cleaning. Wheels with sprayed on desiccant coatings are not acceptable. Wheels with desiccant applied after wheel formations are not acceptable.

5. Energy recovery device shall transfer moisture entirely in the vapor phase.

6. Energy recovery drive belt material shall be high strength urethane and shall be factory installed in a pre-stretched state, eliminating the need for field belt tension adjustment. Link style belts are not acceptable.

7. Unit shall be provided with wheel modulation frost control.

H. Access Doors

1. All components shall be easily accessible through removable doors for exhaust, supply, filter, and damper compartments.

2. Energy recovery wheels (smaller than 54 inches) shall be mounted in a slide-out track for ease of inspection, removal, and cleaning.

I. Fan Sections

1. Centrifugal fans to be double width, double inlet, forward curved type. All blower wheels shall be statically and dynamically balanced.
2. Ground and polished steel fan shafts shall be mounted in permanently lubricated, sealed ball bearing pillow blocks.
3. Bearings shall be selected for a minimum (L10) life in excess of 100,000 hours at maximum cataloged operating speeds.
4. Separate motors for exhaust and supply blowers shall be provided.
5. Adjustable sheaves on belt-driven fans with motors less than 10 hp shall allow independent balancing of exhaust and supply airflows.
6. Fan and motor assemblies are mounted to unit base with neoprene isolators as standard.
7. Fans shall be located in draw-through position in reference to the energy recovery wheel.

J. Motor and Drives

1. Motors shall be energy efficient, complying with EPACT standards, for single speed ODP and TE enclosures.
2. Motors shall be permanently lubricated, heavy-duty type, matched to the fan load and furnished at the specified voltage, phase, and enclosure.
3. Drives shall be sized for a minimum of 150% of driven horsepower.
4. Pulleys shall be of the fully machined cast type, keyed and securely attached to the fan wheel and motor shafts; 10 horsepower and less shall be supplied with an adjustable drive pulley.
5. Energy wheel motors shall have integral overload protection.
6. Refer to Motors and Drives section of specifications for additional requirements.

K. Filters

1. Supply and exhaust air filters shall be 2-inch thick pleated fiberglass, 30% efficient and tested to meet UL Class 2. Provide 4” 65% Final Filters on Supply side.
2. Filter racks shall be die-formed galvanized steel.

L. Electrical

1. All internal electrical components shall be factory wired for single point power connection.
2. All electrical components shall be UL Listed, Approved, or Classified where applicable and wired in compliance with the National Electrical Code.
3. Weatherproof, integral door interlocking disconnect switch, motor starters, control circuit fusing, control transformer for 24 VAC circuit, and terminal strip shall be supplied as standard components in the control center.
4. Motor starters consist of a contactor and Class 20 electronic adjustable overload protection and shall be provided for all motors in the unit.

M. Gas Heating Section

1. Gas furnace shall be minimum 80% efficient, UL Listed to ANSI Standard Z83.8 - 2002, CGA approved per 2.6 - 2002 and have a blow through fan design.

2. Furnace shall be capable of operation with natural gas or LP gas and have a power venting system.

3. The burner and heat exchanger shall be constructed of aluminized steel.

4. Standard furnace features shall include main gas pressure regulator, main gas valve, electronic staged or electronic modulating controls, direct spark ignition system, high limit and a 24-volt control transformer.

N. Warranty

1. The energy recovery ventilator shall be warranted to be free from defects in material and workmanship for a period of eighteen months from the purchase date of for one year after substantial completion.

2. The energy recovery wheel and heat exchanger shall be warranted to be free from defects in material and workmanship for a period of five years from the purchase date.

2.10 EXPANSION JOINTS

A. Expansion joints shall be provided where indicated on the Drawings. Equipment shall be as manufactured by Advanced Thermal Systems, ADSCO Division of Yube Industries or approved equal.

B. Expansion joints shall have internal and external guides, fabricated steel body with 150 PSIG service ratings, single or double slide arrangement to suit the installation location. Bases shall be provided for mounting on framing or to other framing structure. Joints shall have flanged pipe ends on all sizes, polished duplex chrome/nickel plated sleeve sections and entire unit shall be provided with external packing application connections for addition of lubricant under full line pressure. Provide proper packing for both hot and cold lines, together with sufficient spare material and applicator for one year period.

C. Provide guides for expansion joints on the movement side of each expansion joint. Two guides shall be provided prior to each moveable section of expansion joint. Guides shall be ADSCO Model H, for high temperature and Model H-1TB for low temperature lines. Guides shall be located as recommended by the expansion joint supplier for his equipment to minimize lateral misalignment.

D. Provide fintube compensators where indicated on the Drawings or very 50 feet on straight fintube runs. Compensators shall be enclosed bellows type with internal guides.

2.11 EXPANSION TANKS

A. Expansion tanks shall be of the types, sizes and capacities indicated on the drawings. Equipment shall be as manufactured by Taco, Bell and Gossett, Thrush, or Massachusetts Engineering Company.

B. Equipment shall be designed for 125 psig ASME working pressure and so labeled. Tanks shall be provided with gauge glass with tricocks and drain, tank drain, charging valve and mounting saddles or cradles.

C. Bladder-type tanks shall be designed for 125 psig ASME working pressure and be so labeled. Tanks shall be provided with tank drain, charging valve, replaceable bladder, lift ring and base support or cradle. Acceptance capacity shall be the capacity scheduled

2.12 FANS (ROOF EXHAUST)

A. Roof exhaust fans shall be of the sizes and capacities indicated on the drawings. Equipment shall be as scheduled on drawings or equal as manufactured by Cook, Greenheck, or Penn Ventilator Company.

B. Roof exhaust fans shall be belt-driven as indicated on drawings. Fans shall have all spun aluminum housing, centrifugal air foil, fan wheels, totally enclosed motors, with full thermal overload protection, sealed or permanently lubricated ball bearings, aluminum outlet screen and

inlet dampers. Dampers shall be motor operated type with normally open face unless otherwise indicated on drawings.

C. Manufacturer shall provide not less than two (2) spare sets of belts for each fan.

D. Prefabricated roof curb with a minimum height of 12 inches shall be furnished with each fan unless indicated otherwise on the drawings.

2.13 FINTUBE RADIATION

A. Fintube radiation shall be of the types, sizes and capacities indicated on the drawings. Fintube elements, brackets, hanging strips, floor angles and enclosure panels shall be as manufactured by Vulcan, Sterling or Standard Fin.

B. Fintube radiation covers shall be as detailed on the drawings. They shall run continuous wall to wall, except where otherwise indicated on the drawings. Enclosures shall have prime paint.

C. Fintube enclosure shall extend the full width at walls with square end caps at columns. Enclosure covers shall have hinged access panels for valving.

D. Wall mounted type enclosure mounted in front of glazing shall have full backplate.

2.14 FLEXIBLE CONNECTIONS

A. Flexible connections shall be compatible with the system fluid and be manufactured by Mason Industries or an approved equal.

B. Flexible neoprene connectors shall be used on all equipment as indicated on the Drawings or on the equipment schedule. They shall be manufactured of multiple plies of nylon tire cord fabric and neoprene, both molded and cured in hydraulic rubber presses. No steel wire or rings shall be used as pressure reinforcement. Straight connectors shall have two (2) spheres. Connectors up to and including 2 inches and larger shall be manufactured with floating galvanized flanges recessed to lock the connector's raised face neoprene flanges. Hoses shall be installed on the equipment side of the shut-off valve.

C. Connectors shall be rated a minimum of 150 PSI at 220 degrees F. Flanged equipment shall be directly connected to neoprene elbows in the size range 2-1/2 through 12 inches if the piping makes a 90 degree turn at the equipment. All straight-through connections shall be made with twin spheres properly pre-extended as recommended by the manufacturer to prevent additional elongation under pressure. 12 inch and larger sizes operating above 100 PSI shall employ control cables with end fittings isolated by means of 1/2 inch thick bridge bearing neoprene washer bushings designed for a maximum of 1000 PSI.

D. Elbows shall be Mason-Flex Type MFNEC, straight connectors Mason-Flex Type MFTFU or MFTNC and control cable assemblies Type ACC, all as manufactured by Mason Industries, Inc., or an approved equal.

E. Flexible connectors in systems with operating temperatures in excess of 220 degrees F. or operating pressures in excess of 150 PSI shall be selected in accordance with manufacturer's recommendations and, where applicable, shall include control rods or other suitable devices to prevent elongation and shall incorporate special heavy duty construction.

2.15 FOUNDATIONS AND SUPPORTS

A. All mechanical equipment and systems shall be substantially supported without distortion or excessive vibration. The methods of support shall be as hereinafter described, except as otherwise noted on the Drawings. This Contractor shall locate all equipment bases and shall provide all anchor bolts and templates to the General Contractor who shall form and set all concrete work and shall set all anchor bolts. Anchor bolts and nuts shall be galvanized.

B. Concrete housekeeping pads shall follow equipment plan shape and be 6 inches in height. Where equipment is set directly on housekeeping pads the space between equipment base and pad top shall be filled by the General Contractor with non-shrinking grout. Where equipment shape or mounting is such as to require an air space between equipment base and pad, the pad

shall then be furnished with a smooth troweled surface. All equipment shall be anchored to housekeeping pads or all intervening vibration isolator bases shall be anchored to the structure.

C. Where steel frame floor supports are indicated to be provided, such framing shall be all-welded type with two coats of red primer. The framing system shall be substantial type with members sized to prevent equipment distortion or excessive vibration. Framing shall be simple post and beam box type with diagonal bracing to prevent lateral movement. Beam members shall be positioned to align with equipment support points for proper bolting and posts shall be positioned to prevent excessive beam cantilevering. Posts shall be provided with baseplate anchored to the structure.

D. Where steel framing supports are indicated to be provided for roof mounted equipment (those without integral curbs for setting into roof structure) the same framing system as described above shall be used, except members shall be galvanized and bolted together. Posts shall be positioned to align both framing and roof structural members with pitch pockets at roof penetrations.

E. Ground-mounted equipment shall be supported with framing system similar to roofing application described above except that posts shall be set on poured-in-place concrete piers with galvanized anchor bolts. Concrete piers shall be provided by the General Contractor.

2.16 GAS FIRED HEATING AND VENTILATING UNIT

A. General: Heating and Ventilating unit shall be as manufactured by Greenheck, Reznor, or Sterling provided all specifications are met. Greenheck Model IG-HV is used as the basis of design. Performance shall be as scheduled on plans.

B. Furnace: Indirect gas fired furnace shall be 80% efficient, ETL Listed and have a blow through fan design. Furnace shall be capable of operation with natural or LP gas and have a power venting system with post purge cycle. The heat exchanger shall be constructed of aluminized steel or stainless steel. Standard furnace features shall include main gas pressure regulator, main gas valve, electronic staged controls, direct spark ignition system, high limit and a 24 volt control transformer. Furnace shall be insulated and have double wall construction.

C. Temperature Control: Heating and cooling output shall be controlled by a room thermostat to maintain desired room temperature. Economizer control shall provide the first stage of cooling, where specified. Furnaces shall provide 1 or 2 stages of heat output control.

D. Unit Casing and Frames: All frames and panels shall be G90 galvanized steel. Where top panels are joined there shall be a standing seam to insure positive weather protection. All metal-to-metal surfaces exposed to the weather shall be sealed, requiring no caulking at job site. All components shall be easily accessible through removable doors.

E. Unit shall have double wall construction and be insulated from the mixing box intake through to the supply discharge. Insulation shall be in accordance with NFPA 96 and tested to meet UL 181 erosion requirements.

F. Weatherhoods: Weatherhoods shall be the same finish as the unit and shall incorporate a louvered design with moisture eliminators.

G. Motors and Drives: Motors shall be energy efficient, complying with EPACT standards, for single speed ODP and TE enclosures. Motors shall be permanently lubricated, heavy duty type, matched to the fan load and furnished at the specified voltage, phase and enclosure. Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be cast and have machined surfaces, 10 horse power and less shall be supplied with an adjustable drive pulley.

H. Mixing Box: Mixing box shall contain outside air and return air dampers with low leak, pressure activated, extruded vinyl blade seals, aluminum jamb seals, Belimo actuator and 30% efficient pleated filters in a V-bank arrangement such that velocities across the filters do not exceed 550 feet per minute. Filters shall be easily accessible through a removable access panel. The mixing box shall modulate the amount of outdoor and return air by use of dampers. Input signal for

return damper shall be from economizer controller, potentiometer, 2-10 volt signal, or 4-20 mA signal.

I. Fan Section: Centrifugal fans shall be double width, double inlet. Fan and motor shall be mounted on a common base and shall be internally isolated. All blower wheels shall be statically and dynamically balanced. Ground and polished steel fan shafts shall be mounted in permanently lubricated ball bearings (up to size 118) or ball bearing pillow blocks (size 120 and larger). Bearings shall be selected for a minimum (L10) life in excess of 100,000 hours at maximum cataloged speeds.

J. Electrical: All internal electrical components shall be prewired for single point power connection. All electrical components shall be UL listed, recognized or classified where applicable and wired in compliance with the National Electrical Code. Control center shall include motor starter, control circuit fusing, control transformer for 24 VAC circuit, integral disconnect switch with separate motor fusing and terminal strip. Contactors, Class 20 adjustable overload protection and single phase protection shall be standard.

2.17 INSULATION MATERIALS (GENERAL REQUIREMENTS)

A. All insulation materials to be furnished for installation under this section shall be as manufactured by Owens-Corning, Certainteed, Knauf, or Schiller Company.

B. Shop drawings shall be submitted for all insulation system materials to be furnished for installation under this section. Submittals shall include descriptions of the application of all materials to be used for each insulation class and catalog cuts of all materials furnished.

C. All insulation materials to be furnished for installation under this section shall conform to fuel contributed flame spread and smoke developed limits set forth in NFPA Standard 90A as determined by NFPA 255, ASTM E84 or UL723 tests.

2.18 INSULATION MATERIALS (PIPING)

A. Piping systems shall be insulated as specified herein and as indicated on the drawings.

Insulation Materials In
Inches for Pipe Sizes

Piping System Types	Fluid Temp. Range F.	Runouts Up to 2"	1" & Less	1¼" – 2"	2½" – 4"	5" to 6"	8" & Larger	Class
Heating Systems								
Hot Water								
Low Temp	201-250	1	1½	1½	2	2	3½	104
Low Temp	80-200	1/2	1½	1½	1½	1½	1½	104
Cooling Systems								
Chilled Water	40-60	1/2	1/2	3/4	1	1	1	104
Coil Drains	Any	3/4	3/4	3/4	3/4	3/4	3/4	104

Runouts not exceeding twelve inches (12") in length.

Note: Provide 0.016 inch thickness embossed aluminum protective jacketing on all insulated piping within mechanical rooms within 6 feet of floors.

B. Insulation shall be omitted from the following piping:

1. Equipment vent piping.

2. Equipment drain piping beyond shut off valve.

3. Steam coil condensate piping from equipment outlets to steam trap.

4. Compressed air piping.

Class 104

Piping: Insulation shall consist of high density (minimum #4) molded fiberglass sectional pipe insulation with a minimum R value of 4.0 H. degrees F. ft.²/BTU per inch, with factory applied all-service jacket with vapor barrier, butt and lap end strips shall be self-sealing or secured with vapor seal adhesive.

Fittings, Valves and Flanges: All sizes shall be insulated with 1 pound density and secured with 0.047 at stainless steel tie wire. Then apply insulating and finish cement to match the adjacent pipe insulation thickness and then have two (2) 1/8 inch thick smoothing and finishing coats of vapor seal adhesive applied using intermediate glass fabric reinforcing. Vapor seal adhesive shall lap adjacent pipe cover. Final finish shall be re-wettable glass cloth.

2.19 INSULATION MATERIALS (SHEET METAL)

A. Sheet metal work shall be insulated as specified herein and as indicated on the drawings.

B. Insulation shall be applied to the following:

1. All air conditioning systems ductwork and associated equipment exposed to view. All portions of heating and ventilating and air conditioning unit casings not internally insulated shall have Class 131 insulation.
2. All concealed air conditioning system supply and fancoil return air ductwork and associated equipment including terminal box reheat coil casings, shall have Class 135 insulation.
3. All sound attenuators in insulated system ductwork shall be insulated. Sound attenuator sections furnished with air handling units shall be insulated in field when not furnished insulated by the unit manufacturer.

C. Insulation shall be omitted from the following sheet metal work:

1. General and hot cell exhaust ductwork except where noted on drawings.

Class 131

Insulation shall consist of 1½ inch thick minimum 4 pound density rigid fiberglass board with reinforced foil vapor barrier cut to fit duct shape and applied by impaling insulation on pins attached to duct surface. Pins shall be located approximately 1 per square foot of surface. Insulation shall be secured on pins using metal washers with excess pin length trimmed. Seal seams and all vapor barrier penetrations using 4 inch wide reinforced foil tape self-sealing type or secured using vapor seal adhesive.

Note: Flanges protruding from sheet metal shall be covered with 4 inch wide insulation board strips and sealed with 4 inch wide reinforced tape secured with vapor seal adhesive.

Finish shall consist of pre-sized glass fabric jacket applied to insulation surface and secured with lagging adhesive. All plenums and ducts within 5 feet of floors shall have edges reinforced with metal corner beads applied to insulation and sealed with 4 inch reinforced foil tape secured with vapor seal adhesive prior to finish.

Class 135

Insulation shall consist of minimum 1½ inch thick flexible fiberglass blanket with reinforced foil vapor barrier. Insulation shall be tightly wrapped around duct and secured using bonding adhesive covering not less than 50 percent of sheet metal surface. Seams

and penetrations shall be sealed by using 4 inch wide reinforced foil tape self-sealing type or secured with vapor seal adhesive. The bottom of ducts over 24 inches wide shall have additional support for blanket consisting of pins attached to duct surface at a rate of 1 per 2 square feet, evenly spaced. Insulation shall be impaled on pins and secured using mechanical washers with excess pin length trimmed.

2.20 MECHANICAL WALL AND FLOOR PENETRATIONS

A. Piping penetrations of partitions and/or floors shall incorporate a modular mechanical seal consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and the wall and/or floor opening.

B. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut. Following positioning of the seal assembly in the pipe sleeve around the pipe, tightening of the bolts shall deform the rubber seal elements to provide a watertight seal.

1. Seal assembly shall be inherently non-conductive electrically to reduce the cathodic reactions between the pipe and the pipe sleeve.

2. Each wall/floor opening shall contain a sleeve, constructed of Schedule 40 steel conforming to ASTM A-53, with an integral anchor/water baffle plate.

3. Sleeve shall be sized in conformance with the recommendations of the mechanical seal assembly.

a. Sleeves shall be cut and ground flush on either side of the masonry walls.

b. Sleeves to extend 2” above finish floor as a water dam.

C. Non-Fire-Rated, Mechanical, Wall and Floor Penetrations:

1. Assembles for non-fire-rated penetrations shall be rated for twenty (20) psi pressure differential.

2. Mechanical seal shall be constructed of elements of the following materials:

a. Sealing Element: Ethylene Propylene Diene Monomer

b. Pressure Plate: Glass reinforced nylon

c. Bolt and Nut: Low carbon steel, zinc galvanized

3. Modular mechanical seal assemblies shall be LINK-SEAL as manufactured by Thunderline Corporation or approved equal.

D. Fire-Rated, Mechanical, Wall and Floor Penetrations:

1. Piping penetrations of fire-rated partitions and/or floors specifically at penetrations to the interstitial space shall incorporate two (2) modular mechanical seals, mounted in series, each seal independently meeting the details noted above. Assemblies shall be rated for three (3) hour fire separation protection when tested in accordance with ASTM E-119-76.

2. Mechanical seal shall be constructed of elements of the following materials:

a. Sealing element: Silicon rubber

b. Pressure plate: Low carbon steel, zinc galvanized

c. Bolt and Nut: Low carbon steel, zinc galvanized

3. Modular mechanical seal assemblies shall be PYRO-PAC as manufactured by Thunderline Corporation or approved equal.

2.21 MOTORS

A. This section identifies basic requirements for motors. It includes motors that are factory-

installed as part of equipment and appliances as well as field-installed motors.

B. Quality Assurance:

1. Comply with NFPA 70 “National Electrical Code”.
2. NRTL Listing: Provide NRTL listed motors.
    a. Term “Listed”: As defined in “National Electrical Code”, Article 100.
    b. Listing Agency Qualifications: “Nationally Recognized Testing Laboratory” (NRTL) as defined in OSHA Regulation 1910.7.
3. Comply with NEMA MG 1: “Motors and Generators”.
4. Comply with UL 1004: “Motors, Electric”.

C. All motors provided for this project shall comply with the requirements of this section, except as otherwise indicated.

1. Motors 1/2 HP and Larger: Polyphase
2. Motors Smaller than 1/2 HP: Single phase.
3. Frequency Rating: 60 Hz.
4. Voltage Rating: Determined by voltage of circuit to which motor is connected for the following motor voltage ratings (utilization voltages):
    a. 120V Circuit: 115 V – motor rating.
    b. 208V Circuit: 200 V – motor rating.
    c. 240V Circuit: 230 V – motor rating.
    d. 480V Circuit: 460 V – motor rating.
5. Service factors indicated for motors are minimum values and apply at frequency and utilizing voltage at which motor is connected. Provide motors which will not operate in service factor range when supply voltage is within 10 percent of motor voltage rating.
6. Capacity: Sufficient to start and operate connected leads at designated speeds in indicated environment, and with indicated operating sequence, without exceeding nameplate ratings. Provide motors rated for continuous duty at 100 percent of rated capacity.
7. Temperature Rise: Based on 40 degree C. ambient except as otherwise indicated.
    a. Enclosure: Totally Enclosed Air Over

D. Polyphase Motors:

1. General: Squirrel-cage induction type conforming to the following requirements except as otherwise indicated.
    a. NEMA Design Letter Designation: “B”
2. Multi-Speed Motors: Separate winding for each speed.
3. Energy Efficient Motors: All motors shall be premium efficiency.
4. Variable speed motors for use with solid-state drives: Energy efficient, squirrel-cage induction, design B units with ratings, characteristics, and features coordinated with and approved by drive manufacturer.
5. Internal thermal overload protection for motors: For motors so indicated, protection automatically opens control circuit arranged for external connection. Protection operates when winding temperature exceeds safe value calibrated to the temperature rating of the motor insulation.

6. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading of the application.

7. Rugged Duty Motors: Totally enclosed with 1.25 minimum service factor. Provide motors with regreasable bearings and equipped with capped relief vents. Insulate windings with non-hygroscopic material. External finish shall be chemical resistant paint over corrosion resistant primer. Provide integral condensate drains.

8. Motors for reduced in-rush starting: Coordinate with indicated reduced in-rush controller type and with characteristics of driven equipment load. Provide required wiring leads in motor terminal box to suit control method.

E. Single-Phase Motors:

1. General: Conform to the following requirements except as otherwise indicated.

2. Energy Efficient Motors: One of the following types as selected to suit the starting torque and other requirements of the specific motor application:

a. Permanent Split Capacitor

b. Split-Phase Start, Capacitor-Run

c. Capacitor-Start, Capacitor-Run

3. Shaded-Pole Motors: Use only for motors smaller than 1/20 HP.

4. Internal Thermal Overload Protection for Motors: For motors so indicated, protection automatically opens the power supply circuit to the motor, or a control circuit arranged for external connection. Protection operates when winding temperature exceeds a safe value calibrated to the temperature rating of the motor insulation. Provide device that automatically resets when motor temperature returns to normal range except as otherwise indicated.

5. Bearings, belt connected motors and other motors with high radial forces on motor shaft shall be ball bearing type. Sealed, pre-lubricated sleeve bearings may be used for other single phase motors.

2.22 HANGERS, SUPPORTS AND ANCHORS

A. Provide all necessary labor, supervision, materials, equipment and services required to furnish and install all pipe supports, hangers, anchors and other suitable supporting appliances necessary to support firmly and substantially all parts of the apparatus described in this specification. Equipment shall be as manufactured by B-Line, Uni-Strut, Grinnell or Carpenter & Patterson.

1. Pipe shall be adequately supported by pipe hanger and supports and restrained by anchors. Hangers, etc. for insulated pipes shall be sized to accommodate insulation thickness.

B. Support for the piping and duct systems within this project is not typical industry standard. Some major points of difference:

1. All piping supported from structures using trusses shall make use of trapeze hangers. All trapeze hangers shall be connected to the bottom panel point of the truss.

2. Not more than 500 pounds per panel point is allowed.

3. As the Contractor is developing coordination drawings, panel point loads must be reviewed by the Structural Engineer.

4. The support for duct and piping serving areas on the North edge and South edge of Level 2 will need to fasten to the underside of Level 3. Therefore a full trapeze hanging system which drops through the interstitial space will need to be included. Rod diameters listed in this spec are for typical installations. Extra diameter and lateral bracing will be needed in

these areas. In addition, locations of vertical rods which pass through the interstitial space will need to be coordinated with service requirements of the interstitial space. Show all points on coordination drawings.

5. Duct hangers to be typical duct straps where applicable.

6. Pipe and duct run-outs from trapeze system to be secured to steel structure as much as possible. Where fasteners are shot into the underside of deck, not more than 50 pounds of load per shot is allowed.

7. All methods for securing and attaching equipment pipe and duct must be submitted to the Structural Engineer for approval.

C. Steel pipe hangers, anchors and supports shall have the manufacturer's name, part number, and applicable size stamped into each part for identification.

D. Hangers, anchors and supports shall be designed and manufactured in conformance with the following standards as appropriate.

1. ASTM B633: Specification for Electro-deposited Coatings of Zinc on Iron and Steel.

2. ASTM A123: Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars and Strip

3. ASTM A653 G90: Manufacturers Standardization Society: Supports – Materials, Design and Manufacture

4. MSS SP69: Manufacturers Standardization Society: Supports – Selection and Application

E. Hangers:

1. Uninsulated pipes 2 inches and smaller:

a. Adjustable steel swivel ring (band type) hanger.

b. Adjustable steel swivel J-hanger.

c. Malleable iron ring hanger or hinged ring hanger.

d. Malleable iron split-ring hanger with eye socket.

e. Adjustable steel clevis hanger.

2. Uninsulated pipes 2½ inches and larger.

a. Adjustable steel clevis hanger.

b. Pipe roll with sockets.

c. Adjustable steel yoke pipe roll (insulate annular space).

3. Insulated Pipe – Hot Services (including steam piping):

a. 2 Inch and Smaller Pieps:

(1) Adjustable steel clevis with galvanized sheet metal shield.

b. 2½ Inch and Larger Pipes:

(1) Adjustable steel yoke pipe roll with pipe covering protection.

(2) Pipe roll with sockets with pipe covering protection saddle.

4. Insulated Pipe – Cold Services (including chilled water piping):

a. 5 Inch and Smaller Pipes:

(1) Adjustable steel clevis with galvanized sheet metal shield.

b. 6 Inch and Larger Pipes:

(1) Pipe roll with sockets with pipe covering protection saddle.

(2) Adjustable steel yoke pipe roll with pipe covering protection.

F. Pipe Anchors:

1. Provide a complete system of accessories as required to transmit thermal expansion forces to the building structure for redirection to the piping expansion compensation system. Anchors shall consist of structural attachments, framing members for translating forces to and from the building structure and plates welded to the appropriate piping sections.

2. Structural attachments shall be as appropriate for the point of connection intended. Verify anchor connection points with Project Structural Engineer prior to fabrication.

3. Framing members shall be sized to accept the forces associated with the Contractor's proposed piping system arrangement with a minimum factor of safety of 3.0.

4. Framing point of attachment to the appropriate piping section shall be of a minimum thickness of 1/4" and shall increase by 1/16" in thickness for each two-pipe size increases above three inches in diameter (3"Φ). Framing point of attachment to the appropriate piping section shall be of a minimum length of 16" and shall increase by 2" in length for each two pipe size increases above three inches in diameter (3" Φ).

5. Welds to connect framing point of attachment to the appropriate piping section shall be full penetration fillet welds parallel to the central axis of the piping. All welding processes, including but not limited to procedures and welding operator qualifications, shall be in strict accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code (edition, including any addenda, in effect at the time of the contract execution).

G. Pipe Clamps:

1. Provide pipe clamps with weld-less eye nuts to allow flexibility in the hanger assembly as required to adjust for horizontal movement. Provide double bolted pipe clamps for insulated lines.

H. Multiple or Trapeze Hangers:

1. Trapeze hangers shall be constructed from 12 gauge roll formed ASTM A570 Gr. 33 structural steel channel, 1⅝ x 1⅝" minimum, or stronger as required.

2. Mount pipes to trapeze with 2 piece pipe straps sized for outside diameter of pipe.

3. For pipes subjected to axial movement:

a. Strut mounted roller support. Use pipe protection shield or saddles on insulated lines.

b. Strut mounted pipe guide.

I. Wall Supports:

1. Pipes 4 Inches and Smaller:

a. Carbon steel hook.

b. Carbon steel J-hanger.

2. Pipes Larger than 4 Inch:

a. Welded strut bracket and pipe straps.

b. Welded steel brackets, with roller chair or adjustable steel yoke pipe roll. Use pipe protection shield or saddles on insulated lines.

c. Use 304 stainless steel 3 x 3 x 1/4 angle iron for generator exhaust.

J. Floor Supports:

1. In mechanical spaces where weight of piping or other apparatus makes it impractical to support same suspended only from structure above, flanged pipe standards shall be installed to support the weight of the piping, valves and fittings. Main passageways and access space must not be obstructed.

2. Hot piping under 6 inch and all cold piping:

a. Carbon steel adjustable pipe saddle and nipple attached to steel base stand sized for pipe elevation. Pipe saddle shall be screwed or welded to appropriate base stand.

3. Hot piping 6 inches and larger:

a. Adjustable roller stand with base plate.

b. Adjustable roller support and steel support sized for elevation.

K. Vertical Supports:

1. Steel riser clamp sized to fit outside diameter of pipe.

L. Copper Tubing Supports:

1. Hangers shall be sized to fit copper tubing outside diameters.

a. Adjustable steel swivel ring (band type) hanger.

b. Malleable iron ring hanger, or hinged ring hanger.

c. Malleable iron split-ring hanger with eye socket.

d. Adjustable steel clevis hanger.

2. For supporting vertical runs use epoxy painted or plastic coated riser clamps.

3. For supporting copper tube to strut use epoxy painted pipe straps sized for copper tubing, or plastic inserted vibration isolation clamps.

Note: Copper plating of hangers is for purposes of identification only. This superficial coating shall not be designed to provide significant protection in corrosive areas.

M. Plastic Pipe Supports:

1. V-bottom clevis hanger with galvanized 18 gauge continuous support channel.

N. Supplementary Structural Supports:

1. Design and fabricate supports using structural quality steel bolted framing materials as manufactured by B-Line or Uni-Strut.

2. Channels shall be roll formed, 12 gauge, ASTM A570 Grade 33 steel, 1⅝" x 1⅝" or greater as required by loading conditions. Submit designs for pipe tunnels, pipe galleries, etc., to Engineer for approval.

3. Clamps and fittings shall be specifically designed and listed for use with the strut system.

O. Upper Attachments:

1. Beam clamps shall be used where piping is to be suspended from building steel. Clamp type shall be selected on the basis of load to be supported, and load configuration.

a. C-Clamps shall have locknuts and cup point set screws. Top flange c-clamps shall be used when attaching a hanger rod to the top flange of structural shapes. Refer to manufacturer's recommendations for setscrew torque. Retaining straps shall be used to maintain the position on the beam where required.

b. Center loaded beam clamps shall be used where specified. Steel clamps, malleable iron or forged steel beam clamps with cross bolt shall be as required to fit beams.

2. Concrete Inserts:

a. Cast in place spot concrete inserts shall be used where applicable, either steel or malleable iron body. Spot inserts shall allow for lateral adjustment and have means for attachment to forms. Select inserts to suit threaded hanger rod sizes. Do not use inserts on floors with trusses.

(1) Arrange pipe hangers, and auxiliary framing if required, to limit the maximum pipe load, with pipes fully insulated and filled with water, to not exceed 1500 pounds on any one slab insert.

(2) Inserts shall be spaced not closer than 4 feet o.c. in either direction. Where pipe inserts are closer together than 4 feet o.c. notify the Architect for review.

b. Continuous concrete inserts shall be used where applicable. Channels shall be 12 gauge, ASTM A570 Grade 33 structural quality carbon steel, complete with Styrofoam inserts and end caps with nail holes for attachment to forms. The continuous concrete insert shall have a minimum load rating of 2,000 lbs/ft. in concrete. Select channel nuts suitable for strut and rod sizes.

c. Provide inserts for placement in form-work before concrete is poured.

d. Provide inserts for suspending hangers from reinforced concrete slabs and sizes of reinforced concrete beams.

e. Where concrete slabs form finished ceilings, provide inserts to be flush with slab surface.

f. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.

P. Vibration Isolation and Supports:

1. Refer to Section “Vibration Isolation and Seismic Restraints” for vibration isolation requirements.

2. All horizontal runs of pipe in all mechanical equipment rooms, and for a distance of fifty (50) equivalent pipe diameters beyond the respective mechanical equipment rooms, shall be isolated from building structure by means of units designed for insertion of rids. Selection of correct isolators for each application shall be made by the vibration isolation manufacturer subject to approval of the Architect.

Q. Accessories:

1. Hanger rods shall be threaded both ends, or continuous threaded rods of circular cross section. Use adjusting locknuts at upper attachments and hangers. No wire, chain or perforated straps shall be allowed.

2. Shields shall be 180° galvanized sheet metal, 12” minimum length, 18 gauge minimum thickness, designed to match outside diameter of the insulated pipe.

3. Pipe protection saddles shall be formed from carbon steel, 1/8 inch minimum thickness, sized for insulation thickness. Saddles for pipe sizes greater than 12 inches shall have a center support rib.

R. Finishes:

1. Hangers not in direct contact with copper pipe shall be zinc plated in accordance with

ASTM B633, SC3 or have an electro-deposited epoxy finish.

2. Strut channels shall be pre-galvanized in accordance with ASTM A653 G90

   or

   Strut channels shall be electro-deposited epoxy finish.

3. Hangers and strut located outdoors shall be hot dip galvanized after fabrication in accordance with ASTM A123.

4. Hangers and strut located in corrosive areas shall be Type 316 stainless steel with matching stainless steel hardware.

5. Hangers and clamps for support of bare copper piping shall be painted with electro deposited copper colored epoxy.

S. Support Spacing:

1. Horizontal steel piping shall be supported in accordance with MSS SP-69 Tables 3 and 4, excerpts of which follow below:

NOMINAL PIPE SIZE	ROD DIAMETERS	MAXIMUM SPACING
1/2" – 1½"	3/8"	7'0"
1½"	3/8"	9'0"
2"	3/8"	10'0"
2½"	1/2"	11'0"
3"	1/2"	12'0"
4"	5/8"	14'0"

2. Horizontal copper tubing shall be supported in accordance with MSS SP-69 Tables 3 and 4, excerpts of which follow below:

NOMINAL TUBE SIZE	ROD DIAMETERS	MAXIMUM SPACING
1/2" – 3/4"	3/8"	5'0'
1"	3/8"	6'0"
1¼"	3/8"	7'0"
1½"	3/8"	8'0"
2"	3/8"	9'0"
2½"	1/2"	10'0"
3"	1/2"	11'0"
4"	1/2"	12'0"

3. Provide means of preventing dissimilar metal contact such as plastic coated hangers, copper colored epoxy paint, or non-adhesive isolation tape. Galvanized felt isolators sized for copper tubing may also be used.

4. Install hangers to provide a minimum 1/2 inch space between finished covering and adjacent work.

5. Place a hanger within 12 inches of each horizontal elbow.

6. Support vertical piping independently of connected horizontal piping. Support vertical

pipes at every other floor. Wherever possible, locate riser clamps directly below pipe couplings or shear lugs.

7. Where several pipes can be installed in parallel and at the same elevation, provide trapeze hangers as specified herein above. Trapeze hangers shall be spaced according to the smallest pipe size, or install intermediate supports according to schedule herein above.

8. Do not support piping from other pipes, ductwork or other equipment which is not building structure.

2.23 PRESSURE GAUGES

A. Pressure gauges shall be of sizes, types and capacities specified herein and located as indicated on the drawings. Equipment shall be as manufactured by Ashcroft, Trerice or Manning, Maxwell, Maxwell and Moore.

B. Except as otherwise indicated, all gauges shall be 4½ inch diameter stainless steel case and ring phosphor bronze bourbon type, 1 percent full scale accuracy and bottom connection. Gauges for panel mounting shall have stainless steel flush mounting ring and back connection. Gauges for fluid handling service shall have isolating cock and also fitting with pulsation dampeners and red setpoint indicators at pump inlets and outlets. Gauges for steam service shall have coil syphon and isolating cock. All cocks shall be rated at 150 WSP except on HP steam service, 250 WSP.

C. Gauge range shall be as follows:

Hot Water 0-100 PSIG

Note: Mount all gauges so as to be read from floor. Provide two (2) spare gauges for each range indicated.

2.24 PUMPS

A. Pumps shall be of sizes, types, capacities and arrangements indicated on Drawings. Equipment shall be manufactured by Taco or Bell and Gossett.

B. Equipment shall be complete shop-assembled packages with pump, motor drive couplings, pump base assemblies and accessories. All equipment shall be shop primed and finish painted. All pumps shall be field checked for alignment and corrected prior to start-up. This Contractor shall be responsible for insuring compatibility of chemical treatment program with pump seals used. Pumps shall not overload their drivers along any point of their entire operating curves. All pumps shall have suction and discharge flanges drilled and tapped for pressure gauge installation. All pumps shall be capable of operating at water temperatures from 35 degrees F. to 250 degrees F.

C. Inline Suction Pumps: Pumps shall be base mounted, single stage, double suction design with a foot mounted volute to allow servicing of the impeller and bearing assembly without disturbing piping connections.

1. Shall be rigidly coupled pipe-mounted types. Pump features shall include bronze impeller, alloy steel shaft, 100,000 hour ball bearings, cupro-nickel steel shaft sleeves, stuffing boxes, mechanical seals, 250 PSI test vertically split casings, flanged suction and discharge connections, rigid pump/driver coupling, coupling guard, motor driver and rigid pump-driver mounting baseplate and frame.

2. Pump volute shall be Class 30 cast iron, suitable for 175 PSI working pressure, with integrally-cast pedestal support feet. The impeller shall be cast bronze enclosed, double suction type, dynamically balanced, keyed to the shaft and secured by a locking cap screw.

3. The liquid cavity shall be sealed off at the pump shaft by an internally-flushed mechanical seal with ceramic seal seat and carbon seal ring, suitable for continuous operation at 225 deg. F. A replaceable bronze shaft sleeve shall completely cover the wetted area under

the seal. Seals shall be capable of serviceability without disconnecting the pump from its piping.

4. Pump shall be rated for minimum of 175 psi working pressure. Volute shall have gauge tappings at the suction and discharge nozzles and vent and drain tappings at the top and bottom.

5. Pump bearing bracket shall have oil lubricated bronze journal and thrust openings. Bracket shaft shall be alloy steel having ground and hardened thrust bearing faces. A flexible coupling to dampen starting torque and torsional vibrations shall be employed.

6. Motor shall meet NEMA specifications and shall be of the size, voltage and enclosure called for on the plans. Pump and motor shall be factory aligned, and shall be realigned by the Contractor after installation prior to start-up.

7. Each pump shall be factory tested per Hydraulic Institute Standards. It shall then be thoroughly cleaned and painted with at least one coat of high grade machinery enamel prior to shipment.

D. Shop Drawings shall include complete dimension drawings of all equipment furnished, together with individual pump curves, and electric data.

2.25 REFRIGERANT PIPING AND SPECIALTIES

A. Summary:

1. Extent of refrigeration piping, fittings, valves and accessories is indicated [on the Drawings and by the requirements of this Section and Section 15B.03 "General Requirements - Mechanical".

a. Refrigeration piping is specified on a performance basis and the Contractor is responsible for the design and preparation of Shop Drawings covering all refrigeration piping work.

2. Related Sections: Refer to other Division 15 sections for the following:

a. Mechanical Insulation

B. Quality Assurance:

1. Codes and Standards: Provide refrigeration piping conforming to the requirements of the following:

a. Air Conditioning and Refrigeration Institute (ARI).

b. American National Standards Institute (ANSI).

c. American Society for Testing and Materials (ASTM).

d. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

e. Manufacturer's Standardization Society of the Valve and Fittings Industry, Inc. (MSS).

C. Submittal:

1. Refer to Section 15B.02, "Submittals" for basic information relating to submittal requirements.

2. Product Data: Submit manufacturer's technical product data on the following:

a. Refrigerant valves.

b. Refrigerant specialties.

D. Refrigerant Piping:

1. Refrigerant Piping: Dimensions and material requirements for pipe, pipe fittings and components shall conform to ASHRAE 15 and ANSI B31.5 and shall be compatible with fluids used and capable of withstanding the pressures and temperatures of the service.

a. Tubing used for refrigerant service shall be cleaned, sealed, capped, or plugged prior to shipment from the manufacturer's plant.

E. Valves and Accessories:

1. Valves: Provide valves designed, manufactured, and tested specifically for refrigerant service.

a. Internal parts shall be removable for inspection or replacement without applying heat or breaking pipe connections. Threaded ends of valves shall conform to ANSI B2.1.

F. Execution - General:

1. Installation: Install piping components to ensure proper and efficient operation of the equipment and controls and in accordance with manufacturer's printed instructions.

a. Provide proper supports for the mounting of vibration isolators, stands, guides, anchors, clamps and brackets.

b. Provide piping connected to equipment with vibration isolators with flexible connections which shall conform to vibration and sound isolation requirements for the system.

c. Conform to ASHRAE 15 and ANSI B31.5.

2.26 REFRIGERANT VALVES AND SPECIALTIES

A. General:

1. Complete valve assembly shall be UL listed and designed to conform to ARI 760.

2. Pressure relief valve, low pressure switch and liquid line dryer are factory installed.

3. All valves shall conform to requirements of this specification for the services indicated. Manufacturer’s numbers referenced below are intended as a guide only. The supplier shall verify valves submitted are in accordance with specified materials and construction.

B. Refrigerant Valves and Specialties:

1. Shall be manufactured by the following:

a. Alco Controls Division, Emerson Electric

b. Danfoss Electronics, Inc.

c. EATON Corporation, Control Division

d. Henry Valve Company

e. Parker-Hannifin Corporation, Refrigeration and Air Conditioning Division

f. Sporlan Valve Company

C. Globe Valves:

1. 450 psig maximum operating pressure, 275 degrees F. maximum operating temperature, cast bronze body with cast bronze or forged brass wing cap and bolted bonnet, replaceable resilient seat disk, plated steel stem. Valve shall be capable of being repacked under pressure. Valve shall be straight through or angle pattern, with solder-end connections.

D. Solenoid Valves:

1. 250 degrees F. temperature rating, 400 psig working pressure, forged brass with Teflon valve seat, two-way straight through pattern, and solder end connections. Provide manual operator to open valve. Furnish complete with NEMA 1 solenoid enclosure with 1/2 inch conduit adapter, and 24 volt, 60 Hz normally closed holding coil.

2. Solenoid valves shall be normally closed.

E. Thermal Expansion Valves:

1. Thermostatic adjustable, modulating type. Size as required for specific evaporator requirements, and factory set for proper evaporator superheat requirements. Valves shall have copper fittings for solder end connections. Complete with sensing bulb, a distributor having a side connection for hot gas bypass line and an external equalizer line.

F. Hot Gas Bypass Valve:

1. Adjustable type, sized to provide capacity reduction beyond the last step of compressor unloading and wrought copper fittings for solder end connections.

G. Evaporator Pressure Regulating Valve:

1. Pilot operated, externally equalized, forged brass or cast bronze, complete with pilot operator, stainless steel bottom spring, pressure gauge tappings, 24 volts DC, 50/60 Hz, standard coil, and wrought copper fittings for solder end connections.

2. Thermostatic expansion valves are factory adjusted to proper superheat settings for the evaporator before shipment. Fine tuning is not normally required unless application or operation conditions are different than those anticipated.

H. Suction Line Filter Dryer:

1. 350 psig maximum operation pressure, 225 degrees F. maximum operating temperature, steel shell and wrought copper fittings for solder end connections. Permanent filter element shall be molded flat core surrounded by a desiccant for removal of acids and moisture for refrigerant vapor.

I. Flanged Unions:

1. 400 psig maximum working pressure, 330 degrees F. maximum operating temperature, two brass tailpiece adapters for solder end connections to copper tubing, flanges for 7/8 inch through 1e inch unions shall be forged steel, and for 2c inch through 3c inch shall be ductile iron, four plated steel bolts with silicon bronze nuts and fiber gasket. Flanges and bolts shall have factory applied rust resistant coating.

J. Flexible Connectors:

1. 500 psig maximum operating pressure, seamless tin bronze or stainless steel core, high tensile bronze braid covering, solder connections and synthetic covering, dehydrated, pressure tested, minimum 7 inches in length.

K. Check Valves:

1. Smaller than 7/8 Inch: 500 psig maximum operating pressure, 300 degrees F. maximum operating temperature, cast brass body with removable piston, Teflon seat and stainless steel spring, straight through globe design. Valve shall be straight through pattern, with solder end connections.

L. Strainers:

1. 500 psig maximum working pressure, forged brass body with monel 80-mesh screen and screwed cleanout plug, Y-pattern with solder end connections.

M. Moisture/Liquid Indicators:

1. 500 psig maximum operating pressure, 200 degrees F. maximum operating temperature, forged brass body with replaceable polished optical viewing window, and solder end connections.

N. Filter - Dryer:

1. 500 psig maximum operating pressure, steel shell, flange ring and spring, ductile iron cover plate with steel cap screws and wrought copper fittings for solder end connections. Furnish complete with replaceable filter dryer core kit, including gaskets as follows: Standard capacity desiccant sieves to provide micronic filtration.

2.27 REGISTERS, GRILLES AND DIFFUSERS

A. Registers, grilles and diffusers shall be of model, size and capacity and furnished as scheduled on the Drawings. Equipment shall be as manufactured by Tuttle & Bailey (Agitair), or Titus, and shall be supplied with white baked enamel finish noted otherwise.

B. All supply registers shall be furnished with aluminum, individually adjustable face louvers. Registers and grilles shall have white baked enamel finish except where noted otherwise.

C. Diffusers, registers and grilles for installation in walls or plastered ceilings shall be provided with sponge rubber frame gaskets and Phillips head screws for attachment of device frame to building construction.

D. All ceiling diffusers shall be all aluminum construction unless noted otherwise with white baked enamel finish. The diffuser shall be provided with a removable core permitting easy access to core sections. Diffuser neck shall extend no less than 1 inch above the core to accommodate an internal duct connection to prevent leakage to ceiling space. Diffusers shall be assembled in patterns which provide one, two, three or four-way air discharge with each side delivering a quantity of air proportional to the area served.

E. When indicated by manufacturer's model number on the equipment schedule, the ceiling linear diffusers shall be of the restricted multi-orifice jet induction and air mixing type consisting of louver sections with built-in diffusing vanes. The vanes shall be arranged to discharge air from adjacent louvers at an angle of 45 degrees in opposite directions to ensure rapid mixing of primary and room air. Each individual diffusing vane shall be welded in place and mechanically fastened to adjacent louver sections to make a rigid unit. The vanes shall extend to the discharge edges of the louvers. Where lover sections join core frame, the louver ends shall be welded to core frame. The leaving edge of each louver shall be hemmed and the louver ends shall be rounded and hemmed before welding the core frames.

F. All duct connections to registers, grilles and diffusers shall have all interior surfaces within the line of sight or within 4 feet of the opening painted with dull black paint.

G. Return grilles for fancoil units shall be hinged filter type, constructed of aluminum and shall have white baked enamel finish.

2.28 SHEET METAL WORK

A. General: Ductwork systems shall be fabricated and installed in accordance with recommendations contained in the SMACNA “HVAC Duct Construction Standards”, Third Edition 2005, and as herein specified. Tables and figures referred to hereinafter are taken from the SMACNA publication.

B. Ductwork Material and Classifications:

1. Supply, return and exhaust air headers and mains shall be constructed of galvanized steel, except as noted here-in.

2. Where round or flat oval galvanized, use United McGill, Ductmate or Spiral Pipe of Texas, Eastern Sheet Metal, Hamlin, Graco and Impulse Air. Snap Lock or Pipe Lock

Longitudinal seams are prohibited.

a. +4" SP class supply risers and supply mains on each floor to branch take-off. (SMACNA Standards)

b. +3" SP Class gauge flat oval or round galvanized sheet metal from supply main to supply valve or terminal box (SMACNA Standard).

c. +2" SP class from valves or terminal boxes to diffusers.

d. +2" SP class for supply ductwork from Liebert/FCU to outlet (SMACNA Standards).

3. Return air ductwork shall be constructed of galvanized steel. Static pressure class ratings shall be as follows:
   a. -2" SP class galvanized steel from Liebert/FCU to local inlets (SMACNA Standards).
4. Exhaust air ductwork from hot cell area shall be constructed of Type 304 stainless steel. Associated control volume and slide gate dampers shall be stainless steel. Static pressure class ratings shall be as follows:

   a. -4" SP class 304 stainless steel hot cell exhaust riser (SMACNA Standards). _4" SP class galvanized general exhaust riser (SMACNA Standards).

   b. -3" SP class stainless steel exhaust mains at each floor (SMACNA Standards).

   c. -2" SP class 304 stainless steel from exhaust main to local exhaust inlets (SMACNA Standards).

   d. General exhaust runouts to be 304 stainless – 2" SP class, valve to outlet.

5. See drawings for locations of special exhaust systems. These shall have Vanstone flange or a hardcast, 304 stainless steel ductwork.

6. Exhaust air ductwork serving toilet rooms, general exhausts, office areas and other non-corrosive, non-flammable, airstreams shall be constructed of galvanized steel. Static pressure class ratings shall be as follows:

   a. -2" SP class from exhaust riser to intake registers or open ended duct.

C. Hangers and Supports: Ductwork sheet metal supports shall be in accordance with Chapter IV, including all plenum and casing sheet metal which is suspended. Use truss panel points as much as possible.

D. Sealing: All duct joints and air device connections shall be sealed in accordance with Table 1-1 except that all supply systems shall be sealed Class A. The sealant shall be Hardcast 550 or EC-800 with imbedded fabric, except for joints with dissimilar metals then a butyl gasket shall be provided. Louver plenums shall be sealed water tight to a height of 12 inches above the plenum bottom.

E. Branch Take-Offs: Branch main take-offs for round ductwork shall be Buckley 3300 fittings or 45° lead in as shown in Figure 4-6. Branch take-offs for rectangular ductwork shall be 45° entry (shoe taps) in accordance with Figure 4-6.

F. Elbows: Elbows for round ducts shall be stamped type elbows with centerline radius equal to 1.5 times duct diameter. Where space is limited, the centerline radius may be reduced to 1.0 times the diameter for only those ducts entering into corridor ceiling spaces from vertical duct shafts and shall have full length splitter vanes in accordance with Figure 4-9 and Chart 4-1. Elbows for rectangular and oval ductwork shall have a centerline radius equal to 1.5 times the duct width. Elbows for rectangular ductwork shall have full length splitter vanes in accordance with Figure 4-2 Type RE-3.

1. Where space is restricted and as approved in writing by the Engineer, square throat elbows with single or double thickness turning vanes, as required, may be used. Elbows shall be in accordance with Figure 4-2 except that throat types RE-4, RE-6, RE-7, RE-9

and RE-10 are specifically prohibited. Provide an access door upstream of all square throat elbows with single (or double) thickness turning vanes.

G. Transitions and Offsets: Transitions in round ducts shall be conical reducers. Transitions in rectangular ducts shall be in accordance with Figure 4-7 except that offset type 1 and offset type 2 are specifically prohibited.

H. Connections:

1. Connect inlets and outlets of fancoil units and fans to ductwork with flexible connections unless fan has vibration isolator mounts inside unit with flexible connections and no external vibration isolators.

2. Indoors, flexible connections for supply equipment, shall be neoprene-coated fibrous glass fire retardant fabric, by Ventfabrics, or Durodyne. Outdoors for supply equipment flexible connections, shall be Dupon hypalon-coated fibrous glass fire, weather, and UV resistant by Ventfabrics or Durodyne.

3. Secure flexible connections tightly to air handlers with metal bands. Bands shall be same material as duct construction.

4. Connections from trunk to branch ducts shall be as detailed on drawings.

I. Access Doors: Access doors in sheet metal ducts shall be Ductmate® sandwich type Door insulation shall match adjacent casings. Doors shall be provided on all plenum and mixing sections, fire dampers, smoke dampers, combination fire/smoke dampers, reheat coils (inlet side), air valves and terminal filter equipment.

J. Volume Dampers: Volume dampers shall be in accordance with SMACNA except that, in addition to those indicated on drawings, each branch main and branch shall be provided with damper typical to locations indicated in Figure 4-1. Additional dampers shall be provided where shown on plans, details and where specified elsewhere. Damper gauge to be two (2) gauges heavier than the duct in which they are mounted. Provide with locking quadrants or push rods and pillow blocks as appropriate. Dampers shall be sufficiently large to extend the full width of the branch duct to which it is attached. Provide scooped profile as required.

K. Smoke Dampers: Smoke dampers shall be in accordance with National Fire Code NFPA 90A Standard requirements and bear an Underwriters label. Dampers shall be installed in accordance with manufacturer's installation instructions. Dampers shall be UL listed, labeled, and shall be dynamic-static designed in accordance with UL Standard 555. Dampers shall be listed to support the appropriate fire rating required for wall and/or floor penetrations served. Where required as a condition of damper listing, provide slip joint. To permit breakaway, no screws, rivets, bolts or other fasteners shall be used; each joint shall have an access door as applicable. Provide an access door in the duct to service fusible link. Access doors for insulated ducts shall be double wall insulated sandwich type. Fire dampers shall be out of air stream Type B or C. Combination fire/smoke dampers may be used in lieu of separate dampers. All smoke dampers and combination fire/smoke dampers shall be furnished with pneumatic or electric actuators as required, and appropriate UL label. Provide 10 gauge welded sleeve where dampers can not be placed directly into the fire and/or smoke wall.

1. All smoke dampers and fire/smoke dampers shall be supplied with or pneumatic actuators, 165 degree F. "McCabe Link" (for use in general HVAC ductwork), 185 degree F. "McCabe Link" (for use in smoke control exhaust ductwork). All fire/smoke dampers shall be capable of being reset remotely. All fire/smoke dampers shall be supplied with one (1) end switch that will indicate both full closed and full open. All fire/smoke dampers shall fail open upon loss of control signal. All smoke dampers shall fail closed upon loss of control signal.

2. Except where specifically noted otherwise, the maximum permissible pressure drop for any fire damper at air flow quantity required by Design Documents shall not exceed 0.1 inches of water.

3. Except where specifically noted otherwise, the maximum permissible pressure drop for any smoke damper assembly at air flow quantity required by design documents shall be as follows:
   a. Up to 1,000 FPM 0.05 Inches of Water
   b. 1,000 to 2,000 FPM 0.10 Inches of Water
   c. Over 2,000 FPM 0.20 Inches of Water
4. Damper sizes shall be adjusted accordingly where required to reduce pressure drop.
5. Installed dampers found to have pressure drops in excess of specified values shall be replaced at no additional cost to the Owner.

L. All fire, smoke and combination fire/smoke dampers shall be dynamically rated for the following conditions:

1. Fan (VAV) Discharge to Terminal Units: 3,500 FPM
2. Fan (CV) Discharge to Reheat Coils: 1,500 FPM
3. Terminal Box/Reheat Coil Discharge to Terminal Device (Diffuser, etc.): 1,000 FPM
4. Return/Exhaust Terminal Device (Register, etc.) to fan inlet: 1,800 FPM

M. No ductwork shall be provided with insulation liner.

N. Provide 24 gauge piping sheet metal protective covers, shields or saddles to protect piping insulation. Protective covers shall totally encapsulate any and all exposed HVAC piping within six feet (6') of finished floor. Shields and saddles shall extend a minimum of six inches (6") ahead and behind the projected footprint of the pipe support addressed and shall completely cover the lower 180° arc of the insulated piping.

2.29 SLEEVES, INSERTS AND OPENINGS

A. General:

1. All penetrations for piping, ductwork and conduit in the building walls, floors and roof shall have sleeved or boxed openings except for interior wall of gypsum board and stud construction which are not fire or smoke rated.
2. The Contractor shall be responsible to order all material in accordance with the construction schedule so as to permit orderly inclusion of all sleeves, openings and inserts. Furnish and install all sleeves, boxed openings and inserts as the work progresses. If the Contractor fails to provide the sleeves, boxed openings and inserts, he shall bear the cost of modifications necessary for their inclusion.
3. All cutting and patching shall be done by this Contractor. The Contractor shall not cut into any building construction without first having received permission from the Architect.

B. Sleeves:

1. This Contractor shall furnish all sleeves as required for the work and furnish all labor for installation.
2. Sleeves through exterior building walls or through concrete construction shall be Schedule 40 (galvanized) steel pipe. Sleeves through interior fire or smoke rated walls of gypsum and stud construction shall be 10 gauge sheet metal.
3. Sleeves shall be sized to provide a total of not less than 1/2 inch clearance around the piping, duct or conduit together with any insulation cover.
4. Sleeves for setting into walls shall be flush with finished construction. Sleeves for setting into floors shall be imbedded in concrete slab and extend approximately 2 inch above finished floors. Sleeves through floors of mechanical rooms shall be 12 gauge and shall extend 4 inches above the floor. Sleeves shall be provided with lugs or flanges to permit

firm attachment to the building construction. Wall sleeves shall not be used as support points.

5. All sleeved openings within the building shall be sealed airtight using fire barrier caulking with a UL classification for use as a fire barrier penetration seal for walls and floors with up to a three-hour fire rating, expanded into place for the full depth of the sleeve. Sleeved openings through exterior walls and floor shall also be sealed outside using waterproof mastic.

C. Inserts: None.

D. Openings:

1. Openings shall be framed or boxed by the HVAC Subcontractor.

2. Floor openings into mechanical rooms shall be provided with 4 inch high sleeve. All wall openings shall be flush with both surfaces.

3. Fire damper frames to be set into masonry or concrete construction shall be set into place at the time of the construction of the respective floor or wall. Exterior plywood covers shall be applied to both sides of fire dampers to prevent damage prior to making duct connections. Coordinate installation on existing walls.

4. Openings for the passage of ducts and piping shall have 1/2 inch clearance all around the finished piping or duct and insulation. Boxed openings for gang piping shall be provided with 18 gauge sheet metal on both sides of penetration secured to the opening perimeter cut to fit the pipe shape and the clearance space within the opening filled with fire barrier caulking with a UL classification for use as a fire barrier penetration seal for walls and floors with up to a three-hour fire rating, expanded into place so as to make the penetration airtight.

E. Escutcheon Plates: Escutcheon plates shall be provided for all pipe penetrations into finished spaces as follows:

1. Pipe penetrations shall have chromium plated spun or pressed brass two-piece hinged escutcheon covers sized to fit the piping and insulation (if any) outside diameter and cover pipe sleeve.

2. Duct penetrations shall be 28 gauge stainless steel strips fastened with stainless steel screws or bolts and sized to cover the duct with any insulation and the wall opening. Round ducts shall be provided with escutcheon plates as indicated above for piping.

3. Penetrations through finished floors shall have matching finish extension escutcheon sleeves sized to the escutcheon and finished in a neat, workmanlike manner.

4. Pipe penetrations through ceilings shall be same as E.1 except with clip ring backing.

2.30 SOUND ATTENUATORS

A. Silencers shall be of the size, configuration, capacity and acoustic performance as scheduled on the drawings. All silencers shall be factory fabricated and supplied by the same manufacturer. Silencers shall be Vibro-Acoustics or Industrial Acoustics Company (IAC).

B. Alternate manufacturers must request and obtain written approval by the Engineer to bid the project at least 10 days prior to the bid due-date. As a condition of pre-approval, alternate manufacturers must submit to the Engineer a minimum of twenty (20) different HVAC silencer test reports. Each report shall be for a silencer tested in full accordance with the ASTM E-477-96 silencer test standard in an aero-acoustic test facility which is NVLAP accredited for the ASTM E477-96 standard. Each test shall have been conducted within the last 12 month period. A copy of the laboratory's NVLAP accreditation certificate must be included with the submitted reports. Any changes to the specifications must be submitted and approved in writing by the Engineer at least 10 days prior to the bid due-date.

C. Silencer inlet and outlet connection dimensions must be equal to the duct sizes shown on the drawings. Duct transitions at silencers are not permitted unless shown on the contract drawings.

D. Elbow Silencers: All elbow silencers, including models REFL shall be constructed with an 18 gauge galvanized steel outer casing unless HTL casing is specified and 22 gauge galvanized perforated steel. All acoustical splitters shall be internally radiused and aerodynamically designed for efficient turning of the air. Half and full splitters are required as necessary to achieve the scheduled insertion loss. All elbow silencers with a turning cross-section dimension greater than 48" shall have at least two half splitters and one full splitter.

E. Acoustic Plenum:

1. The plenum panels shall be Vibro-Acoustics Model APFL Tongue and Groove connection type. Panels shall have a nominal thickness of 4 inches with roll formed skins interlocked with reinforcing channels such that both the interior and exterior surfaces of the Tongue and Groove joint are flush after assembly. Panels shall be adequately stiffened to ensure proper acoustical performance.

2. Exterior skin shall be a minimum of 18 gauge galvanized steel. Interior skin shall be 22 gauge perforated steel with 3/32 inch diameter holes on 3/16 inch staggered centers. Reinforcing shall be a minimum 22 gauge galvanized steel.

F. Media shall be of acoustic quality, shot-free glass fiber insulation with long, resilient fibers bonded with a thermosetting resin. Glass fiber density and compression shall be as required to insure conformance with laboratory test data. Glass fiber shall be packed with a minimum of 15% compression during silencer assembly. Media shall be bacteria and fungus resistant, resilient such that it will not crumble or break, and conforming to irregular surfaces. Media shall not cause of accelerate corrosion of aluminum or steel. Mineral wool will not be permitted as a substitute for glass fiber.

G. The acoustic media shall be completely wrapped with Tedlar film to help prevent shedding, erosion and impregnation of the glass fiber. The wrapped acoustic media shall be separated from the perforated metal by a factory installed ½ inch thick acoustically transparent spacer. The spacer shall be flame retardant and erosion resistant. A mesh, screen or corrugated perforated liner will not be acceptable as a substitute for the specified spacer.

H. Silencer materials, including glass fiber, Tedlar film and acoustical spacer shall have maximum combustion ratings as noted below when tested in accordance with ASTM E84, NFPA 255 or UL 723.

1. Flamespread Classification: 20

2. Smoke Development Rating: 45

I. Silencers shall have high transmission loss (HTL) walls externally applied and completely sealed to the silencer casing by the silencer manufacturer to assure quality controlled transmission loss. The HTL walls shall consist of media, airspace, mass and outer protective metal skin, as required, to obtain the specified room noise criteria. Standard acoustical panels will not be accepted as HTL walls. If requested by the Engineer, breakout noise calculations for each air handling and fan system shall be provided with the silencer submittal to insure compliance with the room noise criteria. Breakout noise calculations shall be based on the sound power levels of the specified equipment.

J. Silencers shall be constructed in accordance with ASHRAE and SMACNA Standards for the pressure and velocity classification specified for the air distribution system in which it is installed. Material gauges noted in “Section B Materials” are minimums. Material gauges shall be increased as required for the system pressure and velocity classification. The silencers shall not fail structurally when subjected to a differential air pressure of 8 inches water gauge.

1. Casings shall be lockformed and sealed, except as noted in Section B Materials, to provide leakage resistant construction. Airtight construction shall be achieved by use of a duct-sealing compound supplied and installed by the Contractor at the job site.

2. All perforated steel shall be adequately stiffened to insure flatness and form. All spot welds shall be painted.

K. Acoustic Performance:

1. Silencer dynamic insertion loss shall not be less than that listed in the silencer schedule.

2. Silencer generated noise shall not be greater than that listed in the silencer schedule.

3. Acoustic performance shall include dynamic insertion loss and generated noise for forward flow (air and noise in same direction) or reverse flow (air and noise in opposite direction) in accordance with the project's air distribution system requirements.

4. All silencer ratings shall be determined in a duct-to-reverberant room test facility which provides for airflow in both directions through the test silencer in accordance with the ASTM E-477-96 test standard. The test set-up, procedure and facility shall eliminate all effects due to flanking, directivity, end reflection, standing waves and reverberation room absorption.

L. Silencer pressure drops shall not exceed those listed in the silencer schedule. Silencer pressure drop measurements shall be made in accordance with the ASTM E-477-98 test standard. Tests shall be conducted and reported on the identical units for which acoustical data is presented.

M. The manufacturer shall supply certified test data for each scheduled silencer. The data shall include dynamic insertion loss, generated noise and pressure drop for forward or reverse flow, matching the project's air distribution system requirement. All ratings shall be conducted in the same facility and shall utilize the same silencer.

1. Test facilities and test reports shall be open to inspection upon request from the Engineer. Silencer performance must have been substantiated by laboratory testing according to ASTM E477-96 and so certified when submitted for approval. The aero-acoustic laboratory must be NVLAP accredited for the ASTM E477-96 test standard. A copy of the accreditation certificate must be included with the submittals. Data from non-NVLAP accredited test facilities will not be accepted.

2.31 STRAINERS

A. Strainers shall be provided where shown on the drawings and as specified herein. Equipment shall be as manufactured by Sarco, RP&C, Mueller, Armstrong or Barnes and Jones.

B. Strainers shall be provided on inlets to all pressure regulating valves, temperature control valves and makeup water control valves. Strainer baskets shall be heavy duty perforated type with openings sized as recommended for the line size and service by the manufacturer. All strainers 2½ inch size and larger shall be provided with blow-down valves. Blow-down valves shall be ball valves. Blow-down valves shall have short nippled outlets angled down toward floor.

C. Strainers for all services, except as otherwise specified, shall conform to the following:

1. Strainers on lines 2 inches and smaller shall have 250 working steam pressure bronze bodies with screwed ends.

2. Strainers on lines 2½ inches and larger shall have 125 working steam pressure semi-steel bodies with flanged ends.

2.32 SUPPLEMENTAL SUPPORT SYSTEM

A. This Contractor shall provide all supplemental supports required to direct equipment and materials support loads to approved structural load bearing points. All mechanical equipment

and systems shall be substantially supported without distortion or excessive vibration. The methods of support shall be as hereinafter described, except as otherwise noted on the drawings.

B. The supplemental support system shall be substantial type with members sized to prevent equipment distortion or excessive vibration. The HVAC Subcontractor shall provide support components as required such that all equipment shall operate without objectionable noise or vibration being transmitted to the structure.

C. The supplemental support system shall conform to requirements of this specification. Manufacturer's published characteristics referenced are intended as a guide only. The supplier shall verify support elements submitted are in accordance with specified materials and construction and are appropriately sized to accept and direct the proposed loading.

D. All supplemental support elements shall be by one (1) manufacturer: Unistrut, B-Line or Telestrut. The acceptable standard or quality shall be as follows:

1. Framing Members:
    a. Nominal Size: 1⅝" x 1⅝" "U" channel
    b. Body: Mild Carbon Steel, ASTM A570 Grade 33
    c. Gauge: 12 Gauge (0.105" thick)
    d. Slot Width: 7/8" nominal
    e. Pre-Punching: 9/16" Diameter, 1⅞" on center, 3 sides
    f. Finish: Hot-Dipped Galvanizing, G90 weight, ASTM A123
    g. Conformance: Metal Forming Manufacturers Association (MFMA) Standard Publication MFMA-1.
2. Fittings:
    a. Nominal Size: 1⅝" (length per device)
    b. Shape: Per Service from Manufacturer's Standard Catalog
    c. Body: Hot Rolled Mild Carbon Steel, ASTM A570, Grade 33
    d. Gauge: 1/4" Nominal Thickness
    e. Hole Size: 9/16" Nominal
    f. Finish: Hot Dipped Galvanizing, G90 weight, ASTM A123
    g. Conformance: Metal Forming Manufacturer's Association (MFMA) Standard Publication MFMA-1
3. Accessories:
    a. Nominal Size: Per Service from Manufacturer's Standard Catalog
    b. Shape: Per Service from Manufacturer's Standard Catalog
    c. Body: Hot Rolled Mild Carbon Steel, ASTM A570, Grade 33
    d. Gauge: 1/4" Nominal Thickness
    e. Hole Size: 9/16" Nominal
    f. Conformance: Metal Forming Manufacturer's Association (MFMA) Standard Publication MFMA-1.
    g. Rollers: Gray Cast Iron
4. Nuts and Bolts:
    a. Nominal Size: 1/2" diameter x (Size per device)
    b. Body: Mild carbon steel, ASTM A570, Grade 33, and Case Hardened

c. Threading: Coarse, Unified & American, UNC Classes 2A and 2B

d. Mounting: Spring or non-spring

e. Finish: Electro-Galvanized, G90 weight, ASTM A123

f. Conformance: Metal Forming Manufacturer's Association (MFMA) Standard Publication MFMA-1

5. Supplemental support system members shall be positioned to align with equipment support points for proper bolting.

2.33 TERMINAL BOXES

A. Provide single duct variable air volume terminal units of the sizes and capacities as scheduled. Terminals must be certified by ARI and shall bear the ARI 880 seal. Manufacturer to be Titus, Envirotec, Price or Nailor. All boxes to comply with MGH Technical Bulletin #72.

B. Terminals shall be constructed of not less than 22 gauge galvanized steel with a minimum G60 zinc coating, able to withstand a 125 hour salt spray test per ASTM B-117. Stainless steel casings, or galvannealed steel casings with a baked enamel paint finish, may be used as an alternative. The terminal casing shall be mechanically assembled (spot-welded casings are not acceptable).

C. Casing shall be hospital grade, double wall construction, using a 22 gauge galvanized metal liner with a chromate finish covering insulation. Insulation shall meet ASTM C1136 and STMC C665 for biological growth in insulation and shall be a minimum ½ inch thick. Adhesive as the only method of fastening the insulation to the casing is not acceptable. Minimum thermal conductivity shall be 0.24. Insulation must meet all requirements of UL 181 and NFPA 90A. Raw insulation edges on the discharge of the unit must be covered with metal liner to eliminate flaking of insulation during field duct connections. Simple "buttering" of raw edges with an approved sealant is not acceptable. All appurtenances including control assemblies, control enclosures, hot water heating coils and electric heating coils shall not extend beyond the top and bottom of the unit casing, and shall be provided with a factory gasketed access door with camlock attachment for inspection and heating coil cleaning.

D. The primary air valve shall consist of a minimum 22 gauge cylindrical body that includes embossment rings for rigidity. The damper blade shall be connected to a solid shaft by means of an integral molded sleeve which does not require screw or bolt fasteners. The shaft shall be manufactured of a low thermal conducting composite material and include a molded damper position indicator visible from the exterior of the unit. The damper shall pivot in self lubricating bearings. The damper actuator shall be mounted on the exterior of the terminal for ease of service. The valve assembly shall include internal mechanical stops for both full open and closed positions. The damper blade seal shall be secured without the use of adhesives. The air valve leakage shall not exceed 1% of maximum inlet rated airflow at 4" w.g. inlet pressure.

E. Differential pressure airflow sensor shall traverse the duct using the equal cross sectional area or log-linear traverse method along two perpendicular diameters. Single axis sensor shall not be acceptable for duct diameters 6" or larger. A minimum 12 total pressure sensing points shall be utilized. The total pressure inputs shall be averaged using a pressure chamber located at the center of the sensor. A sensor that delivers the differential pressure signal from one end of the sensor is not acceptable. The sensor shall output an amplified differential pressure signal that is at least 2.5 times the equivalent velocity pressure signal obtained from a conventional pitot tube. The sensor shall develop a differential pressure of 0.03" w.g. at an air velocity of ≤ 450 FPM. Documentation shall be submitted which substantiates this requirement. Brass balancing taps and airflow calibration charts shall be provided for field airflow measurements.

F. Terminal shall include an integral hot water coil. The coil shall be manufactured by the terminal unit manufacturer and shall have a minimum 22 gauge galvanized sheet metal casing with a minimum G60 zinc coating. Stainless steel casings, or galvannealed steel casings with a baked enamel paint finish, may be used as an alternative. Coil to be constructed of pure aluminum fins with full fin collars to assure accurate fin spacing and maximum tube contact. Fins shall be

spaced with a minimum of 10 per inch and mechanically fixed to seamless copper tubes for maximum heat transfer. Each coil shall be tested at a minimum of 350 psig under water. Hot water coils to be selected by the following:

1. Winter max load condition with 180°F. EHWT.
2. Summer reheat load only condition with 95°F EHWT.

G. BAS will provide the controls for terminal boxes. Terminal box manufacturer shall provide control cabinet for BAS to be factory mounted. Extend differential pressure air flow tubing to cabinet. BAS controls will pick up signal at this point.

2.34 THERMOMETERS

A. Thermometers shall be of sizes, types and capacities specified herein, and shall be located as indicated on the drawings. Equipment shall be as manufactured by Taylor Company, Mueller Company or Foxboro Company.

B. Thermometers shall be industrial type with 9 inch scale, red perma colored liquid, black scale divisions on white background, union hub, separable brass well and adjustable swivel base. Provide extension wells on insulated lines. Locate wells so as to provide minimum restriction to flow.

C. Thermometer ranges shall be as follows:

1. Hot Water (All) 30-240 Degrees F.

Note: Mount all thermometers so as to be read from the floor. Provide two (2) spare thermometers of each range indicated.

2.35 UNIT HEATERS

A. Unit heaters shall be of sizes, capacities for the throw and mounting heights indicated on the Drawings. Equipment shall be of manufacturer and size scheduled on the Drawings, or approved equal as manufactured by Vulcan, Trane or Sterling.

B. Horizontal unit heaters shall have direct driven propeller fan, steel fan guard, vertically adjustable louvers, horizontally adjustable fins and built-in motor thermal overload protection.

C. Vertical unit heaters shall have direct driven propeller fan, steel fan guard, adjustable outlet diffusers and built-in motor thermal overload protection.

2.36 VALVES

A. All valves shall conform to requirements of this specification for the services indicated. Manufacturer's numbers referenced are intended as a guide only. The supplier shall verify valves submitted are in accordance with specified materials and construction.

B. All valves of a given type shall be by one (1) manufacturer. The acceptable standard of quality shall be as follows.

C. Gate Valves: Jenkins, Grinnell or Crane

Nominal Size	Through 2"	2½" and Above
Service	Hot Water	Hot Water
Pressure Rating	125 PSIG Steam, 200 PSIG WOG	125 PSIG Steam, 200 PSIG WOG
Body	ASTM B-62 Bronze; Threaded	ASTM A-126 Class B; Flanged
Bonnet	ASTM B-62 Bronze; Rising Stem	ASTM A-126 Class B; Bolted OS&Y

Bolts	N.A.	ASTM A-307
Gaskets	N.A.	Non-Asbestos Graphite/Aramid Fiber
Packing	Non-Asbestos Graphite/Aramid Fiber	Non-Asbestos Graphite/Aramid Fiber
Stem	ASTM B-371 Alloy C69400 or ASTM B-99 Alloy C65100 H04	ASTM B-16 UNS-C36000
Wedge	ASTM B-62 Bronze	ASTM A-126 Class B Cast Iron
Seat & Wedge Rings	N.A.	ASTM B-584 Bronze
Conformance	WW-V-54 Class A, Type I & MSS-SP-80	WW-V-58 Class 1, Type 1 & MSS-SP-70

D. Globe Valves: Jenkins, Grinnell or Crane

Nominal Size	Through 2”	2½” and above
Service	Hot Water	Hot Water
Pressure Rating	125 PSIG Steam, 200 PSIG WOG	125 PSIG Steam, 200 PSIG WOG
Body	ASTM B-62 Bronze; Threaded	ASTM A-126 Class B; Flanged
Bonnet	ASTM B-62 Bronze; Rising Stem	ASTM A-126 Class B; Bolted OS&Y
Bolts	N.A.	ASTM A-307
Gaskets	N.A.	Non-Asbestos Graphite/Aramid Fiber
Packing	Non-Asbestos Graphite/Aramid Fiber	Non-Asbestos Graphite/Aramid Fiber
Stem	ASTM B-371 Alloy C69400	ASTM B-16 UNS-C36000
Seat Disc	ASTM B-62 Bronze	ASTM B-584 Alloy C84400 Bronze or ASTM A-126 Class B Cast Iron
Seat Ring	N.A.	ASTM B-584 Alloy C84400 Bronze
Conformance	WW-V-51 Class A, Type I & MSS-SP-80	MSS-SP-85

E. Ball Valves: Jamesbury, Grinnell or Watts

Nominal Size	To 3” φ	To 3” φ
Service	Hot Water	Hot Water
Pressure Rating	125 PSIG Steam, 400 PSIG WOG	125 PSIG Steam, 400 PSIG WOG
Body	ASTM B-584 Alloy 845 Bronze, Threaded (to 2”φ) or	ASTM B-584 Alloy 845 Bronze, Threaded (to 2”φ)

Nominal Size	To 3" φ	To 3" φ
	Soldered (2½"φ & 3"φ)	or Soldered (2½"φ & 3"φ)
Thrust Washer	Reinforced Polytetrafluoro ethylene	Reinforced Polytetrafluoro ethylene
Ball	ASTM B-584 Alloy 845 Bronze; Full Port	ASTM B-584 Alloy 845 Bronze; Full Port
Seats	Reinforced Polytetrafluoro ethylene (Teflon)	Reinforced Polytetrafluoro ethylene (Teflon)
Stem	ASTM B-371 Alloy 694 Silicon Bronze	ASTM B-371 Alloy 694 Silicon Bronze
Packing	Reinforced Polytetrafluoro ethylene (Teflon)	Reinforced Polytetrafluoro ethylene (Teflon)
Packing Nut	ASTM B-16	ASTM B-16
Operator	Infinite Lever w/Memory Stop	Infinite Lever w/Memory Stop
Conformance	WW-V-35, Type II, Class A, Style 3	WW-V-35, Type II, Class A, Style 3

F. Silent Check Valves: Grinnell or Watts

Nominal Size	Through 2"	2½" and above
Service	Hot Water	Hot Water
Pressure Rating	125 PSIG Steam, 250 PSIG WOG	125 PSIG @ 200°F., 230 PSIG WOG
Body	ASTM B-584 Alloy C84400 Bronze; Threaded	ASTM A-48 Class 35; Globe Style, Flanged
Stem	ASTM A-582 Alloy S30300 Stainless Steel	ASTM A-582 Alloy S30300 Stainless Steel
Disc	Polytetrafluor ethylene (Teflon)	ASTM B-584 Alloy 836 Bronze
Spring	ASTM A-313 T316 Stainless Steel	ASTM A-313 T304 Stainless Steel
Seat Ring	Polytetrafluor ethylene (Teflon)	ASTM B-584 Alloy 836 Bronze
Conformance	N.A.	N.A.

2.37 VARIABLE FREQUENCY DRIVES

A. Section Includes: Variable Frequency Drive (VFD).

B. Related Sections: Section 16000 – Electrical.

C. References:

1. NEMA ICS 3.1: Safety Standards for Construction and Guide for Selection, Installation and Operation of Variable Frequency Drive Systems.

2. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum).

3. UL, and cUL approved.
4. IEEE Standard 444 (ANSI-C343)
5. IEEE Standard 519-1992
6. EC: 146A
7. UL 508C (Power Conversion)
8. CSA 22.2 No. 14-95 (Industrial Control Equipment)
9. UL 1995 (Plenum rating)
10. EN 50178 (LVD)
11. EN 61800-3
12. IEC 529
13. FCC CRF 47 Part 15 Subpart B

D. Submittals:

1. Submit under provisions of Section 01340.
2. Shop drawings shall include: Wiring diagrams, electrical schematics, front and side views of enclosures, overall dimensions, conduit entrance locations and requirements, nameplate legends, physical layout, enclosure details, and heat output.
3. Product Data: Provide data sheets showing: voltage, ratings of customer use switching and over-current protective devices, short circuit ratings, and weights.
4. Manufacturer's Installation Instructions and Technical Manuals: Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of adjustable speed drive. Document the sequence of operation, cautions and warnings, trouble shooting procedures, spare parts lists and programming guidance.
5. Harmonic analysis for compliance with IEEE 519, shall be provided. Engineer shall provide transformer specs and one line diagram of the system to help the manufacturer complete the analysis.
6. Tuning and deadband report, as necessary.

E. Quality Assurance: VFD shall have a minimum MTBF (mean time between failure) rating of 28 years (245,280 hours).

F. Operation and Maintenance Data:

1. Submit under provisions of Section 01700.
2. Include instructions for starting and operating VFD, and describe operating limits, which may result in hazardous or unsafe conditions.

G. Qualifications: Manufacturer must have a minimum of 25 years of documents experience, specializing in variable frequency drives.

H. Delivery, Storage and Handling:

1. Deliver, store, protect and handle products to site, under provisions of Section 01610.
2. Accept VFD on site in original packing. Inspect for damage.
3. Store in a clean, dry space. Maintain factory wrapping, or provide an additional heavy canvas or heavy plastic cover, to protect units from dirt, water, dust, construction debris and traffic.

4. Handle carefully, in accordance with manufacturer's written instructions, to avoid damage to components, enclosure and finish.

I. Warranty: Provide VFD warranty, for two years parts and labor from date of startup, not to exceed 18 months from date of shipment. Warranty shall include parts, and labor allowance for repair hours.

J. Manufacturers:

1. VFD shall be manufactured by Yaskawa Electric, Danfoss or ABB. No substitutes.

2. All drives shall be by the same manufacturer. Motors shall be inverter duty rated, per NEMA MG1 parts 30 and 31, for motor-drive compatibility.

K. Description: Provide enclosed variable frequency drives suitable for operation at the current, voltage, and horsepower indicated on the schedule. Conform to requirements of NEMA ICS 3.1

L. Ratings:

1. A VFD must operate, without fault or failure, when voltage varies plus 10% or minus 15% from rating, and frequency varies plus or minus 5% from rating.

2. VFD shall be 480 or 208 volts, 60 Hz, 3 phase.

3. Displacement Power Factor: 0.98 over entire range of operating speed and load.

4. Operating Ambient Temperature: -10 degrees C. to 40 degrees C (14 degrees F to 104 degrees F).

5. Humidity: 0% to 95% non-condensing.

6. Altitude: to 3,300 feet, higher altitudes achieved by derating.

7. Minimum Efficiency: 96% at half speed; 98% at full speed.

8. Starting Torque: 100% starting torque shall be available from 0.5 Hz to 60 Hz.

9. Overload Capability: 110% of rated FLA (full load amps) for 60 seconds; 180% of rated FLA, instantaneously.

10. The VFD must meet the requirements for Radio Frequency Interference (RFI) above 7 MHz as specified by FCC regulations, Part 15, Subpart J, Class A devices.

11. Total Harmonic Distortion (THD) Compliance: Given the information provided by the customer's electric power single line diagram and distribution transformer data, the VFD manufacturer shall carry out an analysis of the system. The analysis reviews the potential for the proposed equipment, and any existing equipment, to meet IEEE 519 (tables 10.2 and 10.3) recommendations at the Point of Common Coupling (PCC). If the results determine that additional power quality measures are required, these measures shall be provided at no additional cost.

12. VFD's must have a minimum short circuit rating of 65K amps RMS (100K amps RMS with a DC bus reactor) without additional input fusing.

M. Design:

1. A VFD shall employ microprocessor based inverter logic, isolated from all power circuits.

2. VFD shall include surface mount technology with protective coating.

3. VFD shall employ a PWM (Pulse Width Modulated) power electronic system, consisting of :

a. Input Section:

(1) VFD input power stage shall convert three-phase AC line power into a fixed DC voltage via a solid state full wave diode rectifier, with MOV (Metal Oxide Varistor) surge protection.

b. Intermediate Section:

(1) DC bus as a supply to the VFD output section shall maintain a fixed voltage with filtering and short circuit protection.

(2) DC bus shall be interfaced with the VFD diagnostic logic circuit, for continuous monitoring and protection of the power components.

(3) 5 HP to 150 HP @ 208 VAC, and 5 HP to 500 HP 480 VAC, VFD's shall include a DC bus reactor to minimize reflected harmonics.

c. Output Section:

(1) Insulated Gate Bipolar Transistors (IGBT's) shall convert DC bus voltage to variable frequency and voltage.

(2) The VFD shall employ PWM sine coded output technology to power the motor.

4. The VFD must be selected for operation at carrier frequencies at or above 5 kHz without derating to satisfy the conditions for current, voltage, and horsepower as indicated on the equipment schedule. Exception to this requirement is allowed only for VFDs providing 506 amps or more.

5. The VFD shall have an adjustable carrier frequency. The carrier frequency shall have a minimum of six (6) settings to allow adjustment in the field.

6. VFD shall have embedded Building Automation System (BAS) protocols for network communications; Johnson Metasys N2, Siemens System 600 APOGEE, Modbus/Memobus. These protocols shall be accessible via a RS-422/485 communication port. In addition, LonWorks BACNet and Ethernet TCP/IP shall be available options.

7. VFD shall have a quick disconnect, removable control I/O terminal block to simplify control wiring procedures.

8. VFD shall include two independent analog inputs. One shall be 0-10 VDC. The other shall be programmable for either 0-10 VDC or 4-20 mA. Either input shall respond to a programmable bias and gain.

9. VFD shall include a minimum of seven multi-function digital input terminals, capable of being programmed to determine the function on a change of state. These terminals shall provide up to 30 functions, including, but not limited to:

a. Remote/local operation selection

b. Detection of external fault condition

c. Remote reset

d. Multi-step speed commands

e. Run permissive

f. Floating control

10. VFD shall include two 0-10 VDC or 4-20 mA analog output for monitoring, or "speed tracking" the VFD. The analog output signal will be proportional to output frequency, output current, output power, PI (Proportional & Integral control) feedback or DC bus voltage.

11. VFD shall provide terminals for remote input contact closure, to allow starting in the automatic mode.

12. VFD shall include at least one external fault input, which shall be programmable for a normally open or normally closed contact. These terminals can be used for connection of firestats, freezestats, high pressure limits or similar safety devices.

13. VFD shall include two form "A" contacts and one form "C" contact, capable of being programmed to determine conditions that must be met in order for them to change state. These output relay contacts shall be rated for at least 5A at 120 VAC and shall provide up to 18 functions, including, but not limited to:

    a. Speed agree detection

    b. Low and high frequency detection

    c. Missing frequency reference detection

    d. Overtorque/undertorque detection

    e. Drive running

    f. Drive faulted

14. VFD shall include a power loss ride through of 2 seconds.

15. VFD shall have DC injection braking capability, to prevent fan "wind milling" at start or stop, adjustable, current limited.

16. VFD shall have a motor preheat function to prevent moisture accumulation in an idle motor.

17. VFD shall include diagnostic fault indication in selected language, last 10 faults storage and heatsink cooling fan operating hours.

18. VFD shall have a digital operator with program copy and storage functions to simplify set up of multiple drives. The digital operator shall be interchangeable for all drive ratings.

19. VFD shall include a front mounted, sealed keypad operator, with an English language (or one of 6 additional international languages) illuminated LCD display. The operator will provide complete programming, program copying, operating, monitoring, and diagnostic capability. Keys provided shall include industry standard commands for Hand, Off and Auto functions.

20. VFD plain language display shall provide readouts of: output frequency in hertz, PI feedback in percent, output voltage in volts, output current in amps, output power in kilowatts, DC bus voltage in volts, interface terminal status, heatsink temperature and fault conditions. All displays shall be viewed in an easy-to-read illuminated LCD with International language selectability.

21. VFD unit shall include the following meters to estimate use of energy and shall be accessible via VFD keypad.

    a. Elapsed Time Meter

    b. Kilowatt Meter

    c. Kilowatt Hour Meter

22. VFD shall include PI control logic, to provide closed loop setpoint control capability, from a feedback signal, eliminating the need for closed loop output signals from a building automation system. The PI controller shall have a differential feedback capability for closed loop control of fans and pumps for pressure, flow or temperature regulation in response to dual feedback signals.

23. VFD shall include loss of input signal protection, with a selectable response strategy including speed default to a percent of the most recent speed.

24. VFD shall include electronic thermal overload protection for both the drive and motor. The electronic thermal motor overload shall be approved by UL. If the electronic thermal motor overload is not approved by UL, a separate UL approved thermal overload relay shall be provided in the VFD enclosure.

25. VFD shall include the following program functions:

    a. Critical frequency rejection capability: 3 selectable, adjustable deadbands

    b. Auto restart capability: 0 to 10 attempts with adjustable delay between attempts.

    c. Ability to close fault contact after the completion of all fault restart attempts.

    d. Stall prevention capability.

    e. “S” curve soft start capability.

    f. Bi-directional “Speed Search” capability, in order to start a rotating load.

    g. 14 preset and 1 custom volt per hertz pattern.

    h. Heatsink over temperature speed fold back capability.

    i. Terminal status indication.

    j. Program copy and storage in a removable digital operator.

    k. Current limit adjustment capability, from 30% to 200% of rated full load current of the VFD.

    l. Motor pre-heat capability.

    m. Input signal or serial communication loss detection and response strategy.

    n. Anti “wind-milling” function capability.

    o. Automatic energy saving function.

    p. Undertorque/Overtorque detection

    q. Preset speeds

26. VFD shall include factory settings for all parameters, and the capability for those settings to be reset.

27. VFD shall include user parameter initialization capability to re-establish project specific parameters.

28. VFD shall include the capability to adjust the following functions, while the VFD is running:

    a. Speed command input

    b. Acceleration adjustment from 0 to 6000 seconds.

    c. Deceleration adjustment from 0 to 6000 seconds.

    d. Select from 5 preset speeds.

    e. Analog monitor display

    f. Removal of digital operator

29. Provide a built in timer clock. The clock shall have a battery back-up with minimum 10 years life span.

N. Additional Product Features to be Provided:

1. Two (2) contactor manual bypass shall be provided. VFD and bypass components shall be mounted inside a common NEMA 1 enclosure, fully pre-wired, and ready for installation as a single UL listed device. Bypass shall include the following:
    a. Input service switch for the drive, output, and bypass contactors, to disconnect power to the VFD, when the motor is running in the bypass mode.
    b. 120 VAC control transformer, with fused primary.
    c. Magnetic overload relay, to protect the motor while operating in the bypass mode.
    d. Circuit breaker or fused disconnect switch, with a pad-lockable through-the-door handle mechanism, that will disconnect all input power to the drive.
    e. Control and safety circuit terminal strip.
    f. Drive/bypass selector switch, Hand/Off/Auto selector switch, Normal/Test selector switch.
    g. Switch selectable smoke purge, auto transfer to bypass and remote transfer functions.
    h. Pilot lights for Control Power, Drive Ready, Drive Run, Drive Selected, Drive Fault, Drive Run, Drive Test, Bypass Selected, Bypass Run, Motor OL, Safety Fault, Damper Closed, Auto Run, Auto Transfer and Smoke Purge.
    i. Normal/test selector switch, shall allow testing and adjustment of the VFD, while the motor is running in the bypass mode.
    j. Hand/Off/Auto selector switch shall provide the following operation:
        (1) Hand Position: The drive is given a start command, operation is via the local speed input (digital operator or speed pot). If in bypass mode, the motor is running.
        (2) Off Position: The start command is removed, all speed inputs are ignored, power is stilled applied to the drive. If in bypass mode, the motor is stopped.
        (3) Auto Position: The drive is enabled to receive a start command and speed input from a building automation system. If in bypass mode, the motor start/stop is controlled by the building automation system.
    k. Annunciation contacts for drive run, drive fault, bypass run and motor OL/safety fault.
    l. Damper control circuit with end of travel feedback capability.
    m. VFD operator/keypad, LCD type.
    n. H/O/A control panel section, touch pad or rotary switch types.
    o. VFD circuit breaker shall be provided only for the VFD without affecting the bypass. Service switch to protect drive from bypass mode voltage.
2. Soft start on transfer to bypass shall be provided for motors 50 HP and above.
3. Enclosure:
    a. NEMA 1 extended enclosure, to house additional equipment within the VFD enclosure for VFD's not requiring bypass, for dry, clean interior installation.
    b. NEMA 1 FVFF (Forced Ventilation Inlet Filter and Outlet Filter) enclosures with filters and blower for AHU service vestibules.

c. NEMA 3R enclosures for outdoor installations; include alternate sun shade.

4. Oversized control transformer shall be provided to power customer supplied logic circuits.
5. RFI (Radio Frequency Interference) filters to further attenuate possible VFD generated noises shall be provided. VFD shall meet the requirements RFI above 7MHZ as specified by FCC regulations, Part 15, Subpart J, Class A devices.
6. Current limiting input fusing or DC bus fuse and MDV's for short circuit protection of VFD semiconductor devices shall be provided.
7. Line reactors (2.5 % min) shall be provided on the input side of the drive for harmonic suppression.
8. Output reactors (2.5 % min) shall be provided on the output side of the drive for motor protection in long motor lead length (above 300 feet) situations. Output motor protection (dv/dt) filter shall be provided to accomplish, long motor lead length solutions.
9. DC bus reactor, to attenuate harmonic distortion shall be provided on: 20 HP and below @ 208 VAC, and 30 HP and below @ 480 VAC.
10. 6 Pulse VFD's shall be provided on 5 HP to 20 HP @ 208 VAC, and 5 HP to 30 HP @ 480 VAC models to minimize THD generated by the VFD.
11. 18 pulse phase shifting transformer shall be provided on: 25 HP to 150 HP @ 208 VAC, and 40 HP to 500 HP @ 480 VAC models to minimize THD generated by the VFD.
12. Analog output (4-20 mA), shall be provided to make available two analog current outputs.
13. Serial communication shall be provided via an isolated RS-422/485 circuit board with the following features:
    a. Command and monitor in excess of 64 points.
    b. Ability to integrate into BYPASS configuration without losing end switch and/or safety interlock functionality.
    c. Serial communication board self test.
    d. Drive parameter storage within communication board.
    e. Drive parameter download capability.
    f. Drive parameter comparison feature.
    g. 5 indication LED's to indicate power, reception, transmission, fault and service of serial communications (Power, Rxd, Txd, Fault, Service).
    h. Polarity insensitive.
    i. Alternate network connection through RJ-45J plug/jack.
14. Remote digital operator, with keypad and display, to control and monitor the VFD from a remote location shall be provided.
15. H/O/A selector switch shall be provided in addition to the digital keypad operation selection capabilities.
16. Local/remote selector switch shall be provided in addition to the digital keypad operation selection capabilities.
17. Analog meter shall be provided in addition to the digital keypad monitoring capabilities.
18. Relays, motor overload or time delay shall be provided.
19. PC software and cable for parameter upload/download/graphing shall be provided.
20. VFD Input MCP circuit breaker or fused disconnect shall be provided.

21. VFD bypass manual disconnect shall be provided.

22. Engraved cabinet nameplates shall be provided.

23. Provide a fireman's override input. Upon receipt of a contact closure, preset signal from fireman's control station, the VFD shall operate at an adjustable preset speed. This mode shall override all other inputs. Override mode shall be displayed on the key pad. VFD shall resume normal operation upon removal of the signal.

O. Fabrication: All standard and optional features shall be included in a single NEMA 1, 12 or 3R, plenum rated enclosure with a UL certification label.

P. Source Quality Control:

1. In circuit testing of all printed circuit boards shall be conducted, to insure the proper mounting and correct value of all components.

2. Final printed circuit board assemblies shall be functionally tested, via computerized test equipment. All tests and acceptance criteria shall be preprogrammed. All test results shall be stored as detailed quality assurance data.

3. All fully assembled controls shall be functionally tested, with fully loaded induction motors. The combined test data shall then be analyzed, to insure adherence to quality assurance specifications.

4. Inspect and production test, under load, each completed VFD assembly.

Q. Examination:

1. Verify that surface is suitable for VFD installation.

2. Do not install VFD until the building environment can be maintained, within the service conditions required by the manufacturer.

R. Installation:

1. Install VFD where indicated, in accordance with manufacturer's written instructions and NEMA ICS 3. Verify compliance with NEC Section 70 for panelboard clearance.

2. Tighten accessible connections and mechanical fasteners after placing VFD.

3. Provide a nameplate label on each VFD, identifying rated horsepower, full load amperes, model number, service factor and voltage/phase rating.

S. Field Quality Control:

1. Field inspection and testing to be performed under provisions of Section 01400.

2. Inspect completed installation for physical damage, proper alignment, anchorage and grounding.

T. Manufacturer's Field Services:

1. The manufacturer's representative shall provide start up services and a verification report that all systems are operational and comply with the intent of the specifications.

2. The VFD manufacturer shall conduct on site harmonic measurements before and after start up of the VFD's. Results of the measurements, showing harmonic contribution of the VFDs shall be provided to the Engineer one month after start up.

U. Adjusting: Carry out adjusting work under provisions of Section 01700. Make final adjustments to installed VFD, to assure proper and quiet operation of HVAC systems. VFD vendor to tune out excessive noise/vibration frequencies creating a deadband. Submit report to Engineer of these frequencies.

2.38 VIBRATION ISOLATION AND SEISMIC RESTRAINT

A. Provide vibration isolation and seismic restraint systems as identified by the requirements of this section and the contract documents.

B. The HVAC Subcontractor shall provide vibration isolation components as required such that all equipment shall operate without objectionable noise or vibration being transmitted to the structure.

C. The HVAC Subcontractor shall provide seismic restraint of non-structural building components (HVAC). Restraint systems are intended to withstand the stipulated seismic accelerations applied through the component's center of gravity.

1. Seismic restraint calculations must be based on the acceleration criteria shown in **TABLE A** acting through the equipment's center of gravity.

2. For roof mounted equipment both the seismic acceleration and wind loads (30 psf) shall be calculated, the highest load shall be utilized for the design of the restraints and isolators.

3. Certification of calculations to support seismic restraint designs must be stamped by a professional engineer registered to practice in the Commonwealth of Massachusetts, with at least five years of seismic design experience.

D. Housekeeping pad attachment shall be by this Contractor.

1. Housekeeping pads shall be coordinated with the Seismic Restraint vendor and sized to provide a minimum edge distance of 10 bolt diameters of clearance all around the outermost anchor bolt to allow for the use of full anchor ratings.

E. Supplementary support steel and connections shall be provided by the HVAC Subcontractor for all equipment, piping, ductwork, etc. including roof mounted equipment, as required or specified.

TABLE A			
"G" FORCES FOR VARIOUS CONDITIONS (SEISMIC ZONE 2 – AV > 0.1 ≤ 0.2)			
PIPE AND DUCT	RIGIDLY MOUNTED EQUIPMENT	FLEXIBLY MOUNTED EQUIPMENT	ALL LIFE SAFETY
.25	.40	.40	.60

F. All vibration isolation and seismic devices described in this section shall be the product of a single manufacturer. Mason Industries shall be considered the Base Manufacturer of these specifications for the purposes of establishing a standard of equality; products of other manufacturers are acceptable provided their systems strictly comply with intent, structural design, performance and deflections of the Base Manufacturer.

G. Seismic Restraint and Vibration Isolation Devices:

1. All isolation and seismic restraint devices shall be capable of accepting, without failure, the "G" forces as determined by the seismic certification and calculations as described in this section of the specifications.

2. Corrosion protection for outdoor applications shall be as follows:

a. Springs cadmium plated, zinc electroplated or electrostatically deposited, baked enamel powder coated.

b. Hardware cadmium plated.

c. All other metal parts hot spray or hot dipped galvanized.

3. Seismic Restraint Types:

a. All seismic restraint devices shall maintain the equipment in a captive position and shall not short circuit isolation devices during normal operating conditions.

b. All seismic restraint devices shall have provisions for bolting and/or welding to the structure.

c. Welding of springs to isolator housing, base plans, etc. is strictly prohibited.

d. dTYPE I: Spring Isolator – Restrained

(1) Spring shall have a minimum outer diameter to overall height ratio of 0.8:1 at rated deflection.

(2) Reserve deflection (from published load ratings to solid height) of 50% of the rated deflection.

(3) Ductile top cut with adjusting bolt tapped for equipment attachment locking cap screw.

(4) Minimum 1/4" thick neoprene acoustical base pad or cup on underside, unless designated otherwise.

(5) Integral restraining bolts with elastomeric cushions preventing metal-to-metal contact.

(6) Internal spring adjusting nut or bolt with leveling capability.

(7) Built-in all-directional limit stops with minimum 1/4" clearance under normal operation.

(8) Cast or aluminum housings, (except ductile iron) are not acceptable.

Mason Industries, Type SLR

e. Type II: Where required, each corner or side of equipment base shall incorporate a seismic restraint snubber having an all directional resilient pad limit stop. Restraints shall be fabricated of plate, structural members or square metal tubing. Angle bumpers are not acceptable.

Mason Industries Type Z-1225/Z-1011

f. Type III: Restraints for suspended systems:

(1) Vibration isolated systems shall be braced with multiple 7 x 19 strand galvanized cable rope.

Mason Industries Type SCB

(2) Non-isolated systems shall be braced with structural steel strut type with approved fastening devices to equipment and structure.

Mason Industries Type SSB

(3) Steel angles (by HVAC Subcontractor) shall be provided to prevent rod bending of hung equipment where indicated by the Seismic Restraint vendor's submittals. Steel angles shall be attached to the rods with a minimum of three ductile iron clamps at each restraint location. Welding of support rods to angles is not acceptable. Rod clamp assemblies shall have Anchorage.

Mason Industries Model SRC

(4) Pipe clevis cross braces are required at all restraint locations. They shall be

special purpose preformed channels deep enough to be held in place by bolts passing over the clevis cross bolt. Clevis cross braces shall have Anchorage Preapproval "R" number from California OSHPD.

Mason Industries Model CCB

g. Type IV: Double deflection neoprene isolator encased in ductile iron or steel casing.

Mason Industries Type RC or BR

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

i. Type K: Resilient Pipe Anchors and Guides

(1) All directional acoustical pipe anchor, consisting of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2" thickness of Type H pad.

(2) Vertical restraints shall be provided by a similar material arranged to prevent vertical travel in either direction.

(3) Allowable loads on neoprene pad shall not exceed 500 PSI and the design shall be balanced for equal resistance in any direction.

Mason Industries Type ADA

(4) Double deflection neoprene compression mountings shall have all metal surfaces neoprene coated. (Chilled Water Pumps)

a) Non-skid top and bottom surfaces.

b) Threaded bolting sleeves shall be embedded in the isolator.

c) Drilled tie-down bolt holes shall be provided in the base plate.

Mason Industries Type ND

4. Equipment Bases:

a. All curbs and roof rails are to be bolted or welded to the building steel or anchored to the concrete deck to attain specified acceleration criteria and shall also be capable of resisting a minimum psf wind loads (non-simultaneous).

b. Type B-1: Integral Structural Steel Base: (For Roof Exhaust Fans)

(1) Constructed of structural members as required to prevent base flexure at equipment startup and misalignment of driver and driven units. Perimeter members shall be a minimum of 1/10th the longest unsupported span.

(2) Centrifugal fan bases shall be complete with motor slide rails and drilled for driver and driven units.

(3) Height saving brackets shall be used to reduce operating height and maintain 1" operating clearance under base.

a) Mason Industries Type MSL, WFSL

5. Flexible Connectors:

a. All connectors shall be installed on the equipment side of shutoff valves; horizontal and parallel to equipment shafts whenever possible. Piping shall be supported and/or anchored to resist pipe movement beyond the allowable movement of the

flexible connector.

b. Installations must include check valves and/or other design and installation precautions to reduce the threat to life safety when subjected to the specified seismic accelerations.

2.39 WATER FLOW COMBINATION MEASURING AND BALANCING DEVICES

A. Provide combination balancing valve and flow device where indicated on the drawings or specified. Flow device – valve assembly shall have ball valve construction of bronze, suitable for use as bubbletight service valve, calibrated balance setting indicator plate, shrader valve connections with caps for meter hose connections. Units shall be Taco or B&G circuit setters.

B. Provide pressure independent auto-flow or Griswold balancing valves where shown on plans.

2.40 WATER SYSTEM ACCESSORIES

A. Equipment shall be sized for the service indicated on the drawings. Equipment shall be as manufactured by Bell & Gossett, Armstrong, Taco, or Thrush.

B. Piping system air vents shall be provided with indicated on drawings and at high points of all hot water and chilled water piping sections. Vents shall be as manufactured by Bell & Gossett, Armstrong, Taco, or Thrush. Any vents not accessible shall be piped to an accessible location.

1. Air vents, except where noted otherwise, shall be manual air vents suitable for 150 PSIG system pressure as manufactured by Bell & Gossett #4V coil-operated type.

2. Air vent at the high point of each system shall be high capacity industrial automatic air vents of the float type with drain connection for water overflow as manufactured by Armstrong, Model #1-AV, B&G 107 or Spirax Sarco 13W.

C. Provide adjustable type water make-up pressure regulating valves for each water system indicated on the drawings and not noted to be furnished under Section 15000. Valves shall be as manufactured by Bell & Gossett #6; Taco #335 or Thrush #21.

1. Valves shall be suitable for minimum of 125 psi inlet pressure and shall be adjustable to the system pressure.

2. Valves shall be provided with assemblies consisting of inlet pressure gauge, shut-off valves, inlet strainer, outlet pressure gauge and quick fill bypass with globe valves.

2.41 PIPING MATERIALS

A. All piping materials installed under this section shall be new and shall consist of the following materials of construction:

System or Section	Piping Class
Hot Water Supply and Returns	20
Make-Up Water	20
Relief Valve and Vent Lines	20
Drain Lines	20

B. Class 20 Piping System:

	2 Inches and Smaller	2½ Inches to 8 Inches
Constr.	Solder joint construction with threaded adaptors as required.	Screwed construction with flanged connections to valves and equipment.
Piping	Copper, Type L, hard drawn, ANSI H23.1, ASTM B88.	Carbon steel (galv), Sch. 40, ANSI B36.20, ASTM A120.
Fittings	Cast bronze or wrought copper, solder joint type, ANSI B16.19 or	Cast iron (galv), 125 lb. class, screwed ends, ANSI B16.3, ASTM A197.

	2 Inches and Smaller	2½ Inches to 8 Inches
	B16.22.	
Couplings	Same as “Fittings” above.	Same as “Fittings” above.
Unions	Wrought copper, solder joint type, ANSI B16.19 or B16.22.	Malleable iron fittings (galv), 125 lb. ANSI standard, screw-on type, ANSI B16.1.

C. Solder for Class 20 Piping: 95-5 tin-antimony.

PART 3 EXECUTION

3.1 MATERIALS AND WORKMANSHIP

A. All materials installed in this work shall be new, unless noted for re-use, without damaged functional or aesthetic components. All equipment finished shall be touched up with matching finishes where slight scratches occur. Equipment or material subject to severe deterioration shall be completely refinished or replaced as directed by the Architect.

B. All labor utilized in the installation of work shall be experienced in the respective trade required. The installation of exposed finished materials shall be neatly done flush, straight and/or plumb, without distortion, meeting the building finished surfaces.

C. All HVAC materials and equipment shall conform to the Standards listed within this Section of the Specifications and wherever such standards have been established, items shall bear its respective label.

D. Where labor to be furnished must meet specific Code requirements, only individuals certified to do such shall be used.

E. All equipment shall be installed in accordance with the manufacturer's instructions and recommendations with adequate clearance for access for maintenance.

3.2 COORDINATION DRAWINGS

A. This Contractor shall give full cooperation to other trades and to the General Contractor and shall furnish any information necessary to permit the work of all trades to be installed satisfactorily and with least possible interference or delay. If this Contractor installs his work before coordinating with other trades, he shall make the necessary changes in his work to correct the condition, without extra charge. In areas, if due to construction conditions, more than one trade is required to use common openings in beams, conduits, etc., this Contractor must plan and locate the positions of the items of piping, ducts, conduits, etc., which are under the scope of his Contract with that of items under the scope of other Contractors, in order that all items are properly located and may be accommodated within the space available. Location and positioning shall be done prior to installation and to the satisfaction of the Architect and/or Engineer.

B. This Contractor shall obtain detailed printed information from the manufacturer of equipment which he is to provide for the proper methods of installation. He shall also obtain all information from the General Contractor and other Contractors which may be necessary to facilitate his work and the completion of the whole project. All equipment shall be installed in strict accordance with manufacturer's recommendations.

C. The work to be accomplished under this Section includes work within existing areas adjacent to the site of new construction. Continuity of services within existing areas shall be maintained. Any interruption of services necessary to accomplish the work shall be made only with the consent of the General Contractor and at such time(s) as the Owner designates.

D. This Contractor shall not unnecessarily disturb or interfere with the Owner's use of the facilities associated with or adjacent to this Contract. When interference is necessary, permission shall be obtained from the General Contractor before any operation or service line is disturbed or disconnected.

E. This Contractor shall include under coordination work the installation of all systems in conformance with governing codes. This Contractor is advised that no piping, ducts or equipment foreign to the electrical equipment shall be permitted to be installed in, enter or pass through such spaces or rooms provided for switchboards and panelboards in accordance with Article 384 of the National Electrical Code.

F. Diffusers, grilles and registers located in the ceiling shall be located as shown on the Architectural Reflected Ceiling Plan and coordinated with ceiling grid, lights, speakers, etc. Items shown on the HVAC Drawings, but not located on the Reflected Ceiling Plan shall be

coordinated to be located as indicated on the HVAC Drawings.

3.3 PROTECTION AND CLEAN-UP

A. This Contractor shall be responsible for maintenance and protection of all materials and equipment furnished by him during the construction period from loss, damage or deterioration until final acceptance by the Owner. All materials and equipment on the job site shall be stored and protected from the weather. All piping and equipment openings shall be temporarily closed during construction to prevent obstruction and damage.

B. All equipment with damaged finished surfaces shall be cleaned and repainted with the same paints as were factory applied.

C. Clean-Up: Keep the job site free from the accumulation of waste materials and rubbish daily. At completion of the work, remove all rubbish, construction equipment and surplus materials from the site and leave the premises in a clean condition.

3.4 OPERATING AND MAINTENANCE MANUALS

A. This Contractor shall provide six (6) complete sets of operating and maintenance manuals to the Owner prior to the operating instruction period. Maintenance manuals shall be submitted for approval. The receipt of approved maintenance manuals by the Owner shall be a prerequisite to system acceptance. Each manual shall include the following:

1. A complete set of Shop Drawings arranged in accordance with their appearance in the Specifications. Drawings shall be folded and included in envelopes and bound into the manual.

2. A complete set of operational and servicing instructions for each piece of equipment, bound into the manual adjacent to the corresponding Shop Drawing.

3. A complete listing of all equipment suppliers, together with local agent's names, addresses and telephone numbers.

4. A complete set of valve listings.

5. Copies of all service contracts provided for the guarantee period.

6. Copies of all equipment and system warranties.

3.5 OPERATING INSTRUCTIONS

A. This Contractor shall provide competent representatives of his firm and also qualified representatives for his major equipment to instruct Owner-designated personnel on the start-up, operation, shut-down and servicing of all equipment and systems furnished and installed under this Section. No less than ten (10) days notice shall be given to the Owner for the beginning of the instruction period to permit scheduling of Owner personnel. The instruction period shall be a prerequisite to system acceptance.

B. At the conclusion of the operating instructions, this Contractor shall have the Owner's personnel sign-off stating they have received the required instruction. Separate statements shall be required for each piece of equipment and system. These statements shall include date, names of Owner's representative, name of instructor, and brief description of equipment or system.

3.6 EXISTING WORK AND DEMOLITION

A. This Contractor shall participate in the survey of the existing HVAC systems. He shall disconnect and cap all service lines to be disconnected for those services which normally are included in his field of work. Particular care shall be taken to avoid creating hazard or causing disruption of services in adjoining areas.

B. The demolition, including the dismantling and removal of existing equipment and/or materials therein, shall be performed by the individual Contractors.

C. Disconnect and cap all piping back to the nearest concealed joint from all floors, walls, partitions or ceilings which are removed, as shown on the Drawings.

D. Reroute all concealed piping and ducts which pass through or extend beyond the floors, walls, partitions and ceilings to be removed.

E. All equipment removed shall be turned over to the Owner unless indicated to be re-used or scrapped.

F. Material shall be disposed of off site in a legal and proper manner by this Contractor.

G. Prior to any demolition work, provide balancing test to existing systems or portions of systems indicated for re-use or being modified for re-use. Test should be adequate to re-establish existing flow quantities and establish existing systems are performing properly. System found to be deficient should be further tested to establish the cause and the Architect notified so corrective design measures can be implemented.

H. Existing ductwork which is to be reused shall be thoroughly cleaned of all debris, dust and film prior to being reconnected to any system.

3.7 SYSTEM START-UP AND OPERATION

A. This Contractor shall provide all labor and materials and services necessary for the initial start-up and operation of all systems and equipment furnished and installed under this Section of the Specifications.

B. This Contractor shall provide the services of qualified factory representatives for all major equipment pre-start set-up, start-up and initial operation. Such periods shall be sufficient to insure proper operation of systems and equipment.

C. This Contractor shall check all equipment during the initial start-up to insure correct rotation, proper lubrication, adequate fluid flows, non-overloading electrical characteristics, proper alignment and minimal vibration. Systems shall be checked for air and/or steam and/or water flows throughout without blockages. Miscellaneous equipment shall be started and operated as described above, as applicable. This Contractor shall prepare and submit monthly start-up and status reports for all equipment and systems as indicated on the schedules. Initial form of this report shall be submitted for review with the initial submittals. Upon closing in of the structure or upon first equipment start-up, the report filing shall be started. One copy of this report shall be submitted to the Testing and Balancing Contractor for his record purposes. Submittal of these reports is a prerequisite for processing and evaluating requisitions.

D. During operation of systems, qualified licensed personnel shall be provided and designated for maintenance of the equipment and systems in good running order. Items such as strainer cleanout, bearing lubrication, packing replacement and other consumables shall be provided without cost to the Owner. Failure of equipment during this period due to lack of proper supervision is the responsibility of this Contractor, and continued failures shall be grounds for the Owner to provide such services with back-charges to this Contractor.

3.8 SHEET METAL WORK REQUIREMENTS

A. Furnish and install all sheet metal work as herein specified for all air handling systems shown on drawings and/or described in the specifications.

B. All sheet metal work shall be done in a neat and workmanlike manner with ductwork following building lines and in straight lines with smooth transitions and offsets as required to suit actual installation. Sheet metal work which does not conform to drawings and/or specifications or is poorly done shall be repaired and/or replaced as described by the Architect.

C. Sheet Metal Contractor shall include in his work furnishing and installing volume dampers in accordance with SMACNA requirements; additional dampers as required in the duct system for the purpose of balancing by the Balancing Contractor, as well as dampers shown on the drawings.

3.9 INSULATION APPLICATION REQUIREMENTS

A. Insulation materials shall be installed in accordance with the applicable insulation classes for piping, ductwork and equipment.

B. Insulation shall be applied in a workmanlike manner so as to provide a neat and smooth surface, suitable for painting. Work and/or material that is poorly done or done in a manner not conforming to the specifications and/or drawings shall be repaired or replaced as directed by the Architect.

C. Insulation shall not be applied when ambient temperatures within the space are below 40 degrees F.

D. All insulation shall be applied with edges tightly butted.

E. Equipment nameplates, pressure vessel code labels and equipment access doors shall be left exposed with insulation edges finished as described in Paragraph J. above.

F. When installation thickness specified exceeds that provided as manufacturer's standard, then multiple layered material shall be used to achieve specified thickness.

3.10 PIPING SYSTEM INSTALLATION

A. Installation of Pipe, Fittings and Valves:

1. Furnish and install piping approximately as indicated; straight, plumb and as direct as possible; form right angles on parallel lines with building walls.

2. Keep pipes close to walls, partitions and ceilings; offset only where necessary to follow walls, as indicated.

3. Locate groups of pipes parallel to each other; space them at distances to permit applying full insulation and to permit access for servicing valves.

4. Piping shall be accurately cut to measurements established in the field and worked into place without springing or forcing. All piping shall be assembled using standard manufacturer's screwed or welded fittings. Where standard fittings are not available for branch connections, use "Threadolets" or "Weldolets" as appropriate to suit pipe sizes, neatly cut and welded into the line.

5. All piping shall be reamed to be free of burrs.

6. Keep pipe free from scale and dirt; protect open pipe ends whenever work is suspended during construction to prevent foreign bodies entering and lodging there. Use temporary plug or other approved material for protection.

7. Use all long radius ells on welded piping.

8. Prior to installation of any piping, submit shop drawings indicating location of all pipes larger than 2 inches in diameter. Piping may be shown on Coordination Drawings in lieu of Shop Drawings.

9. Provide solid threaded plug for all drain valves. Cap/chain assembly not allowed.

B. Installation for Chilled and Hot Water:

1. Pitch all piping in direction of flow.

2. Automatic vent valves shall be installed in the piping systems, where indicated on the Drawings or as required at all high points of any piping system.

3. Drain valves shall be located at the base of all low points in the piping systems and at all water connections to associated equipment and pumps. Drain valves shall be 3/4 inch ball valves with solid threaded plug. Cap/chain assembly not allowed.

4. Provide blow-down line with ball valve on each strainer with solid threaded plug. Cap/chain assembly not allowed.

C. Installation of Unions:

1. Provide unions, screwed or flanged, in the following locations:

a. In long runs of piping to permit convenient disassembly for alterations or repairs.

b. Unions shall be installed on both inlet and outlet pipe connections to (but limited to) fancoil units, all traps and control valves.

D. Installation of Valves:

1. Provide shut-off valves where indicated and in the following locations:

a. Risers and main branches at points of take-off from Thier supply or return mains. Valves shall be arranged so that piping mains for the building and for each floor can remain in service while branch line piping is out of service. Balancing valves suitable for shut-off service shall be used in returned piping.

b. Individual equipment, control valves, strainers, traps and other piping systems devices at inlet and outlet to permit unit removal for repairs without interfering with remainder of system.

2. Locate valves for easy access and operation.

3. Do not locate valves with stems below horizontal.

4. Provide balancing valve at outlet of each equipment connection. In water piping systems, locate balancing valve as shown on Drawings where piping details are provided.

E. Pipe Welding: Welding backing rings shall be used at each pipe weld. All pipe welders shall be tested and qualified under the National Certified Pipe Welders Bureau. Welders for high pressure steam shall be certified for ASME Code welding.

F. Expansion:

1. Provide for taking up expansion in chilled and hot water by means of loops, offsets, guides and anchors, where indicated and/or required.

2. When installing expansion loops, they may be cold sprung. Cold springing shall compensate for approximately half of the total expansion between hot and cold conditions.

3.11 PIPING SYSTEM FLUSHING AND CLEANING

A. This Contractor shall make temporary connections and required adjustments to the piping system for the purpose of cleaning and flushing.

B. Chilled and hot water lines shall be chemically cleaned by circulating water solution for not less than four (4) hours, flushed out and cleaned with water run to waste. All strainers shall be removed, cleaned and replaced. All equipment such as fancoil units, coils shall be checked to insure all foreign material has been eliminated. This Contractor shall submit chemical cleaning treatment and method to the Architect for approval.

C. Compressed air lines shall be blown out using compressed air. All filters and instruments shall be removed from system during this flushing and then replaced.

D. Chemical treatment required for cleaning shall be provided as specified under "Chemical Treatment".

3.12 PIPING SYSTEMS PRESSURE TESTS

A. All piping systems furnished and installed under this Section shall be pressure and/or vacuum tested prior to being buried, concealed and/or insulated. This Contractor shall make all

necessary temporary connections and gauges required and shall isolate all equipment which may be damaged by testing procedures. This Contractor shall notify Architect in writing of his testing schedule to permit observation of procedures. Tests shall be initiated only after testing medium has reached ambient temperatures. Systems which fail testing shall be repaired in a manner approved by the Architect and testing repeated. Testing of sections of extensive systems are permitted. Written summary of all testing shall be submitted upon completion of testing indicating system, date of test, testing medium, initial and final pressures and temperatures, repair procedures and supervisor's name.

B. The following systems shall be tested as indicated:

SYSTEM	TEST MEDIUM	TEST PRESSURE PSIG	TIME PERIOD HOURS	ALLOWED DEVIATION PERCENT	NOTES
Condenser, Chilled and Hot Water	Water	100	4	-5	1

Note 1: Water shall be clean, clear liquid.

For testing of piping systems exposed to low ambient conditions, this Contractor shall assume responsibility of taking suitable precautions to prevent freezing within piping systems.

3.13 SYSTEMS IDENTIFICATION

A. General:

1. All equipment, ductwork and piping furnished under this section shall be marked for ease of identification in accordance with ANSI A13.1-1981 Standard or as indicated below by this Contractor.

2. Marking shall be done using painted stenciling applied to clean, smooth surfaces.

3. Lettering type and size shall be in accordance with Paragraph 3.4 and Table 3 of ANSI Standard, with sharply contrasted background for ease of identification. Duct labeling shall not be less than 3 inches in height. Colors shall be in accordance with Paragraph 3.2 and Table 2 of the ANSI Standard.

B. Equipment:

1. Equipment markings shall be prominently painted on each normally visible side of equipment. Equipment intended for installation in finished areas shall have markings located behind normally used access panels mounted so as to be readily found.

2. Equipment identification designations shall be taken from equipment schedules as indicated on the drawings.

C. Piping:

1. Piping marking, except as noted below, shall be prominently painted on all piping concealed and exposed to view, at entries to shafts and at all valving. Marking spacing shall be every 20 feet and at all changes in direction.

2. Piping markings shall indicate direction of flow with piping designation taken from piping legend indicated on drawings.

3. In lieu of painting pipe marking for outside diameters of no less than 3/4 inches but less than 6 inches labeling shall be on semi-rigid plastic which shall be wrapped entirely around the item being identified and attached to itself to form a non-removable band.

4. In lieu of painting pipe marking for outside diameters of 6 inches or greater, springs or metal bands secured to the corners at each end of the semi-rigid plastic marker so as to

hold each end of the marker firmly against the pipe may be utilized.

5. In lieu of painting, for outside diameters less than 3/4 inches, labeling of 1/2 inch high lettering on 1½ inch minimum diameter tags shall be attached so as direction of flow arrows will indicate proper flow direction when tag is being read.

D. Ductwork:

1. Ductwork marking shall be prominently painted on all ductwork concealed and exposed to view. Marking spacing shall be every 20 feet at all dampers and at all changes in direction.

2. Ductwork marking shall indicate direction of air flow with ductwork designation to consist of the equipment designation to which it is connected and indicate either high or low velocity system.

E. Valve Tags:

1. Valve tags shall be 1½ inch diameter brass with 1/4 inch high lettering for service designation over 1/2 inch high valve number designation and shall be provided for all valving.

2. Two (2) sets of valve lists shall be prepared showing tag numbers, valve locations and valve service. Valve tag numbers shall be marked on record drawings. One valve list shall be prepared based on sequenced room numbers of valve locations; one valve list shall be prepared based on valve numbers. One set of lists shall be framed under glass and duplicate list laminated between plastic sheets.

3. One (1) additional copy shall be framed under glass and mounted on the wall in location as designated by the Architect.

3.14 SYSTEMS BALANCING

A. This Contractor, as part of his contract, shall obtain the services of a testing and balancing agency that specializes in this type of work, to perform the work required under this section. The testing and balancing agency selected shall not have installed, fabricated or engineered any part of the system that the testing and balancing work shall be performed on, so as to prevent any conflict of interest. In addition, the selected company shall not be a subsidiary of or be associated with persons having financial interests in the accessories, ductwork, controls, etc., undergoing these tests so that the Owner will receive a completely unbiased test and balance report upon completion of the work.

B. The selected testing and balancing agency shall be a certified member of the AABC or the NEBB. Minimum criteria for this project shall be the General Membership Standards of the Associated Air Balance Council, as published nationally in AABC NSFMI Volume One, #81266 or as otherwise noted herein.

C. All work performed by the approved agency shall be done in full accordance with minimum standards as set forth in AABC National Standards, Fourth Edition (1982) and ASHRAE Systems Manual (1984). In addition, vibration readings shall be taken on all rotating equipment in this section and recorded in mills of deflection.

D. Submittals:

1. The TAB Agency shall submit a company resume listing personnel and project experience in air and hydronic system balancing and a copy of the agency's Test and Balance Engineer (TBE) certificate.

2. The TAB agency shall submit the TAB procedures and agenda proposed to be used.

3. The TAB agency shall submit sample forms, which shall include the minimum data required by the AABC National Standards.

E. This Contractor shall cooperate with the test and balance agency in the following manner:

1. Provide sufficient time before final acceptance data so that tests and balancing can be accomplished and reviewed.
2. Provide immediate labor and tools to make corrections when required without undue delay. Install balancing dampers as required by test and balance agency.
3. Put all heating and ventilating systems and equipment into full operation and shall continue the operation of same during each working day of testing and balancing.
4. Include the costs of test openings, dampers, pulley and belt changes in his contract.

F. The test and balance agency shall test and balance all exhaust systems and equipment and shall also test and balance all hot water and make-up water systems. All systems shall be adjusted so that they achieve within 10 percent of design quantities, except over-all pressure relationship shall be maintained.

1. Where provided, air flow measuring devices shall be utilized to balance air system. Accuracy also shall be verified by the balancing agency.
2. Where combination balancing valve and flow measuring devices, or flow devices, are indicated, the balancing agency shall utilize them for balancing the water system.

G. The items requiring testing, adjusting and balancing include the following:

1. Air Systems:
   a. Exhaust Fans
   b. Zone Branch and Main Ducts
   c. Diffusers, Registers and Grilles
2. Hydronic Systems:
   a. Pumps
   b. System Mains and Branches
   c. Boilers
   d. Radiation

H. TAB Preparation and Coordination:

1. Shop drawings, submittal data, up-to-date revisions, change orders, and other data required for planning, preparation, and execution of the TAB work shall be provided to the TAB agency no later than 30 days prior to start of TAB work.
2. System installation and equipment start-up shall be complete prior to the TAB agency's being notified to begin.
3. The building control system shall be complete and operational. The Building Control System Contractor shall install all necessary computers and computer programs, and make these operational. Assistance shall be provided as required for reprogramming, coordination, and problem resolution.
4. All test points, balancing devices, identification tags, etc., shall be accessible and clear of insulation and other obstructions that would impede TAB procedures.
5. Qualified installation or start-up personnel shall be readily available for the operation and adjustment of the systems. Assistance shall be provided as required for coordination and problem resolution.

I. Reports:

1. The TAB agency shall submit the final TAB report for review by the Engineer. All outlets, devices, HVAC equipment, etc., shall be identified, along with a numbering system

corresponding to report unit identification. The TAB agency shall submit an AABC "National Project Performance Guaranty" assuring that the project systems were tested, adjusted and balanced in accordance with the project specifications and AABC National Standards.

2. Submit four (4) copies of the final TAB Report.

J. Deficiencies:

1. Any deficiencies in the installation or performance of a system or component observed by the TAB agency shall be brought to the attention of the appropriate responsible person.

2. The work necessary to correct items on the deficiency listing shall be performed and verified by the affected contractor before the TAB agency returns to retest. Unresolved deficiencies shall be noted in the final report.

3. System balance reports which, upon field inspection of the systems, are found to be erroneous, shall have the questioned systems corrected by the test and balance agency until a proper balance is achieved. Such correction work shall be done at no cost to the Owner. Balancing Contractor shall field verify balancing settings and measurements as randomly selected by the Architect.

K. The specified systems shall be reviewed and inspected for conformance to design documents. Testing, adjusting and balancing on each identified system shall be performed. The accuracy of measurements shall be in accordance with AABC National Standards. Adjustment tolerances shall be + or – 10% unless otherwise stated.

1. Equipment settings, including manual damper quadrant positions, manual valve indicators, fan speed control levers, and similar controls and devices shall be marked to show final settings.

2. All information necessary to complete a proper TAB project and report shall be per AABC Standards unless otherwise noted. The descriptions for work required, as listed in this section, are a guide to the minimum information needed.

L. Air Systems:

1. The TAB agency shall verify that all ductwork, dampers, grilles, registers and diffusers have been installed per design and set in the full open position. The TAB agency shall perform the following TAB procedures in accordance with the AABC National Standards.

2. For Exhaust Fans:

a. Test and adjust fan RPM to achieve maximum or design CFM.

b. Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure motor is not in or above the service factor.

c. Perform a pitot-tube traverse of main exhaust ducts to obtain total CFM.

d. Test and record system static profile of each exhaust fan.

3. The Balancing Contractor shall make all necessary tests and measurements and provide information as required to provide for replacement of adjustable sheaves utilized for initial balancing with optimum sized fixed sheave and select optimum replacement sheave sizes for existing equipment fan drives for systems indicated to be modified. All adjustable sheaves replaced shall be tagged to indicate which unit it was on and turned over to the Owner.

4. Where air balancing can not be completed due to lack of air flow and the reason for the lack of air flow can not be identified, a static profile shall be performed as required to identify the reason for loss of adequate air flow.

M. Hydronic Systems:

1. The TAB agency shall, as applicable, confirm that all hydronic equipment, piping, and coils have been filled and purged; that strainers have been cleaned; and that all balancing valves (except bypass valves) are set full open. The TAB agency shall perform the following testing and balancing functions in accordance with the AABC National Standards.

2. For Pumps:

   a. Test and adjust hot water pumps to achieve maximum or design GPM. Check pumps for proper operation. Pumps shall be free of vibration and cavitation. Record appropriate gauge readings for final TDH and Block-Off/Dead Head calculations.

   b. Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure pump motor is not in or above the service factor.

3. For System Mains and Branches:

   a. Adjust water flow in pipes to achieve maximum or design GPM.

4. For Boilers:

   a. Verify that boilers have been filled and started by others, and are in operation.

   b. As applicable, test and record motor voltage and amperage, and compare data with the nameplate and limits to ensure motor is not in or above the service factor.

   c. Test and adjust water flow through water boilers.

   d. Test and record temperature and pressure profiles of water boilers.

5. For Radiation:

   a. Test, adjust and balance all hot water radiation within 10% of design requirements.

   b. This information shall be recorded on coil data sheets.

SECTION 25 0000

BUILDING AUTOMATION SYSTEM

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SECTION 25 0000

BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.1 GENERAL

A. Provide a Building Automation System (BAS) consisting of a complete Direct Digital Controls System. The following are approved BAS Manufacturers: Siemens.

B. The BAS Contractor shall be a direct Sub-Contractor to the selected HVAC Contractor.

C. The BAS Contractor shall maintain a local office within 50-mile radius of Project Site, staffed with factory-trained engineers capable of providing instructions to Owner's Personnel, and performing routine and emergency service on All System Components.

D. The BAS Contractor shall furnish all materials (whether or note specifically mentioned in this Section) to meet the control system functions as described in these Specifications and will be responsible for design, installation, and checkout necessary for the proper installation of an Building Automation System capable of commanding, indicating, and monitoring the various remote building equipment field points as specified herein.

E. The BAS Contractor shall provide Warranty of Performance of entire BAS System as required by Contract Documents. Performance and components requirements are established by Control Sequences and by these Specifications.

F. The BAS System shall be installed complete in all respects by competent mechanics, regularly employed by the Manufacturer of the Controls System. All automatic control valves and dampers shall be installed by the Project Mechanical Sub-Contractor in pipelines and ducts under supervision of the BAS System Manufacturer.

G. The BAS Contractor shall coordinate his work with work being performed under the Mechanical and Electrical Sections of these Project Specifications to ensure proper installation and material's standards are maintained throughout.

H. The Project Mechanical Drawings are generally diagrammatic and are intended to convey the Scope of Work and indicate general arrangement of equipment, piping, ductwork, etc. The locations of all items shown on the Drawings or called for in the Specifications that are not definitely fixed by dimensions are approximate only. The exact locations necessary to secure the best conditions and results must be determined throughout the course of the Project and shall have the approval of the Engineer before installation begins. Do not scale drawings.

I. As used in this Section, "Provide" means "furnish and install." "Furnish" means "to purchase and deliver to the Project Site complete with every necessary appurtenance and support." "Install" means to "unload at the delivery point at Project Site and perform every operation necessary to establish secure mounting and correction operation at the proper location in the Project."

J. The technical Scope of Work is defined in this Specification and related Project Drawings, including the Sequences of Operations and Points List. The BAS Contractor shall carefully examine all the Project Documents for a complete understanding of the full Scope of Work.

1.2 SCOPE OF BAS WORK

A. General Scope of Work includes, but is not be limited to:

1. Design and engineering of the specified BAS and additional local independent control systems as outlined in these Specifications.

2. Prepare and submit Shop Drawings and product literature for the Engineer's review and approval. Complete BAS submittal including system Architecture diagrams, wiring diagrams, graphic screen layouts, DDC Field Panels, network wiring layout, and Sequences of Operations.

3. Provide all hardware, software, and miscellaneous control components to achieve specified Sequence of Operations and allow future additions to the BAS; future additions shall be accommodated through modular expansion of the new BAS and shall not require significant modifications to the System Architecture.
4. Provide start-up, testing, and de-bugging of the BAS System.
5. Provide checkout and calibration of all control components.
6. Provide Acceptance Test at Project Completion, witnessed by the Engineer and by the Project's Commissioning Agent.
7. Provide warranty of all materials and workmanship as specified.
8. Provide training of Owner's Building Operations Personnel in the operation and maintenance of the BAS system and all local independent controls systems provided.
9. Prepare and submit As-Built Record Documents and a Project Specific Operations & Maintenance Manual.
10. Provide any required permits.
11. Provide technical instruction and assistance with the TAB Sub-Contractor to calibrate all controls components (i.e., airflow stations and VAV boxes to establish K factors) and to modify valve/damper positioning during System Balancing.

B. Specific BAS Scope of Work shall include, but not be limited to:

1. One file server and Operator Workstations, including alarm and reports printer per workstation, complete with graphical based operating software for user interface with BAS network.
2. Communications network for BAS as further detailed in following paragraph.
3. Provide all necessary drivers, gateways, interface devices to permit direct serial communications with building systems equipment as specified.
4. Provide all required network controls units as required.
5. A network of distributed, stand-alone programmable direct digital control field panels (DDCFP) with all necessary and required software and operating sequences for systems specified. All required relays, transducers, transformer, etc. shall be installed and clearly tagged within the same cabinet (or adjacent).
6. Provide and calibrate/adjust new temperature and relative humidity sensors, pressure switches, flow sensors, transmitters, relays, transducers, current transformers, solenoids, and all components necessary to achieve Specified Sequence of Operations.
7. Furnish meters as specified. Mechanical Contractor shall install all meters in pipe.
8. Furnish control valves, control dampers, fire/smoke combination dampers and smoke dampers for all systems except where noted that control components will be furnished by Specific Equipment Manufacturers. Mechanical Contractor shall install dampers in ductwork and valves in pipe.
9. Provide freezestats, humidity high limit, static pressure hi/lo limit and other required safety devices.
10. Provide hard-wire interlocks for chiller flow switches, refrigerant alarm panel, tower vibration switch, fan static limit switches, and other local safeties specified to be independent of the BAS.
11. Provide new cabinets for mounting of all interface devices including relays, transducers, etc.

12. Provide power and control wiring for all control devices. All devices are to be powered by emergency power circuits. Provide UPS capacity for each Master DDCFP capable of up to sixty (60) minutes back-up.

13. Provide equipment and system maintenance during Project Construction and through Warranty Period.

14. Provide BAS points for monitoring of miscellaneous plumbing, electrical and medical equipment as outlined in the EMS Points List and EMS Sequence of Operations.

1.3 BAS EQUIP ENT & SYSTEMS WORK SCOPE

A. BAS controls shall be provided for the following systems but is not limited to (Refer to EMS Points List and Sequence of Operations for further information):

B. Mechanical HVAC Systems:

1. Steam systems (steam control)

2. Heating Hot Water systems

3. Air handling units

4. Exhaust systems (general exhaust, isolation, emergency department, decontamination, etc.)

5. Meters (CHW, HW, Steam, Condensate, electric)

6. Critical Room Systems – pressurization and exhaust (Operating Rooms, Procedure Rooms, Isolation Rooms, Control Rooms, Radiology Rooms, Trauma/Decontamination area, etc.)

7. Supply terminal box controls- (For terminal box manufacture factory installation of controllers) and field programming

8. Unitary equipment (i.e. fancoil units, unit heaters, finned tube, convectors, etc.)

9. Smoke Dampers and/or fire/smoke combination dampers.

10. Unit heaters, fintube radiation, etc.

1.4 LOCAL CONTROLS WORK SCOPE

A. The BAS Contractor shall provide (installation and wiring) of all local safeties, controls, and control accessories for all new mechanical equipment installed as listed below as specified in this Section, on the Drawings and on the Points List:

1. Air Handling Units and Heating/Ventilating Units

2. Variable Frequency Drives

3. Fans

4. Other miscellaneous mechanical equipment specified and noted on drawings

1.5 BAS ARCHITECTURE

A. Tier 1 - Owner’s Ethernet

1. The new BAS system shall communicate over the Owner’s existing Ethernet.

2. All new Workstations, File Server and Network Control Units installed for this BAS system shall be capable of directly residing directly on the Owner’s Ethernet TCP/IP/LAN/WAN with no required gateways. The NCUs, Workstations and File Server shall be capable of using standard, commercially available, off the shelf Ethernet infrastructure components such as routers, switches and hubs.

3. The native protocol for the BAS System Server software shall be BACNet IP Protocol over Ethernet DataLink as defined by ASHRAE Standards SPI135. Proprietary protocols over Owner's Ethernet is not acceptable.

4. Via a direct Ethernet connection, furnish and install the following main servers and workstations.

5. All workstation platforms (furniture) shall be furnished by others.

6. BAS Contractor to coordinate with the Owner's IS Personnel number and location of tie-ins required into existing Ethernet for new BAS system.

7. The following equipment/systems shall have their own dedicated network controllers tied in directly with the Owner' Ethernet:

   a. Chiller Plant Equipment.

   b. Steam/Hot Water Heating Equipment.

   c. Air Handling Systems

B. Tier 2 – Fieldbus

1. DDCFPs serving each system network controller shall be controlled over a fieldbus provided by the BAS Contractor.

2. CV and VAV box controllers and local space temperature sensors will controlled over the fieldbus provided by the BAS Contractor.

C. System Expansion

1. The BAS System shall be scalable and expandable at all levels of the system using the same software interface, and the same Tier 1 and Tier 2 controllers. Systems that require replacement of either the workstation software or field controllers in order to expand the BAS system shall not be acceptable.

2. The system shall use the same application programming language for all levels: Operator Workstation, Network Control Unit, Remote Site Control Unit and Standalone Digital Control Unit. Furthermore, this single programming language shall be used for all applications: environmental control, card access control, intrusion detection and security, lighting control, leak detection / underground storage tank monitoring, and digital data communication interfaces to third party microprocessor-based devices.

D. System Support For Open Systems Protocols

1. The BAS design must include solutions for the integration of the following "open systems" protocols: BACnet, and digital data communication to third party microprocessors such as chiller controllers, fire panels and variable frequency drives (VFDs).

E. BAS Architecture Alternatives

1. If a Bidder believes that significant economies can be saved from a different architecture, a voluntary alternate may be submitted for Owner's and Engineer's review.

1.6 COORDINATION WITH OTHER CONTRACTORS

A. Coordinate the following with the Mechanical Contractor:

1. Installation of all new pipe and duct taps and sensing wells for new pressure and temperature sensing points. The BAS Contractor shall furnish wells for the Mechanical Contractor to install in pipe.

2. Installation of new automatic control valves in pipe.

3. Installation of meters in pipe.

4. Installation of new automatic control dampers in ductwork.

5. Installation of new airflow stations in ductwork.
6. Coordinate with VFD Start-up Technician for interfacing of VFDs to BAS System.
7. Coordinate with other equipment manufacturers start-up and interfacing of BACNet interface with BAS System.

B. Coordinate the following with the Electrical Contractor:

1. Sources of electric power (circuit breakers in panels) for new Network Controllers and DDCFPs and other electric devices. Once identified, the BAS Contractor is responsible for providing all power wiring related to control components from circuit breaker panels. Electrical Contractor is providing electrical panels which will be furnished electrical power via a Rotary UPS. These panels will be located on alternate floors with 8 circuits with junction box located throughout each floor. BAS Contractor shall furnish all power wiring to/from these circuits to the BAS devices that require power (i.e. Network Controllers, DDCFPs, and unitary controllers, etc.)
2. Electrical Contractor shall furnish all smoke detectors; Mechanical Contractor shall mount all smoke detectors in equipment and/or ductwork. The Electrical Contractor shall wire all smoke detectors and connect detectors to building fire alarm system. The BAS Contractor shall interface smoke detectors with BAS System and provide any hard-wired interlocks to shut down fans upon activation.
3. Provide monitoring points for critical electrical equipment as noted in EMS Points List.
4. Coordinate location of lighting controllers and circuits to be controlled.

C. Coordinate the following with the Custom AHU Manufacturer:

1. Supply fan airflow stations and transmitters furnished (located outside AHU casing) and factory installed and wired by the Custom AHU Manufacturer. BAS Contractor shall wire transmitter to BAS.
2. BAS Contractor shall furnish all damper actuators for field installation. Mechanical Sub-Contractor shall field mount damper actuators. BAS Contractor shall interface all damper actuators to new BAS System, including providing all main pneumatic air and control air.

D. Coordinate the following with the Owner's Commissioning Agent:

1. BAS Contractor shall provide support for Independent Commissioning of all systems as outlined in the Commissioning Specification Section. Refer to BAS Commissioning Responsibilities described in further detail in this Specification Section. In addition refer to the Owner's Commissioning Agent's (CX) Specification.
2. BAS Contractor shall include all labor, materials, and equipment required to assist Commissioning Agent.

1.7 RELATED WORK SPECIFIED ELSEWHERE

A. The following items of labor and materials incidental to, or related to the installation of the BAS work shall be provided by Others at no cost to the BAS Contractor:

1. Cutting and patching shall be provided under Division One.
2. Provision of temporary lighting, power, water, and heat and costs of usage shall be provided under Division One.
3. Concrete work for equipment bases, housekeeping pads, vibration isolation frames, inertia blocks, boxed openings, and perimeter curbs shall be provided under Section 03300.
4. Undercut doors and door louvers shall be provided under Division 8.
5. Flashing and counterflashing shall be provided under Division 7.

6. All finish field painting shall be provided under Division 9.
7. Pipe fluids sources shall be provided under Division 15 to the points indicated on the Drawings.
8. All power wiring, motor starters and interlocking, except as indicated or specified otherwise, shall be provided under Division 16.

1.8 SUBMITTALS

A. Per requirements in Division One of these Project Contract Documents, submit shop drawings, product data, and samples as listed below.

B. Materials and equipment for which Shop Drawings and Product submittal are required shall include:

1. File Servers
2. Operator workstations and peripheral devices
3. Network Controllers
4. Direct digital field control panels
5. Unitary Controllers
6. Duplex air compressor and accessories
7. Control components such as: temperature, humidity, flow, level, pressure switches and sensors.
8. Current transformers, relays, transducers, and transmitters
9. RTU-1 mounted Airflow stations
10. Automatic Control Valves/Dampers and actuators, with a schedule noting equipment served, signal range, normal position of device, maximum static and differential pressure shut-off ratings, minimum torque requirements, etc.
11. Electric wiring

C. Submit the following for approval:

1. BAS architecture schematic
2. Communications network diagram and building routing
3. Control diagrams with detailed wiring and piping diagrams for each system and bills of material for each system diagram
4. Floor plans of building showing location of all control panels (including unitary box controllers, space sensors) and all remote devices.
5. Points List
6. Sequence of Operations (including Alarms)

D. Software Submittal:

1. Description of operating system software. Function of software shall be described in detail. User interface shall be described with examples of how users will call up ‘screens,’ generate reports, upload and download information to and from field panels, back-up the hard disk, etc.
2. Description of programmable DDC field panel software. Provide flow/logic diagrams and/or ‘high level’ software code that illustrate the Sequence of Operations. Functions of software shall be described in detail. User interface shall be described with examples of

how users will rewrite code, change setpoints, modify schedules, generate status reports, etc.

3. Description of factory programmable DDC field panel firmware. Submit copies of editing screens user will use to modify variables. Submit sample reports.
4. Provide Graphic Screens for each unique system for review and approval before installation and mapping of these screens.
5. Submit sample reports.
6. Operating Histories (Trend Logs) as further detailed in Part Three.

E. Other Required Submittals:

1. Operator's Manual.
2. Proposed Construction Schedule
3. Proposed Training Plan
4. 'Initial' and 'As-Built' Construction Drawings
5. Narrative Description of 'As-Built' Sequences of Operations
6. Operation and Maintenance Manuals

1.9 COMMISSIONING ASSISTANCE

A. The BAS Contractor shall be expected to fully cooperate with the Building Commissioning Agent and his process. The following is a list of the Commissioning Agent's duties to help understand the scope of work that the BAS will be required to comply with.

B. All work, time, tools, software required for BAS Contractor to comply with commissioning requirements shall be included in the Base Bid of the new BAS System.

C. Purpose of Commissioning:

1. The purpose of the Commissioning will be to demonstrate that the temperature control (for all HVAC systems- chiller, hot water, steam, AHUs, H/Vs, etc.) , ventilation control and space pressurization control sequences work as intended by design. Refer to the specific acceptance criteria outlined.
2. The end result of the Commissioning process is to both verify that acceptance criteria can be met as well as maintain the conditions of the building in a repeatable reliable manner.

D. Execution:

1. Verification that control wiring, tubing, controllers, sensors and software has been adequately installed.
2. Verification that control loop tuning and de-bugging has been performed.
3. Verification of trend data requirements, monitoring and alarm points are active.
4. Verification that control sensors used have been calibrated.
5. Verification that control parameters listed on drawings function as intended.

E. Responsibility:

1. Installation, calibration and start-up of the BAS shall be performed by this Contractor (BAS Contractor) prior to the Commissioning Agent's functional checkout process begins. In effect the BAS will have commissioned the new BAS system prior to observation by the Commissioning Agent.

F. Acceptance Criteria:

1. The BAS shall demonstrate that at the selected portions of the Project, control wiring, tubing, controllers, and end devices are installed in proper workman like manner.
2. The BAS shall demonstrate to the Commissioning Agent that the individual points have been properly tuned.
3. The BAS Contractor, in conjunction with the TAB Contractor, shall prove that the lowest possible static pressure for supply and exhaust systems has been tuned into the system.
4. The BAS Contractor shall prove that all equipment installed with VFDs is operating properly and that the VFDs are appropriately ramping up and down per specified Sequence of Operations.
5. The BAS Contractor shall verify that all flow sensors have been calibrated and assist the TAB Contractor for any calibration that is required to be performed by the TAB Contractor.
6. The BAS Contractor shall verify that all pressure sensors use for space pressurization control have been properly set up and checked by the TAB Contractor and scaled properly into the BAS for proper monitoring and readout.
7. The BAS Contractor shall verify that all critical alarm points are being properly relayed.
8. The BAS Contractor, via the Commissioning Agent's selection, shall verify that miscellaneous monitoring has been installed and operating properly
9. The BAS Contractor, via the Commissioning Agent's selection, prove that special spaces (i.e. OR rooms, etc.) work in accordance with the specified Sequence of Operations. At a minimum, the following shall occur:
    a. 100% of Operating Rooms will be tested for temperature controls.
    b. 20% of patient and clinical spaces will be inspected for temperature control
    c. 20% of rooms with fan coil units will be tested for temperature controls.
    d. 20% of toilet rooms will be tested for temperature and ventilation controls
    e. Ventilation of special spaces (i.e. electric rooms, tel-data closets, etc.) are properly operating.
    f. 100% of Isolation and Decontamination Rooms will be tested.
10. The BAS Contractor shall verify that all points per EMS Points List and Sequences are displayed in graphic form on the work station.
11. The BAS Contractor shall verify that all EMS points are retrievable by the Owner's existing Head End.

1.10 WARRANTY

A. Warranty, in writing, a BAS control system free from defects in material and workmanship and guarantee performance of Systems as required by the Contract Documents for two year from date of formal certification of Substantial Completion of Whole BAS System. The warranty period shall cover one (1) complete heating and one (1) complete cooling season regardless of calendar period. In addition, the following conditions shall be included in the warranty:

1. All changes needed to optimize the database or software shall be provided to the Owner at no cost.
2. All material or equipment that required excessive service during the warranty period shall be replaced as directed by the Engineer.
3. Damage caused in the process of making necessary repairs and replacements under warranty shall be corrected to the Owner's satisfaction.

4. Final Acceptance of system is contingent upon receiving written warranty.
5. The BAS Contractor shall provide, at no extra cost, remote access service during the warranty period to assist the Owner's personnel.
6. Nothing herein implies that this warranty shall apply to Work which has been abused or neglected by the Owner.

1.11 CONTINUITY OF SERVICES

A. As new building systems are enabled and put into operation over the course of the Project, BAS Contractor shall carefully coordinate and plan any requirements for interruption of critical building services.

1.12 CODES AND STANDARDS

A. Perform work in strict accordance with rules, regulations, standards, codes, ordinances and laws of local, state, and federal governments and other authorities that have lawful jurisdiction, and be responsible for compliance therewith. Unless specified otherwise, materials and equipment shall be manufactured, tested, and installed in accordance with the latest editions of applicable publications and standards of the following organizations:

1. American Society of Mechanical Engineers (ASME)
2. BOCA Building Codes
3. National Fire Protection Association (NFPA).
4. National Electric Code (NEC).
5. Occupational Safety and Health Administration (OSHA).
6. State and Local Building Codes

B. Material and equipment shall be Underwriter’s Laboratory (UL) and ASME approved, as applicable, for intended service.

C. When requirements cited in this Paragraph conflict with each other or with Project Contract Documents, most stringent requirements shall govern conduct of Work. Engineer may relax this requirement when such relaxation does not violate ruling of authorities that have jurisdiction.

1.13 COORDINATION DRAWINGS

A. The BAS Contractor will be required to participate in the development of coordination drawings for all areas of this Project prior to commencing work.

B. Coordination drawings shall be initiated under the following sections for particular trades:

1. HVAC System - Section 23 0000
2. Plumbing Systems – Section 22 0000
3. Fire Protection Systems – Section 21 0000
4. Medical Systems – in various sections
5. Electrical Section 26 0000

C. It is the responsibility of each contractor (Mechanical, Plumbing, Fire Protection, Electrical) to prepare coordination drawings showing installation of all equipment, piping, ductwork, wiring, and accessories that each trade is providing.

D. As part of the BAS Requirements, the BAS Contractor shall provide coordination drawings that reflect location of all main BAS control panels, sensors, NCUs, and DDCFPs, and any other BAS devices that require coordination with other Contractors.

1.14 CONTRACTOR'S CLOSE-OUT SUBMITTALS

A. Full As-Built Documentation, furnished to Owner both electronically and hard copy.

B. Warranties and Bonds: to the requirements of the Project Contract Documents

C. Evidence of Payment and Release of Lien: Provide an AIA copy of the 'Release of Liens' as specified in the requirements of the General and Supplementary Conditions. Refer to Division 1 for further requirements.

1.15 SYSTEM MAINTENANCE AND SOFTWARE UPDATE

A. Submit Vendor's agreement to provide necessary Programmed Maintenance (PM) and to maintain all new components of the BAS system for two year from date of Whole System Substantial Completion. Final Acceptance is contingent upon receiving written PM agreement.

B. Programmed maintenance agreement shall identify maintenance work to be performed within one year of the end of the Warranty period. Warranty shall include all parts and labor and shall quote cost of work for two years subsequent to guarantee period. The following is an example of the type of activities that shall be included in the PM Contract:

1. Optimization of file server, operator workstations, virus scan, and de-fragmentation of the server and workstation hard drives. BAS Contractor shall also make-up dated copies of the system database and graphic screens.

2. Test and calibrate all new sensors/transmitters/transducers, including all unitary box controllers and room temperature sensors.

3. Calibrate all flow stations

4. Override operation of all new control valves and dampers to confirm proper operation and full "stroke" of the device. This does not include terminal devices in rooms (e.g., VAV boxes, heating coils. etc.).

5. Test all new system safeties (e.g. freezestats, pressure switches, smoke detectors, etc.). Confirm that safeties perform as intended and annunciate the specified alarm condition.

6. Test for proper operation of all "status" devices (e.g. CTs, pressure switches, etc.)

7. Test for proper operation of all alarms and confirm proper annunciation of specified alarm condition.

C. Provide regularly schedule preventative maintenance and service of at least one man-day per month by factory trained service representative.

D. Include incorporating improve system reliability as it becomes available for the BAS system. This provision includes direct component replacements and wiring changes but shall not include major system design changes.

E. To make available upon request, 24-hour emergency service maintenance service which included on-site response to emergency service call within four (4) hours of initial request and system interrogation within two (2) hours of initial request via telephone modem interface

F. All manufacturers' software updates appropriate for this system that is issued during guarantee period shall be installed free of charge.

G. Submit Vendor's Agreement to provide (Add Alternate #1 Bid Price) the Preventative Maintenance (PM) described above and to maintain all new components of the BAS for an additional three years beyond the expiration of the two year warranty period.

1.16 PHASES

A. See Division 1 for phasing. There are significant phases in scope which this Contractor will be required to price per Division 1 language.

1.17 ACCEPTANCE OF INSTALLATION CONDITIONS

A. This Contractor shall be fully responsible for the proper execution and performance of the work described herein. It shall be his responsibility to inspect all installation conditions and request the Contractor to correct any conditions which may affect his work adversely.

PART 2 - PRODUCTS

2.1 BAS NETWORK OVERVIEW

A. The file server and Operator Workstations shall serve as the user's graphical access into the BAS network. The file server and workstations shall not be centralized processors which directly control operation of the building equipment. Rather, their purpose will be to display system status and alarm conditions, gather and store data from network controllers, field panels, and unitary controllers for purpose of trend and report generation, and act as a storage medium for information relative to the HVAC systems in a manner that is consistent with the HVAC and building design and layout. The user shall not be overly constrained by the DDC Architecture which shall be essentially transparent.

B. All existing Owner's work stations shall remain and be capable of being used to operate the new BAS System.

C. All workstations shall access the server via a direct Ethernet connection (on the Owner's Ethernet).

D. The file server shall support Microsoft Explorer (5.5 or later versions) and Windows as well as non-Window operating systems. No special proprietary software shall be required to be installed on the PCs used to access the BAS via a web browser. The BAS shall be sized and configured to handle up to five (5) concurrent users via the Web access without noticeable degradation in response of the system.

E. The BAS server software shall utilize a Java DataBase Connectivity (JDBC) compatible database such as: MS SQL 8.0, Oracle 8i, IBM DB2. BAS systems written to non-standard and/or Proprietary are not acceptable.

2.2 BAS NETWORK HARDWARE

A. Refer to following requirements for File Serve and Operator Workstations.

B. Each Server/Workstation shall consist of IBM-PC compatible workstation manufactured by IBM, Dell, Compaq, or approved equal, with the following hardware requirements :

Item	**Server**	**Workstations**
Processor (Intel Pentium)	P-4, 2.8 GHz, 1MB L2 Cache	P-4, 2.8 GHz, 1MB L2 Cache
Memory (SDRAM)	2 GB	1 GB
Primary Hard Drive ATA/100 7200RPM	200GB	200 GB
Secondary "Mirrored" Hard Drive ATA/100 7200RPM	200GB	None
CD-RW Drive 48x/24x/48x Max	Yes	Yes
DVD Burner 4.7 GB	Yes	No
40/80 GB tape Back-up	Yes	No
Video Card with 128 MB RAM	Yes	Yes
Sound Card & Speakers	No	Yes
Serial Port, Parallel Port, (4) USB ports	Yes	Yes

Keyboard & Scroll Mouse	Yes	Yes
56 KB Int. Modem	Yes	Yes
Ethernet Card	Yes	Yes
PCI Exp Slots	4	4
Flat Panel Color Monitor Size	17”	19”
InkJet Printer equal to HP-995c	No	Yes
Dot Matrix Printer	Yes	Yes
Operating System	Windows XP (Professional)	Windows XP (Professional)

C. File server and Operator Workstations shall be powered from emergency power circuit and be equipped with UPS to carry load for ten (10) minutes.

2.3 BAS NETWORK SOFTWARE

A. Provide BAS operating system software for workstations with a “Windows” style Graphical User Interface (GUI). The graphics shall be accessible to users via the Operator Workstations that are hard-wired to the network or via a web browser.

B. Graphics shall illustrate HVAC system in pictorial format, similar to those shown on the System Schematics found in the Project Drawings. Provide a color slide depicting the new Building and existing Buildings that have HVAC systems interfaced with the Building’s HVAC Systems. From this screen the operator shall be capable of selecting any building or floor of the new building or floor of existing building floor that has HVAC equipment that serves the new Building. If a floor is selected, the plan view of the floor will be depicted showing all equipment/systems located on the floor. From here, the operator shall be capable of selecting the equipment or system of interest. Provide one color slide for each system connected to the BAS. The slides shall display all major components, their status, and all variables and setpoints. All points on the BAS System shall be graphically represented at BAS workstations. Systems/points not specifically listed as requiring a pictorial graphic shall at a minimum indicated location of point in the building (e.g., room number, duct riser shaft, and floor). The intent is to have BAS graphics fully document the function and location of all BAS points to assist Operator in understanding function and in troubleshooting system problems.

C. Provide a color graphic screen of each floor with terminal boxes and fan coil units. Each floor graph shall display all boxes, fan coil units, with space temperature, space setpoint, CFM, CFM setpoint, etc.

D. Provide graphical representations of specific individual rooms (i.e., Mechanical, Electrical Equipment Rooms, Elevator Machine Rooms, etc.)

E. Provide automatic downloading of all trend data from the DDCFP’s to the file server for archiving. Archiving from the file server to DVD discs will be performed periodically by the Owner.

F. Provide 40/80 GB Tape back-up, 20 tapes, and software to automatically back-up the database on the server and all DDCFP programs (a copy of which is kept on the server).

G. User shall be able to adjust setpoints through graphics slide. All variables/setpoints noted in the Sequences of Operation shall be adjustable via the graphics interface.

H. Alarm conditions shall be displayed by blinking or modified color to visually distinguish the alarm state.

I. Provide status reports for each system (including system-related space sensors) which will supplement the information presented in graphical form. This will allow the operator to obtain timely, hard-copy system reports indicating the status of all system variables, many of which may not be presented in the graphic mode. System printouts shall include space sensors used for reset control. Status reports shall not be generated and printed in graphic mode.

J. To ensure security of the System, Operator must access the System through an assigned password. To ensure both security and flexibility for a range of operators, the password system shall have a minimum of four levels of authorization and capacity for assignment of up to 12 different operators. The lowest level of authorization shall restrict the operator to viewing data.

K. Communications between DDC field panels and the file server shall utilize communications verification routines such as check summing or cyclical redundancy checking (CRC) to ensure proper and complete transfer of data. Systems which only repeat the message multiple times (without error checking) shall not be acceptable.

L. Software shall also perform the following functions:

1. Initiation of logs and reports automatically on selective time, date or day basis and on combinations of time, date and day. Reports shall be in English with information formatted logically. Reports and logs shall be attainable for single points and for user-defined groups of points. Provide at least the following report categories:

   a. Summaries (all point, motor status, alarms, etc)

   b. Historical trend log

   c. Totalization logs

   d. Operator security access report

   e. Current system database

   f. Historical energy consumption logs

2. Refer to Sequences of Operation for additional information regarding reports.

3. Alarms and requested information shall be displayed and printed within 30 seconds of occurrence of request regardless of amount of simultaneous system activity.

4. Downloading programs from field panels to computer and uploading programs to the field panels from computer disk storage.

5. Automatic recovery from a power failure without operator intervention. The date and time clock must be backed up by battery for a minimum of 72 hours.

M. Software/graphics package shall permit Operators to override schedule and/or setpoint functions for a designated period of time via the graphics screen. A graphics screen shall be provided to indicate the current status of all systems operating in the override mode. A history log shall be maintained of all override activities on the system including the Operator's initiation of the software override.

2.4 OFF-SITE COMMUNICATION

A. BAS shall be configured to annunciate an alarm via a web-based email and phone dial-out messaging system (Owner to provide phone line). When a critical alarm occurs, BAS shall automatically dial out up to three phone numbers and deliver an alarm message. Critical alarm shall also dial-out to Owner’s pager system and deliver an alphanumeric message. A web-based email alarm message shall also be sent to a pre-programmed list of email recipients.

2.5 NETWORK CONTROL UNITS

A. Provide as required all Ethernet-based network controllers to provide support for the required controllers of the specified BAS building systems. These controllers shall directly connect to the Operator Workstation over the Owner’s Ethernet, provide communication to the standalone

DDC field panels and/or other Input/Output Modules and serve as a gateway to equipment furnished by Others.

B. Network Control Units shall be microprocessor based, multi-tasking, multi-user, and employ a real time operating system. Each NCU control panel shall consist of modular hardware including power supply, CPU board, and input/output modules.

C. Provide a minimum of one (1) Master Network Controller on each floor of the building, in addition to Network Control Units (DDC Field Panels), as required to support the number of control points and unitary controllers on each floor (with specified spare points capacity).

D. Assume closets will be provided on each floor to accommodate Master Controllers, UPS, DDC Field Panels, etc. Final closet locations will be determined at a later date.

E. All NCUs shall have the capability to automatic restart after power failure. Upon restoration of power after an outage, the NCUs shall automatically and without human intervention update all monitored functions, resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

F. All NCUs shall be wired with emergency power and have UPS capability.

2.6 STANDARD NETWORK SUPPORT

A. All workstations and NCUs shall be capable of residing directly on the Owner's Ethernet TCP/IP LAN/WAN with no required gateways. The BAS system shall use standard, commercially available, off-the-shel Ethernet infrastructure components such as routers, switches, and hubs.

2.7 DIRECT DIGITAL CONTROL FIELD PANELS (DDCFPS)

A. General

1. DDCFPs shall communicate via the Tier 2 fieldbus to network control units.

2. DDCFPs shall be used for Automatic Temperature Control and HVAC system automation. The DDCFPs shall be networked to provide building-wide coordination of all HVAC systems. They shall collect information from field sensors and shall execute applications programs, calculations and commands through a microprocessor in the DDCFP which shall sequence equipment and modulate controlled devices to achieve the specified Sequences of Operations. All new DDCFPs shall be designed to provide a minimum of 20% future point capacity.

3. All new DDCFPs shall be capable of "stand-alone" operation, requiring another DDCFP for automatic control of their connected points. Master-slave architectures, point expanders, or multiplexers will not be accepted.

4. All points associated with a particular system shall be wired to a single DDCFP. Control loops using network communications are not acceptable.

5. Factory-programmed DDCFPs that satisfy this Specification may be used to control the operation of the HVAC equipment. The operational capabilities of the factory-programmed DDCFPs shall be similar to the programmable DDCFPs. However, their flexibility is recognized as being limited to the factory furnished firmware. The BAS Contractor shall carefully study these documents, particularly the Sequence of Operations, to determine if the proposed factory-programmed DDCFPs meets the Specification. If it does not, a programmable DDCFP shall be used for this application.

B. DDCFP Hardware Requirements

1. DDCFP shall accommodate four point types:

a. DIGITAL IN (DI) for monitoring status, alarms and accumulating pulses.

b. DIGITAL OUT (DO) for commanding two-state devices.

c. ANALOG IN (AI) for measuring values.

d. ANALOG OUT (AO) for controlling variable-state devices. DDCFP analog output shall support either a 0-10V DC or 4-20 ma. signal.

2. DDCFPs without analog output capability may be used in application not requiring that type of function. DDCFP shall have sufficient "point" capacity for application; use of multiple DDCFPs for control of a single piece of HVAC equipment shall not be allowed.

3. All DDCFPs (except VAV box, unitary type controllers) shall have a hand-off-auto switch on all outputs to facilitate testing and servicing. HOA circuit for analog outputs shall incorporate a potentiometer for manually positioning end device.

4. Program and data shall be stored in memory of sufficient capacity to provide complete Sequences of Operation as specified. Memory shall be protected with a 24-hour battery backup. Units with non-volatile memory do not require battery backups. Programmable DDCFPs shall have at least 20% of spare programming space left after final programming.

5. DDCFPs shall have sufficient memory to store up to 7 days of trend data of all hardware and software points it is connected to (including any unitary controllers). The trend data shall be collected every 15 minutes. The DDCFPs shall download all the trend data to the File Server for permanent storage.

6. Idle time for DDCFP processors shall be at or above 70% during normal operation.

7. DDCFPs shall communicate with the file server/operator workstations and other DDCFPs via the Local Area Network (LAN) and shall be capable of sharing information for purposes of coordinating building-wide BAS functions such as demand limiting. The loss of the LAN shall not render the DDCFPs inoperable. At the very least, the DDCFP must be able to continue to maintain setpoint control and protect the HVAC equipment with its safety control loops. The loss of any one DDCFP shall not prevent the operation of other DDCFPs. Loss of the LAN or failure of a DDCFP shall be registered automatically at the operator workstations. Provide automatic self-test diagnostic that allows DDCFP to report malfunction to operator workstations.

8. System shall be capable of phased start-up, DDCFPs shall be capable of communicating properly while remaining DDCFPs are being installed.

9. Provide transient surge protection at DDCFP against supplier-induced voltage spikes. All outside sensors and modem inputs shall be lightning-protected.

10. Terminate control wiring and system communications wiring in separate wiring block compartment within the DDCFP.

11. Provide communications port on all DDCFPs for communications via hand-held terminal.

12. DDCFP shall operate from 120 VAC, 60 Hz power and from line voltages as law as 105V AC. Line voltages below system operating range shall be considered outages; a 24-hour battery backup shall supply power to units with volatile memory. Master Panels shall be backed up for sixty (60) minutes via UPS.

13. Connect all DDCFPs to Building Emergency Power System as noted in these Specifications and on Project Drawings. Provide each branch circuit with UPS in order for all DDCFPs that are wired from branch circuits to have UPS back-up capability.

14. DDCFPs shall be furnished with a digital display capable of addressing all the points located in the DDCFP. The display shall normally default to a display of one of the variables (such as the discharge air temperature, etc.).

15. DDCFP shall operate from 32°F to 120°F and up to 90% RH (noncondensing). DDCFP shall be in a NEMA 1 enclosure.

16. Location of DDCFPs and associated interface panels shall be reviewed and approved by the Owner and Engineer prior to installation.

2.8 SOFTWARE FOR PROGRAMMABLE DDC FIELD PANELS

A. DDCFP software shall be provided to accomplish the control sequences specified. The software shall reside in the DDCFP memory and backup copies shall be stored on the central workstation/file server hard disk. Off-site copies shall be maintained by the BAS Contractor at least through the warranty period. Transferring software to and from DDCFPs shall occur via central workstation/filer server.

B. The software shall be structured to allow the user to flexibly alter all significant functions. The software shall present these selection options to the user in the form of editing screens. The user shall not have to access the software code to make ordinary modifications to control strategies. The software code shall be written in an English-based, structured, high-level programming language, interspersed with descriptive comment statements preceding each basic algorithm performed by the software or object-oriented “block” programming.

C. The Contractor is obligated to provide software code that accurately performs the specified Sequence of Operations. "Canned" software routines that do not operate the equipment as specified will not be accepted.

D. The applications software shall be capable of performing the following functions:

1. Stop/start control based on schedule, system temperature, relative humidity, pressure, demand limiting controls, smoke evacuation sequence, etc.

2. Scheduling flexibility shall satisfy the following criteria:

a. Allows a dated schedule to be entered up to one year in advance.

b. Schedules shall be self-deleting when effective dates have passed.

c. Provides for normal, holiday, "special events" and override scheduling.

d. Adjusts for standard and daylight savings time.

e. Adjusts for leap years.

3. Optimized start based on outside air temperature, inside air temperature, space mass, heat transfer coefficients and other empirically derived values. Optimized start program shall continually revise and update its own database in a ‘self-tuning’ manner.

4. Alarm messages based on a digital input status change, an analog point out of range (user adjustable), or override of an output.

5. Setpoint control of temperature, humidity, pressure and flow. Typical PID control loops include: discharge air temperature with reset, economizer control (dry bulb or enthalpy), warm-up, hot and chilled water supply temperature, fan capacity control, air and water flow, differential pressure, humidity, and chiller optimization.

6. BTU metering.

7. Steam/Electric Demand Limiting and Load Shedding

2.9 FIRMWARE REQUIREMENTS FOR FACTORY PROGRAMMABLE DDCFPS

A. Unitary controllers (CV box, VAV Box, Misc Points) shall communicate via BACNet MS/TP Protocols.

B. These unitary controllers shall communicate with the Tier-1 level controllers via a communications controller. The communications controller shall have sufficient memory to store up to 7 days of trend data of all hardware and software points on all the unitary controllers it is connected to. The trend data shall be collected every 15 minutes. The communications controller shall download all the trend data to the file server for permanent storage.

C. Firmware in the unitary controllers shall accomplish Sequences of Operation as specified. Firmware in DDCFPs shall be resident in Read-Only Memory (ROM, PROM). Operational

variables such as setpoints, stop/start time, etc. shall be resident in non-volatile EEPROM. Battery backup shall not be required.

D. The firmware shall be structured to allow the user to flexibly alter all significant control variables. These variables shall be presented to the user in the form of editing screens at the BAS workstation.

E. AHU firmware shall support a minimum of four DDC PID control loops (heating, cooling, economizer, and fan static). Control loops shall have user-adjustable PID constants.

F. AHU/VAV firmware shall be capable of communications to a DDCFP to accomplish the following:

1. Time-of-day scheduling
2. Optimal start/stop
3. Tenant billing
4. Custom programming
5. Run time and maintenance
6. Duty cycling
7. Custom alarm messages
8. Diagnostic functions
9. Reports and logs

2.10 DDCFP SENSORS AND POINT HARDWARE

A. All BAS input and output devices provided under this Contract shall be new.

B. Temperature Sensors

1. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of –30 to 230 degrees F. Space temperature sensors shall be accurate to +/- .5 degrees F over a range of 40 to 100 degrees F within 3 minutes (assuming stagnant air flow) span.
2. Standard space temperature sensors to be furnished are TAC Smartsensor TTS-SD-LCD-1, available in an off white enclosure for mounting on a standard electrical box.
3. Provide local display, the sensor shall incorporate either an LED or LCD display for viewing the space temperature, setpoint and other operator selectable parameters. Using built in buttons, operators shall be able to adjust setpoints directly from the sensor.
4. Duct temperature sensors, Vaisala HMD 60U – 2% accuracy, shall incorporate a thermistor bead embedded at the tip of a stainless steel tube. Probe style duct sensors are useable in air handling applications where the coil or duct area is less than 14 square feet. Sensors have a range from 40 -120 deg F, +/-1 deg F within 30 seconds of time span.
5. Averaging duct sensors shall be employed in ducts which are larger than 14 square feet. The averaging sensor tube must contain at least one thermistor for every 3 feet, with a minimum tube length of 12 feet.
6. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications. Sensors to be 32-80 deg F for chilled water and 32 – 240 deg F for hot water. Sensors to be accurate to +/-1 deg F within 30 seconds of span
7. A pneumatic signal shall not be allowed for sensing temperature.

C. Outside Air Sensor

1. The dry bulb and humidity sensor shall be included as one field device. This sensor shall be provided with shaded enclosure to minimize effects of solar heating. Use Vaisala Model HMD60YO or approved equal.

2. Location and mounting of outdoor weather sensor shall be subject to review and approval of Engineer.

D. Humidity Transmitters

1. Humidity transmitter shall be solid state capacitance-type or bulk polymer resistance-type with operating range of 20-95% RH, accurate to +/-2% over this range. Repeatability shall be 1%, long-term drift less than 1%/yr. Sensor shall have an allowable ambient operating temperature range of 0-120^{O}F.

2. Transmitters shall be as manufactured by Vaisala, no substitutes accepted without written approval from Engineer.

3. Room sensors shall have tamper-proof housing.

4. Provide electronic duct relative humidity high limit (RHHL) humidstat with cover and duct sampling chamber. Mount RHHL just upstream of custom air handling unit final filters.

E. Air Pressure Transmitters

1. Provide Setra or approved equal pressure transmitters for reading static and differential air pressure as noted in the DDC Points List.

2. Transmitter shall be of the capacitance type and shall be accurate to 1% of range. Transmitter shall provide 4-20 ma signal, proportional to DP.

3. Select transmitter with the lowest range appropriate for the application. Transmitter shall be rated for momentary overpressures at least eight times the pressure range.

4. Where noted on the DDC Points List, provide magnahelic pressure gauge (with three valve manifold) piped in parallel with transmitter to calibrate and verify operation of transmitter. Select gauge with lowest range appropriate for application.

F. Static Pressure Switches

1. Provide static pressure switches suitable for duct static pressure limit control and low pressure alarm indication.

2. Switches shall be externally adjustable with visual setpoint scale. Switch setpoint ranges shall be carefully selected for the specific application, subject to approval by the Engineer. Maximum overpressure for water shall be 180 PSIG.

3. AHU unit static pressure limit switches shall be wired to shut down AHU supply and associated return fans when static pressure exceeds setpoint. Provide switches with manual reset button.

G. I/P Transducers

1. Provide new Modus Setra current-to-pneumatic transducers that provide a pneumatic output pressure that is proportional to the electrical input current.

2. Transducers shall operate with a minimum air pressure of 18 PSIG.

3. Transducers shall have zero and span adjusters. Linearity shall be 1% of span.

4. Provide a 0-20 PSIG pneumatic gauge on output branch line. Provide label on gauge for ID. Provide a 0-20 PSIG pneumatic gauge on main air line at entry to cabinet and downstream of all regulators and switches.

5. All transducers shall be mounted in new cabinets and shall be labeled to identify their function.

H. Water Pressure Transmitters

1. Provide pressure transmitter with stainless steel construction where specified in the Points List. Transmitter shall be capable of withstanding the temperatures, pressures and corrosiveness of the media measured.
2. The transmitter shall utilize stainless steel moisture sealed case to protect the electronics. Select lowest range available depending on application.
3. Transmitter shall provide a 4-20mA output and with an accuracy of ±1%.
4. Provide a liquid filled pressure gauge with proper scale for transmitter reading confirmation and calibration.
5. All water pressure transmitter installed in the Building HW, CHW, CW and Process CHW systems shall be rated for a minimum of 150 PSIG working pressure.

I. Water Differential Pressure Transmitters

1. Provide electronic differential pressure transmitters as shown on Project Drawings. Acceptable Manufacturer shall be Setra 230 with a 3 valve manifold.
2. Mechanical Contractor shall field install DP transmitters in pipe and provide taps as required for DP transmitters. BAS Contractor shall furnish required wells to Mechanical Contractor.
3. Transmitter shall be mounted on three valve manifold for reading static and differential water pressure.
4. For each water differential pressure transmitter installed, furnish a differential pressure gauge for Mechanical Contractor to install in pipe. Acceptable Manufacturer is Orange Research or approved equal.
5. DP gauge for HW and CHW system shall be rated for a minimum of 150 PSIG working pressure.
6. Transmitter shall be capable of withstanding temperatures, pressures and corrosiveness of the media measured. The transmitter shall utilize stainless steel moisture sealed case to protect the electronics.
7. Transmitter shall be of the piezo-resistance balanced bridge type and shall be accurate to 1% of range. Repeatability shall be 0.25% of range. Transmitter shall provide 4-20 ma or 0-10 VDC signal, proportional to DP. Transmitter shall have zero and span adjustment.
8. Transmitter shall be rated for momentary overpressures at least two times the differential pressure range, and at least 50% over the design static pressure.
9. Dwyer differential pressure transmitters are not acceptable.
10. Install transmitters in steel cabinet and mount on wall in location accessible without ladder.
11. Select transmitter with the lowest range appropriate for the application and as noted below:

System Served	**Range, PSID**	**Working Pressure, PSIG**	**Location**
Across H.W. Mains	0-30 PSID	150 PSIG	TBD

J. Electric Relays

1. Provide electric relays (rated for the correct voltage and load) where required to achieve the specified sequence of operations. All fan relays shall have Hand-Off-Auto switches and LED to indicate status.

K. Equipment Status

1. Refer to EMS Points List for equipment status points.

2. For motors less than 5 HP, current switches may be used for equipment status. Current switches shall be available in solid and split core models, and offer either a digital or an analog signal to the BAS. Acceptable Manufacturer is Veris or approved equal.

3. For motors 5 HP and greater, status shall be sensed with current transformer. Device shall sense current through one leg of motor starter, unless otherwise noted on Points List. For analog sensors, set proper analog limits in software for full range of equipment capacity. Accuracy shall be 1% of full scale. Use minimum range sensor possible for the application.

4. Measurement of three phase power shall be by a kW/kWH transducer. This device shall utilize direct current transformer inputs to calculate the instantaneous (kW) and a pulsed output proportional to the energy usage (kWh). Provide Veris Model 6000 Power Transducer or approved equal.

L. Thermostats

1. Provide line voltage electric thermostat for control of specified equipments (i.e., unit heaters, cabinet unit heaters)

2. Single stage thermostat shall be equal to Penn T22JAA-1, with concealed adjustment or cover.

3. Provide aquastat for lockout of unit fan operation, equal to Penn A19DAC-1.

M. Low Temperature Thermostat

1. Provide low pressure thermostats as shown on Drawings. Thermostat shall register alarm condition and shutdown fan when temperature along one foot of element length falls below setpoint.

2. Do not provide averaging element. Provide one foot of element for every square foot of AHU CHW coil face area.

3. Wire to shutdown fan as specified in control sequences.

4. Provide auxiliary contact and wire to BAS to directly monitor freezestat status.

5. Provide low temperature thermostat with manual reset button.

2.11 AUTOMATIC CONTROL VALVES

A. General

1. Furnish new control valves as specified on the control valve schedule and as specified below. Valves shall be field installed in the piping by the Mechanical Contractor.

2. Control valves not scheduled on the drawings shall be sized by Manufacturer and shall be guaranteed to provide specified flow rates at specified design pressure drops. Valves shall be sized to operate accurately and with stability from 10% to 100% of maximum design flow.

3. Valves sequenced with other valves or control devices shall be equipped pilot positioners.

4. For valves controlled by pneumatic actuators, provide all required pneumatic control air (main air and branch air) and instrument piping.

5. For valves controlled by electric actuators, provide all required electric power and control wiring.
6. Motorized isolation valves shall be line size, unless noted otherwise.
7. All valves installed in Building CHW lines shall have working pressure rating of 150 PSIG unless noted otherwise. Valves shall be able to open and close against a 70 PSIG minimum differential pressure.
8. All valves installed in CW, HW, and Process CHW lines shall have working pressure rating of 150 PSIG unless noted otherwise. Valves shall be able to open and close against a 50 PSIG minimum differential pressure.

B. Valve Actuators

1. Actuators shall be sized appropriately for required duty.
2. Note on Points List which 2-position control valve actuators shall have two (2) end switches (open and close status).
3. All valve actuators for modulating control shall have adjustable pilot positioners.
4. All control valves 2-1/2" and larger shall have pneumatic actuators.
5. All control valves 2" and smaller shall have electric actuators.
6. For any valve actuators exposed to weather, provide industrial grade electric actuator with weatherpoof enclosure. Note on Points List if electric heater with thermostat is required for valve actuator.
7. Note on schedule if actuators to have spring return and what position (open or closed is normal fail position).

C. Butterfly Control Valves (2-1/2 Inches And Above)

1. Provide butterfly valves for intended service and as scheduled on Project Drawings. Note on Valve Schedule required flow coefficient (Cv) for modulating control valves.
2. For CW and HW, Butterfly valves shall be threaded lug, cast iron or ductile iron body, with resilient EPDM seats, aluminized bronze disc and 316 stainless steel where available, otherwise 304 stainless steel. Valve shall be equal to Bray 30/31 Lug Butterfly Control Valve, Keystone, Centerline, Dezurik, or approved equal. Valves shall be rated for a minimum Working pressure of 175 PSIG.
3. For CHW, Butterfly valves shall be threaded lug, carbon steel body, with Teflon Seats, 316 stainless steel disc, and 17-4 PH stainless stem. Valves shall have dry stem journals with no leakage to stems at rated pressure. Valves shall be equal to Bray/McCannalok Series 40 Lug Butterfly Control Valve, Class 150, Keystone, Centerline, DeZurik or approved equal.

D. Steam Control Valves

1. Provide automatic control valves for low pressure steam as shown on drawings for steam to hot water heat exchangers and AHU pre-heat steam coils.
2. Note on Project Drawings which steam valves are configured as 1/3 and 2/3 flow control.
3. Valves shall be selected for modulating service; refer to schedule on Drawings for Cv requirements. Valves shall provide "equal percentage" flow characteristic and shall be equal to Honeywell V5011 Series valve if threaded. If flanged, valves shall be equal to Honeywell VGF series. Valve shall be constructed with cast brass or bronze body including integral seat, stainless steel stem, brass plug with molded high temperature Teflon disc.
4. Valves installed in LPS shall be rated for a minimum Working pressure of 175 PSIG.

E. Valves 2-1/2" And Smaller For Water Systems

1. Provide 2-way modulating globe or ball valves to control CHW, HW, and LPS for fan coil units, terminal HW reheat, and steam unit heaters.
2. Provide 2-way, 2-poistion (open/closed) for city water make-up service.
3. Valves shall have equal percentage flow characteristics. Valves shall be constructed with cast brass or bronze body including integral seat, stainless steel stem, brass plug with molded and composition disc. Valve working pressure shall be 175 PSIG, and shall be capable of operating against a maximum close-off differential pressure of 50 PSID.
4. Refer to Valve Schedule on Project Drawings for flow coefficient and pressure drop requirements for valves specified for modulating control.
5. Provide valves with electric actuators, sized for required duty.

2.12 AUTOMATIC CONTROL DAMPERS

A. General

1. Provide automatic control dampers (ACD) in location and size as noted and shown on the Project Drawings. Dampers shall be all aluminum construction, be multiple opposed blade, designed for low leakage.
2. For rectangular ducts, acceptable Manufacturer/Models are Ruskin Model CD-50, Greenheck Model VCD43R, or approved equal.
3. For round ducts, acceptable Manufacturer/Models are Ruskin CDR-25, Greenheck VCDR-53, or approved equal.
4. As part of submittal, provide leakage and flow characteristic charts.
5. Coordinate with Mechanical Contractor that access door is provided upstream and downstream of each automatic control damper installed in ductwork.

B. Damper Actuators

1. Furnish electronic actuators all automatic control dampers.
2. Actuators shall be mounted to provide Normal control action as noted on Project Drawings or as noted in Points List or Sequence of Operations.
3. Actuators for 2-position dampers shall have end switches.
4. Actuators for modulating dampers shall have adjustable pilot positioners.
5. Actuators shall be adequately sized to provide necessary torque for damper area.
6. Adjust linkages and actuator ranges to properly sequence damper with other dampers and valve actuators if Sequence of Operations designates interfacing of dampers with other control end system devices.
7. No more than eight (8) square feet of damper section shall be controlled by a single linkage connection and no more than sixteen (16) square feet by a single actuator. Individual sections shall not exceed 48 inches by 48 inches.
8. For dampers requiring electric actuators, provide electric actuator and accessories as required. Motor shall be rated for 110 Volt electric power. Actuator shall have Spring Return. Actuator shall be of the type which provides positive damper positioning in proportion to control signal.
9. For dampers requiring pneumatic actuators, provide pneumatic actuators with pilot positioners, normally closed with spring return.
10. For any damper actuators exposed to weather, provide industrial grade electric actuator with weatherpoof enclosure.

C. Dampers

1. Dampers shall be suitable for high velocity performance, ultra-low leakage type with leakage not greater than 6.2 CFM/S.F. at 4" W.G. pressure differential for a 48 inch x 48 inch damper size, as published under AMCA certified ratings. Damper leakage shall be less than 0.1% of total CFM at maximum damper system velocity. Airflow pressure drop at design airflows shall not exceed 0.10" inches W.C.

2. Dampers frames shall be extruded aluminum, and if duct mounted, shall have flanges.

3. Blades shall be airfoil type (for minimum pressure drop and noise generation), fabricated from extruded aluminum with integral structural reinforcing tube running full length of each blade. Blades shall not exceed 6 inches in width.

4. Blade edge seals shall be replaceable butyl rubber and jamb seals shall be flexible metal compression type (aluminum).

5. Bearings shall be non-corrosive, two-piece molded synthetic. Axles shall be square or hexagonal.

6. All multiple damper sections must have jackshafts.

7. Mechanical Contractor shall mount dampers in ductwork. Dampers shall be installed in strict accordance per manufacturer's instructions and details.

D. Actuators For Custom Air Handling Units

1. For Custom Air Handling Units, furnish electronic actuators for the following automatic control dampers that are being furnished by the Custom AHU Manufacturer:

   a. For Minimum Outside Air Dampers, 2-position, electronic actuator with end switches.

   b. For Economizer Outside Air Damper, modulating electronic actuator with pilot positioners.

   c. For Mixed air intake dampers, modulating, electronic with pilot positioners.

   d. For units with dual supply fans, for each supply fan isolation damper, furnish 2-position, pneumatic actuator, normally open, with end switch

2. All smoke dampers installed in custom air handling units shall have an electric actuator with end switches.

2.13 SMOKE AND FIRE/SMOKE COMBINATION DAMPERS

A. Coordinate smoke isolation dampers with actuators as noted on Project Drawings. Mechanical Contractor shall furnish and install smoke and fire/smoke dampers.

B. Smoke dampers and actuators shall be qualified under UL555S to a minimum elevated temperature of 250ºF. Acceptable Manufacturers are Greenheck SMD-43, Ruskin SM-50, or approved equal.

C. Smoke damper shall be fabricated with all aluminum. Frames shall be extruded aluminum. Damper blades shall be extruded aluminum airfoil shape to withstand high velocities and static pressures. Dampers shall be provided with stainless steel blade end seals and flexible synthetic blade edge seals to keep leakage to a minimum. Linkage, bearing sleeve, and hexagonal axle shall be stainless steel.

D. Dampers shall be opposed blade design capable of withstanding 8" W.G. differential pressure and 2,000 FPM approach velocity. Damper shall meet requirements of Leakage Class II at 350ºF.

E. Dampers shall be normally closed (powered open).

F. Damper actuator shall be pneumatic with spring return and end switches. Provide a minimum of one damper actuator per 16 S.F. maximum damper area. Actuator shall be sized by the manufacturer to deliver the necessary torque.

G. Duct-mounted smoke detectors associated with a smoke damper shall be furnished and wired by the Electrical Contractor. The Mechanical Contractor shall install the duct-mounted smoke detector. The BAS Contractor shall be responsible for providing power and control wiring to smoke dampers.

H. Coordinate with Mechanical Contractor that access door is provided upstream and downstream of each smoke damper installed in duct.

I. BAS Contractor shall provide all required hard-wired interlocking so that upon fan shutdown based on fire and/or smoke detection, the associated smoke damper will close.

J. Note which smoke discharge air dampers are being furnished with custom air handling units by AHU Manufacturer as an integral component of air handling unit.

2.14 SMOKE DETECTION

A. All supply and return ventilation systems 2,000 CFM and greater shall automatically stop when the associated smoke detectors are activated, except for return systems are utilized for exhaust systems.

B. BAS Contractor shall provide all required hard-wire interlocks to shutdown designated supply and return fans.

2.15 FIRE DAMPERS

A. Mechanical Sub-Contractor shall furnish and install fire dampers. All fire dampers with a dimension larger than 96” wide x 50” high shall have motorized electric actuators. All other fire and smoke dampers shall have fusible links. Actuators shall be furnished as part of UL listed fire damper assembly.

B. BAS Contractor shall provide all associated power/control wiring for motorized fire dampers.

C. Assume that (10) fire dampers shall have electric actuators.

D. Refer to Section 23 0000 for further information regarding fire dampers.

2.16 AIRFLOW STATIONS

A. For the custom air handling units, the AHU Manufacturer shall furnish and factory install the supply fan airflow stations.

B. All airflow measuring devices required to be installed in ductwork shall be furnished by BAS Contractor and installed in ductwork by Mechanical Contractor. Prior to installing devices, review final location with Owner’s Engineer.

C. BAS Contractor shall submit list of number of airflow stations, noting flow, and duct size. Coordinate final duct dimensions with Mechanical Contractor’s Sheetmetal Sub-Contractor.

D. Airflow measuring devices shall be of the Vortex Shedding type, capable of continuously monitoring the airflow volume of the duct served and electronically transmitting a signal linear to the airflow volume. Airflow measuring devices shall be of the insertion type, or built into airflow control valves, as required, with the capability of measuring velocity over the full range of 400 to 7000 FPM. Devices shall consist of multiple velocity sensors, supported on insertion probe bars. Acceptable Manufacturer is Vortek VT5000 or approved equal

E. Individual airflow sensors shall be of rugged construction, and shall not require special handling during installation. Sensors shall be mounted on support bars, as required to achieve an equal area traverse.

F. Standard Materials shall be aluminum bars with aluminum and ABS sensors. Support bars over one foot in length shall be supported on both ends. Where utilized in corrosive air streams, sensors and support bars shall be manufactured of corrosion resistant CPVC and ABS.

G. Individual velocity sensors shall not be effected by dust, temperature, pressure, or humidity. The sensors shall be passive in nature, with no active parts within the air stream. The output from individual sensors shall be linear with respect to airflow velocity and shall be capable of sensing airflow in one direction only. The velocity sensors shall not require calibration.

H. Multiple sensors shall be utilized in all ducts with areas over .3 square feet in accordance with the following recommendations:

Area, S.F.	**Rectangular**	**Circular**
Less than 0.30	1	1
0.3 to .80	2	2
3.0 to 5.0	4	4 (note 1)
5.0 to 8.0	8	4 or 8 (note 2)
8.0 to 15.0	12	8 (note 1)
15.0 to 32. 0	16	12 (note 2)

Note 1: Two support bars in cross pattern
Note 2: Three support bars in cross pattern

I. Where sensors are installed at the inlet of Pneumavalve airflow control valves, fewer sensors are allowable due to improvement of airflow profile by vanes in Pneumavalve.

J. Velocity measurements from individual sensors shall be summed in the associated airflow transmitter. The transmitter shall be connected to the probes via factory-assembled cables, provided by Airflow Controls Manufacturer.

K. The measurement shall be input and conditioned digitally to eliminate Analog-to-Digital conversion input error. The transmitter shall provide a scaleable output over the full range of control of the unit, via on-board adjustments. The output signal of the transmitter shall be industry standard electronic signals, selectable on-board via jumpers or switches, for 4-20ma, 1-5vdc or 2-10vdc. Power requirement for the transmitter shall be 24VAC or DC.

L. Measurement system accuracy shall be plus or minus 2% of volumetric airflow rate. Turndown capability shall be at least 10:1.

M. Velocity sensing methods other than those specified shall be acceptable, provided the basic requirements for linear electronic output, turndown, accuracy, materials of construction, and output signal are met. If differential pressure devices are used, dual differential pressure transmitters, the span of the lower transmitter being one tenth the span of the higher, with an accuracy not less than +/- 0.5%, shall be utilized to provide the required turndown. Orifice type devices shall have a Beta ratio of 0.7 or less, and shall be installed in accordance with ASME guidelines for up and downstream conditions.

N. Pitot devices constructed of aluminum are not acceptable in fume hood exhaust air; 304 stainless steel shall be used.

O. The airflow sensors shall be easily removed from the duct for inspection. If this is not possible, then access doors must be installed in the duct upstream and downstream of the airflow sensor.

P. Use of valve or damper position for calculation of airflow volume is not acceptable. Direct airflow measurements must be taken.

Q. Sensing methods employing thermal devices in the airstream shall not be acceptable.

R. The TAB Contractor shall measure airflow at each airflow station in order to calibrate airflow stations; the TAB Contractor shall furnish a certified report verifying calibration.

2.17 UNITARY CONTROLLERS

A. Provide unitary controllers for control of the following mechanical equipment: 4-pipe fan coil units, 2-pipe fan coil units. All mechanical equipment shall be furnished and installed by the Mechanical Contractor.

B. The I/O of each unitary controller shall contain sufficient quantity and types as required to meet the specified Sequence of Operations. In addition, each controller shall have the capability for: time of day scheduling, occupancy mode control, after hours operation, lighting control, alarming, and trending.

C. Field install each unitary controller. Unitary controller shall be housed in steel cabinet.

D. For each space served by unitary controller, provide new DDC wall-mounted thermostat for each room with setpoint adjustment slidebar.

E. Provide 120 VAC power wiring to each unitary controller, temperature sensor wiring, and communications wiring between controller and tie-in to new BAS system.

2.18 DDC CONTROLLERS FOR TERMINAL BOXES

A. All air terminal boxes shall be furnished and installed by the Mechanical Contractor.

B. For each terminal box, provide unit controller.

C. The BAS Contractor shall furnish terminal box controllers to selected Terminal Box Manufacturer for Manufacturer to mount controllers at terminal box factory. Controllers shall be house in a steel cabinet. As part of the Base Bid, BAS Contractor shall include all costs to ship unit controllers to Terminal Box Manufacturer.

D. For single duct applications, controllers shall be equipped with built-in actuator for modulation of air damper. Actuator shall have a minimum torque rating of 35 inch-pounds, and contain an override mechanism for manual positioning during start-up and service. Actuator shall be removable and separate from terminal box controller. If integral to terminal controller, actuator shall be removable for servicing without removing terminal controller.

E. Controllers shall have an integral velocity sensor accurate to +/- 5% of full range of box's CFM setting.

F. Each controller shall be capable of performing the specified Sequence of Operations and have the capability of time of day scheduling, occupancy mode control, after hours operation, lighting control, alarming, and trending.

G. Controllers shall be able to communicate with any other standalone DDCFP on the same field bus with or without communication to the Network Control Unit managing the field bus.

H. For boxes with hot water reheat coils, furnish 2-way modulating control valve, with electric actuator. Mechanical Contractor shall install valve in pipe. Provide output signal from new controller to each box's hot water reheat control valve. Connect to box's velocity probes and install discharge air temperature sensor.

I. For each supply air box, furnish and install wall-mounted thermostat with setpoint adjustment slide bar. Refer to Project Drawings for location of thermostats.

J. Work with Owner's TAB Contractor to establish K factor for each box. Refer to Project Drawings for scheduled CFM settings. Tag ceiling grid just below terminal box.

K. Provide all software for each box controller to achieve specified Sequence of Operations. Controllers shall have required software to allow Owner's TAB Contractor to balance the system and calibrate airflow measurement of the controller.

L. Provide any required service tool to access the box controllers for balancing. Provide written instructions on how to access box information. Via a laptop computer, the TAB Contractor will

be responsible to input the measured CFM into the BAS System to calibrate the DDC controller box measurement.

2.19 ELECTRIC WIRING

A. The BAS, all network control units, DDCFPs, electric actuators, and any other BAS device requiring electric power shall have be powered via Emergency Power.

B. Electric wiring and wiring connections required for installation of BAS and local controls, as herein specified, shall be provided by BAS Contractor, unless otherwise indicated.

C. All wiring shall comply with requirements of the National Electric Code.

D. All wire will be copper and meet the minimum wire size and insulation class listed below:

Wire Class	**Wire Size**	**Insulation Class**
Power	12 Gauge	600 Volt
Class One	14 Gauge Standard	600 Volt
Class Two	18 Gauge Standard	300 Volt
Class Three	18 Gauge Standard	300 Volt
Communications	Per Manufacturer	Per Manufacturer

E. Power and Class One wiring may run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.

F. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per NEC.

G. Single conductor 120 VAC wiring shall be type Type THHN 12 AWG or larger stranded copper with 600 V. insulation, color coded, red for hot leg, white for neutral, black for all others, for use in conduit or EMT.

H. All new low voltage wiring shall be 18 AWG or larger if single strand conductors are used, 22 gauge or larger if multi-strand conductors are used.

I. Analog signal cables shall be 18 gage twisted pair wiring is acceptable for analog signal cabling)

J. BAS Network communications cables shall be 22 gage twisted and shielded pair wiring is acceptable for Field Bus Communication) Network communications cables, point wiring, and power wiring shall be run separately in approved raceways (conduit, cable, trays, or EMT).

K. Low level signal wiring homeruns to local control stations may be by means of multi-pair cables. The number of pairs of such cables shall be uniform throughout the installation, and in general, there shall be at least 20% spare pairs per bundle.

L. For indoor installation, conduit shall be rigid steel hot dipped galvanized, threaded with couplings, -3/4 inch minimum size or EMT with compression fittings. Percent fill of conduit or EMT shall not exceed Code maximum regardless of service.

M. Wiring shall be independently supported from building structure with bridal rings and clips. The support of wiring from mechanical ductwork or pipe is not acceptable. Use of tie wraps for supporting conduit, wire, cable, etc. is not permitted.

N. All low voltage wiring is to be run in a separate conduit from High Voltage wiring.

O. Above ceilings, communications and low voltage control wiring may be installed ‘soft,’ but cabling must be plenum rated. Plenum rated cabling must be suspended from building structure. Wiring shall not be supported from sprinkler piping, electric EMT, or other piping systems. Wiring shall not be draped unsupported on top of suspended ceiling. Plenum rated cable shall be identified with a tag every 25 feet sand shall be color coded.

P. Any wire run in suspended ceiling that is used to control outside air dampers or to connect the BAS to the fire management system shall be in conduit.

Q. Flexible metallic conduit (maximum 3 feet) shall be used for connections to motors, actuators, controllers and sensors mounted on vibration producing equipment. Liquid tight flexible conduit shall be used in exterior locations and interior locations subject to moisture.

R. Junction boxes shall be provided at all cable splices and equipment termination. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.

S. All outdoor wiring (control and power) shall be installed in rigid galvanized steel conduit (RDSC), with weatherproof fittings and supports. All associated straps and screws shall be corrosion proof.

T. Provide centralized 120/24 transformers (capable of handling up to 32 controllers) for power distribution to local controllers and provide a 24vAC line adjacent to the communication cable. Provide 24/24 isolation transformers at each local controller.

U. For each field control unit, provide each FCU with a local transformer directly from the FCU source.

V. Provide labeling of all wiring (power, communications, control). Label all junction boxes.

2.20 ALARM WIRING

A. Wire alarm contacts normally closed (NC). When in alarm condition or if wiring to contact is opened (wire cut), DDCFP shall sense alarm condition.

2.21 TAGS

A. Provide tags for all control panels, input sensors, controlled outputs, and all wiring.

B. Tags shall be rigid plastic with engraved lettering and shall be attached to device with brass chain.

C. Provide labels for all panels installed as part of BAS System. Labels shall be secured to panel with screws.

D. Review tagging and labeling with Owner prior to starting.

2.22 CO2 SENSORS

A. Provide CO_2 sensors for return air duct of designated AHUs as shown on control schematic diagrams. Acceptable Manufacturer for CO_2 sensors is Greystone, duct mounted type. Provide sensor with LCD, field calibration kit, and control relay. Provide sensors with all required software. Sensors shall have 5 year calibration warranty.

B. Provide all associated control wiring for CO_2 sensors.

2.23 ROOM PRESSURE MONITORING

A. A room pressure monitor system shall be furnished and installed to monitor the measured room pressure.

B. The system shall include a room pressure monitor, a pressure sensor, a low voltage transformer, and all low voltage wiring.

C. All components of the room pressure monitor system shall be part of a completely designed, tested, cataloged, and factory coordinated package by a single manufacturer for single point responsibility. Specifications and drawings are based on TSI Inc., Model 8630 PRESSURA Room Pressure Monitor. Field designed systems are not acceptable.

D. The system shall continuously monitor the measured room pressure to confirm the requirements set forth in Section 6-4.2 of the NFPA 45 Standard.

E. Room Pressure Monitor:

1. A room pressure monitor shall be provided to measure and display the pressure differential between a controlled space and a reference space. It shall provide access to menu driven configuration and calibration options through a keypad.

2. The room pressure monitor shall be factory fabricated with an industrial grade metal case that can be mounted on a single gang electrical box (2" wide x 3" tall x 2.5" deep) on a wall inside the controlled space.

3. The room pressure monitor shall have the following characteristics:

   a. A digital display indicating the measured room pressure in inches of H_2O. The display shall have a range of -0.19999 to +0.19999 in. H_2O with a resolution of 5% of reading. The display shall be updated every second.

   b. A smooth, spill-proof membrane switch keypad to operate menu-driven programming.

   c. Four (4) indicator lights shall be shown on the front of the monitor indicating the following conditions:

      1) Red: Low Alarm Light

      2) Green: Normal Light

      3) Red: High Alarm Light

      4) Yellow: Mute Light

   d. An audible alarm that sounds when the pressure in the controlled room is in an alarm condition, assuming it has not been previously muted.

   e. Alarm contacts for low and high alarm which shall be SPST (N.C.). The contacts shall close in alarm conditions and loss of power.

   f. A 0-10 VDC or 4020 mA linear analog output. The analog output must be specified at the time of order.

4. All wiring to the room pressure monitor shall be wired to a terminal strip which plugs into the back of the monitor for easy installation.

F. Pressure Sensor:

1. The pressure sensor shall consist of two (2) velocity sensing elements mounted in line with each other and a temperature compensating element as described in U.S. Patent #4,787,251. Constant temperature thermal anemometry shall be used to make the air velocity measurement. Pressure transducers are not acceptable.

2. A hard molded plastic “dumbbell” assembly shall be used to mount the pressure sensor. The “dumbbell” shall consist of two (2) wall mounted plastic housings and PVC tubing. The housing with the sensor shall be mounted on the wall in the controlled space, the other in the referenced space, with the PVC tubing between them through the wall. The wall thickness shall not exceed two feet.

3. A bell shaped air inlet design shall be used for smooth laminar airflow across the sensing elements

4. The velocity sensing elements shall be ceramic coated platinum RTD for corrosion resistance and easy cleaning.

5. The pressure sensor shall be temperature compensated over a range of 55EF. to 95EF.

6. The sensor shall be able to accurately measure the room pressure in the range of -0.19999 to +0.199999 in. H_2O. The sensor shall be bi-directional to determine the proper direction of pressure. Uni-directional sensors are not acceptable.

7. A 6 foot, 4-conductor, 22 AWG cable with 4 pin, polarized plug-in connectors at both ends shall be provided for the wiring connection between the sensor and the pressure monitor.

G. Transformer:

1. A low voltage transformer shall be provided to power the room pressure monitoring system.

2. The transformer shall have a primary-side voltage of 120 VAC and a secondary-side voltage of 24VAC.

3. The transformer shall be UL and CSA listed.

4. The transformer shall have a rating of 20 VA with 0.5 amps maximum.

5. The transformer shall be installed in a standard 4" x 4" electrical box provided by the Automated Temperature Control (ATC) Contractor.

6. A 25 foot, 2 conductor, 22 AWG cable shall be provided as the electrical interface between the transformer and the pressure monitor.

H. Operation:

1. Configuration:

a. User-friendly, menu-driven programming shall be done using the keypads on the front panel for proper configuration of the room pressure monitor.

b. Low alarm and high alarm setpoints shall be selectable. A 0.0002 in. H_2O minimum deadband shall be provided to prevent unnecessary alarms.

c. The room pressure monitor shall have an adjustable display averaging period ranging from 2 to 10 seconds.

d. Three types of alarms shall be available to indicate an unsafe room condition. Each type of alarm shall have the capability to be configured for alarm latched or alarm unlatched (alarm follow) operation independent of the other alarm types.

1) Visual indicators on the front panel shall indicate low and high alarm conditions (via the red LOW ALARM light and the red HIGH ALARM light).

2) Audible alarms shall sound in all alarm conditions (unless the audible alarm has been muted). The audible alarm shall be silenced at any time by pressure MUTE key.

3) Low alarm and high alarm relays, for remote monitoring of alarm conditions, shall be closed when the appropriate alarm condition has been initiated.

e. The room pressure monitor shall be programmable to mute the audible alarm.

f. The configuration menu options shall be protected from unauthorized personnel through the use of a passcode.

2. Calibration:

a. The room pressure monitor shall be factory calibrated. No initial field calibration shall be needed. The monitor and the sensor shall be delivered and installed as a matching set.

b. Field calibration shall be available for future use. It shall be done electronically through the use of the keypad on the front panel. Calibration through the use of potentiometers is not acceptable.

c. Calibration shall consist of calibrating the sensor span.

d. The calibration functions shall be protected from unauthorized personnel through the use of a passcode.

I. Installation:

1. The room pressure monitor shall be installed as recommended by the manufacturer's installation instructions.

2. The Automatic Temperature Controls (ATC) Contractor shall install the pressure sensor and the room pressure monitor in each room.

3. All wiring shall be done by the ATC Contractor as specified by the manufacturer.

J. Equipment Start-Up, Calibration and Training:

1. Start-up shall be performed by the manufacturer or a factory authorized representative.

2. Start-up shall include verifying the monitors and sensors are mounted in a appropriate position in the controlled room. This shall be performed only after substantial completion of the building. Ceilings and doors shall be installed and the HVAC systems (exhaust and supply fans) shall be properly air-balanced.

K. Warranty:

1. All components of the room pressure monitor system shall have a two year limited warranty for all parts.

2. The warranty shall commence on the date of shipment from the manufacturer.

L. Sequence Of Operation

1. Room Pressure Monitor:

a. The room pressure monitor shall measure the air velocity between the controlled space and the reference space. The measurement shall be done using a thermal anemometer with two velocity sensing elements mounted in an in-line position. The velocity between the spaces shall be used to calculate the pressure differential.

b. An alarm mode shall be indicated when the room pressure falls below the programmable low alarm setpoint, rises above the programmable high alarm setpoint, or has a direction that is opposite to the low alarm setpoint. An alarm mode shall cease to exist when the measured room pressure rises 0.00010 inches H_2O above the low alarm setpoint or falls 0.00010 inches H_2O below the high alarm setpoint. This condition must occur for five (5) minutes or more prior to alarm sounding. Coordinate with Owner's Maintenance staff.

c. The room pressure monitor shall indicate normal operating mode when the green NORMAL light is annunciated.

M. The Controls Contractor shall provide the above room pressure controls, test the same (each device) and record the reading to be submitted with the O&M's.

PART 3 - EXECUTION

3.1 INSTALLATION OF SYSTEMS

A. The BAS Contractor shall provide all labor (except where otherwise specified) as required for the installation and modification of the systems.

B. If building systems are operable during installation of BAS System, any systems or equipment which require shut-down for installation of BAS shall be carefully coordinated with the Owner.

C. After completion of the work in this Section, test, regulate, and adjust system equipment, sensors, controllers, alarms, thermostats, humidstats, automatic control valves/dampers, flow meters, and related system accessories, the entire BAS system, and any other equipment or system that the BAS system interfaces with, and place these items in complete and satisfactory operating condition.

3.2 TESTING, CALIBRATION & COMMISSIONING

A. Refer to Commissioning Requirements in Part One of this specification section.

B. All EMS hardware for this project shall be new. All end device components shall be properly calibrated prior to BAS becoming fully operational.

C. Furnish as required labor and test apparatus to calibrate and prepare for service instruments, controls, and accessory equipment furnished under this Section. This shall include but not be limited to: zero, span, and range calibration checks of instruments and accessories, both field and panel mounted. In addition, the BAS Contractor shall check actuators, control valves and dampers to insure proper action, stroke each actuator, and make necessary adjustments for steam and blade travel.

D. Furnish as required labor and test apparatus required to check the operation of control loops, set points, and interlocks, as well as electronic/pneumatic equipment. The BAS Contractor shall test every input/output point for proper performance through the entire BAS system and maintain accurate test records for each point throughout the testing cycle and thereafter. In addition, the BAS Contractor shall be responsible for integrated system testing with equipment and vendors not covered under this Section but with whom the BAS interfaces. The Owner and Engineer reserves the right to inspect these test records at any time and also to witness any of the point tests deemed appropriate.

E. All new adjustable sensors (e.g., RTDs, transmitters, etc) shall be calibrated prior to being placed in service.

F. Calibration of RTDs shall be made with a temperature instrument held next to the actual sensor. Instrument shall be NBS-certified within 6 months. Offset adjustments shall be made through the BAS to calibrate the sensor.

G. All transmitters shall be checked with a certified instrument at two points: zero and one operating point. For example, a differential pressure transmitter shall be checked with a certified magnahelic gauge or manometer. The transmitter shall be read and adjusted with zero differential and with some operating differential.

H. The Contractor shall check for accurate display of the data at the operator's console.

3.3 CUT-OVER PROCEDURES

A. The purpose of these procedures is to establish an efficient means of performing the "cut-over" with a minimum of downtime of systems from systems operating manually or via local controls to fully control via the BAS System.

B. At the point in construction when system "cut-overs" are ready to begin, the Contractor shall meet with the Owner's BAS operator at the beginning of every work day to carefully coordinate the day's activities. He shall discuss the "cut-over" plans and strategies for that day and describe the systems to be affected.

C. During the course of the "cut-over" period, the Contractor shall carry a walkie-talkie to communicate with the Owner's BAS Operator, while he is working in the building. The walkie-talkies shall be provided by the Owner. Every time the Contractor moves on to a new system or subsystem, he shall inform the Owner's BAS Operator of his status.

D. Air handling units shall be “cut-over” as complete systems with both the supply and return fans activated together.

E. Water systems shall be "cut-over" as a complete system including control valves, chillers, heat exchangers, cooling towers, and pumps.

F. Before to any ‘cut-over’ work commencing, the following tasks should be substantially completed:

1. System file server and operator workstations shall be installed and functioning.
2. All Operating System and DDCFP software shall be generated, tested at BAS Contractor’s offices. Testing in the office shall ensure the software shall meet this Specification. Testing shall include modifications to setpoints, outside air temperature, time of day, etc. to ensure proper sequencing of devices and initiation of specified alarms.
3. Once software has been tested in the office, then software can be loaded in the field (to file server and workstations).
4. Training of the operating engineers shall have begun.
5. All network controllers, DDCFPs, unitary controllers, end devices, wiring, and piping should be substantially completed.

G. Prior to the start of a system "cut-over", the Contractor shall minimize the number of control devices to be tied in when "cut-over" of a system occurs.

H. At the completion of "cut-over", the Contractor shall:

1. Verify that the wiring is terminated to the correct controller input by breaking the connection at the device and recording the change of state of the input.
2. Stroke the damper and valve actuators to verify correct operation and control range of the device.
3. Stop and start all chillers, fans and pumps to verify the status function is operational. Avoid excessive stop/starts.
4. Tune all modulating device control loops and set-up one minute histories. Monitor the histories over a variety of operating conditions to insure that the operation is stable and per the Sequences of Operation.
5. Provide print-outs of one-minute histories to Engineer for all systems after conclusion of loop tuning. Histories shall encompass a complete working day and shall include transition from stop to start and vice versa. Engineer will request additional loop tuning and submittal if histories indicate control instability.
6. Notify the Owner and Engineer that the specific system has been "cut-over".
7. The Owner's operating engineer shall be instructed to notify the Contractor immediately if a problem develops.

3.4 START-UP TRENDING

A. The Contractor shall provide printouts of system “trending” collected at 30 minute intervals for a period of 24 hours for all points in all systems installed as part of this Project. The purpose of this Trending is to indicate that the equipment is starting and stopping as commanded and operating per the control strategy.

B. The BAS Contractor shall provide printouts of system "trending" collected at one minute intervals for a 30 minute period for all analog inputs and analog outputs in all systems. The purpose of these "trends" is to indicate that the PID loops are functioning without hunting. If possible, Trends should be collected when systems are changing operating states (e.g. transition from unoccupied to occupied state). One minute Trending shall be provided for equipment capable of modulating control (e.g., chillers, towers, heat exchangers, pumps, AHUs, fans, VAV boxes).

C. The trended points must be in logical groupings (e.g. all points from one equipment/system in a trend).

D. In lieu of printouts, trend logs may be provided in graphical form at the operator's workstation for review by the Engineer in one or two visits.

E. The BAS Contractor shall first review the trends and make corrections as required. Once the trending data indicates proper operation, the BAS Contractor shall notify the engineer that the trending is completed and provide the trending data for review by the Engineer. The Engineer will review the trends and may provide additional feedback to the BAS Contractor. The BAS Contractor shall modify the system as required to correct problems identified by the Engineer.

3.5 ACCEPTANCE TESTING

A. At Substantial Completion of the Work, the BAS Contractor shall prepare a Punch List of all items remaining to be completed or corrected. The failure to include any items on such list does not alter the responsibility of the BAS Contractor to complete all Work in accordance with the Contract Documents. This list shall be delivered to the Engineer.

B. The Engineer will prepare a list of items to be corrected or completed that shall include the Punch List items identified by the BAS Contractor, and any additional items found to be incomplete or incorrect. All items on both lists shall be completed or corrected before Acceptance Testing may proceed. The BAS Contractor shall notify the Engineer when he believes the Project is substantially complete and he is ready to proceed with Acceptance Test. Notice shall certify that system is complete and operates as required by Contract Documents. Refer to Division 1, Section 01700 "Contract Closeout for further requirements.

C. Acceptance Test Procedure

1. Prior to Acceptance Testing, the BAS Contractor shall submit a test plan to the Engineer. After review the Test Plan, the BAS Contractor shall prepare and submit a detailed test procedure for Engineer review. The test procedure shall include reference to the Specification Section and Paragraph with which each test is intended to demonstrate compliance, together with the criteria for acceptance or rejection.

2. The system test, conducted by the BAS Contractor in accordance with the Test Procedures, and witnessed by the Owner and Engineer, shall be a comprehensive test of the system to demonstrate that all aspect of the hardware and software are in conformance with the requirements of this Specification Section. The Engineer will inspect the installation and witness operation of critical control sequences of operations in the presence of the BAS Contractor's Field Engineer. The system test shall include testing of the system computer alarms (at workstations), reporting and communications throughout all levels of communication of the BAS system. Notify the Owner and Engineer at least five (5) working days in advance prior to any testing occurring.

3. The BAS Contractor shall demonstrate in the presence of the Engineer that the BAS system is operating as specified in the Contract Documents, including any required Change Orders. The Acceptance Test shall occur after the BAS Contractor has completed start-up tests and trending. The Acceptance Test will include, but not be limited to, the following items:

a. Verification of the location, calibration and proper wiring connection of BAS input and output devices.

b. A sampling of critical BAS software and output functions, tested individually.

c. "Spot Checks" of the proper operation and calibration of BAS devices and actuators.

4. Minimum validation and sign-off requirements (on operator workstations) shall be as follows:

a. Run samples of specified reports and trends.

b. Execute menu tree.

c. Display all required graphics.

d. Execute digital and analog commands via mouse and keyboard.

e. Demonstrate data entry/point modification/programming.

f. Demonstrate program downloading.

g. Demonstrated program uploading.

h. Demonstrate control loop execution and stability.

i. Demonstrate specified diagnostics.

j. Demonstrate scan, update, and alarm response.

k. Execute all points summary.

l. Execute communication status checks.

5. When system performance is deemed satisfactory, system parts will be accepted for beneficial use. Warranty shall begin. The Engineer will note all minor deficiencies found in writing. The BAS Contractor shall correct all deficiencies so noted before the Final Acceptance will be issued.

6. The BAS Contractor shall allow sufficient time to complete the Acceptance Test procedure. It is anticipated that thirty (30) days of acceptance testing will be required. Should the Acceptance Testing be extended beyond thirty (30) days due to system deficiencies unreported by the BAS Contractor in their written request for inspection, re-inspection fees paid to the Engineer by the Owner will be deducted from the BAS Contractor's final payment as compensation to the Owner.

7. The warranty period shall not start until BAS system has been approved and accepted by the Owner and Engineer. The Owner will notify the BAS Contractor in writing of the acceptance of the system in its entirety. This does not preclude the beneficial use by the Owner of any portion of the BAS System prior to Final Acceptance of the whole BAS System.

8. During the warranty period, the BAS Contractor shall test the BAS system under varying seasonal conditions to ensure all operational sequences, as specified, are performed correctly. This shall include at least ten (0) additional visits after Initial Owner Acceptance. Where necessary, the BAS Contractor shall make programming adjustments and instrument calibration at no additional cost to the Owner.

3.6 SOFTWARE MODIFICATIONS

A. As a result of Acceptance Testing, it may be necessary to make minor modifications to the setpoints and sequences of operations to address problems uncovered in Start-up Trending and Acceptance Testing. The BAS Contractor shall include in his Bid price up to 120 (one hundred twenty) man-hours of software modifications for such purposes. It shall be the responsibility of the Engineer to define the sequence changes in writing to the BAS Contractor.

B. In addition, the BAS Contractor shall be responsible for reducing nuisance alarms as described below.

1. The BAS Contractor shall include in his bid price, the cost to make modifications to the alarm software sequences to eliminate (or greatly diminish) the occurrences of nuisance alarms. Nuisance alarms are defined as being those alarms that occur regularly and/or with predictability, (often at times of change in operating mode) and do not actually indicate a problem condition at the time of the nuisance alarm occurrence.
2. The BAS Contractor shall modify software to diminish the frequency of these alarms.
3. The Owner shall be responsible for providing the BAS Contractor with a hardcopy alarm printout (or electronic file) that provides a record of the problem.
4. This service shall be provided during the warrantee period and shall be provided at no additional cost to the Owner. Modifications required after that time shall be provided as a service call.

3.7 TRAINING

A. Basic Requirements

1. The BAS Contractor shall provide up to a total of forty (40) hours of training for each hospital for a group of up to four people. The training shall begin prior to Substantial Completion, and shall consist of four separate sessions. Training shall be designed to acquaint personnel in the day-to-day operation and maintenance of the BAS equipment specifically installed at the site. All training shall be “hands-on” in nature. The training shall be at the site. Final Acceptance shall be conditional upon completion of all Training Sessions and can occur once Training Session II is completed if all other conditions of Project Closeout Requirements are deemed meet by the Owner and Engineer.
2. The Owner may videotape all training sessions for purpose of future training. Provide a review and written critique of the Owner’s videotape within one (1) month after completion of the instruction sessions and receipt of the Owner’s videotapes. The critique shall correct all mistakes and clarify all outstanding questions which arise during the sessions.

B. Course Outline

1. The BAS Contractor shall submit to the Engineer an outline of the course. The outline shall include the following:
   a. Major topics to be covered.
   b. Training hours associated with each topic.
   c. Resumes of personnel to be providing training.

C. Training Schedule

1. The training schedule shall be provided on three separate occasions, as follows:
   a. Session I: Shall include sixteen (16) hours of training and shall be completed by Substantial Completion.
   b. Session II: Shall be eight (8) hours in length, held at the site and shall occur just prior to final acceptance. It shall consist of a brief review of the original training. The instructor(s) shall spend the rest of the time answering questions and reviewing procedures with building personnel.
   c. Session III: Shall be eight (8) hours in length and occur within six months after Session II. Session III shall consist of a question and answer period along with review of specific procedures as requested by building personnel. Session III shall be scheduled at the request and convenience of the Owner.

d. Session IV: Shall be eight (8) hours in length and occur within one month prior to the end of the initial Warrantee period. Session IV shall be similar to Session III. Session IV shall be scheduled at the request and convenience of the Owner.

3.8 USER ASSISTANCE

A. The ATC/EMS Sub-Contractor shall provide, at no extra cost, up to 60 hours of remote access service during Warranty Period to assist the Owner's personnel with questions and/or apparent problems. This service shall include time between Final Acceptance and the end of the Warranty Period.

B. If the cause of the request for assistance is due to a hardware or software problem that is covered under warranty, the time required to resolve such a matter shall not be deducted from the specified time stated above.

C. The BAS Contractor shall submit to the Owner, a timeslip (invoice) for the services provided. The invoice shall note the time spent and work performed. The dollar amount billed shall be zero, until the exhaustion of the specified time.

3.9 MANUALS

A. At the conclusion of the Work, the Contractor shall submit five (5) copies of an Operations Manual to the Engineer for approval, containing the following:

1. A title page and Table of Contents. The Table of Contents is to contain a listing of major headings found in the manual and the page numbers of each section.

2. Updated copies of all submittal data.

3. Manufacturer's instructions regarding the installation, maintenance and calibration, as required, of each component used in the BAS system installed by the Contractor.

4. Copies of all warranties and guarantees issued by each equipment manufacturer.

5. A complete listing of the source code for each program developed for the BAS System, and a programming manual. Source code shall include descriptive English comment statements to aid a layman's understanding of Sequences.

6. User's Manual: A set of instructions or "User's Manual" detailing operation of the BAS. The manual shall describe hardware operation as well as provide instructions in computer access and programming. This manual shall be submitted under separate cover. The User's Manual shall be written for an inexperienced user. It shall describe, in layman's language, the following functions and procedures.

a. Care and maintenance of the hardware.

b. "Powering up" the computer and logging onto the system.

c. Offsite Access procedures

d. "Booting up" programs.

e. Operation of telephone modem and communications software.

f. Operation of remote alarm annunciation

g. Program backup from field panels to host computer disk and tape back-up.

h. Program download from host computer disk to field panels.

i. Accessing and modifying programs in the field panels.

j. Changing setpoints of programs in field panels through menu-driven software.

k. Retrieving, viewing and modifying historical trend logs.

l. Generating reports and logs.

m. Any other features of the System that the end-user will employ.

B. The Operations Manual shall be bound in three-ring binders. All major sections shall be separated by tabbed cardboard dividers, labeled for each section of the Manual.

3.10 RECORD DRAWINGS

A. Provide Record "As-Built" Drawings as specified in Division 1. Drawings shall be complete point-to-point wiring and piping diagrams for all systems controlled or monitored by the BAS. The Contractor shall, at a minimum, indicate the interface between the BAS and all peripheral control and safety systems that are not modified under this Contract.

B. For each system, provide an 11 x 17 copy of the 'As-Built' control diagram and a 8-1/2" x 11 copy of the Sequence of Operations, laminated in plastic. These copies shall be stored in the appropriate control cabinet.

C. Provide AutoCAD files for all 'As-Built' Drawings.

3.11 COORDINATION WITH TAB CONTRACTOR

A. The BAS Contractor shall assist the TAB Contractor with the testing and calibration of the following flow devices and DP transmitters:

1. Air Flow stations at supply fans of custom air handling units
2. Air flow stations, duct-mounted for return fans.
3. Air flow stations at all supply and exhaust CV and VAV boxes equipped with flow measuring stations.
4. Static pressure transmitters in supply and return ducts.
5. Water differential pressure transmitters
6. Space pressurization differential pressure transmitters.