SECTION 15010 - MECHANICAL GENERAL REQUIREMENTS

1.1 APPLICATION:

A. This section applies to all sections of Division 15,"Mechanical" of this project.

1.2 REFERENCES:

A. The publications listed throughout the specifications form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

CODE OF FEDERAL REGULATIONS (CFR)

29 CFR 1910.147, Control of Hazardous Energy
(Lock Out/Tag Out)

1.3 GENERAL:

A. The contract drawings indicate the extent and general arrangement of the work. The contractor shall be responsible for installing the proposed systems as indicated, without violation of applicable codes, standards, or specification requirements. The contractor is also responsible for coordinating the installation and operation of these systems with the other sections of this specification to provide a complete and operable system. Items shall be arranged such that they fit the space as indicated and shall allow adequate and approved clearance for entry, servicing and maintenance. Detailed drawings of any proposed departures due to actual field conditions shall be submitted to the Engineer for approval. All work shall conform to the requirements of the referenced publications and as specified herein.

1.4 CONFORMANCE WITH AGENCY REQUIREMENTS:

A. Where materials or equipment are specified to conform to requirements of the Underwriters' Laboratories, Inc., or other agency, institute, codes, councils or regulatory bodies, the contractor shall submit proof of such conformance. The label or listing of the specified agency will be acceptable evidence. In lieu of the label or listing, the contractor may submit a written certificate from any approved, nationally recognized testing organization adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the requirements, including methods of testing, of the specified agency. Where equipment is specified to conform to requirements of the ASME Boiler and Pressure Vessel Code, the design, fabrication, and installation shall conform to the code in every respect and bear the ASME stamp.

1.5 CAPACITIES:

A. Capacities of all equipment and material shall be as indicated in the specifications or shown on the drawings. The Engineer can accept equipment, which may be less than the indicated values in a certain area if its clear the intent of the requirements is fulfilled.

1.6 EQUIPMENT INSTALLATION:

A. Necessary supports shall be provided for equipment and systems components as required. Isolation vibration and systems components units shall be provided to minimize the intensity of vibration transmission to the building structure where required. Concrete pads shall be provided for all outside equipment installed. The pads shall extend 6" pass the unit on all sides.

1.7 ELECTRICAL WORK:

A. Electric-motor-driven equipment specified herein shall be provided complete with motors and controls. Electric equipment and wiring shall be in accordance with Division 16, "Electrical". Electrical characteristics shall be as indicated. Each motor shall be of sufficient capacity to drive the equipment at the specified capacity without exceeding the nameplate rating of motor when operating at proper electrical system voltage. Manual or automatic control and protective or signal devices required for the operation herein specified and any control wiring required for controls and devices, but not shown on the electrical plans, shall be provided under this section as required, this includes 120 volt power wiring to power the controls.

1.8 SUBMITTAL OF MATERIALS AND EQUIPMENT FOR APPROVAL:

A. Before purchasing any materials or equipment, the contractor shall submit for approval, in five bound copies, data of the materials he proposes for the work. Items to be submitted include, but are not limited to, the items listed in each individual section. Partial submittals will not be acceptable and will be returned without review. Submittals shall include the manufacturer's names, trade name, catalog model or number, nameplate data, size, layout dimensions, capacity, project specification and paragraph reference, applicable Federal, Military, industry, and technical society publication references, and other information necessary to establish contract compliance of each item the contractor proposes to furnish.

1. Shop Drawings. Drawings shall be a minimum of 8.5 inches by 11 inches in size, except as specified otherwise.

2. Manufacturer's Data. Submittals for each manufactured item shall be manufacturer's descriptive literature of cataloged products, equipment drawings, diagrams, performance and characteristic curves, catalog cuts, and manufacturer's installation recommendations.

3. Cataloged Products. Materials and equipment shall be cataloged products of manufacturers regularly engaged in production of such materials or equipment and shall be manufacturer's latest design that complies with the specification requirements. Materials and equipment shall duplicate items that have been in satisfactory commercial or industrial use at least 2 years prior to bid opening. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the

items need not be the products of the same manufacturer.

4. Submittal Organization. The submittal shall be organized in the same order as the specification sections. The cut sheets shall be marked with equipment number which is shown on the drawings or name for something general such as piping. The submittal sheets shall document the piece of equipment meets the performance requirements of the contract documents. Note: Unmarked submittals will be rejected without review.

5. Samples. The samples shall be such as to illustrate the functional and aesthetic characteristics of the product.

6. Equipment Application. The contractor shall note on the submittal or in writing of any equipment provided which may not operate satisfactory when installed as indicated on the plans.

1.9 NAMEPLATES:

A. Each major item of equipment shall have the manufacturer's name, address, date of manufacture, serial and model numbers on a plate securely attached to the item.

1.10 VERIFICATION OF DIMENSIONS:

A. The contractor shall visit the premises to thoroughly familiarize him with all details of the work and working conditions and verify all dimensions in the field, and shall advise the Engineer of any discrepancy before performing any work. The contractor shall be specifically responsible for the coordination and proper relation of his work to other structures and to the work of all other trades.

1.11 DRAWINGS:

A. Because of the scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that are required. The contractor shall carefully investigate the structural and finish conditions affecting his work and he shall furnish fittings, offsets, transitions, unions, etc., as may be required to meet such conditions at no additional cost to the Owner.

1.12 CUTTING AND REPAIRING:

A. The work shall be carefully laid out in advance and no excessive cutting of construction will be permitted. Damage to building, piping, wiring, or equipment as a result of cutting for installation shall be repaired by mechanics skilled in the trade involved at no additional expense to the Owner.

1.13 SAFETY REQUIREMENTS:

A. Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts located so that any person can come in close proximity thereto shall be fully

enclosed or properly guarded. High-temperature equipment and piping so located as to endanger personnel or create a fire hazard shall be properly guarded or covered with insulation of a type as specified herein. Items such as catwalks, ladders, and guardrails shall be provided where required for safe operation and maintenance of equipment.

1.14 MANUFACTURER'S RECOMMENDATIONS:

A. Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Owner prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

1.15 PAINTING:

A. At the completion of all work, all equipment on this project shall be checked for damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal item that has been provided which has not been painted or otherwise protected shall be painted with primer and final coating as recommended by the paint manufacture for the particular application.

1.16 FINAL CLEANUP:

A. At the completion of all work, all equipment on the project shall be checked and thoroughly cleaned, including coils, plenums, under equipment, and any and all other areas around or in equipment. Any filters used during construction shall be replaced with new filters during final cleanup.

1.17 OPERATING AND MAINTENANCE INSTRUCTIONS:

A. Bound instructions. Three complete sets of instructions containing the manufacturer's operating and maintenance instructions for each piece of equipment shall be furnished to the Owner before the contract is completed. Each set shall be permanently bound and shall have a hard cover. The following identification shall be inscribed on the covers: The words "Operating and Maintenance Instructions", the name and location of the building, the name of the contractor and the contract number. Flysheet shall be placed before instructions covering each subject. The instruction sheet shall be approximately 8-1/2 by 11 inches, with large sheets of drawings folded in. The instructions shall include, but shall not be limited to, the following:

1. Approved wiring and control diagrams, with data to explain the detailed operation and control of each component.

2. A control sequence describing startup, operation and shutdown.

3. Operating and maintenance instructions for each piece of equipment, including lubrication instructions.

4. Manufacturer's bulletins, cuts and descriptive data.

5. Parts list and recommended spare parts.

B. Framed Instructions. Approved wiring and control diagrams showing the complete layout of the entire system, including equipment, piping, valves and control sequence, framed under glass or in approved laminated plastic, shall be posted, where directed. In addition, condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form framed as specified above for the wiring and control diagrams and posted beside the diagram. Proposed diagrams, instructions, and other sheets shall be submitted prior to posting. The framed instructions shall be posted before acceptance testing of the system.

1.18 DELIVERY AND STORAGE:

A. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations. Damaged or defective items shall be replaced.

1.19 LOCKOUT OF ENERGY SOURCES:

A. Provide appropriate lockout devices for energy isolating valves and for machines or other equipment to prevent unexpected start-up or release of stored electrical, mechanical, hydraulic, pneumatic, thermal, chemical, or other energy in accordance with 29 CFR 1910.147. Lockout devices for valves shall provide a means of attachment to which, or through which, a lock can be affixed or shall have a locking mechanism built into it so that the valve cannot be moved from the lockout position until the lock is removed. Electrical isolation of machines or other equipment shall be in accordance with requirements of Division 16 "Electrical."

1.20 PROJECT RECORD DOCUMENTS

A. Maintain on site one set of the following record documents; record actual revisions to the work:

1. Drawings.
2. Specifications.
3. Addenda.
4. Change orders and other modifications to the contract, reviewed shop drawings, product data, and samples, manufacturer's instruction for assembly, installation, and adjusting.

B. Ensure entries are complete and accurate, enabling future reference by Owner.

C. Store record documents separate from documents used for construction.

D. Record information concurrent with construction progress.

E. Specifications: Legibly mark and record at each product section description of actual products installed, including the following:

1. Manufacturer's name and product model and number.
2. Product substitutions or alternates utilized.
3. Changes made by addenda and modifications.

F. Record Drawings and Shop Drawings: Legibly mark each item to record actual construction including:

1. Measured depths of foundations in relation to finish floor datum.
2. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
3. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
4. Field changes of dimensions and details.
5. Details not on original contract drawings.

G. Submit documents to Owner upon completion of project.

1.21 EQUIPMENT DRAINS

A. The contractor shall mount air-handling units on rails or bases as required to provide enough clearance for the condensate traps.

1.22 ENERGY CODE

A. The equipment installation and ductwork shall meet the requirements of the Florida Energy Code or as required by the specifications whichever is more stringent.

1.23 TRAINING/START UP

A. The contractor shall meet on the site after the job is complete and review the systems operation with the building manager and maintenance personnel. During the review the contractor shall verify that all system settings and timetables are satisfactory with the building manager.

END OF SECTION 15010

SECTION 15056 - COMMISSIONING HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC) SYSTEMS

1. GENERAL REQUIREMENTS: This section covers the commissioning of HVAC systems which are a part of this project. The purpose of commissioning is to bring the project HVAC system to a state of dynamic operation in accordance with the contract plans specifications by verifying the operation of individual components, subsystems, and systems.

   A. Tools and Equipment: The Contractor shall furnish all special tools and equipment required during the commissioning process. A list of tools and equipment to be used during commissioning shall be submitted for approval. The Government will furnish necessary utilities for the commissioning process.

2. COMMISSIONING DOCUMENTATION:

   A. The Contractor shall maintain the commissioning documentation in ring binders. The commissioning documentation shall be organized by system and subsystem when practicable. All pages shall be numbered and a table of contents page shall be provided. The commissioning documentation shall include, but not be limited to, the following.

      (1) Approved Test and Balance Report for the building (project) being commissioned.

      (2) All approved shop drawings of HVAC equipment to be commissioned. Shop drawings shall be full size sheets folded as required to fit in binders.

      (3) All pre-commissioning checklists initialed by indicated personnel organized by system and subsystem.

      (4) All functional performance test checklists signed by indicated personnel organized by system and subsystem.

      (5) Three copies of the Operation and Maintenance Manuals specified on other sections of these specifications shall be included with the Commissioning Documentation. The manuals shall be incorporated in the Commissioning Documentation prior to the commencement of the training required in this and other sections of the specifications.

      (6) When more than one item is listed on a submittal sheet then the Contractor shall Xerox the sheet as required to provide a sheet for each piece of equipment.

Preparation of Operation and Maintenance Manuals shall be as specified in other sections of these specifications.

   B. HVAC Shop Drawings and As Built Drawings and Specifications shall be assembled after completion of HVAC pre-commissioning phase and prepared as indicated above. Changes as a result of subsequent HVAC Commissioning procedures will be

incorporated (as required) at the conclusion of final HVAC Commissioning.

C. The Contractor shall be responsible for maintaining the commissioning documentation until final acceptance of the project. All checklists included in this section of the specifications shall become part of the commissioning documentation. The commissioning documentation shall be kept current by the Contractor and shall be available for inspection at all times. At the time of acceptance of the project, the Contractor shall furnish 3 copies of the commissioning documentation to the Contracting Officer.

3. COMMISSIONING SCHEDULE:

A. Phase 1 - Preliminary Commissioning: All HVAC shop drawings, including but not limited to equipment, controls, test and balance reports, operation and maintenance manuals, shall be submitted and approved by the Contracting Officer. In addition, all pre-commissioning checklists shall be completed (initialed by all parties).

B. Phase 2 - Functional Performance Testing shall be performed as indicated on the Functional Performance Test Checklists. Functional Performance Testing shall not begin until Phase 1 of the commissioning process is complete.

(1) Functional Performance Test Notification: The Contractor shall notify the Contracting Officer 2 weeks before functional performance testing is to begin.

C. Phase 3 - HVAC Training shall be conducted as indicated in the specifications for each item of equipment.

4. SYSTEM PERFORMANCE CRITERIA: All HVAC related equipment commissioned in this section of the specifications will be evaluated based on the sequences of operational/control and the equipment schedules. Sequences of equipment operation and control and design performance data shall be as specified for the equipment item in other sections of these specifications and on the contract drawings.

5. PRE-COMMISSIONING CHECKLISTS:

A. Pre-commissioning checklists shall be completed prior to the commencement of functional performance testing. The indicated initial is required in each location for all items, except where an "X" is shown indicating an initial is not required. See initials legend below for required initials. The pre-commissioning checklist will not be accepted as complete until all items have been initialed signifying this portion of the project is ready for Functional Performance Testing. The Contracting Officer's representative shall be the last person to initial each checklist item. The Contractor shall submit for approval a list of all Contractor and subcontractor representatives responsible for the completion of the pre-commissioning checklist phase of the project. This list of representatives shall be submitted 2 weeks prior to the installation of any HVAC equipment. Representatives may be replaced only after written approval from the

Contracting Officer.

(1) Initials Legend:

A - General Contractor's representative.
B - Mechanical Contractor's representative.
C - Electrical Contractor's representative.
D - Contracting Officer's representative.
E - Balancing Contractor's representative.
F - Controls Contractor's representative.

B. Blank pre-commissioning checklists are in Appendix 1 located at the end of this section of the specifications.

6. FUNCTIONAL PERFORMANCE TEST CHECKLIST:

A. Functional performance testing shall be performed by a commissioning team consisting of the individuals indicated on the Functional Performance Test Checklists. The Contractor shall submit in writing a list of all Contractor and subcontractor representatives responsible for the completion of the functional performance testing phase of the project. This list of representatives shall be submitted 2 weeks prior to commencement of functional performance testing of HVAC equipment. All representatives shall remain on the commissioning team throughout functional performance testing. Substitutions will not be permitted. Functional performance test checklists shall be completed in the presence of all commissioning team personnel at the time of the functional performance test.

(1) Upon failure of completion of a functional performance test checklist, the contractor shall provide a written report to the Contracting Officer listing the deficiencies causing the failure and remedies to correct all deficiencies. After the Contractor has corrected all deficiencies, the entire functional performance test checklist for the item of equipment shall be repeated. If possible, corrections can be accomplished during the functional performance testing of equipment in other non-related systems. In any case, no system will be accepted until all equipment items in the system have complete functional performance test checklists thereby demonstrating satisfactory performance.

(2) Failure to complete 3 functional performance test checklists constitutes failure of phase 2 of the HVAC commissioning process, however functional performance testing shall be continued to identify all failures. The Contractor shall provide a written report to the Contracting Officer listing the deficiencies causing all failures and remedies to correct all deficiencies. After correction of all deficiencies, phase 2 of the HVAC commissioning process shall be repeated in its entirety. The Contractor shall give the Contracting Officer 2 weeks notice before repeat functional performance testing is scheduled.

(a) In the event of a failure of the functional performance testing phase of the commissioning process as defined herein, the Contractor will be assessed charges to acquire Government personnel back on site for retesting observation. See SPECIAL CLAUSE paragraph entitled: HVAC COMMISSIONING FUNCTIONAL PERFORMANCE TESTING.

B. Blank functional performance test checklists are in Appendix 2 located at the end of this section of the specifications.

7. QUALITY CONTROL:

A. General: The Contractor shall establish and maintain quality control for operations under this section to assure compliance with contract requirements and maintain records of his quality control for all the activities listed hereinbefore. A complete quality control report shall be made of each of the activities outlined in this section of the specifications listing attendees, items discussed, deficiencies noted and corrective actions taken. The quality control reports for this section shall be made in duplicate so that one copy can be transmitted through quality control channels and the other made a part of the commissioning documentation.

COMMISSIONING HVAC SYSTEM

PARAGRAPH NUMBER	DESCRIPTION OF SUBMITTAL	TYPE OF SUBMITTAL (*) 1	2	3	4	5	6	7	TECH REVIEW BY
1.a	List of all tools and Equipment							XA	CO
2.a.	Commissioning Documentation							XB	CO
3.a.	HVAC shop drawings, equipment, controls, test/balance reports, operation/ maintenance manuals	X					X	XC	CO
5.a. & 6.a.	Contractor/ Subcontractor representatives							XD XE	CO
6.a.1	Deficiencies/ remedies report							XF	CO
7.a	Quality Control report							XG	CO

(*)1 =Shop Drawings
2 =Sample
3 =Guarantee
4 =Mfr's Data
5 =Certificate
6 =Test Report
7 =Other As Noted
CO = Contracting Officer
A = For Approval
I = For Information
XA = List of tools to be used for commissioning
XB = Three ring binder containing reports, drawings, checklists
XC = Maintenance and operation manuals
XD = List of contractor and subcontractor representatives responsible for completing pre-commissioning checklist
XE = List of contractor and subcontractor representatives responsible for completing performance testing
XF = Written report written report listing deficiencies and

remedies
XG = Quality control report-listing corrective actions and people who attended the meeting to determine the action.

APPENDIX 1

PRE-COMMISSIONING CHECKLISTS

INITIALS LEGEND

A - General Contractor's representative
B - Mechanical Contractor's representative
C - Electrical Contractor's representative
D - Contracting Officer's representative
E - Balancing Contractor's representative
F - Controls Contractor's representative

NOTE: "X" INDICATES THESE INITIALS NOT REQUIRED

1. PRE-COMMISSIONING CHECKLIST - DUCTWORK

For Air Handler:

CHECKLIST ITEM	A	B	C	D	E	F
Installation						
a. Ductwork complete.			X			X
b. As-built shop drawings submitted.			X			X
c. Ductwork insulated as required.			X			X
d. Access doors and panels installed.			X			X
Test and Balance						
a. Test and Balance operation complete.			X			

2. PRE-COMMISSIONING CHECKLIST - PUMPS

For Pump:

CHECKLIST ITEM	A	B	C	D	E	F
Installation						
a. Pumps grouted in place.			X		X	X
b. Pump vibration isolation devices functional.			X		X	X
c. Pump alignment verified.			X		X	X
d. Piping system installed.			X		X	X
e. Piping system pressure tested.			X		X	X
f. Pump not leaking.			X		X	X
Electrical						
a. Power available to pump disconnect.					X	X
b. Pump rotation verified.					X	X
c. Control system interlocks functional.					X	
Test & Balance						
a. Pressure/temperature gauges installed.			X			X
b. Piping system cleaned.			X		X	X
c. Chemical water treatment complete.			X		X	X
d. Water balance complete.			X			X
e. Water balance with design maximum flow.			X			X
f. Test and Balance Report submitted.			X			X

3. PRE-COMMISSIONING CHECKLIST - HVAC SYSTEM CONTROLS

For HVAC System:

CHECKLIST ITEM	A	B	C	D	E	F
Installation						
a. Layout of control panel matches drawings.			X		X	
b. Framed instructions mounted in or near control panel.			X		X	
c. Components properly labeled (on inside and outside of panel).			X		X	
d. Control components piped and/or wired to labeled terminal strip(s).			X		X	
e. Control wiring and tubing labeled at all terminations, splices, and junctions.			X		X	
g. Shielded wiring used on electronic sensors.			X		X	

4. PRE-COMMISSIONING CHECKLIST - FANS

For Fans:

CHECKLIST ITEM	A	B	C	D	E	F
Installation						
a. Fan installed correctly.			X			X
Electrical						
a. Power available to fan disconnect.					X	
b. Proper motor rotation verified.						X
Controls						
a. Control interlocks properly installed.					X	
b. Control interlocks operable.					X	
Test and Balance (T&B)						
a. T&B results +/- 10% cfm shown on drawing.			X			X
b. Test and Balance Report submitted.			X			X

5. PRE-COMMISSION CHECKLIST - DX AIR COOLED CONDENSING UNIT

For Condensing Unit:

CHECKLIST ITEM	A	B	C	D	E	F
Installation						
a. Condensing Unit in place with recommended service/air clearances.			X		X	X
b. Condensing Unit piped.			X		X	X
c. Refrigerant pipe leak tested.			X		X	X
Electrical						
a. Power available to unit disconnect.					X	X
b. Power available to unit control panel.						X
Controls						
a. Unit safety/protection devices tested.			X		X	
b. Control system and interlocks installed.			X		X	
c. Control system and interlocks operational			X		X	

6. PRE-COMMISSIONING CHECKLIST - SINGLE ZONE DX AIR HANDLING UNIT

For Air Handling Unit:

CHECKLIST ITEM	A	B	C	D	E	F
Installation						
a. Vibration isolation devices installed.			X		X	X
b. Access doors are operable and sealed.			X			X
c. Casing undamaged.			X		X	X
d. Insulation undamaged.			X		X	X
e. Condensate drainage is unobstructed.			X		X	X
f. Fan belt adjusted.			X			X
Electrical						
a. Power available to unit disconnect.					X	X
b. Power available to unit control panel.					X	
c. Power available to electric heating coil.					X	
d. Proper motor rotation verified.						X
Coils						
a. Refrigerant piping properly connected.			X		X	X
b. Refrigerant piping pressure tested.			X		X	X

7. PRE-COMMISSIONING CHECKLIST - SINGLE ZONE AIR HANDLING UNIT

For Air Handling Unit:

CHECKLIST ITEM	A	B	C	D	E	F
Controls						
a. Controls properly installed.			X			
b. Controls operable.			X			
Test and Balance (T&B)						
a. Construction filters removed and replaced.			X			X
b. T&B simulate 1/2 loaded filters.			X			X
c. T&B results +/- 5% cfm shown on drawings.			X			X
d. Test and Balance Report submitted.			X			X

8. PRE-COMMISSIONING CHECKLIST - CONSTANT VOLUME AIR HANDLING UNIT

For Air Handler:

CHECKLIST ITEM	A	B	C	D	E	F
Installation						
a. Vibration isolation devices installed as specified.			X		X	X
b. Inspection and access doors are operable and sealed.			X		X	X
c. Casing undamaged.			X		X	X
d. Insulation undamaged.			X		X	X
e. Condensate drainage is unobstructed. (Visually verify pan drains completely by pouring a cup of water into drain pan.			X		X	X
f. Fan belt adjusted.			X		X	X
g. Manufacturer's required maintenance clearance provided.			X		X	X
Electrical						
a. Power available to unit disconnect.						
b. Power available to unit control panel.						
c. Proper motor rotation verified.					X	
d. Verify that power disconnect is located within sight of the unit it controls.						
Controls						
a. Control valves/actuators properly installed.			X			

b.	Control valves/actuators operable.		X	
Coils				
a.	Chilled water piping properly connect.		X	X
b.	Chilled water piping pressure tested.		X	X X
c.	Hot water piping properly connected.		X	X
d.	Hot water piping pressure tested.		X	X X
e.	Air vents installed on water coils with shutoff valves as specified.		X	X X
f.	Any damage to coil fins has been repaired.		X	X X X
Testing, Adjusting, and Balancing (TAB)				
a.	Construction filters removed and replaced.		X	X X
b.	TAB report submitted.		X	X X
c.	TAB results within +10%/-0% of CFM shown on drawings.		X	X X
d.	TAB results for outside air intake within +10%/-0% of CFM shown on drawings.		X	X X

APPENDIX 2

FUNCTIONAL PERFORMANCE TEST CHECKLISTS

1. FUNCTIONAL PERFORMANCE TEST CHECKLIST - HVAC CONTROLS

The Contracting Officer will select HVAC control system to undergo functional performance testing. The number of control panels shall not exceed 4.

For HVAC system:

A. Functional Performance Test: Contractor shall verify operation of HVAC controls by performing the following tests:

1. Verify that controller is maintaining the setpoint by manually measuring the controlled variable with a thermometer, sling psychrometer, inclined manometer, etc.

2. Verify sensor/controller combination by manually measuring the controlled medium. Take readings from control panel display and compare readings taken manually. Record all readings.

SENSOR_____
MANUAL MEASUREMENT_____
PANEL READING VALUE_____

3. Verify system stability by changing the controller setpoint as follows:
a. Air Temperature - 10 degrees F
b. Water Temperature - 10 degrees F
c. Static Pressure - 10 percent of setpoint. The control system shall be observed for 10 minutes after the change in setpoint. Instability or excessive hunting will be unacceptable.

4. Verify interlock with other HVAC controls.

5. Verify interlock with fire alarm control panel.

B. Results:

1. Contractor shall record and submit results obtained in item 1 above to the Contracting Officer.

2. If specified equipment performance is not verified, Contractor shall report remedial action required and re-

schedule Functional Performance Test.

C. Certification:

We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

DATE: _____ Signature and Date

General Contractor's Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Balancing Contractor's Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Engineering Division's Representative _____

Air Force Representative _____

2. FUNCTIONAL PERFORMANCE TEST CHECKLIST - PUMPS

For Pump:

A. Activate pump start using control system commands (all possible combinations, on/auto, etc.). ON _____ AUTO_____ OFF _____

1. Verify pressure drop across strainer:

STRAINER INLET PRESSURE _____ psig

STRAINER OUTLET PRESSURE _____ psig

2. Verify pump inlet/outlet pressure reading, compare to Test and Balance report, pump design conditions, and pump manufacturer's performance.

	DESIGN	T&B	F.P.T
PUMP INLET PRESSURE (psig)	_____	_____	_____
PUMP OUTLET PRESSURE (psig)	_____	_____	_____

3. Operate pump at shut-off, 50% and 100% of scheduled flow. Plot test readings on pump curve.

	SHUT-OFF	50%	100%
PUMP INLET PRESSURE (psig)	_____	_____	_____
PUMP OUTLET PRESSURE (psig)	_____	_____	_____
PUMP FLOWRATE (gpm)	_____	_____	_____

B. Verify motor amperage each phase and voltage phase to phase and phase to ground.

	PHASE 1	PHASE 2	PHASE 3
AMPERAGE	_____	_____	_____
VOLTAGE	_____	_____	
VOLTAGE TO GROUND	_____	_____	_____

C. Check and report unusual vibration, noise, etc.

D. Results

1. Contractor shall record and submit results obtained in items 1 and 2 above to the Contracting Officer.

2. If specified equipment performance is not verified, Contractor shall report remedial action required and re-schedule Functional Performance Test.

E. Certification

We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

DATE: _____ Signature and Date

General Contractor's Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Balancing Contractor's Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Engineering Division's Representative _____

Air Force Representative _____

3. FUNCTIONAL PERFORMANCE TEST CHECKLIST - SINGLE ZONE AIR HANDLING UNIT

For Air Handling Unit:

A. Functional Performance Test: Contractor shall verify operation of air handling unit as per specification including the following:

1. Verify activation of air handling unit using control system command.

   ON_____ AUTO_____ OFF_____

2. The following sequence of control shall be verified during start-up:

   a. System safeties allow start if safety conditions are met._____

3. Normal day-time operation.

   a. Fan runs when set in on position._____

   b. Unit cycles to maintain space temperature setpoint. _____

4. Unoccupied mode.

   a. Verify space low limit protection operation as specified in sequence of operation._____

5. System shut down.

   a. Fan de-energizes._____

6. Verify cooling coil and heating coil operation by varying thermostat setpoint from cooling setpoint to heating setpoint and returning to cooling setpoint. _____

7. Verify unit shut down during fire event initiated by smoke/heat sensor._____

B. Results:

1. Contractor shall record and submit results obtained in item 1 above to the Contracting Officer.

2. If specified equipment performance is not verified, Contractor shall report remedial action required and re-schedule Functional Performance Test.

C. Certification

We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

DATE:_____ Signature and Date

General Contractor's Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Balancing Contractor's Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Engineering Division's Representative _____

Air Force Representative _____

4. FUNCTIONAL PERFORMANCE TEST CHECKLIST - AIR COOLED CONDENSING UNIT

For Condensing Unit:

A. Functional Performance Test: Contractor shall demonstrate operation of refrigeration system as per specifications including the following: Start building air handler to provide load for condensing unit. Activate controls system start sequence as follows.

1. Start Air Handling Unit. Verify control system energizes condensing unit start sequence._____

2. Shut-off air handling equipment to verify condensing unit de-energizes._____

3. Re-start air handling equipment 1 minute after condensing unit shut down. Verify condensing unit restart sequence. _____

B. Verify condensing unit amperage each phase and voltage phase to phase and phase to ground.

	PHASE 1	PHASE 2	PHASE 3
AMPERAGE	_____	_____	_____
VOLTAGE	_____	_____	_____
VOLTAGE	_____	_____	_____
VOLTAGE TO GROUND	_____	_____	_____

C. Record the following information:

AMBIENT TEMPERATURE_____F.

D. Check and report unusual vibration, noise, etc.
_____

E. Results:

1. Contractor shall record and submit results obtained in items 1, 2, 3, and 4 above to the Contracting Officer.

2. If specified equipment performance is not verified,

Contractor shall report remedial action required and re-schedule Functional Performance Test.

F. Certification:

We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

DATE:_____ Signature and Date

General Contractor's Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Balancing Contractor's Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Engineering Division's Representative _____

Air Force Representative _____

5. FUNCTIONAL PERFORMANCE TEST CHECKLIST - CONSTANT VOLUME AIR

Handling Unit For Air Handling Unit:

A. Functional Performance Test: Contractor shall verify operation of air handling unit as per specification including the following:

1. Verify activation of air handling unit using control system command. ON _____.

2. The following sequence of control shall be verified during start-up:
   a. All valves in normal position._____
   b. System safeties allow start if safety conditions are met._____

3. System shut down:
   a. All dampers in normal position._____
   b. All valves in normal position._____
   c. Fan de-energizes._____

4. Verify unit shut down during fire event initiated by smoke/heat sensors._____

B. Results

1. Contractor shall record and submit results obtained in item 1 above to the contracting officer.

2. If specified equipment performance is not verified, Contractor shall report remedial action required and re-submit Functional Performance Test.

C. Certification

We the undersigned have witnessed the above functional performance test and certify that the item tested has met the performance requirements in this section of the specifications.

DATE: _____ Signature and Date

General Contractor's Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Balancing Contractor's Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Engineering Division's Representative _____

Air Force Representative _____

END OF SECTION 15056

SECTION 15135 - GAGES AND METERS

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Pressure gages and Pressure gage taps.

B. Thermometers and thermometer wells.

C. Test plugs.

1.2 RELATED SECTIONS

A. Section 15010 - Mechanical General Requirements.

1.3 REFERENCES

A. ASME B40.1 Gages - Pressure Indicating Dial Type - Elastic Element.

B. ASTM E1 - Specification for ASTM Thermometers.

C. ASTM E77 - Verification and Calibration of Liquid-in-Glass Thermometers.

D. UL 393 - Indicating Pressure Gages for Fire and Protection Services.

E. UL 404 - Gages, Indicating Pressure, for Compressed Gas Service.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Product Data: Provide list which indicates use, operating range, total range and location for manufactured components.

C. Provide one test kit with gauges and thermometers as indicated in the specifications.

PART 2 PRODUCTS

2.1 PRESSURE GAGES

A. Gage: ASME B40.1, UL 393 UL 404, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
   1. Case: Cast aluminum with phosphor bronze bourdon tube.
   2. Size: 4-1/2 inch diameter.
   3. Mid-Scale Accuracy: One percent.
   4. Scale: Psi.

2.2 PRESSURE GAGE TAPPINGS

A. Gage Cock: Tee or lever handle, brass for maximum 150 psig.

B. Pulsation Damper: Pressure snubber, brass with 1/4 inch connections.

2.3 STEM TYPE THERMOMETERS

A. Thermometer: ASTM E1, adjustable angle, red appearing mercury, lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device.
   1. Size: 9 inch scale.
   2. Window: Clear Lexan.
   3. Stem: 3/4 inch NPT brass.
   4. Accuracy: ASTM E77 2 percent.
   5. Calibration: Degrees F.

2.4 DIAL THERMOMETERS

A. Thermometer: ASTM E1, stainless steel case, adjustable angle with front recalibration, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed lens, stainless steel stem.
   1. Size: 5 inch diameter dial.
   2. Lens: Clear Lexan.
   3. Accuracy: 1 percent.
   4. Calibration: Degrees F

2.5 THERMOMETER SUPPORTS

A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.

2.6 TEST PLUGS

A. Test Plug: 1/4 inch or 1/2 inch brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with neoprene core for temperatures up to 200 degrees F.

B. Test Kit: Carrying case, internally padded and fitted containing two 3-1/2 inch diameter pressure gages, two gage adapters with 1/8 inch probes, two 1-1/2 inch dial thermometers. The gauges for the test kit shall be the calibrationable type.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install all instruments and plugs in accordance with manufacturer's instructions.

B. Provide one pressure gage per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gage.

C. Install pressure gages with pulsation dampers. Provide gage cock to isolate each gage. Extend nipples to allow clearance from insulation.

D. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch for installation of thermometer sockets. Ensure sockets allow clearance from insulation.

E. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets.

F. Install gages and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

G. Adjust gages and thermometers to final angle, clean windows and lenses, and calibrate to zero.

H. Air duct thermometers shall have perforated stem guards and 45-degree adjustable duct flanges with locking mechanisms.

I. Thermometers shall have the ranges as indicated or to the following application table:

1. Mixed air temperature: 0 to 100 degrees F in 1-degree graduations.

2. Return air temperature: 0 to 100 degrees F in 1-degree graduations.

3. Cooling coil discharge temperature: 0 to 100 degrees in 1-degree F graduations.

4. Heating coil discharge temperature: 30 to 180 degrees in 2-degree F graduations.

5. Hydronic heating systems below 220 degrees F: 40 to 240 degrees F in 2-degree graduations.

6. Chilled water temperature: 0 to 100 degrees F in 1-degree F graduations.

7. Condenser water temperature: 40 to 140 degrees in 1-degree F graduations.

J. The gauges ranges shall go from zero pounds per square inch to 1.5 time maximum normal pressure of system or as indicated.

K. Provide one test kit with gauges and thermometers as specified.

END OF SECTION 15135

SECTION 15140 - SUPPORTS AND ANCHORS

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Pipe and equipment hangers and supports.

B. Equipment bases and supports.

C. Sleeves and seals.

D. Flashing and sealing equipment and pipe stacks.

1.2 RELATED SECTION

A. Section 15010 - General Mechanical Requirements.

1.3 REFERENCES

A. ASME B31.1 - Power Piping

B. ASME B31.2 - Fuel Gas Piping

C. ASME B31.5 - Refrigeration Piping

D. ASME B31.9 - Building Services Piping

E. ASTM F708 - Design and Installation of Rigid Pipe Hangers.

F. MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacture.

G. MSS SP69 - Pipe Hangers and Supports - Selection and Application.

H. MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

I. NFPA 13 - Installation of Sprinkler Systems.

J. NFPA 14 - Installation of Standpipe and Hose Systems

K. UL 203 - Pipe Hanger Equipment for Fire Protection Service

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Shop Drawings: Indicate system layout with location and detail of trapeze hangers.

C. Product Data: Provide manufacturers catalog data including load capacity and all features required by the specifications.

D. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.

E. Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

1.5 REGULATORY REQUIREMENTS

A. Conform to applicable code for support of piping.

B. Supports for Sprinkler Piping: In conformance with NFPA 13.

C. Supports for Standpipes: In conformance with NFPA 14.

PART 2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Fire Protection Piping:

1. Conform to NFPA 13 NFPA 14.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch): Malleable iron or Carbon steel, adjustable swivel, split ring.
3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
5. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
6. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
7. Vertical Support: Steel riser clamp.
8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
9. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

B. Plumbing Piping - DWV:

1. Conform to ASME B31.9 ASTM F708 MSS SP58 MSS SP69 MSS SP89.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron or Carbon steel, adjustable swivel, split ring.
3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.

4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
5. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
6. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
7. Vertical Support: Steel riser clamp.
8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
9. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

C. Plumbing Piping - Water:

1. Conform to ASME B31.9 ASTM F708 MSS SP58 MSS SP69 MSS SP89.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron or Carbon steel, adjustable swivel, split ring.
3. Hangers for Cold Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
4. Hangers for Hot Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
5. Hangers for Hot Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
6. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
7. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
8. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
9. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
10. Wall Support for Hot Pipe Sizes 6 Inches and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
11. Vertical Support: Steel riser clamp.
12. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
13. Floor Support for Hot Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
14. Floor Support for Hot Pipe Sizes 6 Inches and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
15. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

D. Hydronic Piping:

1. Conform to ASME B31.9 ASTM F708 MSS SP58 MSS SP69 MSS SP89.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron or Carbon steel, adjustable swivel, split ring.
3. Hangers for Cold Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.

4. Hangers for Hot Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
5. Hangers for Hot Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
6. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
7. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
8. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
9. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
10. Wall Support for Hot Pipe Sizes 6 Inches and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
11. Vertical Support: Steel riser clamp.
12. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
13. Floor Support for Hot Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
14. Floor Support for Hot Pipe Sizes 6 Inches and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
15. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

E. Steam and Steam Condensate Piping:

1. Conform to ASME B31.1 MSS SP58 MSS SP69 MSS SP89.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron or Carbon steel, adjustable swivel, split ring.
3. Hangers for Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
4. Hangers for Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
5. Multiple or Trapeze Hangers for Pipe Sizes to 4 inches: Steel channels with welded spacers and hanger rods.
6. Multiple or Trapeze Hangers for Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods; cast iron roll and stand.
7. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
8. Wall Support for Pipe Sizes 4 to 5 Inches: Welded steel bracket and wrought steel clamp.
9. Wall Support for Pipe Sizes 6 Inches and Over: Welded steel bracket and wrought steel clamp; adjustable steel yoke and cast iron roll.
10. Vertical Support: Steel riser clamp.
11. Floor Support for Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
12. Floor Support for Pipe Sizes 6 Inches and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
13. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

F. Refrigerant Piping:

1. Conform to ASME B31.5 MSS SP58 MSS SP69 MSS SP89.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch (13 to 38 mm): Malleable iron or Carbon steel, adjustable swivel, split ring.
3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
5. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
6. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
7. Vertical Support: Steel riser clamp.
8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
9. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.2 ACCESSORIES

A. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

2.3 INSERTS

A. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.4 FLASHING

A. Metal Flashing: 26 gage galvanized steel.

B. Metal Counterflashing: 22 gage galvanized steel.

C. Lead Flashing:
1.Waterproofing: 5 lb/sq ft sheet lead
2.Soundproofing: 1 lb/sq ft sheet lead.

D. Flexible Flashing: 47 mil thick sheet butyl; compatible with roofing.

E. Caps: Steel, 22 gage minimum; 16 gage at fire resistant elements.

2.5 EQUIPMENT CURBS

A. Fabrication: Welded 18 gage galvanized steel shell and base, mitered 3 inch cant, variable step as required to match roof insulation, 1-1/2 inch thick insulation, factory installed wood nailer.

2.6 SLEEVES

A. Sleeves for Pipes Through Non-fire Rated Floors: 18 gage galvanized steel.

B. Sleeves for Pipes Through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Schedule 40 galvanized steel pipe.

C. Sleeves for Pipes Through Fire Rated and Fire Resistive Floors and Walls, and Fire Proofing: Prefabricated fire rated sleeves including seals, UL listed.

D. Sleeves for Round Ductwork: Galvanized steel.

E. Sleeves for Rectangular Ductwork: Galvanized steel or wood.

F. Stuffing Insulation: Glass fiber type, non-combustible.

G. Sealant: Acrylic.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.2 INSERTS

A. Provide inserts for placement in concrete formwork.

B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

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

D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.3 PIPE HANGERS AND SUPPORTS

A. Support horizontal piping as scheduled or required by Code whichever is more strigent.

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

adjacent work.

C. Place hangers within 12 inches of each horizontal elbow.

D. Use hangers with 1-1/2 inch minimum vertical adjustment.

E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.

F. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.

G. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

H. Support riser piping independently of connected horizontal piping.

I. Provide copper plated hangers and supports for copper piping.

J. Design hangers for pipe movement without disengagement of supported pipe.

K. Coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

3.4 EQUIPMENT BASES AND SUPPORTS

A. Provide housekeeping pads of concrete, minimum 6 inches thick with reinforcement bars and extending 6 inches beyond supported equipment.

B. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.

C. Construct supports of steel members. Brace and fasten with flanges bolted to structure.

D. Provide rigid anchors for pipes after vibration isolation components are installed.

3.5 FLASHING

A. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.

B. Flash vent and soil pipes projecting 3 inches minimum above finished roof surface with lead worked one inch minimum into hub, 8 inches minimum clear on sides with 24 x 24 inches sheet size. For pipes through outside walls, turn flanges back into wall and calk, metal counterflash, and seal.

C. Seal floor drains watertight to adjacent materials.

D. Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms, installed in accordance with manufacturer's instructions for sound control.

E. Provide curbs for mechanical roof installations 14 inches minimum high above roofing surface. Flash and counterflash with sheet metal; seal watertight. Attach counterflashing mechanical equipment and lap base flashing on roof curbs. Flatten and solder joints.

F. Adjust storm collars tight to pipe with bolts; calk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.6 SLEEVES

A. Set sleeves in position in formwork. Provide reinforcing around sleeves.

Size sleeves large enough to allow for movement due to expansion and contraction minimum 1/4". Provide for continuous insulation wrapping.

B. Extend sleeves through floors one inch above finished floor level. Calk sleeves.

C. Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with stuffing insulation and calk. Provide close fitting metal collar or escutcheon covers at both sides of penetration.

D. Install chrome plated steel escutcheons at finished surfaces.

3.7 SCHEDULES

PIPE SIZE Inches	MAX. HANGER SPACING Feet	HANGER ROD DIAMETER Inches
1/2 to 1-1/4	6.5	3/8
1-1/2 to 2	10	3/8
2-1/2 to 3	10	1/2
4 to 6	10	5/8
8 to 12	14	7/8
14 and Over	20	1
PVC (All Sizes)	6	3/8

END OF SECTION 15140

SECTION 15190 - MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Nameplates.

B. Tags.

C. Stencils.

D. Pipe Markers.

1.2 RELATED SECTION

A. Section 15010 - General Mechanical Requirements.

1.3 REFERENCES

A. ASME A13.1 - Scheme for the Identification of Piping Systems.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Submit list of wording, symbols, letter size, and color coding for mechanical identification.

C. Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

D. Product Data: Provide manufacturers catalog literature for each product required.

E. Samples: Submit two labels and tags.

F. Manufacturer's Installation Instructions: Indicate special procedures, and installation.

1.5 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 15010.

B. Record actual locations of tagged valves.

PART 2 PRODUCTS

2.1 NAMEPLATES

A. Description: Laminated three-layer plastic with engraved white letters on dark contrasting background color.

2.2 TAGS

A. Plastic Tags: Laminated three-layer plastic with engraved white letters on dark contrasting background color. Tag size minimum 1-1/2 inch square.

********** OR *********

B. Metal Tags: Stainless Steel with stamped letters; tag size minimum 1-1/2 inch square with smooth edges.

C. Chart: Typewritten letter size list in anodized aluminum frame.

2.3 STENCILS

A. Stencils: With clean cut symbols and letters of following size:
   1. 3/4 to 3 inch Outside Diameter of Pipe: 8 inch long color field, ½ inch high letters.
   2. 3-1/2 to 8 inch Outside Diameter of Pipe: 12 inch long color field, 1-1/4 inch high letters.
   3. Over 8 inch Outside Diameter of Insulation or Pipe: 32 inch long color field, 3-1/2 inch high letters.
   4. Ductwork and Equipment: 2-1/2 inch high letters.

B. Stencil Paint: Semi- gloss enamel, colors conforming to ASME A13.1.

2.4 PIPE MARKERS

A. Color: Conform to ASME A13.1.

B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

D. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

2.5 CEILING TACKS

A. Description: Steel with 3/4 inch diameter color coded head.

B. Color code as follows:
1. Yellow - HVAC equipment
2. Red - Fire dampers/smoke dampers
3. Green - Plumbing valves
4. Blue - Heating/cooling valves

PART 3 EXECUTION

3.1 PREPARATION

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

B. Prepare surfaces in accordance with manufacturer's recommendations for stencil painting.

3.2 INSTALLATION

A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install tags with corrosion resistant chain.

C. Apply stencil painting in accordance with manufacturer's recommendations.

D. Install plastic pipe markers in accordance with manufacturer's instructions.

E. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.

F. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.

G. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with stencil painting. Small devices, such as in-line pumps, may be identified

with tags.

H. Identify control panels and major control components outside panels with plastic nameplates.

I. Identify thermostats relating to zones with nameplates.

J. Identify valves in main and branch piping with tags.

K. Identify air terminal unit valves with numbered tags.

L. Tag automatic controls, instruments, and relays. Key to control schematic.

M. Identify piping, concealed or exposed, with plastic pipe markers. Use tags on piping 3/4 inch diameter and smaller. Identify service, flow direction, and also pressure for steam piping. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure, enclosure, or obstruction.

N. Identify ductwork with stenciled painting. Identify air handling units with identification number and area served. Locate identification of ductwork at each side of penetration of structure, enclosure, or obstruction.

O. Provide ceiling tacks to locate valves or dampers above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION 15190

SECTION 15261 - PIPING INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Piping insulation.

B. Jackets and accessories.

1.2 RELATED SECTION

A. Section 15010 - General Mechanical Requirements

1.3 REFERENCES

A. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.

B. ASTM C177 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.

C. ASTM C518 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.

D. ASTM C195 - Mineral Fiber Thermal Insulation Cement.

E. ASTM C335 - Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.

F. ASTM C449 - Mineral Fiber Hydraulic-setting Thermal Insulating and Finishing Cement.

G. ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation.

H. ASTM C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

I. ASTM C547 - Mineral Fiber Preformed Pipe Insulation.

J. ASTM C552 - Cellular Glass Block and Pipe Thermal Insulation.

K. ASTM C640 - Corkboard and Cork Pipe Thermal Insulation.

L. ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.

M. ASTM D1056 - Flexible Cellular Materials - Sponge or Expanded Rubber.

N. ASTM E84 - Surface Burning Characteristics of Building Materials.

O. ASTM E96 - Water Vapor Transmission of Materials.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Product Data: Provide product description, list of materials and thickness for each service, and locations.

C. Manufacturer's Installation Instructions: Indicate procedures which ensure acceptable workmanship and installation standards will be achieved.

1.5 QUALITY ASSURANCE

A. Materials: Flame spread/smoke developed rating of 25/50 or less in accordance with ASTM E84.

1.6 QUALIFICATIONS

A. Applicator: Company specializing in performing the work of this section with minimum three years experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle products to site according to manufacturer's recommendations.

B. Deliver materials to site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

C. Store insulation in original wrapping and protect from weather and construction traffic.

D. Protect insulation against dirt, water, chemical, and mechanical damage.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.1 GLASS FIBER

A. Insulation: ASTM C547; rigid molded, noncombustible.
1. Maximum Thermal Conductivity: ASTM C335, 0.24 at 75 degrees F.

2. Minimum Service Temperature: -20 degrees F.
3. Maximum Service Temperature: 850 degrees F.
4. Maximum Moisture Absorption: 0.2 percent by volume.

B. Vapor Barrier Jacket
1. ASTM C921, White kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
2. Moisture Vapor Transmission: ASTM E96; 0.02 perm inches.
3. Secure with self sealing longitudinal laps and butt strips.
4. Secure with outward clinch expanding staples and vapor barrier mastic.

C. Tie Wire: 18 gage stainless steel with twisted ends on maximum 12 inch centers.

D. Vapor Barrier Lap Adhesive
1. Compatible with insulation.

E. Insulating Cement/Mastic
1. ASTM C195; hydraulic setting on mineral wool.

F. Fibrous Glass Fabric
1. Cloth: Untreated; 9 oz/sq yd weight.
2. Blanket: 1.0 lb/cu ft density.

G. Outdoor Vapor Barrier Mastic
1. Vinyl emulsion type acrylic, compatible with insulation, white color.

H. Insulating Cement
1. ASTM C449.

2.2 CELLULAR GLASS

A. Insulation: ASTM C552.
1. Maximum Thermal Conductivity 0.40 at 75 degrees F.
2. Maximum Water Vapor Transmission: 0.1 perm.

2.3 CELLULAR FOAM

A. Insulation: ASTM C534; flexible, cellular elastomeric, molded or sheet.
1. Maximum Thermal Conductivity ASTM C177 or C518; 0.28 at 75 degrees F.
2. Minimum Service Temperature: -20 degrees F.
3. Maximum Service Temperature: 220 degrees F.
4. Maximum Moisture Absorption: ASTM D1056; 1.0 percent (pipe) by volume, 1.0 percent (sheet) by volume.
5. Moisture Vapor Transmission: ASTM E96; 0.20 perm inches.
6. Maximum Flame Spread: ASTM E84; 25.
7. Maximum Smoke Developed: ASTM E84; 50.
8. Connection: Waterproof vapor barrier adhesive.

B. Elastomeric Foam Adhesive
   1. Air dried, contact adhesive, compatible with insulation.

2.4 JACKETS

A. PVC Plastic
   1. Jacket: ASTM C921, One piece molded type fitting covers and sheet material, off white color.
      a) Minimum Service Temperature: -20 degrees F.
      b) Maximum Service Temperature: 150 degrees F.
      c) Moisture Vapor Transmission: ASTM E96; 0.5 perm inches.
      d) Maximum Flame Spread: ASTM E84; 25.
      e) Maximum Smoke Developed: ASTM E84; 50.
      f) Thickness: 20 mil.
      g) Connections: Brush on welding adhesive.

   2. Covering Adhesive Mastic
      a) Compatible with insulation.

B. All Service Jacket: UL listed
   1. Fabric: Foil type with reinforcement.
   2. Lagging Adhesive
      a) Compatible with insulation.

C. Aluminum Jacket: ASTM B209.
   1. Thickness: 0.020 inch sheet.
   2. Finish: Smooth.
   3. Joining: Longitudinal slip joints and 2 inch laps.
   4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
   5. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that piping has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

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

B. On exposed piping, locate insulation and cover seams in least visible locations.

C. Insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature:

1. Provide vapor barrier jackets, factory applied or field applied.
2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe.
3. PVC fitting covers may be used.
4. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
5. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.

D. For insulated pipes conveying fluids above ambient temperature:
1. Provide standard jackets, with or without vapor barrier, factory applied or field applied.
2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe.
3. PVC fitting covers may be used.
4. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
5. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.

E. Inserts and Shields:
1. Application: Piping 2 inches diameter or larger.
2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
3. Insert Location: Between support shield and piping and under the finish jacket.
4. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
5. Insert Material: ASTM C640 cork, hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

F. Finish insulation at supports, protrusions, and interruptions.

G. For pipe exposed in mechanical equipment rooms or in finished spaces below 10 feet above finished floor, finish with all service jacket prepared for finish painting.

H. For exterior applications, provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

I. For heat traced piping, insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

3.3 PIPING INSULATION THICKNESS

	Tube And Pipe Size (Inches)

Service	Material	1/4-1 1/4	1 ½-3	3 ½-5	6-10	11-36
Chilled Water Supply & Return Piping (40EF Nominal)	Cellular Glass	1.5	2.0	2.0	2.0	3.0
Hot Domestic Water Supply and Recirculating Piping (Maximum 200EF)	Glass Fiber	1	1	1.5	1.5	1.5
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
Cold Domestic Water Piping Above & below Ceilings	Glass Fiber	0.75	1	1	1	1
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flexible cellular	0.5	0.5	0.5	N/A	N/A
Heating Hot Water (Supply & Return, Maximum 250EF)	Glass Fiber	1.5	1.5	2	2.5	3
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
Refrigerant Piping (35EF nominal)	Flexible cellular	0.5	N/A	N/A	N/A	N/A
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
A/C condensate Drain Located Inside Bldg.	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flexible cellular	0.5	0.5	0.5	N/A	N/A

END OF SECTION 15261

SECTION 15281 - EQUIPMENT INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Equipment insulation.

B. Covering.

1.2 RELATED SECTION

A. Section 15010 - General Mechanical Requirements.

1.3 REFERENCES

A. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.

B. ASTM C177 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.

C. ASTM C195 - Mineral Fiber Thermal Insulation Cement.

D. ASTM C335 - Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.

E. ASTM C518 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.

F. ASTM C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

G. ASTM C552 - Cellular Glass Block and Pipe Thermal Insulation.

H. ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.

I. ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.

J. ASTM D1056 - Flexible Cellular Materials - Sponge or Expanded Rubber.

K. ASTM E84 - Surface Burning Characteristics of Building Materials.

L. ASTM E96 - Water Vapor Transmission of Materials.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Product Data: Provide product description, list of materials and thickness for equipment scheduled.

C. Manufacturer's Installation Instructions: Indicate procedures which ensure acceptable workmanship and installation standards will be achieved.

1.5 QUALITY ASSURANCE

A. Materials: Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84.

1.6 QUALIFICATIONS

A. Applicator: Company specializing in performing the work of this section with minimum three years experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site as recommended by the manufacturer.

B. Deliver materials to site in original factory packaging, labeled with manufacturer's density and thickness.

C. Store insulation in original wrapping and protect from weather and construction traffic.

D. Protect insulation against dirt, water, chemical, and mechanical damage.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.1 GLASS FIBER, RIGID

A. Insulation: ASTM C612; rigid, noncombustible.
   1. Maximum Thermal Conductivity: ASTM C335, 0.24 per inch at 75 degrees F.
   2. Maximum service temperature: 450 degrees F.

3. Maximum moisture absorption: 5.0 percent by weight.
4. Density: 3.0 lb/cu ft.

B. Vapor Barrier Jacket
1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
2. Moisture vapor transmission: ASTM E96; 0.04 perm.
3. Secure with self sealing longitudinal laps and butt strips.
4. Secure with outward clinch expanding staples and vapor barrier mastic.

C. Facing: 1 inch galvanized steel hexagonal wire mesh stitched on one face of insulation.

D. Vapor Barrier Lap Adhesive
1. Compatible with insulation.

E. Insulating Cement/Mastic
1. ASTM C195; hydraulic setting on mineral wool.

2.2 CELLULAR GLASS

A. Insulation: ASTM C552.
1. Maximum Thermal Conductivity: 0.35 per inch at 75 degrees F.
2. Density: 8.0 lb/cu ft.

2.3 CELLULAR FOAM

A. Insulation: ASTM C534; flexible, cellular elastomeric, molded or sheet.
1. Maximum Thermal Conductivity: ASTM C177 or C518; 0.28 per inch at 75 degrees F.
2. Minimum service temperature: -40 degrees F.
3. Maximum service temperature: 220 degrees F.
4. Maximum moisture absorption: ASTM D1056; 1.0 percent (pipe) by volume, 1.0 percent (sheet) by volume.
5. Moisture vapor transmission: ASTM E96; 0.20 perm inches.
6. Maximum flame spread: ASTM E84; 25.
7. Maximum smoke developed: ASTM E84; 50.
8. Connection: Waterproof vapor barrier adhesive.

B. Elastomeric Foam Adhesive
1. Air dried, contact adhesive, compatible with insulation.

2.4 JACKETS

A. PVC Plastic
1. Jacket: ASTM C921, Sheet material, off white color.

a) Minimum service temperature: -40 degrees F.
b) Maximum service temperature: 150 degrees
c) Moisture vapor transmission: ASTM E96; 0.2 perm inches.
d) Maximum flame spread: ASTM E84; 25.
e) Maximum smoke developed: ASTM E84; 50.
f) Thickness: 20 mil.
g) Connections: Brush on welding adhesive.

2. Covering Adhesive Mastic
   a) Compatible with insulation.

B. All Service Jacket: UL listed
   1. Fabric: Foil type with reinforcement.
   2. Lagging Adhesive
      a) Compatible with insulation.

C. Aluminum Jacket: ASTM B209.
   1. Thickness: 0.024 inch sheet.
   2. Finish: Smooth.
   3. Joining: Longitudinal slip joints and 2 inch laps.
   4. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.

D. Stainless Steel Jacket: Type 316 stainless steel.
   1. Thickness: 0.016 inch.
   2. Finish: Smooth. Corrugated.
   3. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that equipment has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

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

B. Do not insulate factory insulated equipment.

C. On exposed equipment, locate insulation and cover seams in least visible locations.

D. Finish insulation at supports, protrusions, and interruptions.

E. For exterior applications, cover with aluminum jacket with seams located on bottom side of horizontal equipment.

F. Do not insulate over nameplate or ASME stamps. Bevel and seal insulation around such.

G. Install insulation for equipment requiring access for maintenance, repair, or cleaning, in such a manner that it can be easily removed and replaced without damage.

H. Insulate pumps used for hot service with 2-inch thick preformed rigid glass mineral fiber insulation and pumps used for chilled water service with 2-inch thick cellular glass insulation. Insulate pumps by forming a box around pump housing, drive shaft, and piping. Apply insulation to inside surfaces of 20-gage galvanized sheet-metal boxes having openings for drive shaft and pipes. Construct box by forming bottom and sides using joints which do not leave raw ends of insulation exposed. Band bottom and sides to form a rigid housing that does not rest on pump. Between top cover and sides, fit joints tightly forming a female shiplap joint on side pieces and a male joint on top cover to make top cover removable. Secure insulation to box with adhesive. Allow clearance for draining and adjustment of pump shaft seal.

I. On equipment operating at less than ambient temperature provide vapor barrier.

J. Provide canvas jackets on all inside equipment sized for painting for all cellular glass and rigid glass fiber insulation.

3.3 CELLULAR FOAM

EQUIPMENT	THICKNESS Inch
A. Heating Systems	
Air Separators	3/4"
Expansion Tanks	3/4"
B. Cooling Systems	
Water Storage Tank	1"
Air Separators	1"
Expansion Tanks	1"
Chiller Cold Surfaces (Not Factory Insulated)	1"

3.4 GLASS FIBER, RIGID

EQUIPMENT	THICKNESS Inch
A. Air Handlers (Not Factory Insulated)	1"

END OF SECTION 15281

SECTION 15291 - DUCTWORK INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Ductwork insulation.

B. Insulation jackets.

1.2 RELATED SECTIONS

A. Section 15010 - General Mechanical Requirements.

1.3 REFERENCES

A. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.

B. ASTM C518 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.

C. ASTM C553 - Mineral Fiber Blanket and Felt Insulation.

D. ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.

E. ASTM E84 - Surface Burning Characteristics of Building Materials.

F. ASTM E96 - Water Vapor Transmission of Materials.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Product Data: Provide product description, list of materials and thickness for each service, and locations.

C. Manufacturer's Installation Instructions: Indicate procedures which ensure acceptable workmanship and installation standards will be achieved.

1.5 QUALITY ASSURANCE

A. Materials: Flame spread/smoke developed rating shall not exceed 25/50 in accordance with ASTM E84.

1.6 QUALIFICATIONS

A. Applicator: Company specializing in performing the work of this section with minimum three years experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site according to the manufacturer's recommendations.

B. Deliver materials to site in original factory packaging, labeled with manufacturer's density and thickness.

C. Store insulation in original wrapping and protect from weather and construction traffic.

D. Protect insulation against dirt, water, chemical, and mechanical damage.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.1 GLASS FIBER, FLEXIBLE

A. Insulation: ASTM C553; flexible, noncombustible blanket.
1. Maximum Thermal Conductivity: ASTM C518, 0.29 per inch at 75 degrees F.
2. Maximum service temperature: 250 degrees F.
3. Maximum moisture absorption: 5 percent by weight.

B. Vapor Barrier Jacket
1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
2. Moisture vapor transmission: ASTM E96; 0.04 perm.
3. Secure with pressure sensitive tape.

C. Vapor Barrier Tape
1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

D. Tie Wire: Annealed steel, 16 gage.

2.2 GLASS FIBER, RIGID

A. Insulation: ASTM C612; rigid, noncombustible board.
1. Maximum Thermal Conductivity: ASTM C518, 0.23 per inch at 75 degrees F.
2. Maximum service temperature: 250 degrees F.
3. Maximum moisture absorption: 5 percent by weight.
4. Density: 3.0 lb/cu ft.

B. Vapor Barrier Jacket
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
   2. Moisture vapor transmission: ASTM E96; 0.04 perm.
   3. Secure with pressure sensitive tape.

C. Vapor Barrier Tape
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

2.3 JACKETS

A. All Purpose Jacket: UL listed
   1. Fabric: Foil type with reinforcement.

   2. Lagging Adhesive
      a) Compatible with insulation.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that ductwork has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

A. Install materials in accordance with manufacturer's instructions. All insulation shall be installed on the exterior of ducts.

B. Insulated ductwork conveying air below ambient temperature:
   1. Provide insulation with vapor barrier jackets.
   2. Finish with tape and vapor barrier jacket.
   3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
   4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, expansion joints, and the backside of air devices.

C. Insulated ductwork conveying air above ambient temperature:
   1. Provide with or without standard vapor barrier jacket.
   2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

D. For ductwork exposed in mechanical equipment rooms or in finished spaces below 10 feet above finished floor, finish with jacket ready for finish painting.

E. For exterior applications, provide insulation with vapor barrier jacket. Cover with calked aluminum jacket with seams located on bottom side of horizontal duct section.

F. External Duct Insulation Application:
1. Secure insulation with vapour barrier with wires and seal jacket joints with vapour barrier adhesive or tape to match jacket.
2. Secure insulation without vapour barrier with staples, tape, or wires.
3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers.
4. Seal vapour barrier penetrations by mechanical fasteners with vapour barrier adhesive.
5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

3.3 GLASS FIBER DUCTWORK INSULATION SCHEDULE

A. The insulation value shall meet the energy code requirements or the following which ever is most stringent.

	THICKNESS Inch	DENSITY Lbs/Ft^3	TYPE
Supply and Return Ducts			
	2"	1.0	Flex
	1 1/2"	3.0	Rigid
Exhaust Ducts			
	1 1/2"	.75	Flex
	1"	3.0	Rigid
Outside Air Intake Ducts			
	1 1/2"	.75	Flex
	1"	3.0	Rigid

END OF SECTION 15291

SECTION 15325 - WET PIPE SPRINKLER SYSTEM

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Wet-pipe sprinkler system.

B. System design, installation, and certification.

C. Fire department connections.

1.2 RELATED SECTIONS

A. Section 15010 - "Mechanical General Requirements".

1.3 REFERENCES

A. NFPA 13 - Installation of Sprinkler Systems.

B. FM - Factory Mutual Approval Guide.

C. UL - Fire Resistance Directory.

1.4 SYSTEM DESCRIPTION

A. System to provide coverage for area of building as shown.

B. Provide system according to NFPA 13.

C. Water flow test data given on drawings is preliminary.

D. Interface system with building fire alarm system.

E. Provide fire department connections where indicated.

F. Contractor to conduct water flow test to obtain flow and pressure data before hydraulic calculations are performed and shop drawings are prepared and submitted. Contractor to fax Engineer copy of flow test immediately if less than values given on drawings.

1.5 SUBMITTALS FOR REVIEW

A. Section 15010 - Mechanical General Requirements.

B. Qualifications of Installer: Prior to installation submit the following for 3 jobs; name of jobs, short description of jobs, locations, and current person with phone number at the job site which would be knowledgeable of the system. Two of the three jobs must have been in for a minimum of 4 years.

C. Product Data: Provide data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections. The product data shall be marked for easy cross reference to drawings.

D. Shop Drawings:
   1. Submit working plans as required in Chapter 6 of NFPA 13. The plans shall have manufacturer's part numbers on the drawings so they can be referenced to the product data submitted.
   2. Submit hydraulic calculations, which will be the summary sheet and detailed pipe input.

E. Submit plans and hydraulic calculations to authority having jurisdiction for approval. Submit proof of approval to Architect/Engineer.

1.6 SUBMITTALS AT PROJECT CLOSEOUT

A. Section 15010 for record drawings, operation and maintenance data, procedures for submittals.

B. Project Record Documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and test locations. The record drawings shall be not smaller than 24" x 30" reproducible drawings on Mylar film.

C. Manufacturer's Certificate: Certify that system has been tested and meets or exceeds code requirements.

D. Operation and Maintenance Data: Include components of system, servicing requirements, record drawings, inspection data, replacement part numbers and availability, and location and numbers of service depot.

E. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.7 QUALITY ASSURANCE

A. Perform Work in accordance with NFPA 13. In the NFPA publications referred to herein, the advisory provisions shall be considered to be mandatory, as though the work "shall" have been substituted for "should" wherever it appears; reference to the "authority having jurisdiction" shall be interpreted to mean the Design Engineer and Local Fire Marshall.

B. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

C. Installer Qualifications: Company specializing in performing the work of this section with minimum five years documented experience.

D. Design system under direct supervision of a Professional Engineer experienced in design of this Work and licensed in the State of Florida.

1.8 REGULATORY REQUIREMENTS

A. Conform to UL and FM.

B. Perform Work in accordance with NFPA 13.

C. Equipment and Components: Bear UL, FM label or marking.

D. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.9 DELIVERY, STORAGE, AND PROTECTION

A. Store products in shipping containers and maintain in place until installation. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

1.10 EXTRA MATERIALS

A. Provide extra sprinklers under provisions of NFPA 13.

B. Provide suitable wrenches for each sprinkler type.

C. Provide metal storage cabinet at the riser.

PART 2 PRODUCTS

2.1 SPRINKLERS

A. Suspended Ceiling:
1. Type: Standard pendant type with matching clamp on escutcheon plate.
2. Finish: Chrome plated.
3. Escutcheon Plate Finish: Chrome plated.
4. Fusible Link: Glass bulb type temperature rated for specific area hazard.

B. Exposed Area Type:
1. Type: Standard upright type with guard.
2. Finish: Chrome plated.
3. Fusible Link: Glass bulb type temperature rated for specific area hazard.

C. Sidewall Type:
1. Type: Standard horizontal sidewall type with matching clamp on escutcheon plate.
2. Finish: Chrome plated.
3. Escutcheon Plate Finish: Chrome plated.
4. Fusible Link: Glass bulb type temperature rated for specific area hazard.

D. Guards: Finish to match sprinkler finish.

2.2 PIPING SPECIALTIES

A. Wet Pipe Sprinkler Riser Check Valve: Check type valve with resilient elastomer non-stick seal, with pressure trim; with test and drain valve.

B. Water Flow Alarm: Electrically operated, exterior mounted, water flow alarm bell shall be provided and installed in accordance with NFPA 13. Water flow alarm bell shall be rated 24 VDC and shall be connected to the Fire Alarm Control Panel (FACP).

C. Water Flow Switch: Vane type switch for mounting horizontal or vertical, with two contacts; rated 10 amps at 125 volt AC.

D. Fire Department Connections:
   1. Type: Flush mounted wall type with chrome plated finish.
   2. Outlets: Two way with thread size to suit fire department hardware; threaded dust cap and chain of matching material and finish.
   3. Drain: 3/4 inch automatic drip, outside.
   4. Label: "Sprinkler - Fire Department Connection".

E. Gauges: Shall be 3-1/2" dial type and shall conform to ANSI B40.1.

F. Monitoring: Valves shall have supervisory contact unit to interface with alarm system.

G. Sprinkler Pipe and Fittings: NFPA 13. Fittings into which sprinkler heads, sprinkler head riser nipples, or drop nipples are threaded shall be welded, threaded, or grooved-end type. Use of plain-end fittings with mechanical couplings (which utilize steel gripping devices to bite into the pipe when pressure is applied) will not be permitted. Rubber gasketed grooved-end pipe and fittings with mechanical couplings shall be permitted in pipe sizes 1.25 inches and larger; fittings shall be UL listed or FM approved for use in sprinkler systems.

H. Identification Signs: Attach properly lettered approved metal signs conforming to NFPA 13 to each valve and alarm device. Permanently affix hydraulic design date nameplates to the riser of each system.

I. Inspector's Test Connection: Provide test connections about 6 feet above the floor for sprinkler system of portion of sprinkler system equipped with an alarm device. Provide test connection piping to a location where the discharge will be readily visible and where water may be discharged without damage.

J. Pipe Sleeves: Provide where piping passes through walls, floors, roofs, and partitions. Secure sleeves in proper position and location. Provide sleeves of sufficient length to pass through entire thickness of walls, floors, roofs, and partitions. Provide not less than 0.25-inch space between exterior of piping or pipe insulation and interior of sleeve. Firmly pack space with insulation and calk at both ends of the sleeve with plastic waterproof cement which will dry to a firm but pliable mass, or provide a segmented elastomeric seal.

   1. Sleeves in Masonry and Concrete Walls, Floors, and Roofs: Provide ASTM A 53 or ASTM A 120, Schedule 40 or Standard Weight, zinc-coated steel pipe sleeves. Extend sleeves in floor slabs 3 inches above the finished floor.
   2. Sleeves in Partitions and Other Than Masonry and Concrete Walls and Floors and Roofs: Provide zinc-coated steel sheet having a nominal weight of not less than 0.9 pounds per square foot.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with NFPA 13.

B. Install equipment in accordance with manufacturer’s instructions.

C. Provide approved double check valve backflow preventer assembly at sprinkler system water source connection. See civil specifications.

D. Locate fire department connection with sufficient clearance from walls, obstructions, or adjacent Siamese connectors to allow full swing of fire department wrench handle.

E. Locate outside alarm gong on building wall.

F. Place pipe runs to minimize obstruction to other work.

G. Place piping in concealed spaces above finished ceilings.

H. Center sprinklers in one direction only in ceiling tile with location in other direction variable, dependent upon spacing and coordination with ceiling elements.

I. Apply masking tape or paper cover to ensure concealed sprinklers, cover plates, and sprinkler escutcheons do not receive field paint finish. Remove after painting.

J. Disinfection: Disinfect the new water piping affected by Contractor's operations in accordance with AWWA C601. Fill the piping systems with solution containing minimum of 50 parts per million of available chlorine and allow solution to stand for minimum of 24 hours. Flush the solution from the systems with clean water until maximum residual chlorine content is not greater than 0.2 parts per million.

K. Field Testing and Flushing:
   1. Preliminary Tests: Hydrostatically test system at 200 psig for a period of 2 hours. Flush piping in accordance with NFPA 13. Piping above suspended ceiling shall be tested, inspected, and approved before installation of ceilings. Test the alarms and other devices. Test the water flow alarms by flowing water through the inspector's test connection. When test have been completed and corrections made, submit a signed and dated certificate, similar to that specified in NFPA 13, with a request for a formal inspection and tests.

   2. Formal Inspection and Tests: The authority having jurisdiction and Architect/Engineer will witness formal tests and approve system before they are accepted. Submit the request for formal inspection at least 15 days prior to the date the inspection is to take place. An experienced technician regularly employed by the sprinkler installer shall be present during the inspection. At this inspection, repeat any or all of the required tests as directed. Correct defects in the work provided by the Contractor, and make additional tests until it has been demonstrated that the systems comply with all contract requirements. Furnish appliances, equipment, electricity, instruments, connecting devices, and personnel for the tests.

3.2 INTERFACE WITH OTHER PRODUCTS

A. The required devices shall be provided, installed and connected as required to interface with the fire alarm system by this Contractor.

END OF SECTION 15325

SECTION 15400 - PLUMBING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. SCOPE

1. The work covered by this section of the specification consists of providing all materials, labor and equipment required for a complete plumbing installation in accordance with the drawings and specifications, together with items reasonably inferred, including installation of equipment as noted. The intent of the specifications is to include everything necessary for the completion of the work with the materials best adapted to the purpose. Even though every item of the work of materials involved is not shown on the drawings or not particularly mentioned, the Contractor shall furnish same and execute the work to the entire satisfaction and approval of the Architect.

2. The work includes the following items but is not necessarily limited to these:

a. All drain, waste and vent piping for complete sanitary sewer system as shown on the plumbing drawings.

b. All storm drainage piping, rainleaders, roof drain, downspout shoe, etc. for complete storm drainage system as shown on the drawings.

c. All water piping including connecting into water service five feet from building and extending to new fixtures as shown on the drawings.

d. All materials, equipment, fixtures, insulation, accessories and trim, as shown, specified and/or required to make a complete usable and finished installation.

e. Necessary trenching and backfilling to install the plumbing system.

f.All insulation as specified herein.

g. All gas piping including connecting into the utility company's gas service and extending to equipment as shown on the drawings.

h. Rough-in, gas, water, sewer and etc. for equipment furnished by others.

1.2 RELATED SECTION

A. Section 15010 - "General Mechanical Requirements".

1.3 REFERENCES

A. ASME - Boiler and Pressure Vessel Code.

B. ASME Sec. 9 - Welding and Brazing Qualifications.

C. ASME A112.6.1M - Supports for the Off-the-Floor Plumbing Fixtures for Public Use.

D. ASME A112.18.1M - Plumbing Fixture Fittings.

E. ASME A112.19.2M - Vitreous China Plumbing Fixtures.

F. ASME A112.19.3M - Stainless Steel Plumbing Fixtures (Designed for Residential Use).

G. ASME A112.19.5 - Trim for Water-Closet Bowls, Tanks, and Urinals.

H. ASME A112.21.1M - Floor Drains.

I . ASME A112.21.2M - Roof Drains.

J. ASME B16.18 - Cast Bronze Solder-Joint Pressure Fittings.

K. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

L. ASME B31.1 - Power Piping.

M. ANSI A13.1 - Scheme for the Identification of Piping Systems.

N. ANSI Z21.22 - Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems.

O. ASTM A 53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.

P. ASTM A 536 - Ductile Iron Castings.

Q. ASTM B 32 - Solder Metal.

R. ASTM B 88 - Seamless Copper Water Tube.

S. ASTM D 1785 - Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

T. ASTM D 2241 - Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR).

U. ASTM D 2466 - Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.

V. ASTM D 2564 - Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.

W. ASTM D 2665 - Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.

X. ASTM D 2855 - Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.

Y. ASTM F 441 - Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.

Z. AWWA C110 - Ductile - Iron and Gray - Iron Fittings 3 in. through 48 in., for Water and Other Liquids.

AA. AWWA C111- Rubber-Gasket Joints for Ductile Iron and Gray-Iron Pressure Pipe and Fittings.

BB. AWWA C500 - Gate Valves for Water and Sewerage Systems.

CC. AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.

DD. AWWA C606 - Grooved and Shouldered Joints.

EE. AWWA C651 - Disinfecting Water Mains.

FF. AWWA C701 - Cold-Water Meters - Turbine Type, for Customer Service.

GG. ARI 1010 - Drinking Fountains, and Self-Contained, Mechanically Refrigerated Drinking-Water Coolers.

HH. ASSE 1019 - Wall Hydrants, Frost Proof Automatic Draining, Anti-Backflow Types.

II. API Spec 6D - Specification for Pipeline Valves (Gate, Plug, Ball, and Check Valves).

JJ. CDA-01 - Handbook: Copper in Architecture.

KK. Florida Building Code – Gas.

LL. Florida Building Code – Plumbing.

MM. FS WW-U-516 - Unions, Brass or Bronze, Threaded Pipe Connections and Solder-Joint Tube Connections.

NN. MIL-T-27730 - Tape, Antiseize, Polytetrafluoroethylene, with Dispenser.

OO. MSS SP-58 - Pipe Hangers and Supports - Materials, Design and Manufacture.

PP. MSS SP-70 - Cast Iron Gate Valves, Flanged and Threaded Ends.

QQ. MSS SP-78 - Cast Iron Plug Valves, Flanged and Threaded Ends.

RR. MSS SP-80 - Bronze Gate, Globe, Angle and Check Valves.

SS. PDI G101 - Testing and Rating Procedure for Grease Interceptors.

TT. PDI WH201 - Water Hammer Arrestors.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010, "General Mechanical Requirements".

B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.

1.5 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 15010, "General Mechanical Requirements".

1.6 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 15010, "General Mechanical Requirements".

B. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.7 QUALITY ASSURANCE

A. Manufacturer's name and pressure rating if applicable marked on each item.

B. Welding Materials and Procedures: Conform to ASME Sec. 9.

C. Welders Certification: In accordance with ASME B31.1.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing the work of this section with minimum three years documented experience.

1.9 REGULATORY REQUIREMENTS

A. The Contractor shall comply with all legal regulations that may be necessary for fully completing the work. When the Contractor finds the specifications and/or drawings to be in conflict or not clear, or any portion to be in conflict with any applicable code or regulation, same shall be brought to the attention of the Architect prior to submitting a bid. All work in this section shall be in compliance with the Florida Building Code – Plumbing, the State of Florida Department of Health, Chapter 64E-6, Florida Administrative Code, and the Florida Building Code - Gas. Latest approved edition.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site according to the manufacturer's recommendations.

B. Accept equipment on site in shipping containers with labeling in place. Inspect for damage.

C. Plumbing fixtures and trim shall be protected against damage or injury due to building materials, acid, tools, equipment or any causes incidental to construction. The finished surface of each fixture shall be covered with building paper or similar protection and the fixtures encased in wood box or crate. Chromium-plated surfaces shall be covered to protect their polish. All fixtures damaged by any cause and any trim marred or scratched shall be replaced at no cost to the Owner. The fixture protections shall be removed and fixtures thoroughly cleaned by the Contractor and shall be ready for use by the Owner.

D. All pipe openings shall be enclosed with plugs or caps during construction. The plugs or caps shall be installed when the pipe is roughed in and shall not be removed until final connections are made. Plugs or caps shall be substantial enough to withstand the test pressures of the system as specified herein.

1.11 ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding are wet or frozen.

1.12 CONNECTIONS

A. Contractor shall contact the Local Utility Companies, prior to submitting a bid, and obtain tap-on information, pay for all permits, fees meter, tap-on fees, main extensions, final connection charges, any and all charges by the gas company, and perform or pay for all work involved to obtain necessary services. All work required shall be done or paid for by this Contractor at not cost to the Owner.

1.13 SITE INSPECTION

A. Before submitting proposals, each bidder shall visit the site and fully familiarize himself with all job conditions and shall be fully informed as to the extent of his work. No consideration will be given after bid opening date of alleged misunderstanding as to the requirements of work involved or as to requirements of materials to be furnished.

1.14 COORDINATION

A. To avoid confusion and in the interest of clearness of the mechanical drawings, the work is not always shown to scale or exact location. The Contractor must check all measurements and locations of pipe, fittings, and equipment with the details and architectural drawings and lay out his work at the building, so that all parts of his work

will fit in with other parts of the building. Normally, ductwork and lighting fixtures shall have priority over plumbing lines, except where absolutely necessary for grading purposes.

B. The drawings and specifications shall be considered as supplementary, one to the other, so that materials and labor indicated, called for or implied by the one and not by the other, shall be supplied and installed as though specifically called for by both.

C. This Contractor shall lay out and proceed with his work so that this work will be executed in harmony with all other crafts pertaining to the building. Should any doubt arise as to the meaning of the drawings or specifications, this Contractor shall first obtain the decision of the Architect before proceeding with such work as may be affected. This Contractor shall work in harmony with all other Contractors and trades on the job and install his work as fast as the progress of the job will permit.

PART 2 PRODUCTS

2.1 WATER PIPING, BURIED BEYOND 5 FEET OF BUILDING

A. PVC Pipe: ASTM D 1785, Schedule 40, or ASTM D 2241, SDR-26 for not less than 150 psig pressure rating.
1. Fittings: ASTM D 2466, PVC.
2. Joints: ASTM D 2855, solvent weld with ASTM D 2564 Solvent cement.

2.2 WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

A. Copper Tubing: ASTM B 88, Type K, soft.
1. Fittings: ASME B16.18, cast bronze or ASME B16.22 wrought copper and bronze.
2. Joints: ASTM B 32, solder, Grade 95 tin-antimony.

2.3 WATER PIPING, ABOVE GRADE

A. Copper Tubing: ASTM B 88, Type L, hard drawn.
1. Fittings: ASME B16.18, cast bronze, or ASME B16.22, wrought copper and bronze.
2. Joints: ASTM B 32, solder, Grade 95 tin-antimony.

2.4 MATERIALS

A. Labels: All piping shall be labeled in accordance with ANSI A13.1. Arrows shall be used to indicate direction of flow.

B. Unions brass or bronze FS WW-U-516.

2.5 DRAIN WASTE AND VENT PIPING

A. Above Ground:

1. Polyvinyl chloride plastic pipe (PVC); Type DWV; PVC plastic type DWV socket-type fitting, solvent cement joints.

B. Underground Building Drain Piping (within 5 feet of the building):

1. Pipe Size 6" and Smaller: Polyvinyl chloride sewer pipe (PVC); Type DWV; PVC plaster type DWV socket-type conforming to ASTM D 2665.

4. Sanitary sewer piping outside the building shall be as indicated in above.

2.6 GAS PIPING

A. Pipe Size 2" and Smaller: Black steel pipe; Schedule 40, malleable-iron threaded fittings.

B. Gas piping and fittings underground shall be protected with Barrett Primer, hot pipeline enamel, asphalt felt wrapping, hot piping asphalt enamel

2.7 RESTRAINED JOINTS

A. The restrained joints shall be retainer glands with setscrews or wedging type follower. The setscrew mechanical joint retainer glands shall be cast from ductile iron no less than grade 70-50-5 and shall comply with all applicable provisions of AWWA C110 and AWWA C111. Setscrew shall be 5/8-11 NC thread with square head and knurled cup-point made of 4140 steel and shall be hardened to Rockwell "C" scale 45-47. The wedging mechanical joint retainer glands shall be cast from ductile iron conforming to ASTM A 536 and shall comply with all applicable provisions of AWWA C111. The restraining wedge shall be ductile iron heat treated to a minimum hardness of 370 BHN. The joints shall be Factory Mutual (FM) approved and Underwriters Laboratories (UL) listed. The maximum allowable deflection shall be as given in AWWA C600.

B. Pipe Joint Materials: Joints and gaskets materials shall conform to the following:

1. Coupling for Steel Pipe: AWWA C606.

2.8 SOLDER FLUX

A. Flux shall be liquid form, non-corrosive, and in conformance with CDA-01, Standard Test 1.

2.9 JOINT TAPE

A. PTFE Tape, for use with Threaded Metal or Plastic Pipe: MS MIL-T-27730.

2.10 UNIONS AND COUPLINGS

A. Pipe Size 2 Inches and Under:

1. Ferrous pipe: 150 psig malleable iron threaded unions.
2. Copper tube and pipe: 150 psig bronze unions with soldered joints.

B. Pipe Size Over 2 Inches:
1. Ferrous pipe: 150 psig forged steel slip-on flanges; 1/16 inch thick preformed neoprene gaskets.
2. Copper tube and pipe: 150 psig slip-on bronze flanges, 1/16 inch thick preformed neoprene gaskets.

C. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, and water impervious isolation barrier.

2.11 GATE VALVES

A. Up to and including 2 Inches: Bronze body, bronze trim, non-rising stem, hand wheel, inside screw, single wedge or disc, solder or threaded ends, MSS SP-80, Class 125.

B. Over 2 Inches: Iron body, bronze trim, rising stem, hand wheel, OS&Y, single wedge, flanged or grooved ends, MSS SP-70, Class 125.

2.12 BALL VALVES

A. Up to and including 2 Inches: Bronze two piece body, stainless steel ball, Teflon seats and stuffing box ring, lever handle and balancing stops, solder or threaded ends with union.

B. Over 2 Inches: Cast steel body, chrome plated steel ball, Teflon seat and stuffing box seals, lever handle, or gear drive hand wheel for sizes 10 inches and over, flanged.

2.13 PLUG VALVES

A. Up to and including 2 Inches: Bronze body, bronze tapered plug, non-lubricated, Teflon packing, threaded ends.

B. Over 2 Inches: Cast iron body and plug, non-lubricated, Teflon packing, flanged ends.

2.14 RELIEF VALVES

A. Bronze body, Teflon seat, steel stem and springs, automatic, test lever, direct pressure actuated, capacities ASME certified and labeled, ANSI Z21.22.

2.15 STRAINERS

A. Strainers shall have blow off outlet with pipe nipple and gate valve.

B. Size 2 inch and Under: Screwed brass or iron body for 175 psig working pressure, Y pattern with 1/32 inch stainless steel perforated screen.

2.16 HOSE BIBBS

A. Provide angle type copper alloy hose bibb with lock shield and hand wheel. Inlet shall have internal threads. Outlet shall have vacuum breaker with 0.75-inch external hose threads.

2.17 WATER METERS

A. AWWA C701 turbine type, with register reading in U.S. gallons.

2.18 THERMOMETERS

A. Provide bi-metal dial type thermometers with stainless steel case, stem, and fixed thread connection; 5-inch diameter dial with glass face gasketed within the case, accuracy within 2 percent of scale range. Provide scale range suitable for the intended service.

2.19 DIELECTRIC CONNECTIONS

A. Provide at connections between copper and ferrous metal piping materials. ASTM F 441, Schedule 80, CPVC threaded pipe nipples, 4-inch minimum length, may be provided for dielectric connections in pipe sizes 2 inches and smaller.

2.20 WATER HAMMER ARRESTERS

A. PDI WH201.

2.21 WATER VALVE BOXES

A. For each buried valve provide cast-iron, ductile-iron, or plastic box of a suitable size. Provide cast-iron, ductile-iron, or plastic cover for the box with the word "WATER" cast on the cover. Plastic boxes shall be construct of ABS plastic or inorganic fiber-reinforced black polyolefin plastic. Coat cast-iron and ductile-iron boxes with bituminous paint.

2.22 BACKFLOW PREVENTERS

A. Reduced pressure principle type. Furnish proof that each make, model/design, and size of backflow preventer being furnished for the project is approved by and has a current "Certificate of Approval" from the FCCCHR-USC. Listing of the particular make, model/design, and size in the current FCCCHR-USC will be acceptable as the required proof.

2.23 PIPE HANGERS

A. The pipe hangers shall be constructed according to MSS SP-58.

2.24 GAS VALVES AND ACCESSORIES

A. Shut-Off Valves: Manually operated shut-off valves for gas distribution main and regulator station piping with a minimum pressure rating of 150 psig.

1. Plug Valves: API SPEC 6D for steel valves or MSS SP-78 for cast iron valves. Valves shall be full bore type. Minimum bore size for full bore valves shall be 95 percent of the internal cross sectional area of pipe of the same nominal diameter. Steel valves installed on buried steel piping shall have butt-welding ends. Steel valves installed on buried PE piping shall have mechanical joint ends. Cast iron valves installed on buried piping shall have mechanical joint ends except where flanged ends. Plug valves shall be lubricated. Lubricating fittings on installed valves shall be accessible for re-lubrication, or extensions shall be provided to make them accessible. Plug valves shall be wrench operated. Wrench operated valves shall have a 2 inch square adaptor securely fastened to the valve stem. Maximum allowable operating torque in foot-pounds shall be limited to:

Nominal Valve Size (Inches)	Torque (Foot-Pounds)
3/4, 1, 1-1/2, 2	25

B. Gas Valve Boxes: Provide each valve on buried piping with a cast-iron valve box of a size suitable for the valve. Valve box shall have a round cover with the word "Gas" cast on it. Valve boxes shall be provided with lock-type covers that require a special wrench for removing. Each cast-iron box shall be given a heavy coat of bituminous paint.

C. Drips: Install at low points where indicated. Conform to details indicated or provide commercial units of the same capacity and type as those indicated.

D. ASTM A 53, Grade A, Schedule 40.

2.25 DRAINS

A. ASME A112.21.1M, provide cast-iron or ductile-iron drains and clamping rings for use with membrane waterproofing. Provide P-traps for each floor drain.

B. Flush Strainer Floor Drains: Provide with double drainage flange, perforated or slotted cast bronze or nickel bronze, polished stainless steel, or chromium-plated copper alloy strainer, and adjustable collar. Drains of sizes 2, 3, and 4 inches shall have strainers with minimum free drainage area of 5, 11, and 18 square inches, respectively.

C. Shower Floor Drains: Provide as specified for flush strainer floor drains, except that finish shall be polished stainless steel or chromium-plated copper alloy and PVC drains may be provided for fiberglass shower stalls where fire separation requirements are not violated.

D. Roof Drains: ASME A112.21.2M; provide hot-dip galvanized cast-iron or ductile-iron drains, with minimum of 10-inch diameter body, non-puncturing flashing clamp device with integral gravel stop and deck clamp, and removable cast-iron or ductile-iron or polypropylene locking dome. Free area of dome shall be not less than two times the

free area of drain outlet. Provide drain flashing ring seat flush with adjacent roof deck, and secure rigidly in place with deck clamp.

2.26 GREASE INTERCEPTORS (TRAPS)

A. PDI G101.

2.27 NONFREEZE WALL HYDRANT

A. ASSE 1019, cast bronze, with lock shield and removable hand wheel or tee-handle, one-inch external thread inlet, 0.75-inch external hose thread outlet with automatic draining vacuum breaker. Hydrant shall be of sufficient length to extend through walls and place the valve seat inside the building or in the crawl space. Bonnet and valve stem shall be removable from outside of the building.

2.28 COMBINATION PRESSURE AND TEMPERATURE RELIEF VALVES

A. ANSI Z21.22 copper alloy body, automatic reseating, test lever, and discharge capacity based on AGA temperature steam rating.

2.29 ACCESS DOORS

A. Provide 12- by 12-inch factory prefabricated and primed flush face steel access doors including steel door frame with continuous hinges and turn-screw-operated latch. Door frame shall be for installation in plaster and masonry walls. Furnish doors under this section to provide proper access to concealed valves; install doors under the appropriate section of this specification.

2.30 DOMESTIC WATER HEATERS

A. See Drawings.

2.31 TRAP PRIMER

A. Equal to Zurn Z-1022, install below plumbing fixture and extend 1/2" line to floor drains.

2.32 HEAT TRACING

A. All hot, hot water return and cold water located above ceiling shall have UL listed system of heaters, components, thermostats and control to prevent pipelines from freezing.

B. The self-regulating heater shall be equal to Raychem Model No. 5XL-2, 5 watts, 277 volts, the heater selection based on 1" fiberglass insulation on metal piping as shown on plumbing and electrical drawings.

C. The entire installation shall be by the manufacturer's recommendations.

D. Test to be performed by manufacturer's representative. After installation and before and after installing the thermal insulation, subject heat to testing using a 1000 VDC megger. Minimum insulation resistance should be 20 to 1000 mega ohms regardless of length.

2.33 FIXTURES, FITTINGS, ACCESSORIES, AND SUPPLIES

A. Provide control-stop valves in each supply to each fixture. The finish of fittings, accessories, and supplies exposed to view shall be chromium-plated per ASME A112.18.1M. Center set faucets shall be top-mounted with inlets on not greater than 4-inch centers. Provide special roughing-in for wheelchair fixtures.

1. Flush Valve Type Water Closets (P-1): ASME A112.19.2M, white vitreous china, floor-mounted, floor outlet as indicated, siphon jet, elongated bowl, white solid plastic elongated open-front seat, and ASME A112.19.5 trim. Provide sensor operated battery powered flush valve with override, including vacuum breaker and angle (control-stop) valve with back check, mounted approximately 39 to 44 inches above floor. The water flushing volume of the flush valve and water closet combination shall not exceed 1.28 gallons per flush for floor outlet water closets from 15 to 90 psi. Provide ASME A112.6.1M carrier with feet.

2. Wheelchair Water Closets (P-1A): Provide same as specified for water closets (P-1) except water closet height to top of seat shall be 17 to 19 inches above floor.

3. Flush Valve Type Urinals (P-2): ASME A112.19.2M, white vitreous china, wall-mounted, wall outlet, siphon jet, integral trap, extended side shields, and ASME A112.19.5 trim. Provide sensor operated battery powered flush valve with override, including vacuum breaker and angle (control-stop) valve with back check. Water flushing volume of the flush valve and urinal combination shall not exceed 0.125 gallons per flush from 15 to 90 psi. Provide ASME A112.6.1M concealed chair carriers.

4. Lavatories (P-3): ASME A112.19.2M white vitreous china with ASME A112.6.1M concealed arm carrier support, straight back type, minimum dimensions of 20 inches wide by 18 inches front to rear. Provide ASME A112.18.1M copper alloy self-closing metering faucets with aerator, perforated grid strainers, and 1.25-inch adjustable P-traps. Provide ASME A112.6.1M concealed chair carriers. Maximum water use 0.25 gpm.

5. Lavatories for Wheelchairs (P-3A): ASME A112.19.2M white vitreous china with ASME A112.6.1M concealed arm carrier support, straight back type, minimum dimensions of 19 inches wide by 16 inches front to rear, 29 inches minimum clearance from bottom of front rim to floor, 34 inches front rim height above floor. Provide ASME A112.18.1M copper alloy self closing metering faucets, gooseneck spout with aerator 5 inches above rim, perforated grid strainers with offset tailpiece, and 1.25-inch adjustable P-trap. Provide ASME A112.6.1M concealed chair carriers.

6. Wall Hung Kitchen Hand Sinks (P-4): ASME A112.19.3M, 20-gage stainless steel with integral mounting rim, minimum dimensions of 14 inches wide by 10 inches front to rear, single compartments with ledge back and undersides coated with sound dampening material. Provide top-mounted ASME A112.18.1M copper alloy faucets, swing spout with aerator, and stainless steel drain outlets with cup strainers. Provide 1.5-inch adjustable P-trap with drain piping to vertical vent stack.

7. Wheelchair Electric Water Cooler (P-6): ARI 1010, wall-mounted split level bubbler style, bottle filler with ASME A112.6.1M concealed chair carrier, air-cooled condensing unit, 4.75 gph minimum capacity, stainless steel splash receptor, and all stainless steel cabinet, with 27-inch minimum knee clearance from front bottom of unit to floor and 36-inch maximum spout height above floor. Bubblers shall also be controlled by push levers, by push bars, or touch pads one on each side or one on front and both sides of the cabinet.

8. Shower Supply Fittings (P-5): ASME A112.18.1M, vandalproof, ball joint, self-cleaning adjustable spray pattern shower heads with 15-gpm flow control devices, connected to concealed pipe connected to copper alloy pressure balance single control type mixing valves with front access integral screwdriver stops. Anchor the mixing valves and the pipe to each shower head in wall to prevent movement. Secure vandalproof shower heads to the wall using anchor plates and interrupted-slot head type exposed screws. Maximum water use 1.5 gpm.

9. ADA Shower Suppply Fitting (P-5A): Same as P-5 above, except provide with hand held shower head, 60” stainless steel flex hose, vacuum breaker and 30” slide bar.

10. Non-plasticized Polyvinyl Chloride (PVC) Shower Pans: Nonplasticized PVC shall be turned up behind walls or wall surfaces a distance of not less than 6 inches in room areas and 3 inches above curb level in curbed spaces with sufficient material to fold over and fasten to outside face of curb. Corners shall be pig-ear type and folded between pan and studs. Only top 1 inch of upstand shall be nailed to hold in place. Nails shall be galvanized large-head roofing type. Approved duct tape shall be used on metal framing or studs to secure pig-ear fold and membrane. Where no backing is provided between studs, the membrane slack shall be taken up by pleating and stapling or nailing to studding at top inch of upstand. To adhere the membrane to vertical surfaces, the back of the membrane and the surface to which it is to be applied shall be coated with adhesive that becomes dry to the touch in 5 to 10 minutes, after which the membrane shall be pressed into place. Trim for drain shall be exactly the size of drain opening. Bolt holes shall be pierced to accommodate bolts with a tight fit. Adhesive shall be used between pan and subdrain. Clamping ring shall be bolted firmly. A small amount of gravel or porous materials shall be placed at weepholes so that holes remain clear when setting bed is poured. Membrane shall be solvent welded with PVC solvent cement. Surfaces to be solvent welded shall be clean (free of grease and grime). Sheets shall be laid on a flat surface with an overlap of about 2 inches. Top edge shall be folded back and surface primed with

a PVC primer. PVC cement shall be applied and surfaces immediately placed together, while still wet. Joint shall be lightly rolled with a paint roller, then as the joint sets shall be rolled firmly but not so hard as to distort the material. In long lengths, about 2 or 3 feet at a time shall be welded. On wood subflooring, two layers of 15 pound felt shall be installed prior to installation of shower pan to ensure a smooth surface installation.

11. Floor Sinks (Drains): Provide cast-iron body with white acid-resisting porcelain enameled or epoxy interior, double drainage flange, nickel bronze rim and slotted grate, removable stainless steel or aluminum slotted buckets, and P-trap.

12. Washing Machine Connector Box: Provide recessed wall box fabricated of aluminum, PVC plastic stainless steel, or hot-dip galvanized steel. Provide hot-dip galvanized steel with epoxy or baked-on enamel finish. Provide drain nipple and locknut with cover nut for locking drain outlet to box. Provide brass pipe fittings for connecting each supply pipe to valve and locking to box. Provide hot water and cold water supply valves similar to hose bibbs, except valve inlet connections shall be of the compression type or union type.

2.34 PLUMBING FIXTURE FAUCETS, TRIM, AND FITTINGS

A. ASME A112.18.1M for plumbing fixture faucets. The finish of plumbing fixture faucets, trim, valves, and fittings exposed to view shall be chromium-plated or polished stainless steel except as modified herein. Bolts, nuts, and screws shall be copper alloy or stainless steel. Provide globe valves or angle valves, and union connections in each supply to each faucet; chromium-plated finish is not required. Faucets shall be washerless type and shall have threaded type end connections, coupling nuts, or union connections. Faucets may be of the single control type. Provide washers and locknuts to secure faucets to lavatories and sinks.

1. Traps: Provide P-traps for each plumbing fixture, which does not have integral traps. Provide 1.5 inch white PVC adjustable P-traps and tubing with slip nuts and gaskets; chromium-plated finish is not required.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that excavations are to required grade, dry, and not over-excavated.

3.2 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and dirt, on inside and outside, before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.

C. Route piping in orderly manner and maintain gradient.

D. Install piping to conserve building space and not interfere with use of space.

E. Group piping whenever practical at common elevations.

F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

G. Provide clearance for installation of insulation and access to valves and fittings.

H. Provide access where valves and fittings are not exposed.

I. Establish elevations of buried piping outside the building to ensure not less than 2 ft of cover.

J. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

K. Provide support for utility meters in accordance with requirements of utility companies.

L. Prepare pipe, fittings, supports, and accessories not pre-finished, ready for finish painting and paint with type of paint recommended for application.

M. Install bell and spigot pipe with bell end upstream.

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

O. Provide one plug valve wrench for every ten plug valves sized 2 inches and smaller, minimum of one.

P. Pipe vents from gas pressure reducing valves to outdoors and terminate in weather proof hood or use UL approved non-vented regulator.

Q. There shall be no joints under slabs in water piping.

R. Material or equipment containing lead shall not be used in any potable water system.

3.4 APPLICATION

A. Install unions downstream of valves and at equipment or apparatus connections.

B. Install brass male adapters each side of valves in copper piped system. Sweat solder adapters to pipe.

C. Install gate ball or butterfly valves for shut-off and to isolate all equipment, vertical risers and all branches from mains where shown or not on drawings.

D. When fixtures require both hot water and cold water supplies, provide the hot water supply to the left of the cold water supply.

E. Plastic piping shall not penetrate fire walls or fire floors and shall be used on one side of fire walls and fire floors not closer than 6 inches to the penetration.

F. Joint compound for pipe threads shall be polytetrafluoroethylene (PTFE) pipe thread paste, pipe cement and oil or PTFE powder and oil; apply only on male threads. Provide exposed ferrous pipe threads with one coat of primer applied to a minimum dry film thickness of 1.0 mil. Do not thread metal pipe into plastic piping.

G. Solder End Valves: Remove stems and washers and other items subject to damage by heat during installation. Reassemble valve after soldering is completed. Valves without heat sensitive arts do not require disassembly but shall be opened at least two turns during soldering.

H. Provide additional supports at the concentrated loads in piping between supports, such as for inline water pumps and flanged valves.

I. Piping to Receive Insulation: Provide temporary wood spacers between the insulation protection shield and the pipe in order to properly slope the piping and to establish final elevations. Temporary wood spacers shall be of the same thickness as the insulation to be provided under insulation section. Wood spacers shall be removed.

J. Adapters: Threaded adapters below 2" size shall be female metal to PVC male thread type, 2" and above shall be flanged and gasketed type. No saddle taps allowed.

3.5 ERECTION TOLERANCES

A. Grade: All building sewers shall have a uniform grade of not less than 1/8" to the foot, downward in direction of flow, for pipe 3" and larger. Pipe smaller 3" shall have grade of 1/4" to the foot.

B. Slope water piping and arrange to drain at low points.

3.6 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

A. Prior to starting work, verify system is complete, flushed and clean. Disinfect new water piping and existing water piping affected by Contractor's operations in accordance with AWWA C651.

B. Ensure PH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda

or soda ash) or acid (hydrochloric).

C. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.

D. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.

E. Maintain disinfectant in system for 24 hours.

F. If final disinfectant residual tests less than 25 mg/L, repeat treatment.

G. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.

H. Take samples no sooner than 24 hours after flushing, from 5 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

3.7 SERVICE CONNECTIONS

A. Provide new water service complete with reduced pressure backflow preventer and water meter with pressure reducing valve.
   1. Provide sleeve in wall for service main and support at wall with reinforced concrete bridge. Calk enlarged sleeve and make watertight with pliable material. Anchor service main inside to concrete wall.

3.8 INSTALLATION OF PIPE SLEEVES

A. Provide pipe sleeves where piping passes through walls, floors, roofs, and partitions. Secure sleeves in proper position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, floors, roofs, and partitions. Provide not less than 0.25-inch space between exterior of piping or pipe insulation and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal at both ends of the sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. Seal both ends of penetrations through fire walls and fire floors to maintain fire resistive integrity with UL listed fill, void, or cavity material. Extend sleeves in floor slabs 3 inches above the finished floor.

3.9 SOIL WASTE AND VENT

A. Soil, Waste and Vent Stacks: Where shown and where required, install soil, waste, and vent stacks of sizes shown on the drawings and with branches connecting all fixtures and other apparatus requiring waste generally as shown. All connections to risers shall have made with "Y" and eighth bends when possible. Stacks shall be offset at beams, roof flashings, and as necessary to miss other obstruction. Vents shall be connected into vent header and installed at least 10 feet from edge of roof.

B. Cleanouts: All cleanout plugs shall be recessed brass type.

1. Cleanouts to finished floors shall be counter sunk bronze plug, clamp ring and flange, level-eze adjustable housing and with satin finish bronze cover and frame. Floor cleanouts in finished spaces shall be set flush and shall have accessory appurtenances to match type of flooring, such as top recessed for tile, terrazzo cover, carpet market, etc. Cleanouts in finished walls shall be brass with polished stainless steel cover and securing screws. Cleanouts shall be full size of pipe on which installed. Provide cleanouts at base of all stacks.

2. Extension to floor shall be made with combination "Y" and eighth bends.

3. Cleanouts to grade shall be with lead caulked cast-iron fittings with brass countersunk plug, set in a 24" square block of poured concrete, 6" thick. All exterior cleanouts shall be brought to grade. PVC shall not be used for cleanouts to grade.

C. Cast-Iron Pipe Joints: Joints shall be made tight using two ounces of picked oakum tightly caulked with 12 ounces of pure soft pig lead for each joint to each inch diameter of the pipe, except that a greater amount shall be used on a cut piece of pipe without spigot. "No-Hub" joints shall be made with approved materials as recommended by the manufacturer. Draw bands shall be 100% stainless steel. "No-Hub" joints below slab shall cast iron and neoprene coupling with Type 304 stainless steel nuts and bolts as manufactured by MG Coupling or approved equal. Submit for approval.

3.10 HANGERS

A. All horizontal suspended soil and vent pipe shall be supported on hangers and inserts spaced not more than 5'-0" on centers. Hangers on screwed and solder joint pipe shall be not more than 9'-0" on centers. Hangers on PVC pipe shall be provided with saddles arranged to prevent damage to pipe, and shall be spaced so there will be no sagging.

B. All materials to be Standard Catalog items, with rust resistant finish and where exposed to the weather, shall be hot dip galvanized. Hangers and inserts shall be in conformance to Federal Specification WW-H-171, Types 1, 10, 11 and 12 hangers for horizontal pipe and Type 8 hangers for vertical pipes. Inserts shall be Type 18 or 19. Hangers to be used with rods of the following sizes:

Pipe 2" and smaller.....3/8" hanger rod
Pipe 2-1/2" to 3-1/2".....1/2" hanger rod
Pipe 4" and up.....5/8" hanger rod

All hangers, brackets, rods, nuts and all hardware shall be painted, if not galvanized or plated with rust resistant finish.

C. Vertical pipe runs shall be adequately braced and supported in accordance with good practice. Provide suitable means to allow for pipe expansion.

3.11 FLOOR PLATES AND ESCUTCHEONS

A. Provide heavy brass nickel-plated ceiling plates with set screws to hold plates in place on all exposed pipes wherever pipes pass through walls, floors, and ceilings.

3.12 FLASHING

A. All vents shall be run 6" above the roof and shall be flashed and counter flashed. Flashing shall consist of 16 ounce soft copper or 4 pound sheet lead, extending all around not less than 8" from the pipe. The counter flashing shall be turned down into the pipe and shall be made of 16 ounce soft copper or 4 pound sheet lead. On standing seam metal roof flashing as required by roofing manufacturer.

3.13 TESTING

A. All pipe systems shall have pressure test applied before any joints are covered (or buried) or concealed in any manner.

B. Concealed work shall remain uncovered until required tests have been completed. All tests shall be made in the presence of representatives of the Owner. Repairs of defects that are discovered as a result of inspections or tests shall be made with new materials. Caulking of screwed joints, cracks, or holes, will not be accepted. Tests shall be repeated after defects have been eliminated.

C. Drain Systems: A water test shall be applied to all parts of the drainage system before the pipes are concealed or fixtures set in place. The test may be applied in the highest opening above the roof, and the entire system shall be filled with water up to the overflow point of this highest opening. All parts of the system shall be subject to not less than 10 feet hydrostatic head except the uppermost ten feet of the piping directly below the opening. The water shall remain in the system for not less than four hours. If leaks at any joint or lowering of water level occur, make necessary corrections.

D. Water supply tests shall be applied to all parts of the water supply system before the piping is concealed or before the fixtures are connected. A hydrostatic pressure of not less than 100 pounds per square inch shall be applied to the system for two hours and there shall be no leaks at any joint in the system at this pressure.

E. Temporary caps on all stub-outs must withstand the test pressure of the system.

F. Gas Test: Shall conform to Standard Gas Code.

G. Rain leader Test: Shall be in accordance with Standard Plumbing Code.

3.14 INSTALLATION OF FIXTURES AND EQUIPMENT

A. Preparations of rough-in, supports and wall finishes shall be completed and tested or inspected before fixtures or equipment are installed.

B. Installation:

1. Mechanical or plumbing connections shall be made with correct fittings, gaskets or setting compound for each fixture. Seal all brass and trim to walls and fixtures with resilient waterproof compound.

C. Fixture Heights:

1. Unless otherwise shown install fixtures to heights above finished floor as indicated.

2. Water-Closet:

a. Standard 15 inches to top of bowl rim.

b. Handicapped 18 inches to top of seat.

3. Urinal:

a. Standard 22 inches to top of bowl rim.

b. Handicapped 17 inches to top of bowl rim.

4. Lavatory:

a. Standard 31 inches to top of basin rim.

b. Handicapped 34 inches maximum to top of basin rim.

5. Drinking Fountain:

a. Standard 40 inches to top of basin rim.

b. Handicapped 36 inches from floor to outlet of spout.

6. Shower Heads:

a. Standard 78 inches to bottom of head.

b. Handicapped mounted on 60 inch flexible hose with height adjustment from 42" to 72" above floor.

3.15 START-UP SERVICE

A. The Contractor shall put all items installed under this section into operation and shall instruct the Owner's maintenance personnel in all points requiring service and maintenance. Further, the Contractor shall make all adjustments and/or perform all service requirements to said equipment during the first year at his expense.

3.16 INSULATION

A. Insulation: The following shall be insulated as indicated:

1. Domestic Cold Water Piping and Fittings Located Above Floor and All Hot Water Piping and Fittings. Underground hot water piping shall have appropriate jacketing mastic or vapor barrier adhesive per manufacturer's instructions. Insulate horizontal rain leader piping and roof drains with above insulation and hot water storage tanks.

3.17 NAMEPLATES

A. Provide laminated plastic nameplates for equipment, gages, thermometers, and valves; stop valves in supplies to fixtures will not require nameplates. Laminated plastic shall be 0.125-inch thick melamine plastic, black with white center core. Surface shall be a matte finish. Corners shall be square. Accurately align lettering and engrave into the white core. Minimum size of nameplates shall be 1.0 inch by 2.5 inches. Lettering shall be minimum of 0.25-inch high normal block lettering. Key nameplates to a chart and schedule for each system. Frame charts and schedules under glass and place where directed near each system. Furnish two copies of each chart and schedule. Each inscription shall identify its function. Equipment nameplates shall show the following information:

1. Manufacturer, type, and model number
2. Contract number and accepted date
3. Capacity or size
4. System in which installed
5. System that it controls

3.18 CONNECTIONS TO EXISTING WATER SUPPLY SYSTEMS

A. Use tapping or drilling machine valve and mechanical joint type sleeves for connections to be made under pressure. Bolt sleeves around mains; bolt valve conforming to AWWA C500 to the branch. Open valve, attach drilling machine, make tap, close valve, and remove drilling machine, without interruption of service. Notify the Contracting Officer in writing at least 15 days prior to the date the connections are required; receive approval before any service is interrupted. Provide materials required to make connections into the existing water supply systems and perform excavating, backfilling, and other incidental labor as required. Furnish Government will furnish only the labor and the tapping or drilling machine for making the actual connections to the existing systems.

3.19 DEWATERING

A. Plan for and provide the structures, equipment, and construction for the collection and disposal of surface and subsurface water encountered in the course of construction.

B. Surface pumping may be used, except where permanent ground water is present above the excavated surfaces, in which case the well point system shall be utilized.

C. Surface Dewater: Remove water by pumping or other methods to prevent the softening of surfaces exposed by excavation, prevent hydrostatic uplift, and provide a stable trench condition for installation of the utility. Use screens and gravel packs or other filtering systems on the dewatering devices to prevent the removal of fines from the soil. Surfaces drainage water shall be diverted by trenches or other means to prevent water from flowing into excavations.

D. Operate the dewatering system continuously until construction work below existing water levels is complete. Ground water shall not be allowed to rise above the bottom of installed piping, grease trap, etc. until all backfill above the tank is in place.

3.20 LOCATION OF GAS LINES

A. The minimum horizontal clearance between gas pipe and parallel utility pipe shall be 2 feet. Do not install gas pipe through catch basins, vaults, manholes or similar underground structures.

3.21 FIELD QUALITY CONTROL

A. Before final acceptance of the work, test each system as in service to demonstrate compliance with the contract requirements. Perform the following tests in addition to the tests specified in the Plumbing Code, except as modified herein. Correct defects in the work provided by the Contractor, and repeat tests until work is in compliance with contract requirements. Furnish water, electricity, instruments, connecting devices, and personnel for performing tests. Before applying insulation, hydrostatically test each piping system at not less than 100 psig with any leakage or reduction in gage pressure for 2 hours.

B. Backflow preventers shall be tested by a locally approved and certified backflow assembly tester. A copy of the test report shall be provided to the Owner prior to placing the domestic water system into operation, or no later than 5 days after the test.

END OF SECTION 15400

SECTION 15510 - HYDRONIC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Pipe and pipe fittings for:
   1. Heating water piping system.
   2. Chilled water piping system.
   3. Condenser water piping system.
   4. Equipment drains and overflows.

B. Valves:
   1. Gate valves.
   2. Ball valves.
   3. Plug valves.
   4. Check valves.

1.2 RELATED SECTIONS

A. Section 15010 - Mechanical General Requirements.

1.3 REFERENCES

A. ASME - Boiler and Pressure Vessel Codes, SEC 9 - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brasing Operators.

B. ASME B16.3 - Malleable Iron Threaded Fittings Class 50 and 300.

C. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.

D. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

E. ASME B31.9 - Building Services Piping.

F. ASTM A53 - Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless.

G. ASTM A234 - Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.

H. ASTM B32 - Solder Metal.

I. ASTM B88 - Seamless Copper Water Tube.

J. ASTM D1785 - Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

K. ASTM D2241 - Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR-Series).

L. ASTM D2466 - Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.

M. ASTM D2467 - Socket-Type Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.

N. ASTM D2855 - Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.

O. AWS D1.1 - Structural Welding Code.

P. AWWA C105 - Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids.

Q. AWWA C110 - Ductile - Iron and Grey -Iron Fittings 3 in. through 48 in., for Water and Other Liquids.

R. AWWA C111 - Rubber-Gasket Joints for Ductile Iron and Grey-Iron Pressure Pipe and Fittings.

S. AWWA C151 - Ductile-Iron Pipe,Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids.

T. MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacture.

U. MSS SP69 - Pipe Hangers and Supports - Selection and Application.

V. MSS SP72 - Ball Valves with Flanged or Butt-welding Ends for General Service.

W. MSS SP80 - Bronze Gate, Globe, Angle and Check Valves.

X. MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Product Data: Include data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.

C. Welders Certificate: Include welders certification of compliance with ASME SEC 9. Submit copies of the welding procedure specifications and procedure qualification test results for each type of welding required. Submit this information on the forms printed in ASME BPVC SEC IX or their equivalent. Submit welders or welding operators names, together with certification of what the individual is performance qualified to perform. The certification shall state the type of welding and positions for which each is qualified, date qualified, and the firm and individual certifying the qualification tests.

D. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 15010.

B. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.6 QUALIFICATIONS

A. Manufacturer: Companies specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing the work of this section with minimum three years documented experience.

C. Welders: Certify in accordance with ASME SEC 9. The Welder shall have been certified within the last 12 months and welded continuously since being certified.

1.7 REGULATORY REQUIREMENTS

A. Conform to ASME B31.9 code for installation of piping system.

B. Welding Materials and Procedures: Conform to ASME SEC 9.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products delivered to site according to manufacturer's

recommendations.

B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

C. Provide temporary protective coating on cast iron and steel valves.

D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

PART 2 PRODUCTS

2.1 HEATING WATER PIPING

A. Steel Pipe: ASTM A53, Schedule 40, 0.375 inch wall for sizes 12 inch and over, black.
   1. Fittings: ASME B16.3, malleable iron or ASTM A234, forged steel welding type fittings.
   2. Joints: Threaded, or AWS D1.1,welded.
   3. The piping shall be threaded or welded up to 2", above 2" shall be welded.

B. Copper Tubing: ASTM B88, Type L, hard drawn.
   1. Fittings: ASME B16.18, cast brass, or ASME B16.22, solder wrought copper.
   2. Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.

2.2 CHILLED OR CONDENSER WATER PIPING, BURIED

A. Steel Pipe: ASTM A53, Schedule 40, 0.375 inch wall for sizes 12 inch and over, black with AWWA C105 polyethylene jacket, or double layer, half-lapped 10 mil polyethylene tape.
   1. Fittings: ASTM A234, forged steel welding type with double layer, half-lapped 10 mil polyethylene tape.
   2. Joints: AWS D1.1, welded.
   3. The piping shall be threaded or welded 2", above 2" shall be welded.

B. Copper Tubing: ASTM B88, Type K, annealed.
   1. Fittings: ASME B16.22, wrought copper.
   2. Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.

C. Ductile Iron Pipe: AWWA C151.
   1. Fittings: AWWA C110, ductile iron, standard thickness.
   2. Joints: AWWA C111, rubber gasket with 3/4 inch diameter rods.

D. PVC Pipe: ASTM D1785, Schedule 40, and Schedule 80 for sizes 8 inch and larger, or ASTM D2241, SDR 21 or 26.
   1. Fittings: ASTM D2466, or ASTM D2467, PVC.
   2. Joints: ASTM D2855, solvent weld.

2.3 CHILLED OR CONDENSER WATER PIPING, ABOVE GRADE

A. Steel Pipe: ASTM A53, Schedule 40, 0.375 inch wall for sizes 12 inch and over, black.
   1. Fittings: ASME B16.3, malleable iron or ASTM A234, forged steel welding type.
   2. Joints: Threaded or AWS D1.1 welded.
   3. The piping shall be threaded or welded up to 2", above 2" shall be welded.

B. Copper Tubing: ASTM B88, Type L, hard drawn.
   1. Fittings: ASME B16.18, cast brass, or ASME B16.22, solder wrought copper.
   2. Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.

2.4 EQUIPMENT DRAINS AND OVERFLOWS

A. Steel Pipe: ASTM A53, Schedule 40 galvanized.
   1. Fittings: Galvanized cast iron, or ASME B16.3 malleable iron.
   2. Joints: Threaded, or grooved mechanical couplings.

B. Copper Tubing: ASTM B88, Type L, hard drawn.
   1. Fittings: ASME B16.18, cast brass, or ASME B16.22 solder wrought copper.
   2. Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.

C. PVC Pipe: ASTM D1785, Schedule 40, and Schedule 80 for sizes 8 inch and larger, or ASTM D2241, SDR 21 or 26.
   1. Fittings: ASTM D2466 or D2467, PVC.
   2. Joints: ASTM D2855, solvent weld.

2.5 PIPE HANGERS AND SUPPORTS

A. Conform to MSS SP58, MSS SP69 and MSS SP89.

B. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Type-6, Malleable iron, adjustable swivel, split ring.

C. Hangers for Cold Pipe Sizes 2 Inches and Over: Type-1, Carbon steel, adjustable, clevis.

D. Hangers for Hot Pipe Sizes 2 to 4 Inches: Type-1, Carbon steel, adjustable, clevis.

E. Hangers for Hot Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll, double hanger.

F. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.

G. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods, cast iron roll.

H. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.

I. Wall Support for Pipe Sizes 4 Inches and Over: Type-33, Welded steel bracket and wrought steel clamp.

J. Wall Support for Hot Pipe Sizes 6 Inches and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.

K. Vertical Support: Type-42, Steel riser clamp.

L. Floor Support for Cold Pipe: Type-37, Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

M. Floor Support for Hot Pipe Sizes to 4 Inches: Type-37, Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

N. Floor Support for Hot Pipe Sizes 6 Inches and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.

O. Copper Pipe Support: Type-6, Carbon steel ring, adjustable, copper plated.

P. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

Q. Inserts: Type-18, Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.6 UNIONS, FLANGES, AND COUPLINGS

A. Unions for Pipe 2 Inches and Under:
1. Ferrous Piping: 150 psig malleable iron, threaded.
2. Copper Pipe: Bronze, soldered joints.

B. Flanges for Pipe Over 2 Inches:
1. Ferrous Piping: 150 psig forged steel, slip-on.
2. Copper Piping: Bronze.
3. Gaskets: 1/16 inch thick preformed neoprene.

C. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.7 GATE VALVES

A. Up To and Including 2 Inches:
1. Bronze body, bronze trim, union bonnet, rising stem, handwheel, inside screw with backseating stem, solid wedge disc, solder or threaded ends, MSS SP-80.

B. Over 2 Inches:
1. Iron body, bronze trim, bolted bonnet, rising stem, handwheel, outside screw and yoke, solid wedge disc with bronze seat rings, flanged ends, AMSE B16.34.

2.8 BALL VALVES

A. Up To and Including 2 Inches:
1. Bronze two piece body, stainless steel ball, teflon seats and stuffing box ring, lever handle, solder or threaded ends.

B. Over 2 Inches:
1. Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle, or gear drive handwheel for sizes 10 inches and over, flanged, MSS SP-72.

2.9 PLUG VALVES

A. Up To and Including 2 Inches:
   1. Bronze body, bronze tapered plug, full port opening, non-lubricated, teflon packing, threaded ends.
   2. Operator: One plug valve wrench for every ten plug valves installed. A minimum of one shall be provided.

B. Over 2 Inches:
   1. Cast iron body and plug, full port opening, pressure lubricated, teflon packing, flanged ends.
   2. Operator: Provide each plug valve with a wrench with set screw.

2.10 SWING CHECK VALVES

A. Up To and Including 2 Inches:
   1. Bronze body, bronze trim, bronze rotating swing disc, with composition disc, solder or threaded ends.

B. Over 2 Inches:
   1. Iron body, bronze trim, bronze or bronze faced rotating swing disc, renewable disc and seat, flanged ends.

2.11 SPRING LOADED CHECK VALVES

A. Iron body, bronze trim, split plate, hinged with stainless steel spring, resilient seal bonded to body.

PART 3 EXECUTION

3.1 SYSTEM DESCRIPTION

A. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Flanges, union, and couplings for servicing shall be provided.

B. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.

C. Use non-conducting dielectric connections whenever jointing dissimilar metals in open

systems.

D. Provide pipe hangers and supports in accordance with MSS SP69 unless indicated otherwise.

E. Use gate, ball or as indicated valves for shut-off and to isolate equipment, part of systems, or vertical risers.

F. Use plug cocks for throttling service when calibrated valves are not required for balancing. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.

G. Use 3/4 inch ball valves with cap for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment.

3.2 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment with flanges or unions.

D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install heating water, chilled water, condenser water, piping to ASME B31.9.

C. Route piping in orderly manner, parallel to building structure, and maintain gradient.

D. Install piping to conserve building space, and not interfere with use of space.

E. Group piping whenever practical at common elevations.

F. Sleeve all pipe passing through partitions, walls and floors.

G. Slope piping and provide for drain at low points.

H. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

I. Inserts:
1. Provide inserts for placement in concrete formwork.
2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above recessed into and grouted flush with slab.

J. Pipe Hangers and Supports:
1. Install in accordance with MSS SP89 or more stringent if required by specifications.
2. Support horizontal piping as scheduled.
3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
4. Place hangers within 12 inches of each horizontal elbow. Hangars shall be placed adjacent to valves, strainers and other appurtenances in such a manner to support the load concentrations and to support the piping in the event components are removed during maintenance. Final arrangement and number of hangars will be as directed by the contracting officer.
5. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
6. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
8. Provide copper plated hangers and supports for copper piping.
9. All exposed steel hangers and supports shall be painted with a prime cost then a finish coat with the color to match existing walls. Hangers and supports located in crawl spaces, pipe shafts, and above suspended ceiling spaces are not considered exposed.

K. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.

L. Provide access doors or panels any place valves are installed behind hard ceiling or

walls.

M. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.

N. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

O. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.

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

Q. The piping system shall be flushed before being connected to the existing system. The flushing shall be performed at water velocities above 12 feet per second before the equipment is connected. Bypass piping shall be provided as required. The system shall be flushed untill the discharge is completely clear.

R. The piping systems shall be tested at 1 ½ times the working pressure or 100 PSI which ever is higher. The system shall maintain the pressure for a minimum of 8 hours without any drop in pressure. After testing all gauges and equipment to do pressure test shall be removed and system checked for leaks at system pressure.

S. The piping system shall be chemically cleaned then flushed and then the operating chemical treatment provided as part of this contract.

3.4 SCHEDULES

A. Pipe Hanger Spacing.

1. Steel and copper shall be according to MSS SP-69.

2.

PVC PIPE SIZE Inches	HANGER ROD MAX. HANGER SPACING Feet
1/2 to 1-1/4	4.0
1-1/2 to 2	4.5
2-1/2 to 3	5.5
4 to 6	6.0
8 and over	8.0

3. HANGER ROD DIAMETER For 3/4" Thur 4"pipes 3/8" Rod
For 5" Thur 8"pipes ½" Rod
For 10" Thur 12"pipes 5/8" Rod
For 12" Thur 18"pipes 3/4" Rod

END OF SECTION 15510

SECTION 15515 - HYDRONIC SPECIALTIES

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Expansion tanks.

B. Air vents.

C. Air separators.

D. Strainers.

E. Pump suction fittings.

F. Combination pump discharge valves.

G. Calibrated balancing valves.

H. Relief valves.

I. Pressure reducing valves.

1.2 RELATED SECTIONS

A. Section 15010 - Mechanical General Requirements.

1.3 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.

C. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

1.4 REFERENCES

A. ASME - Boilers and Pressure Vessel Codes, SEC 8-D-Rules for Construction of

Pressure Vessels.

1.5 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 15010.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 15010.

B. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site according to good construction practices and to prevent damage and deterioration.

B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

C. Provide temporary protective coating on cast iron and steel valves.

D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work then capping, and isolating parts of the completed system from that under construction.

PART 2 PRODUCTS

2.1 DIAPHRAGM-TYPE EXPANSION TANKS

A. Construction: Welded steel, tested and stamped in accordance with ASME SEC 8-D; supplied with National Board Form U-1, rated for working pressure of 125 psig, with a replaceable flexible butyl diaphragm in tank, steel support stand. The tank will have

factory suspension bracket if installed in a hanging arrangement.

B. Accessories: Pressure gage and air-charging fitting, tank drain; precharge to 12 psig.

2.2 AIR VENTS

A. Manual Type: Short vertical sections of 2 inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.

B. Float Type: Brass or stainless steel body, copper, polypropylene, or stainless float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.

2.3 AIR SEPARATORS

A. Centrifugal Vessel Type:

1. The separator shall be a centrifugal type air separator. The unit shall have inlet and outlet connections tangential to the vessel shell. Vessel shell diameter to be three times the nominal inlet/outlet pipe diameter. The unit shall have an internal design suitable for creating required vortex and subsequent air separation, for air release to vent. Provide a blow-down connection with a gate valve piped to nearest floor drain. The air separators must be designed, constructed, and stamped for 125 psig @ 350□F in accordance with Section VIII, Division I of the ASME Boiler and Pressure Vessel Code, and registered with the National Board of Boiler and Pressure Vessel Inspectors. The air separators shall be painted with one shop coat of light gray air dry enamel. A Manufacturer's Data Report for Pressure Vessels, Form U-1 as required by the provisions of the ASME Boiler and Pressure Vessel Code shall be furnished for each air separator.

B. In-Line Baffle Type:

1. The horizontal in-line air separator designed to effectively separate free air in hydronic heating/cooling systems. The air separator shall be heavy duty cast iron designed to function satisfactorily at working pressures up to 175 psi and liquid temperatures up to 300□F. The air separator shall have an integral weir designed to decelerate system flow to maximize air separation.

2.4 STRAINERS

A. Size 2 inch and Under:

1. Screwed brass or iron body for 175 psig working pressure, Y pattern with 3/32 inch stainless steel perforated screen.

B. Size 2-1/2 inch to 4 inch:

1. Flanged iron body for 175 psig working pressure, Y pattern with 1/8 inch stainless steel perforated screen.

C. Size 5 inch and Larger:

1. Flanged iron body for 175 psig working pressure, basket pattern with 1/8 inch stainless steel perforated screen.

2.5 PUMP SUCTION FITTINGS

A. Fitting: Angle pattern, cast-iron body, threaded for 2 inch and smaller, flanged for 2-1/2 inch and larger, rated for 175 psig working pressure, with inlet vanes, cylinder strainer with 3/16 inch diameter openings, disposable fine mesh strainer to fit over cylinder strainer, and permanent magnet located in flow stream and removable for cleaning. The strainer shall have a free area equal to five times the cross section of the pump suction opening. The vane length shall be no less than 2-1/2 times the pump connection diameter.

B. Accessories: Adjustable foot support, blowdown tapping in bottom, gage tapping in side.

2.6 COMBINATION PUMP DISCHARGE VALVES (TRIPLE DUTY VALVE)

A. Valves: Straight or angle pattern, flanged cast-iron valve body with bolt-on bonnet for 175 psig pressure, non-slam check valve with spring-loaded replaceable bronze disc and seat, stainless steel stem, and calibrated adjustment permitting flow regulation. The valves shall be equipped with brass readout valves with integral check valve for taking differential pressure readings across the orifice. The valve construction shall permit repacking under full system pressure.

2.7 CALIBRATED BALANCING VALVES

A. Calibrated, plug type balance valve with precision machined orifice, readout valves equipped with integral check valves and gasketed caps, calibrated nameplate and indicating pointer.

2.8 RELIEF VALVES

A. Bronze body, Teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labeled.

2.9 PRESSURE REDUCING VALVES

A. The valves shall be equipped with an EPDM diaphragm, a brass inlet strainer and integral low inlet pressure check valve.

PART 3 EXECUTION

3.1 INSTALLATION

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

B. Provide automatic air vents at system high points and as indicated.

C. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.

D. Provide air separator on suction side of system circulation pump and connect to expansion tank.

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

F. Provide pump suction fitting on suction side of base mounted centrifugal pumps where indicated. Remove temporary strainers after cleaning systems.

G. Provide combination pump discharge valve on discharge side of base mounted centrifugal pumps where indicated.

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

I. Provide relief valves on pressure tanks, low pressure side of reducing valves and expansion tanks.

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

K. Pipe relief valve outlet to nearest floor drain.

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

END OF SECTION 15515

SECTION 15540 - HVAC PUMPS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Base mounted pumps.

B. In-Line circulators.

1.2 RELATED SECTIONS

A. Section 15010 - Mechanical General Requirements.

1.3 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Submit certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.

C. Submit manufacturer's installation instructions.

1.4 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacture, assembly, and field performance of pumps with minimum three years experience.

B. Alignment: Base mounted pumps shall be aligned by qualified millwright and alignment certified.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 15010.

B. Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site; store and protect product as recommended by manufacturer.

1.7 EXTRA PARTS

A. Provide one extra set of mechanical seals for each pump.

PART 2 PRODUCTS

2.1 GENERAL CONSTRUCTION REQUIREMENTS

A. Balance: Rotating parts, statically and dynamically.

B. Construction: To permit servicing without breaking piping or motor connections.

C. Pump Motors: Operate at 1750 rpm unless specified otherwise.

D. Pump Connections: Flanged.

2.2 BASE MOUNTED PUMPS

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

B. Pump volute shall be cast iron with integrally-cast pedestal support feet. The impeller shall be cast bronze enclose type, dynamically balanced, keyed to the shaft and secured by a locking capscrew.

C. 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 degrees F. A replaceable bronze shaft sleeve shall completely cover the wetted area under the seal.

D. 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.

E. Base plate shall be of structural steel or fabricated steel channel with fully enclosed sides and ends, and securely welded cross members. Grouting area shall be fully opened. A flexible type, center drop-out design coupler, capable of absorbing torsional vibration, shall be employed between the pump and motor. Coupler shall be shielded by a coupler guard securely fastened to the base. The pump shall have a drip pan with drain connection.

F. 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 contractor after installation.

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

2.3 IN-LINE CIRCULATORS

A. Pumps shall be in-line type, closed coupled, single stage design, for installation in vertical or horizontal position, capable of being serviced without disturbing piping connections.

B. Pump volute shall be of Class 30 cast iron. The impeller shall be non-ferrous, enclose type, dynamically balanced, keyed to the shaft and secured by a locking capscrew.

C. The liquid cavity shall be sealed off at the motor shaft by a internally-flushed mechanical seal with ceramic seal seat and carbon seal ring, suitable for continuous operation at 225 degrees F. A non-ferrous shaft sleeve shall completely cover the wetted area under the seal.

D. 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.

E. Motor shall meet NEMA specifications and shall be of the size, voltage and enclosure called for on the plans. It shall have heavy duty grease lubricated ball bearings, completely adequate for the maximum load for which the motor is designed.

F. 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.

PART 3 EXECUTION

3.1 INSTALLATION

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

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

recommended by manufacturer.

C. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate above efficiency indicated.

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

E. Provide line sized shut-off valve and suction diffuser on pump suction, and line sized combination pump discharge valve on pump discharge.

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

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

H. Lubricate pumps before start-up.

I. Install base mounted pumps on concrete base, with anchor bolts, set and level, and grout in place.

J. Qualified millwright shall check, align, and certify base mounted pumps prior to start-up.

END OF SECTION 15540

SECTION 15545 - CHEMICAL WATER TREATMENT

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Cleaning of piping systems.

B. Chemical treatment.

C. Water analysis.

1.2 RELATED SECTIONS

A. Section 15010 - Mechanical General Requirements.

1.3 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Product Data: Provide chemical treatment materials, chemicals, and equipment.

C. Manufacturer's Field Reports: Indicate start-up of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment.

D. The water analysis results and chemicals required.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience. Company shall have local representatives with water analysis laboratories and full time service personnel.

1.5 REGULATORY REQUIREMENTS

A. Conform to applicable code for addition of non-potable chemicals to building mechanical systems, and for to public sewage systems. The chemical shall meet all current environmental standards.

1.6 MAINTENANCE SERVICE

A. Furnish service and maintenance of treatment systems for one year from Date of beneficial occupancy.

B. Provide a 6 month technical service visit to preform field inspections and make water analysis on site. Detail findings in writing on chemical treating requirements and corrective actions needed. Submit two copies of field service report after the visit.

C. Provide laboratory and technical assistance services during this maintenance period.

1.7 MAINTENANCE MATERIALS

A. Provide sufficient chemicals for treatment and testing during warranty period.

PART 2 PRODUCTS

2.1 MATERIALS

A. System Cleaner:
   1. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.
   2. Biocide.

B. Closed System Treatment (Water):
   1. Sequestering agent to reduce deposits and adjust pH.
   2. Corrosion inhibitors.
   3. Conductivity enhancers.

PART 3 EXECUTION

3.1 ANALYSIS

A. The contractor shall perform chemical analysis of water to determine initial chemicals required and at 6 month service to determine the chemicals requirements.

3.2 PREPARATION

A. Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.

B. Place terminal control valves in open position during cleaning.

3.3 CLEANING SEQUENCE

A. Concentration:
   1. As recommended by the chemical manufacturer or as indicated below as minimum.
   2. One pound per 100 gallons of water for hot systems and one pound per 50 gallons of water for cold systems.

B. Hot Water Heating Systems:
   1. Apply heat while circulating, slowly raising temperature to 160 degrees F and maintain for 4 hours minimum.
   2. Remove heat and circulate to 100 degrees F or less; drain systems as quickly as possible and refill with clean water.
   3. Circulate for 2 hours at design temperatures, then drain.
   4. Refill with clean water and repeat until system cleaner is removed.

C. Chilled/Condenser Water Systems:
   1. Circulate for 24 hours, then drain systems as quickly as possible.
   2. Refill with clean water, circulate for 12 hours, then drain.
   3. Refill with clean water and repeat until system cleaner is removed.

D. Use neutralizer agents on recommendation of system cleaner supplier.

E. Remove, clean, and replace strainer screens.

F. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.4 INSTALLATION

A. Install the chemical in accordance with manufacturer's instructions, the chemicals required shall be based on the water analysis of the system performed.

3.5 DOCUMENTATION

A. The Contractor shall provide a written report which contains the dates of cleanings, name of person performing the procedures and amount of each system treatment chemical added after cleaning.

END OF SECTION 15545

SECTION 15625 - UNIT HEATERS

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Electric unit heaters.

B. Gas fired forced air unit heaters.

C. Infra-red unit heaters.

D. Ceiling mounted unit heaters.

E. Hot water unit heaters.

1.2 RELATED SECTIONS

A. Section 15010 - Mechanical General Requirements

1.3 REFERENCES

A. ANSI/ASHRAE 103 - Heating Seasonal Efficiency of Central Furnaces and Boilers, Methods of Testing.

B. ANSI/NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.

C. ANSI/NFPA 211 - Chimneys, Fireplaces, Vents, and Solid Fuel Burning Appliances.

D. ANSI/Z223.1 (NFPA 54) - National Fuel Gas Code.

E. NFPA 70 - National Electrical Code.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.

C. Product Data: Provide manufacturer's literature and data indicating rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.

D. Manufacturer's Installation Instructions: Indicate rigging, assembly, and installation instructions.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation data under provisions of Section 15010.

B. Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listing.

1.6 WARRANTY

A. Provide one year warranty.

B. Warranty: Include coverage for heat exchangers.

PART 2 PRODUCTS

2.1 ELECTRIC UNIT HEATER

A. A UL listed; 5 KW. Provide control-circuit terminals and single source of power supply. Limit leaving air temperature below 140 degrees F at 60 degrees F entering air. Casing minimum of 22 gauge nickel-chromium heating wire element, free from expansion noise and 60 Hz hum. Embed element in magnesium-oxide insulating refractory. Seal element in high-mass steel or corrosion-resisting metallic sheath with fins. Enclose element ends in terminal box. Space fins at maximum six fins per inch. Limit fin surface temperature 550 degrees F at any point during normal operation.

B. Include limit controls for thermal overheat protection of heaters. Provide contactor rated for 100,000 duty cycles with room thermostat.

C. Provide both horizontal and vertical adjustment.

2.2 GAS FIRED FORCED AIR UNIT HEATERS

A. Units:Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heat exchanger, burner, controls. The units shall be AGA certified.

B. Performance Ratings: Seasonal efficiency to ANSI/ASHRAE 103.

C. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access

doors, glass fiber insulation and reflective liner.

D. Heat Exchanger: Aluminized welded construction.

E. Supply Fan: Propeller type with direct drive.

F. Burner:

1. Gas Burner: Factory installed flue vent fan, combination gas valve and pressure regulator incorporating manual shut-off, pilot valve, automatic 100 percent shut-off and thermo-couple pilot safety device and electronic pilot ignition.

2. Gas Burner Safety Controls: Thermo-couple sensor prevents opening of solenoid gas valve until pilot flame is proven and stops gas flow on ignition failure.

G. Burner Operating Controls:

1. Room thermostat: Cycles burner to maintain room temperature setting.

2. High Limit Control: Fixed stop at maximum permissible setting, de-energizes burner on high bonnet temperature and re-energizes when temperature drops to lower value.

H. Accessories:

1. Discharge Louvers: Individually adjustable horizontal and vertical louvers to match cabinet finish.

2.3 INFRA-RED UNIT HEATERS

A. General Requirements:

1. Gas fired vented infra-red space heaters shall be furnished and installed in accordance with governing codes.
2. Heaters shall be Design Certified by the American Gas Association (A.G.A.) and comply with Occupational Safety and Health Act (OSHA) Requirements. The supplier shall provide A.G.A. certificate numbers and heaters shall bear the A.G.A. Seal of Certification.
3. The supplier shall provide a manufacturer's published warranty covering the heater's radiant tube element assembly for a period of five (5) years, and all components utilized in the heater's control assembly for a period of one (1) year.
4. No condensation shall form from the products of combustion in the combustion

chamber or heat exchanger while at operating temperature.

B. Heater Control System:
1. Heater shall be equipped with a direct silicon carbide glo-bar ignition control system. Power supplied to each heater shall be a 120 VAC, 60 Hz.
2. The heater's control system shall be designed to shut off the gas flow to the main burner in the event of either a main gas supply line or power supply line interruption or failure occurs.
3. Control assembly shall be Certified by A.G.A., shall provide main burner regulation, and shall be of the redundant dual solenoid type.
4. Heater controls shall include two (2) differential pressure switches; one to monitor exhaust back pressure and one to monitor air intake flow so as to provide complete unit shut off in the event of insufficient air or flue blockage.
5. Pre-purge of tubes for 45 seconds prior to firing sequence.

C. Heater Construction:
1. The material used in the heater's combustion chamber and emitter tube shall be 16 gauge alloy aluminized steel. 4" O.D., coated with 1200 degree high temperature corrosion resistant black paint with an emissivity rating of .95.
2. The burner control box shall be constructed of enameled steel.
3. The multi-faceted reflectors shall be .025 bright aluminum designed to provide uniform irradiance levels and be adjustable.
4. The fan blower motor shall be protected by a thermal overload switch.
5. Heater shall be vented in accordance with manufacturer's recommendations and provide for venting of products of combustion without the use of a draft hood.
6. Heater shall be equipped with a slight glass for visual inspection of silicon carbide ignitor operation and burner flame.
7. Vent caps shall be UL approved and A.G.A. certified for use with heater. Breidert vent caps only for sidewall venting.
8. The heaters shall be designed such that, outside combustion air may be supplied without the use of additional supply fans.
9. An air intake collar and termination fitting A.G.A. approved for use with the heater shall be provided for outside air intake for combustion.

2.4 CEILING MOUNTED UNIT HEATERS

A. The units shall be UL listed.

B. The heaters shall be designed to fit in suspended ceiling grid. The units shall have unit mounted thermostat, fan with downward discharge, fixed grille.

C. The heater shall have the capacity as indicted on drawings.

2.5 HOT WATER UNIT HEATERS

A. Coils: Seamless copper tubing, 0.025 inch minimum wall thickness, silver brazed to steel headers, and with evenly spaced aluminum fins mechanically bonded to tubing.

B. Casing: 18 gage steel with threaded pipe connections for hanger rod.

C. Finish: Factory apply baked enamel on visible surfaces of enclosure or cabinet.

D. Fan: Direct drive properller type, statically and dynamically balanced, with fan guard; horizontal models and permanently lubricated sleeve bearings.

E. Air Outlet: Adjustable pattern diffuser on vertical throw and two-way adjustable louvers on horizontal throw models.

F. Control: Local thermostat mounted on wall. To control as indicated in sequence of operation.

2.6 Infrared Unit Heater (Tube)

A. General Requirements

1. Gas-fired infrared space heaters shall be furnished and installed in accordance with governing codes and as shown per building drawing and as described.

2. Heaters basis of design is SPACE-RAY LTS series tube heaters, model LTS as manufactured by Gas-Fired Products, Inc., Charlotte, North Carolina.

B. Controls

1. Heaters shall be equipped with a 24-volt direct spark ignition with automatic 100% shutoff system. Power supplied to each heater shall be 120 VAC, 60 HZ. The heater controls shall include a pressure switch designed to provide complete unit shutoff in the event of combustion air or flue blockage. The heaters shall be equipped with an on-line diagnosis monitoring light system. The three lights shall monitor the power to the heater, insufficient air flow, and the spark ignition and the combination gas valve operation. The unit shall be wired for and supplied with wall thermostat.

C. Burner and Emitter

1. The heater’s burner shall consist of a cast iron atmospheric burner. The flame

characteristics shall be highly luminous for maximum radiant heat transfer through the emitter tube wall.

2. The heater's emitter tube shall operate at an average surface temperature of 750□F and shall be made of 16-gauge, aluminized steel for long life. The emitter tube shall be calorized for longevity, corrosion resistance, and high radiant efficiency. The measured surface emissivity shall be .83 to.86 at operating temperature. The calorization process shall produce an emmitter tube that is highly radiant absorptive in the interior and highly radiant emissive on the exterior.

3. The heaters shall operate under negative pressure at all times during operation to preclude the escape of combustion gases inside the building. The heater exhaust assembly shall include a 115-volt draft inducer. The draft inducer shall be equipped with a permanently lubricated, totally enclosed and shielded, fan cooled, and heavy duty ball bearing motor. The motor shall not require maintenance or lubrication for the life of the unit. The draft inducer assembly shall be capable of rotating 90□ for vertical or horizontal venting.

4. The heaters will be A.G.A. and C.G.A. design certified for vertical or horizontal venting, maximum 75 feet horizontal sidewall venting, and for 50 feet outside fresh air inlet duct. There shall be no draft hoods. The combustion chamber shall be no draft hoods. The combustion chamber shall be totally enclosed.

5. The heaters shall utilize factory assembled, highly efficient aluminum reflectors with a reflectivity of 97.5%. The reflector ends shall be enclosed for maximum radiant heat output and minimum convection losses.

6. The heaters shall be factory assembled and tested. The heaters shall not require any field wiring or adjustments to assure maximum performance and safety.

7. Heaters shall operate satisfactorily in any position from horizontal to forty-five degrees (45□) from horizontal, and incline mounted up to 2/12 pitch, and shall be suitable for vented/indirect vented applications.

8. Heaters shall be design certified by the American Gas Association and the Canadian Gas Association. The manufacturer shall provide a written limited warranty covering the heavy one piece cast iron burner for a period of ten years, the emitter tube for a period of three years and all components utilized in the heater's control assembly for a period of one year.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that space is ready for installation of units and openings are as indicated on shop drawings.

B. Verify that proper power supply is available.

C. Verify that proper fuel supply is available for connection.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install to ANSI/NFPA 90B.

C. Install gas fired units to ANSI Z223.1 (NFPA 54).

D. Provide vent connections to ANSI/NFPA 211.

E. Install unit heaters with vibration isolation.

F. Install per NFPA 70.

END OF SECTION 15625

SECTION 15674 - WATER COOLED HEAT PUMP UNIT

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Heat pump unit.

B. Refrigerant piping.

1.2 RELATED SECTIONS

A. Section 15010 - General Mechanical Requirements.

1.3 REFERENCES

A. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.

B. ANSI/UL 207 - Refrigerant-Containing Components and Accessories, Non-Electrical.

C. ANSI/UL 303 - Refrigeration and Air-Conditioning Condensing, and Air-Source Heat Pump Equipment.

D. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.

E. ARI 360 - Commercial and Industrial Unitary Air-Conditioning Equipment.

F. ASHRAE 14 - Methods of Testing for Rating Positive Displacement Condensing Units.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Submit shop drawings indicating components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections.

C. Submit schematic layouts showing condensing units, cooling coils, refrigerant piping, and accessories required for complete system. The layout shall show sizes, traps, valves and other items of the system. The layout shall be approved by the equipment manufacturer.

D. Submit product data indicating rated capacities, weights specialties and accessories,

electrical nameplate data, and wiring diagrams.

E. Submit manufacturer's installation instructions.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 15010.

B. Include start-up instructions, maintenance instructions, parts lists, controls, and accessories.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units on site from physical damage. Protect coils.

1.8 WARRANTY

A. Provide five year compressor warranty.

PART 2 PRODUCTS

2.1 HEAT PUMP UNIT

A. Construction and Ratings: In accordance with AHRI/ISO 13256-1, ARI 210/240 or 360, ANSI/UL 207 and ANSI/UL 303. Testing shall be in accordance with ASHRAE 14.

B. Each unit shall be completely factory assembled, wired, and tested.

C. The water to refrigerant heat exchanger shall be of a copper coil in a steel sheet type.

D. Compressors shall be designed for heat pump use. Compressors shall be sealed hermetic type, rotary or scroll, with external vibration isolating mounts, and shall have crankcase heaters to prevent oil dilution. Compressor section to contain filter dryer and accumulator. Compressors shall have factory mounted suction and discharge line service valves.

E. Controls shall communicate via open protocol (LON or BacNet) and be factory mounted and wired in an accessible enclosure within the compressor compartment. System shall have a fully automatic defrost cycle and timer to prevent the compressor

from short cycling. Safety controls shall consist of high-low pressure cut-out and compressor overload protection. Cabinet shall be the manufacturer's standard of quality in appearance and construction. Cabinet shall be a minimum of zinc coated sheet metal and finished with epoxy paint. Compressor section shall have a large access panel for ease of service.

F. Units shall have capacities as per schedule on drawings. The efficiency performance shall meet the requirements of heat pump unit schedule on the drawings. Units shall be UL listed and ARI rated.

G. The units shall be completely factory assembled with insulated metal cabinet, direct expansion coil, insulated drain pan, fan and filter section complete with disposable filters. Units shall be designed for vertical or horizontal mounting as shown on the plans.

H. Evaporator coil shall be direct expansion, refrigerant R-410A, copper tube aluminum fin mechanically bonded. Thermal expansion valves shall have bypass line and check valve installed for heat pump use. Minimum tube size 1/2" O.D.

I. Evaporator fan shall be forward curved double inlet mounted on a common shaft with permanently lubricated ball bearings. Fan shall be statically and dynamically balanced for smooth operation. Fans shall be 3-speed, direct drive or shall be "V" belt driven if standard for larger sizes, provide adjustable motor pulley. Fan shall have vibration isolation.

J. Cabinet shall be constructed of hot dip galvanized sheet steel with a minimum thickness of 18 gauge. Interior panels and top shall be covered with insulation to prevent heat gain and noise transmission. Provide factory or shop fabricated insulated metal base for each unit, unless shown otherwise, to match cabinet of unit furnished. If base is not available from the equipment manufacturer the Contractor shall provide a base constructed of galvanized structural angle iron frame with minimum 18 gauge panels. Paint to match unit furnished. Provide permanent air seal gasket between top of base and the unit and between base and floor. Provide factory furnished filter section with sectional throwaway filters. Submit metal base shop drawings if shop fabricated.

K. Filter to be of standard size throwaway and not less than 1" thick. Filter section shall be accessible from front of unit.

L. The drain pans shall be sloped in two directions to insure 100% drainage. The pans shall be plastic or stainless steel and insulated.

M. The insulation shall be provided with foil facing or coating on air side.

2.2 CONTROLS

A. For each compressor, provide across-the-line starter, non-recycling compressor overload, starter relay, and control power transformer.

B. Provide the following safety controls arranged so that operating any one will shut down machine.

C. High discharge pressure switch (manual reset).

D. Low suction pressure switch (automatic reset).

E. Current overload protection (manual reset).

F. The heat pump shall be provided with 7 day programmable thermostat.

G. The units shall be supplied with high temperature condenser water lock-out if water rises above 95^{o}F.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with ANSI/ASHRAE 15.

C. Install units so the condensate traps have proper clearance based on static pressure of the units.

3.2 MANUFACTURER'S FIELD SERVICES

A. Provide initial start-up, including first year routine servicing and check out.

END OF SECTION 15674

SECTION 15713 - FORCED DRAFT CLOSED CIRCUIT EVAPORATIVE COOLER

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Cooling tower. The tower shall be Spectrum, EVAPCO, B.A.C. or equal.

B. Controls.

1.2 SCOPE

A. The equipment representative shall provide the specified equipment for installation by a contractor selected by School Board.

1.3 REFERENCES

A. AFBMA 9 - Load Rating and Fatigue Life for Ball Bearings.

B. AFBMA 11 - Load Rating and Fatigue Life for Roller Bearings.

C. ASME PTC-23 - Atmospheric Water-Cooling Equipment.

D. Cooling Tower Institute (CTI) ATC-105 - Acceptance Test Code for Water Cooling Towers.

E. Cooling Tower Institute (CTI) - Certification Standard STD-201.

F. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

1.4 SUBMITTALS FOR REVIEW

A. Shop Drawings: Indicate suggested structural steel supports including dimensions, sizes, and locations for mounting bolt holes.

B. Product Data: Provide rated capacities, dimensions, weights and point loadings, accessories, required clearances, electrical requirements and wiring diagrams, and location and size of field connections. Submit schematic indicating capacity controls.

C. Submit manufacturer's installation instructions.

D. Manufacturer's Certificate: Certify that cooling tower performance, based on CTI STD-201 or ASME PTC-23, meet or exceed specified requirements, and submit performance curve plotting leaving water temperature against wet bulb temperature.

E. Operation and Maintenance Data: Include start-up instructions, maintenance data, parts lists, controls, and accessories.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.6 REGULATORY REQUIREMENTS

A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND PROTECTION

A. Factory assemble entire unit. For shipping, disassemble into large sub-assemblies to minimize field work required for re-assembly.

B. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

1.8 WARRANTY

A. Provide a one year warranty to include coverage for cooling tower package labor and materials.

PART 2 PRODUCTS

2.1 MANUFACTURED UNITS

A. Furnish as specified a forced draft counterflow design centrifugal fan equipped closed circuit evaporative cooler.

B. Fan and fan section shall be constructed of hot dip galvanized sheet steel. All structural angles and motor and fan supports shall be made of heavy gauge galvanized steel material. Centrifugal fan wheels shall feature forward curved blades and shall be statistically and dynamically balanced. Standard electrical motors shall be TEFC designed for outdoor service; motors shall be easily accessible for service and maintenance. V-Belt drives shall be selected for 150% of motor horsepower name plate rating. Fan bearing shall have cast iron housing and have a minimum L-10 life rating of 50,000 hours. All rotating components shall be protected by a removable hot dip galvanized steel wire screen. Extended lube fittings shall be provided to permit bearing lubrication without removing protective screens. Additional pan section accessories shall include a float operated water make-up valve, a suction strainer and anti-vortex suction assembly. Gasketed access doors shall be included to permit inspection and service of water sump.

C. Coil(s) shall be fabricated from heavy duty, high quality steel tubing and encased in structural steel framework. After fabrication, the entire assembly is subjected to hot-dip galvanizing as per ASTM A123 specifications. Coil(s) shall be designed with sloping tubes for free drainage of fluid under gravity. Each circuit element of the coil(s) is

individually tested as 350 psig air pressure under water.

D. The water distribution section shall be encased in stainless sheet steel panels. Water distribution shall be accomplished by a closed pressurize arrangement of Schedule 40 PVC pipe fitted with non-clog type ABS spray nozzles to insure the best possible wetting of heat transfer surface.

E. Drift eliminators shall be constructed of PVC material formed to provided at least three changes of air flow direction and yield an efficient limitation of drift loss to less than 0.002 percent of total circulated water.

F. Water recirculation pump shall be a close-coupled, centrifugal type and mounted vertically to allow free drainage under gravity on shut down.

G. All sheared and/or welded sections of casing material and structural components shall be pretreated using zinc rich cold galvanizing compound followed by careful surface preparation of entire unit for a final coating of chromatized aluminum paint. The sump shall be stainless steel.

H. The unit shall be provided with a electric basin heater for freeze protection.

I. The unit shall be provided with the factory standard capacity control package. The controls shall include phase protection for the motor. The cooler control panel shall be in a NEMA 4X enclosure incorporating a main power electrical disconnect, individual circuit protection fuses, fused control power transformer, fan and spray pump motor magnetic starters with thermal overload protection, fan and spray pump hand-off-auto selector switches, spray pump and fan interlock to prevent fan operation when the spray pump is off, basin heater contactor and fan cycling aquastat. The control panel shall provide 120/1/60 power to and interlock with the capacity control dampers.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide piping connections and accessories as indicated.

C. Provide for connection to electrical service.

D. The contractor shall clean tower as recommended by manufacturer before putting in service.

3.2 MANUFACTURER'S FIELD SERVICES

A. Manufacturers representative to check boiler installation and final connection.

B. The Contractor shall provide a 4-hour on-site training course on the cooling tower operation and maintenance.

END OF SECTION 15713

SECTION 15765 - DESICCANT ENERGY RECOVERY VENTILATOR

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Desiccant Energy Recovery Ventilator.

1.2 RELATED SECTIONS

A. Section 15010 - Mechanical General Requirements

1.3 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.

C. Product Data: Provide manufacturer's literature and data indicating rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.

D. Manufacturer's Installation Instructions: Indicate rigging, assembly, and installation instructions.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation data under provisions of Section 01700.

B. Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listing.

1.5 WARRANTY

A. Provide one year warranty under provisions of Section 15010.

B. Warranty: Includes 5 year parts warranty on the thermal and desiccant wheels.

PART 2 PRODUCTS

2.1 DESICCANT ENERGY RECOVERY VENTILATOR

A. General

1. Unit shall be a complete, factory assembled and tested energy recovery ventilator as manufactured by Cook, Greenheck, Semco or approved equal. Design shall utilize single wheel, total enthalpy desiccant cooling, using regeneration air supplied by the exhaust air stream. Manufacturer must have similar desiccant wheel systems installed and operating for a minimum of three years. Unit must be per the specifications herein without exception unless approved by the specifying authority in advance of bid.

2. Unit construction shall include supply fan, exhaust fan, total enthalpy desiccant wheel for dehumidification, controls, and housing as specified herein to form a complete packaged system.

3. Performance shall be as shown on the Schedule and as specified herein.

B. Unit Construction

1. General - Housing shall be suitable for indoor installation. It shall be designed for either structural or curb mounting without field modification. The enclosure system shall be air-tight (2% maximum leakage at 150% design static pressure) from section to section.

2. Base - The unit base shall be constructed of formed 11 GA. steel coated with red-oxide primer. Cross members will be located to support each major component. The longitudinal members will be fitted with lifting lugs.

3. Housing - The unit housing and internal partitions shall be constructed of minimum 18 GA galvanized steel with the exterior panels treated to allow for painting. All external walls shall be insulated with foil-faced fiber glass insulation at least 1" thick and secured by permanent mechanical fasteners welded to the panels. Adjoining panels shall be sealed to one another with a silicone compound.

4. Removable service access panels shall be provided for all components. The openings shall be of sufficient size to allow service to all maintenance items. All service panels shall be provided with resilient gaskets and hardware to assure compression. Access doors shall be provided for coil and control sections and shall have continuous hinges.

5. Finish - The exterior shall be painted with a beige color, air-dry, low gloss enamel.

6. The unit shall have external spring isolation as specified.

C. Supply and Exhaust Fan Assemblies

1. The unit shall be equipped with direct drive or belt driven blowers and employ backward curved impellers for draw-through regeneration air and blow-through supply air. Blowers shall be AMCA rated.

2. V-belts rated for 150% of motor horsepower shall be used on each fan. The motor sheave on the supply air blower shall be adjustable to allow for air balancing at installation.

3. The motors shall be NEMA design B with open drip-proof housings and a service factor of 1.15 or more, sized as shown on the Schedule.

D. Desiccant Dehumidification Wheel

1. Supply and exhaust air streams shall be counterflow. The dehumidifier shall be a rotary type designed for continuous operation. The wheel structure shall be of the extended surface type in the axial flow direction and the geometry shall provide for laminar flow over the operating range for minimum air pressure differentials.

2. The dehumidifier shall be complete with a drive system utilizing a fractional-horsepower electric motor and speed reducer assembly driving the rotor with a flexible circumferential belt. A slack-side tensioner shall be included for automatic take-up.

3. The desiccant material shall be adsorption type silica gel or titanium silicate.

4. The wheel shall be fitted with full-face, low-friction (Teflon surface) contact seals on both sides to prevent cross leakage.

E. Air Filters

1. Air filters shall be provided for the process and regeneration airflows.

2. Air filters shall be 2" deep pleated disposable type, minimum MERV 7 efficiency (ASHRAE 52.2-2007).

F. Electrical

1. The factory wired unit shall be equipped with a central electrical control panel mounted inside the service compartment. A single power supply shall be required. All internal wiring shall be in accordance with the National Electrical Code. All electric components required for automatic operation, based on signals from building controls, will be included. Connections to remote devices will be made at the marked terminals. All devices will be supplied to interface with building system.

2. Each three phase motor shall be wired to a separate three leg contactor with motor thermal overload protection. Fuses shall be provided for each motor larger than one hp. An integral disconnect or VFD shall be provided as indicated on the drawings.

G. Services

1. Start-up shall be provided by a factory employed or certified service technician.

H. Performance

1. Dehumidification shall be accomplished by adsorption of water vapor by a desiccant. The unit will be capable of dehumidification, heating and cooling without the use of refrigerants or a compressor.

2. Desiccant wheels shall have respectively a minimum moisture removal and heat transfer effectiveness for performance as shown on the Schedule.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

END OF SECTION 15765

SECTION 15787 - DUCTLESS SPLIT SYSTEM AIR CONDITIONING UNIT

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Air Conditioning Units.

B. Controls.

1.2 RELATED SECTIONS

A. Section 15010 - General Mechanical Requirements.

1.3 REFERENCES

A. NFPA 70 - National Electrical Code.

1.4 SUBMITTALS

A. Section 15010: Procedures for submittals.

B. Product Data: Provide manufacturers literature and data indicating water, drain, and electrical characteristics and connection requirements.

C. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data.

1.5 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.6 REGULATORY REQUIREMENTS

A. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc., as suitable for the purpose specified and indicated.

1.7 WARRANTY

A. Provide one year warranty on compressor.

PART 2 PRODUCTS

2.1 APPROVAL

A. The unit shall be UL listed.

2.2 AIR CONDITIONING UNIT

A. Description: Split system air cooled heat pump, factory assembled, pre-wired and consisting of cabinet, fan, filters, controls.

B. Assembly: For wall mounting of indoor unit.

C. Cabinet: Welded steel with baked enamel finish, and lined with 1/2 inch thick acoustic duct liner.

D. Evaporator Fan: Forward curved centrifugal, directly driven.

E. Compressor: Inverter driven hermetic with resilient suspension system, oil strainer, internal motor overload protection, low pressure switch, manual reset high pressure switch.

F. Evaporator Coil: Direct expansion cooling coil of seamless copper tubes expanded into aluminum fins, with thermal expansion valve with external equalizer, liquid line filter-drier, service shut-off valves and charging valves.

G. Air Cooled Condenser: Integral copper tube aluminum fin coil sized for rated capacity at 95 degrees F with fan driven by evaporator fan motor.

H. Filter: One inch thick disposable glass fiber media.

2.3 CONTROL SYSTEM

A. Unit Mounted: Main fan contactor, compressor and condenser fan contactor, compressor start capacitor, controls transformer with circuit breaker, temperature control module, time delay relay, heat contactor, and high temperature thermostat.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide all supports as required for mounting unit.

C. Provide adequate drainage connections for unit condensate.

3.2 MANUFACTURER'S FIELD SERVICES

A. Prepare and start system and set initial temperature set points. Instruct operating personnel.

END OF SECTION 15787

SECTION 15870 - POWER VENTILATORS

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED ON EACH ITEM)

A. Roof exhaust fan.

B. Cabinet exhaust fans.

C. Ceiling exhaust fans.

D. Sidewall centrifugal exhausters.

E. Belt driven sidewall.

F. Roof curbs.

G. Direct driven sidewall.

H Individual toilet exhaust fans.

I. In-line fan.

J. Roof supply fan (axial type)

1.2 RELATED SECTIONS

A. Section 15010 - General Mechanical Requirements

1.3 REFERENCES

A. AMCA 99 - Standards Handbook.

B. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

C. AMCA 261 - Directory of Products Licensed to Bear the AMCA Certified Ratings Seal.

D. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

E. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.

F. NEMA MG1 - Motors and Generators.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, sound power levels at rated capacity, and electrical characteristics and connection requirements.

C. Manufacturer's Installation Instructions.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 15010.

B. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

PART 2 PRODUCTS

2.1 GENERAL

A. All products shall be UL listed.

2.2 ROOF EXHAUST FAN

A. Roof exhaust fan shall be up blast centrifugal belt driven type. The fan shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel carefully matched to the inlet one for precise tolerances. Wheels shall be statically and dynamically balanced. The fan housing shall be constructed of heavy gauge aluminum with a rigid internal support structure. Windband shall have a rolled bead for added strength and shall be joined to curbcaps with a welded seam. Motors shall be heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure. Motors and drives shall be mounted on vibration isolators, out of the airstream. Fresh air for motor cooling unit shall be drawn into the motor compartment from an area free of discharge contaminants. Motors shall be readily accessible for maintenance. Drive assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators. Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearing shall be selected for a minimum life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor pulleys shall be adjustable for final system balancing. A disconnect switch shall be factory installed and wired from the fan motor to junction box installed within the motor compartment. A conduit chase shall be provided through the curb cap to the motor compartment for ease of electrical wiring. The fans shall bear the AMCA certified rating seal for sound and air performance.

B. Roof exhaust fan shall be upblast centrifugal direct drive type. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced. The fan housing shall be constructed of aluminum with a rigid internal support structure. Windbands shall have a rolled bead for added

strength and shall be joined to curbcaps with a leakproof, continuously welded seam. Motors shall be mounted out of the airstream on vibration isolators. Fresh air for motor cooling shall be drawn into the motor compartment from an area free of discharge contaminants. Motors shall be readily accessible for maintenance. A disconnect switch shall be factory installed and wired from the fan motor to a junction box within the motor compartment. A conduit chase shall be provided through the curb cap to the motor compartment for ease of electrical wiring. All fans shall bear the AMCA Certified Ratings Seal for sound and air performance. Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number for future identification.

2.3 CABINET EXHAUST FANS

A. Duct mounted, exhaust fans shall be of the centrifugal, belt driven in-line type. The fan housing shall be of the rectangular design constructed of heavy gauge galvanized steel and shall include rectangular duct mounting collars. A hinged or removable panel shall be provided in the fan cabinet of sufficient size to permit access for service to all of the fan's internal components without dismantling the cabinet. The fan wheel shall be of the galvanized steel, forward curved, centrifugal type. Wheels shall be dynamically and statically balanced. Motors shall be of the heavy duty type with permanently sealed ball bearings. The wheel shaft shall be ground and polished steel mounted in permanently sealed pillow block bearings. Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the machined cast iron type, keyed and securely attached to the wheel and motor pulleys shall be adjustable for final system balancing. All fans shall bear the AMCA certified ratings seal for air performance. The fans shall have backdraft dampers and have base or hanging spring vibration isolation as the application requires. The housings shall be insulated.

2.4 CEILING EXHAUST FANS

A. Ceiling mounted exhaust fans shall be of the centrifugal direct drive type. The fan housing shall be constructed of heavy gauge galvanized steel with prepunched mounting brackets. The housing interior shall be lined with 1/2" acoustical fiberglass insulation. The outlet duct collar shall include an aluminum backdraft damper and shall be adaptable for horizontal or vertical discharge. The access for wiring shall be external. The motor disconnect shall be internal and of the plug in type. The motor shall be mounted on vibration isolators. The fan wheel(s) shall be of the forward curved centrifugal type, constructed of galvanized steel and dynamically balanced. The fans shall have integral aluminum ceiling grille. The fans shall be ducted as shown on drawings. Provide ductwork factory fabricated wall or roof cap. Fans shall have capacities as scheduled on drawings and shall be controlled as indicated. Provide with electronic speed control.

2.5 IN-LINE EXHAUST FANS (DIRECT DRIVE)

A. In-line mounted exhaust fans shall be of the centrifugal direct drive type. The fan housing shall be constructed of heavy gauge galvanized steel with prepunched mounting brackets. The housing interior shall be lined with 1/2" acoustical fiberglass

insulation. The outlet duct collar shall include an aluminum backdraft damper and shall be adaptable for horizontal or vertical discharge. The access for wiring shall be external. The motor disconnect shall be internal and of the plug in type. The motor shall be mounted on vibration isolators. The fan wheel(s) shall be of the forward curved centrifugal type, constructed of galvanized steel and dynamically balanced. Factory fabricated wall or roof cap. Fans shall have capacities as scheduled on drawings and shall be controlled as indicated. Provide with speed controller.

2.6 SIDEWALL CENTRIFUGAL EXHAUSTERS

A. Sidewall exhaust fans shall be of the centrifugal belt driven type. Construction of the windband shall be of heavy gauge aluminum with a rolled bead on the outer edge for strength. The fan wheel and inlet cone shall be aluminum and of the high performance centrifugal blower type. The fan wheel shall be of the aluminum, non-overloading, backward inclined type, statically and dynamically balanced. Blades, fins, inlet cones and back plates shall be securely fastened together into a rigid assembly. Motors and drives shall be isolated from the exhaust airstream. Motors shall be of heavy duty type with permanently lubricated, sealed ball bearings. Air for cooling the motor shall be taken into the motor compartment by means of an air tube from a location free of discharge contaminants. The entire drive assembly and wheel, as a unit, shall be removable through the support structure without dismantling the fan housing. The wheel shaft shall be mounted in heavy duty, permanently lubricated, sealed ball bearing pillow blocks. Drives shall be sized for 165% of driven horsepower. Pulleys shall be of the machined cast iron type, keyed securely to the fan and motor shafts. Motor pulleys shall be of the adjustable type to allow for final system balancing. The entire drive assembly shall be mounted on vibration isolators to minimize noise transmission. Fan shall be AMCA licensed for air and sound performance data. Fans shall be Model GWB as manufactured by Greenheck or equal. The fans shall have birdscreens and backdraft dampers.

2.7 ROOF CURBS

A. Roof curbs shall be factory fabricated with sheet-metal structural members complying with the National Roofing Contractors Association (NRCA) requirements. The roof curbs shall be of approved by the roofing manufacture for this type of installation and meet the vibration isolation requirements specified.

2.8 BACKDRAFT DAMPERS

A. The backdraft dampers shall be gravity actuated, aluminum multiple blade construction with nylon bearings.

2.9 BELT DRIVEN SIDEWALL

A. The sidewall fan shall be belt driven axial type. Propellers shall be constructed with die formed galvanized steel blades riveted to a steel hub. Propellers shall be statically and dynamically balanced.

B. Motors shall be of heavy duty ball bearing type, matched to the fan load, and furnished at the specified voltage, phase and enclosure.

C. Ground and polished steel fan shafts shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. Propellers shall be attached to fan shafts with a standard square key and set screws or tapered bushings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speeds. Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor sheaves shall be adjustable for final system balancing.

D. Drive frame assemblies shall be formed galvanized steel construction. Fan panels shall have prepunched mounting holes, formed flanges with welded corners and a deep formed inlet venturi.

E. The axial exhaust or supply fans shall bear the AMCA Certified Ratings Seals for both air and sound performance.

F. The fans shall have the performance as scheduled on the drawings.

2.10 DIRECT DRIVEN SIDEWALL

A. Sidewall fans shall be direct driven axial type. Propellers construction shall be of die formed aluminum blades riveted to a steel hub. Hubs shall be securely attached to motor shafts with set screws.

B. Motors shall be permanently lubricated, heavy duty type matched to the fan load and furnished at the specified voltage, phase and enclosure.

C. The fan panel shall be steel construction with prepunched mounting holes, formed flanges and a deep spun venturi. Panels shall have a protective coating. Motor supports shall be heavy gauge welded wire, zinc plated. Four neoprene vibration isolators shall be installed between the motor support and the motor mounts. The fan shall be provided with backdraft dampers and OSHA approved guards.

D. The axial exhaust or supply fans shall bear the AMCA Certified Ratings Seals for air performance. The fans shall have the performance as scheduled on the drawings.

2.11 INDIVIDUAL TOILET EXHAUST FANS

A. Ceiling mounted individual exhaust fans shall be of the centrifugal direct drive type. The fan housing shall be constructed of steel. The duct collar shall be a tapered sleeve for ease of connection to ductwork and shall include a backdraft damper. The grille shall be attached to the housing with torsion springs. The access for wiring shall be external. The motor disconnect shall be internal and of the plug in type. All fans shall bear the AMCA Certified Ratings Seals for sound and air performance and shall be UL listed.

2.12 ROOF SUPPLY FAN (AXIAL TYPE)

A. The axial roof supply fan shall be direct drive axial type and meet the following requirements. The hood construction shall be aluminum, with an integral, prepunched, roof mounting curb. The housing support frame shall be constructed of heavy gauge, zinc plated steel and designed in concentric rings to serve as a bird guard. Propeller construction shall be of die formed aluminum blades riveted to a steel hub. The hub shall be securely attached to the motor shaft with set screws. The motor shall be permanently lubricated, heavy duty type matched to the fan load and furnished at the specified voltage and phase. The motor shall be mounted on vibration isolators. A NEMA 1 disconnect switch shall be provided and wired to the motor. The axial roof supply fan shall be licensed to bear the AMCA Certified Ratings Seal for air performance.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install flexible connections between fan inlet and ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.

C. Provide sheaves required for final air balance.

D. Install backdraft dampers on inlet to roof and wall exhausters.

E. Provide backdraft dampers on outlet from cabinet and ceiling exhauster fans and as indicated.

F. Do not operate fans for any purpose until ductwork is clean, filters in place, bearings lubricated, and fan has been test run under observation.

END OF SECTION 15870

SECTION 15891 - DUCTWORK

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Insulated flexible ducts.

B. Galvanized steel duct material.

C. Duct sealer.

1.2 RELATED SECTIONS

A. Section 15010 - General Mechanical Requirements

1.3 REFERENCES

A. ASTM A 36 - Structural Steel.

B. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles.

C. ASTM A 525 - General Requirements for Steel Sheet, Zinc- Coated (Galvanized) by the Hot-Dip Process.

D. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.

E. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

F. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.

G. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Manufacturer's catalog data showing that ratings, capacities, weights, etc. meet specification.

C. Manufacturer's Installation Instructions: Indicate procedures for duct installation.

1.5 PERFORMANCE REQUIREMENTS

A. No variation of duct configuration or sizes permitted except by written permission. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.

1.6 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 15010.

B. Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.7 QUALITY ASSURANCE

A. Perform Work in accordance with SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

B. Maintain one copy of document on site.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing the work of this section with minimum five years documented experience.

1.9 REGULATORY REQUIREMENTS

A. Construct ductwork to NFPA 90A and NFPA 90B standards.

1.10 ENVIRONMENTAL REQUIREMENTS

A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.

B. Maintain temperatures during and after installation of duct sealants.

PART 2 PRODUCTS

2.1 MATERIALS

A. Galvanized Steel Ducts: ASTM A525 and ASTM A527 galvanized steel sheet, lock-forming quality, having G90 zinc coating of in conformance with ASTM A90.

B. Insulated Flexible Ducts:

1. The insulated flexible duct shall meet UL 181 Class 1.

2. Multiple layers of aluminized duct fabric supported by helically wound spring steel wire; fiberglass insulation; aluminized vapor barrier film and the thermal conductive shall not be more than .23.

3. Pressure Rating: 6 inches WG positive and 1.0 inches negative.

4. Maximum Velocity: 4000 fpm.

5. Temperature Range: -20 degrees F to 210 degrees F.

C. Fasteners: Rivets, bolts, or sheet metal screws.

D. Sealant:

1. Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic.

E. Hanger Rod: ASTM A36; steel; threaded both ends, threaded one end, or continuously threaded.

2.2 DUCTWORK - LOW PRESSURE

A. This part of the specification shall apply to all low pressure rectangular shop fabricated ductwork for all supply air distribution systems, return air systems, outside air systems and exhaust systems. Ductwork shall be constructed of galvanized steel sheets, furnished and installed in sizes as indicated and located where shown on the drawings. This part of the work shall include all ductwork, manual dampers, access panels, louvers, etc., with all accessories to make a complete air distribution system. Noise, vibration or drumming of air in ductwork, noises at air outlets or returns, excessive air leaks, malfunctioning of dampers, etc., will be cause for rejecting affected parts of the ductwork.

The Mechanical Contractor shall coordinate with the General Contractor all ductwork penetrations of walls which require lintels or sleeves.

B. The following weights of materials, types of joints and bracing shall be followed for sheetmetal ductwork.

Steel US Std. Gauge	Maximum Inches	Type of Transverse Joint Conn.	Bracing
24	Up to 12	S-Drive, pocket or bar clips, on 7" - 10" centers	None
24	13 to 24	S-Drive, pocket or bar clips, on 7" - 10" centers	None
24	25 to 30	A-Drive, pocket	1x1x1/8"

		or bar clips, on 7"-10" centers	**angle**
20	**30 and Greater**	**S-Drive, pocket or clips, on 7"-10" centers**	**1x1x1/8" angle**

C. The following details of duct construction shall be adhered to without deviation:

1. Longitudinal seams for metal shall be Pittsburgh lock.

2. Sweep elbows shall be made with inside radius equal to width of ducts, except as shown on the drawings. Square elbows must be provided with approved turning vanes to assure good air flow to outlets.

3. Provide vanes at all elbows. Provide adjustable splitter dampers and turning vanes at duct tees.

4. Horizontal ducts shall be hung at intervals not exceeding 8'-0" with 18-gauge galvanized iron hangers extending the full height of the duct.

5. Shop drawings of all ductwork shall be submitted when for any reason there are differences from contract drawings for approval.

6. All ductwork shall be fabricated in strict accordance with SMACNA HVAC Duct Construction Standard - Metal and flexible unless more stringent requirements are called for in the specifications. All seams shall be caulked or taped to prevent air leakage for all pressure duct classifications.

D. 45 degree shoe fittings shall be provided at all rectangular or square branch connections to main headers in accordance with SMACNA Standards. Provide manual volume damper if branch duct serves two or more air devices.

2.3 DUCTWORK FABRICATION

A. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated or specified whichever is the most stringent. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.

B. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where rectangular elbows are used, provide turning vanes.

C. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

D. Fabricate continuously welded round fittings two gages heavier than duct gages

indicated in SMACNA Standard. Joints shall be minimum 4 inch cemented slip joint, brazed or electric welded. Prime coat welded joints.

E. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible unless more stringent items are required by specifications. All ducts are to be sealed.

C. Duct Sizes are inside clear dimensions. All duct joints shall be sealed with tape or mastic for all pressure classes.

D. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation so that it can be removed and replaced.

E. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

F. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with crimp in direction of air flow.

G. Use double nuts and lock washers on threaded rod supports.

H. Hanger straps shall be used to support the flexible ductwork. These straps shall be of galvanized sheet metal or aluminum, shall be 4" wide, and have smooth edges to prevent puncturing exterior wrap insulation. Hanger straps may be suspended with wire from building structure. Install flexible ductwork supports at center of flex duct.

I. The flex duct shall be a maximum of 8' long.

J. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

3.2 CLEANING

A. Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning. The

duct systems may be cleaned with high power vacuum machines.

3.3 SCHEDULES

A. DUCTWORK MATERIAL SCHEDULE

AIR SYSTEM	MATERIAL
Supply	Steel
Return	Steel
General Exhaust	Steel
Outside Air	Steel

B. DUCTWORK PRESSURE CLASS SCHEDULE

AIR SYSTEM	PRESSURE CLASS
Supply	1 inch
Return	1 inch
General Exhaust	1 inch
Outside Air Intake	1 inch

END OF SECTION 15891

SECTION 15910 - DUCTWORK ACCESSORIES

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM)

A. Air turning devices.

B. Backdraft dampers.

C. Duct access doors.

D. Duct test holes.

E. Fire dampers.

F. Flexible duct connections.

G. Volume control dampers.

1.2 RELATED SECTIONS

A. Section 15010 - General Mechanical Requirements

1.3 REFERENCES

A. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

B. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

C. UL 33 - Heat Responsive Links for Fire-Protection Service.

D. UL 555 - Fire Dampers and Ceiling Dampers.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers duct access doors and duct test holes.

C. Product Data: Provide for shop fabricated assemblies including volume control

dampers duct access doors duct test holes and hardware used.

D. Manufacturer's Installation Instructions: Provide for fire dampers.

1.5 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 15010.

B. Record actual locations of access doors and test holes.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products according to good construction practices.

B. Protect dampers from damage to operating linkages and blades.

1.8 EXTRA MATERIALS

A. Furnish under provisions of Section 15010.

B. Provide two of each size and type of fusible link.

PART 2 PRODUCTS

2.1 AIR TURNING DEVICES

A. The turning vanes shall be per SMANCA single thickness.

2.2 DUCT ACCESS DOORS

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.

B. Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover. Door to have continuous piano hinge.

1. Less Than 12 Inches Square: Secure with cam locks.

2. Up to 18 Inches Square: Provide two cam locks.

3. Up to 24 x 48 Inches: Three latches.

C. Access doors with sheet metal screw fasteners are not acceptable.

D. In locations where space is limited the hinge may be deleted and cam locks provided on each side of door. Provide two cam locks on each side for doors with sides over 18" long.

2.3 DUCT TEST HOLES

A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

B. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.4 FIRE DAMPERS

A. Fabricate in accordance with NFPA 90A and UL 555, and as indicated.

B. Curtain Type Dampers: Galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations and closure under air flow conditions. Configure with blades out of air stream. The dampers shall bear a UL label and have a 1-1/2 hour rating unless indicated otherwise .

C. Fusible Links: UL 33, separate at 165 degrees F.

2.5 FLEXIBLE DUCT CONNECTIONS

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.

B. Connector: Fabric crimped into metal edging strip.

1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz per sq yd.

2. Net Fabric Width: Approximately 2 inches wide.

3. Metal: 3 inch wide, 24 gage thick galvanized steel.

2.6 VOLUME CONTROL DAMPERS.

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.

B. Splitter Dampers:

1. Material: Same gage as duct to 24 inches size in either direction, and two gages heavier for sizes over 24 inches.

2. Blade: Fabricate of double thickness sheet metal to streamline shape, secured with continuous hinge or rod.

3. Operator: Minimum 1/4 inch diameter rod in self aligning, universal joint action, flanged bushing with set screw.

C. Single Blade Dampers: Fabricate for duct sizes up to 6 x 30 inch.

D. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 x 72 inch. Assemble, center and edge crimp blades in prime coated or galvanized channel frame with suitable hardware.

E. End Bearings: Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or bronze bearings.

F. Quadrants:

1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.

2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters so the dampers can be adjusted without disturbing the insulation.

3. Where rod lengths exceed 30 inches provide regulator at both ends.

G. Spin Ins: The spin-ins shall have scoop with adjustable manual volume damper. The damper shall have lockable quadrant with stand off to clear insulation.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible. Refer to "Ductwork" Section for duct construction and pressure class.

B. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

C. Provide duct access doors for inspection and cleaning before and after automatic dampers, at fire dampers, and elsewhere as indicated. Review locations prior to fabrication. The access doors shall be the following minimum sizes.

Duct Diameter	Access Opening
8" thru 10"	7" dia.
11" thru 13"	10" dia.
14" thru 19"	13" dia.
20" and over	14" dia.

D. For rectangular ducts, the nominal size of the access opening shall be:

Duct Size	Access Opening
8" thru 16"	8" X 12"
17" thru 24"	12" X 12"
25" and over	18" X 18"

E. Provide duct test holes where as required for testing and balancing purposes.

F. Provide fire dampers at locations indicated, where ducts and outlets pass through fire rated components. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs and hinges.

G. Demonstrate re-setting of fire dampers to Owner's representative.

H. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum 2 duct widths from duct take-off.

I. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

END OF SECTION 15910

SECTION 15940 - AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTALS REQUIRED FOR EACH ITEM)

A. Supply registers.

B. Return registers.

C. Return grilles.

D. Louvers.

1.2 RELATED SECTIONS

A. Section 15010 - General Mechanical Requirements

1.3 REFERENCES

A. ADC 1062 - Certification, Rating and Test Manual.

B. AMCA 500 - Test Method for Louvers, Dampers and Shutters.

C. ASHRAE 70 - Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

1.5 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 15010.

1.6 QUALITY ASSURANCE

A. Test and rate air outlet and inlet performance in accordance with ADC Equipment Test Code 1062 and ASHRAE 70.

B. Test and rate louver performance in accordance with AMCA 500.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

PART 2 PRODUCTS

2.1 GRILLES AND REGISTERS

A. Panel ceiling diffusers shall meet the following requirements. Factory-furnished diffusers, constructed of aluminum. Exterior and exposed edges shall be rolled, or otherwise stiffened and rounded. Color shall be white. Manufacturer certified sound pressure level rating of outlets shall be less than 25 dB room sound pressure level. The distance from the diffuser, to the point which the air velocity falls below 150 feet per minute shall not exceed 1.5 times the outlet mounting height. Maximum drop of air stream shall not be within 6 feet of the floor at the end of the throw. Equip with baffles or other devices required to provide proper air distribution pattern. Provide factory-fabricated, single key, opposed blade volume dampers. Internal parts shall be removable through the diffuser neck for access to the duct and without the use of special tools. Construct each ceiling diffuser of four or more concentric elements designed to deliver air in a generally horizontal direction without excess smudging of the ceiling. Interior elements of square and rectangular ceiling diffusers may be square or rectangular as manufacturer's standard. Provide with panel for installation in 24" x 24" lay-in type ceiling and square to round duct connection.

B. Ceiling diffusers for other than lay-in ceilings shall be equal to panel diffusers without the panel.

C. Sidewall registers shall have aluminum double deflection 3/4" airfoil blades with front blades parallel to long dimension that are individually adjustable for any degree of deflection and an opposed blade damper. Finish shall be white.

D. Exhaust registers shall be steel grilles with 1/2" spacing at 0 degrees fixed deflection with damper. The finish shall be white.

E. Ceiling return air registers shall be aluminum with 3/4" spacing at 0 degrees fixed deflection with damper. The registers shall fit in 2' X 2' ceiling grid and the register shall have a minimum of 6" deep full face transition from the register to duct. Finish to be white.

F. Wall return air registers shall be steel with 3/4" spacing at 0 degrees fixed deflection with damper. The finish shall be off-white.

G. Transfers grilles the grilles shall be the same as ceiling return air registers without dampers.

H. Ceiling return air grilles same as registers without dampers.

I. Eggcrate Return Grille. The grilles shall be all aluminum with 1/2" x 1/2" x 1/2" core, high face area, with panel for 24" x 24" lay in type ceiling.

J. Fire rated diffusers shall be UL classified fire rated ceiling diffuser assemblies listed in Underwriters Fire Resistance Directory. The diffusers shall be installed according to the manufacturer's written instructions.

2.2 WALL LOUVERS

A. Furnish and install louvers as hereinafter specified where shown on plans or as described in schedules. Louvers shall be stationary type with downspouts in jambs and mullions. Blades shall be entirely contained within a 4" frame. Louver components (heads, jambs, sills, blades & mullions) shall be factory assembled by the louver manufacturer. Louver sizes too large for shipping shall be built up by the contractor from factory assembled louver sections to provide overall sizes required. Louver design shall incorporate structural supports required to withstand a wind load of 20 lbs. per sq. ft.

B. Louvers shall be construction as follows:

1. Frame: 4" deep, 6063T5 extruded aluminum with .080" nominal wall thickness. Downspouts and caulking slots provided.

2. Blades: 6063T5 extruded aluminum .080" nominal wall thickness. Blades are positioned at 45 degree angle and spaced approximately 5 3/32"" center to center.

3. Screen: 3/4" X .051" expended, flattened aluminum bird screen in removable frame.

4. Finish: Baked enamel, color to be selected by Owner from standard color chart.

C. Published louver performance data bearing the AMCA Certified Ratings Seal for Air Performance must be submitted for approval prior to fabrication and must demonstrate pressure drop. The static pressure drop shall be less than .1 inch of water at a air velocity of 600 feet per minute. The louvers shall have a minimum of 50% free area.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

C. Install diffusers to ductwork with air tight connection.

1. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.

2. Paint ductwork visible behind air outlets and inlets matte black.

3. The backside of the inlets and outlets shall be insulated and have a vapor barrier.

END OF SECTION 15940

SECTION 15970 - SPACE TEMPERATURE CONTROLS (DDC)

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The Building Automation System (BAS) manufacturer shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.

Provide open communications system. System shall be capable of utilizing standard protocols as follows as well as be able to integrate third-party systems via existing vendor protocols. System shall be capable of BACnet communication according to ASHRAE standard SPC-135A/95 and/or LONTALK according to ANSI/CEA 709.1-B.

B. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer. The installing manufacturer shall certify in writing, that the shop drawings have been prepared by the equipment manufacturer and that the equipment manufacturer has supervised their installation. In addition, the equipment manufacturer shall certify, in writing, that the shop drawings were prepared by their company and that all temperature control equipment was installed under their direct supervision.

C. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specially for this project. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.

D. BAS manufacturer shall be responsible for all BAS and Temperature Control wiring for a complete and operable system. All wiring shall be done in accordance with all local and national codes.

1.2 WORK BY OTHERS

A. The temperature controls contractor shall be responsible for all related work to the control system installation. If they do not do it directly they shall coordinate the installation by other trades

1.3 QUALITY ASSURANCE

A. The BAS system shall be designed and installed , commissioned and serviced by factory trained personnel. Contractor shall have an in-place support facility within 100 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment.

The contractor shall provide full time, on site, experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the B.M.S.

The Bidder shall be regularly engaged in the installation and maintenance of BMS systems and shall have a minimum of ten (10) years of demonstrated technical expertise and experience in the installation and maintenance of B.M.S. systems similar in size and complexity to this project. A maintained service organization consisting of at least three (3) competent servicemen for a period of not less than ten years and provide a list of 10 projects, similar in size and scope to this project, completed within the last five years.

B. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

C. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels to current level of technology, and extend new field panels on a previously installed network.

Compatibility shall be defined as the ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers or protocol converters.

1.4 SUBMITTALS

A. Submit 5 complete sets of documentation in the following phased delivery schedule:

1. Valve and damper schedules
2. Equipment data cut sheets
3. System schematics, including:
   sequence of operations
   point names
   point addresses

interface wiring diagrams
panel layouts.
system riser diagrams

4. Auto-CAD compatible as-built drawings

B. Upon project completion, submit operation and maintenance manuals, consisting of the following:

Index sheet, listing contents in alphabetical order
Manufacturer's equipment parts list of all functional components of the system, Auto-CAD disk of system schematics, including wiring diagrams
Description of sequence of operations
As-Built interconnection wiring diagrams
Operator's Manual
Trunk cable schematic showing remote electronic panel locations, and all trunk data
List of connected data points, including panels to which they are connected and input device (ionization detector, sensors, etc.)
Conduit routing diagrams

1.5 WARRANTY

A. Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of one year after beneficial use.

B. The adjustment, required testing, and repair of the system includes all computer equipment, transmission equipment and all sensors and control devices.

C. The on-line support services shall allow the local BAS subcontractor to dial out over telephone lines or connect via the internet to monitor and control the facility's building automation system. This remote connection to the facility shall be within 2 hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekends and holidays.

If the problem cannot be resolved with on-line support services, the BAS manufacturer shall dispatch the appropriate personnel to the job site to

resolve the problem within 3 hours of the time that the problem is reported.

1.6 TECHNICAL PROPOSALS

A. Technical proposals shall be prepared in accordance with these specifications. Proposals that are unbound, loose, loose in a file folder, stapled, stapled in a manila file folder, etc., will not be acceptable. The technical proposal shall include the following data/information as a minimum. The order of listing here is not intended to indicate, nor should it be construed to indicate, the relative importance of the data/information:

1. Information on organizational capability to handle this project (management, personnel, manufacturing, single source responsibility, etc.)

2. Information on training program to demonstrate specification compliance.

3. System Configuration as Proposed:

a. Describe system architecture including a schematic layout with location and type (model number) of all control panels.

b. Describe system operation, functions and control techniques.

c. Modularity.

d. Provisions against obsolescence due to technological advancement.

e. Provide hardware and software data sheets on interfaces third party systems (e.g. chiller).

4. Technical data to support the information on the hardware configuration.

5. Detailed description of all operating, command, application and energy management software provided for this project.

6. A signed certificate stating the Contractor "has read the performance and functional requirements, understands them and

his technical proposal will comply with all parts of the specification."

7. Other requirements for inclusion in the technical proposal are located throughout this specification.

8. Line by line specification concordance statement.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Siemens Building Technologies, Inc.
B. Schneider Electric Inc.
C. Automated Logic Corporation.

2.2 NETWORKING COMMUNICATIONS

A. The design of the BAS shall network operator workstations and stand-alone DDC Controllers. The network architecture shall consist of three levels, a campus-wide (Management Level Network) Ethernet network based on TCP/IP protocol, high performance peer-to-peer building level network(s) and DDC Controller floor level local area networks with access being totally transparent to the user when accessing data or developing control programs.

B. The design of BAS shall allow the co-existence of new DDC Controllers with existing DDC Controllers in the same network without the use of gateways or protocol converters.

C. System shall have the capability to communicate with a BACnet network over Ethernet or BACnet/IP. The intent is to use the system provided under this contract to communicate with control systems provided by other vendors. In order to accomplish monitoring, commanding, and alarming as described in this specification the following BACnet objects and services must be supported by the system.

1) The following BACnet standard objects, at a minimum, must be supported by the system:
   a) Device
   b) Analog Input
   c) Analog Output
   d) Binary Input
   e) Binary Output
   f) Notification Class

2) The following BACnet services must be supported for the system to act as a BACnet server as described below:

a.) For the system to communicate with/on a BACnet network, it must support the following:

BACnet Service	Initiate	Execute
Who-Has		X
I-Have	X	
Who-Is		X
I-Am	X	

b.) For the system to allow other BACnet devices to monitor its point values, the system must support the following:

BACnet Service	Initiate	Execute
Read Property		X

c.) For the system to allow other BACnet devices to command its point values, the system must support the following:

BACnet Service	Initiate	Execute
Write Property		X

d.) For the system to be able to send alarms to other BACnet devices and receive alarm acknowledgement, the system must support the following:

BACnet Service	Initiate	Execute
Add List Element		X
Remove List Element		X
Acknowledge Alarm		X
Get Alarm Summary		X
Confirmed or Unconfirmed Event Notification	X	

e.) If the system will be sending messages to other BACnet devices via COV, it must support the following:

BACnet Service	Initiate	Execute
Subscribe COV		X
Confirmed or Unconfirmed COV Notification	X	

3) The following BACnet services must be supported for the system to act as a BACnet client as described below:

a.) For the system to communicate with/on a BACnet network, it must support the following:

BACnet Service	Initiate	Execute
Who-Has		X
I-Have	X	
Who-Is		X
I-Am	X	

b.) For the system to be able to monitor point values from other BACnet devices, the system must support the following:

BACnet Service	Initiate	Execute
Read Property	X	

c.) For the system to be able to command point values in other BACnet devices, the system must support the following:

BACnet Service	Initiate	Execute
Write Property	X	

d.) For the system to be able to receive alarms from points in other BACnet devices, the system must support the following:

BACnet Service	Initiate	Execute
Add List Element	X	
Remove List Element	X	
Acknowledge Alarm	X	
Get Alarm Summary	X	
Confirmed or Unconfirmed Event Notification		X

e.) If the system is capable of receiving BACnet point messages via COV, it must support the following:

BACnet Service	Initiate	Execute
Subscribe COV	X	
Confirmed or Unconfirmed COV Notification		X

D. System shall have the capability to be an OPC Server for dynamic communication with OPC Clients over an Ethernet network. At a minimum, the following must be supported:

1.) Data Access 1.0 (96), 1.0A (97) and 2.0 (11/98)
2.) Alarms & Events 1.0 (1/99)

E. Peer-to-Peer Building Level Network:

1. All operator devices either network resident or connected via dial-up modems shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. No hardware or software limits shall be imposed on the number of devices with global access to the network data at any time.

2. The peer-to-peer network shall support a minimum of 100 DDC controllers and PC workstations

3. The system shall support integration of third party systems (fire alarm, security, lighting, PCL, chiller, boiler) via panel mounted open protocol processor. This processor shall exchange data between the two systems for interprocess control. All exchange points shall have full system functionality as specified herein for hardwired points.

4. Field panels must be capable of integration with open standards including Modbus, BACnet, and Lonworks as well as with third party devices via existing vendor protocols.

5. Telecommunication Capability:

    a. Auto-dial/auto-answer communications shall be provided to allow DDC Controllers to communicate with remote operator stations and/or remote terminals via telephone lines, as indicated in the sequence of operations.

    b. Auto-dial DDC Controllers shall automatically place calls to workstations to report alarms or other significant events. The auto-dial program shall include provisions for handling busy signals, "no answers" and incomplete data transfers.

    c. Operators at workstations shall be able to perform all control functions, all report functions and all database generation and modification functions as described for workstations connected via the network. Routines to automatically answer calls from remote DDC or HVAC Mechanical Equipment Controllers shall be inherent in the Controller. The use of additional firmware or software is not acceptable. The fact that communications are taking place with remote DDC or HVAC & Mechanical Equipment Controllers over telephone lines shall be completely transparent to an operator.

d. Multiple modems shall be supported by DDC or HVAC & Mechanical Equipment Controllers on the Peer-to-Peer Network to ensure continuous communication to workstation.

2.3 DDC CONTROLLER FLOOR LEVEL NETWORK:

A. This level communication shall support a family of application specific controllers and shall communicate with the peer-to-peer network through DDC Controllers for transmission of global data.

2.4 DDC & HVAC MECHANICAL EQUIPMENT CONTROLLERS

A. The DDC & HVAC Mechanical Equipment Controllers shall reside on the Building Level Network.

B. DDC & HVAC Mechanical Equipment Controllers shall use the same programming language and tools. DDC & HVAC Mechanical Equipment Controllers which require different programming language or tools on a network are not acceptable.

2.4.1 DDC CONTROLLER

A. DDC Controllers shall be a 16-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point I/O schedule. Each controller shall support a minimum of three (3) Floor Level Application Specific Controller Device Networks.

B. Each DDC Controller shall have sufficient memory to support its own operating system and databases, including:

1. Control processes
2. Energy management applications
3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
4. Historical/trend data for points specified
5. Maintenance support applications
6. Custom processes
7. Operator I/O
8. Dial-up communications
9. Manual override monitoring

C. Each DDC Controller shall support firmware upgrades without the need to replace hardware.

D. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

E. DDC Controllers shall provide a RS-232C serial data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

F. The operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points.

1. Switches shall be mounted either within the DDC Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.

2. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.

G. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.

H. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

I. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

- IEEE Standard 587-1980
- UL 864 Supply Line Transients

J. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 60 days.

1. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.

2. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.

2.4.2 HVAC MECHANICAL EQUIPMENT CONTROLLERS

A. HVAC Mechanical Equipment Controllers shall be a 16-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors.

B. Each HVAC Mechanical Controller shall have sufficient memory to support its own operating system and databases, including:

1. Control processes
2. Energy management applications
3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
4. Historical/trend data for points specified
5. Maintenance support applications
6. Custom processes
7. Operator I/O
8. Dial-up communications

C. Each HVAC Mechanical Equipment Controller shall support firmware upgrades without the need to replace hardware.

D. HVAC Mechanical Equipment Controllers shall provide a RS-232C serial data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals.

E. HVAC Mechanical Equipment Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

F. Each HVAC Mechanical Equipment Controller shall continuous lyperformself-diagnostics, communication diagnosis and diagnosis of all components. The HVAC Mechanical Equipment Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

G. In the event of the loss of normal power, there shall be an orderly shutdown of all HVAC Mechanical Equipment Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

1. Upon restoration of normal power, the HVAC Mechanical Equipment Controller shall automatically resume full operation without manual intervention.

2. Should HVAC Mechanical Equipment Controller memory be lost for any reason, the user shall have the capability of reloading the HVAC Mechanical Equipment Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.

H. The operator shall have the ability to manually override automatic or centrally executed commands at the HVAC Mechanical Equipment Controllers via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points.

1. Switches shall be mounted either within the HVAC Mechanical Equipment Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.

2. HVAC Mechanical Equipment Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.

2.5 DDC & HVAC MECHANICAL EQUIPMENT CONTROLLER RESIDENT SOFTWARE FEATURES

A. General:

1. The software programs specified in this Section shall be provided as an integral part of DDC and HVAC Mechanical Equipment Controllers and shall not be dependent upon any higher level computer for execution.

2. All points shall be identified by up to 30 character point name and 16 character point descriptor. The same names shall be used at the PC workstation.

3. All digital points shall have user defined two-state status indication (descriptors with minimum of 8 characters allowed per state (i.e. summer/winter)).

B. Control Software Description:

1. The DDC and HVAC Mechanical Equipment Controllers shall have the ability to perform the following pre-tested control algorithms:

a. Two-position control

b. Proportional control

c. Proportional plus integral control

d. Proportional, integral, plus derivative control

e. Automatic tuning of control loops

C. DDC and HVAC Mechanical Equipment Controllers shall provide the following energy management routines for the purpose of optimizing energy consumption while maintaining occupant comfort.

1. Start-Stop Time Optimization (SSTO) shall automatically be coordinated with event scheduling. The SSTO program shall start HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone condition by time of occupancy. The SSTO program shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period, and still maintain desired comfort conditions.

a) The SSTO program shall operate in both the heating and cooling seasons.

1) It shall be possible to apply the SSTO program to individual fan systems.
2) The SSTO program shall operate on both outside weather conditions as well as inside zone conditions and empirical factors.

b) The SSTO program shall meet the local code requirements for minimum outside air while the building is occupied.

2. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or groups of points according to a stored time.

a) It shall be possible to individually command a point or group of points.

b) For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start or stop within that group.

c) The operator shall be able to define the following information:

1. Time, day
2. Commands such as on, off, auto, and so forth.
3. Time delays between successive commands.
4. There shall be provisions for manual overriding of each schedule by an appropriate operator.

d) It shall be possible to schedule events up to one year in advance.

1. Scheduling shall be calendar based.
2. Holidays shall allow for different schedules.

3. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

4. Night setback control: The system shall provide the ability to automatically adjust setpoints for night control.

D. DDC and HVAC Mechanical Equipment Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1. A single process shall be able to incorporate measured or calculated data from any and all other DDC and HVAC Mechanical Equipment Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC and HVAC Mechanical Equipment Controllers on the network. Database shall support 30 character, English language point names, structured for searching and logs.

2. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

3. DDC and HVAC Mechanical Equipment Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task orientated information from the user manual.

4. DDC and HVAC Mechanical Equipment Controller shall be capable of comment lines for sequence of operation explanation.

E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC and HVAC Mechanical Equipment Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC and HVAC Mechanical Equipment Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to

provide full flexibility in defining the handling of system alarms. Each DDC and HVAC Mechanical Equipment Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after hours destinations) or based on priority.

4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.

5. In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.

F. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the I/O summary.

1. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC and HVAC Mechanical Equipment Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of l minute to 7 days shall be provided. Each DDC and HVAC Mechanical Equipment Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of __ data samples. All trend data shall be available for transfer to a Workstation without manual intervention.

2. DDC and HVAC Mechanical Equipment Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary.

a. Loop tuning shall be capable of being initiated either locally at the DDC and HVAC Mechanical Equipment Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall

be limited to authorized personnel through password protection.

G. DDC and HVAC Mechanical Equipment Controllers shall be capable of automatically accumulating and storing run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O schedule.

H. The peer to peer network shall allow the DDC and HVAC Mechanical Equipment Controllers to access any data from or send control commands and alarm reports directly to any other DDC and HVAC Mechanical Equipment Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC and HVAC Mechanical Equipment Controllers shall send alarm reports to multiple workstation without dependence upon a central or intermediate processing device. The peer to peer network shall also allow any DDC and HVAC Mechanical Equipment Controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.

I. The peer to peer network shall allow the DDC and HVAC Mechanical Equipment Controllers to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control the points that the operator is authorized for. All other points shall not be displayed on the PC workstation or portable terminal (e.g. all base building and all tenant points shall be accessible to any base building operators, but only tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

2.6 FLOOR LEVEL NETWORK APPLICATION SPECIFIC CONTROLLERS (ASC)

A. Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs) through Floor Level LAN Device Networks.

B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Provide the following types of ASCs as a minimum:

1. Central System Controllers

2. Terminal Equipment Controllers

Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device. ASC controllers for water source heat pumps shall be provided by unit manufacturer may be standalone controller provided by DDC controls contractor.

C. Central System Controllers:

1. Provide for control of central HVAC systems and equipment including, but not limited to, the following:

   a. Packaged air handling units

   b. Condenser water systems

   c. Heating systems

2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide a hand/off/automatic switch for each digital output for manual override capability. Switches shall be mounted either within the controller's key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides. In addition, each switch position shall be supervised in order to inform the system that automatic control has been overridden.

3. Each controller shall support its own real-time operating system. Provide a time clock with battery backup to allow for stand-alone operation in the event communication with its DDC Controller is lost and to insure protection during power outages.

4. All programs shall be field-customized to meet the user's exact control strategy requirements. Central System controllers utilizing pre-packaged or canned programs shall not be acceptable. As an alternative, provide DDC Controllers for all central equipment in order to meet custom control strategy requirements.

5. Programming of central system controllers shall utilize the same language and code as used by DDC Controllers to maximize system flexibility and ease of use. Should the system controller utilize a different control language, provide an DDC Controller to meet the specified functionality.

6. Each controller shall have connection provisions for a portable operator's terminal. This tool shall allow the user to display, generate or modify all point databases and operating programs.

D. Terminal Equipment Controllers:

1. Provide for control of each piece of equipment, including, but not limited to, the following:

a. Unit Conditioners

b. Heat Pumps

c. Room Pressurization

2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control, 3-15 psi pneumatic, 0-10v ,allowing for interface to a variety of modulating actuators.

3. All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over the FLN, BLN or MLN is not acceptable

2.7 PORTABLE OPERATOR'S TERMINAL (POT)

A. Provide industry standard, commercially available portable operator terminals with a LCD display and a full-featured keyboard. The POT shall be handheld and plug directly into all DDC Controllers, HVAC & Mechanical Equipment Controllers, and Floor Level Network Controllers as described below. Provide a user-friendly, English language-prompted interface for quick access to system information, not codes requiring look-up charts.

B. Functionality of the portable operator's terminal connected at any DDC Controller:

1. Access all DDC Controllers and ASCs on the network.

2. Backup and/or restore DDC Controller data bases for all system panels, not just the DDC Controller connected to.

3. Display all point, selected point and alarm point summaries.

4. Display trending and totalization information.

5. Add, modify and/or delete any existing or new system point.

6. Command, change setpoint, enable/disable any system point.

7. Program and load custom control sequences as well as standard energy management programs.

8. Acknowledge alarms

C. Functionality of the portable operator's terminal connected to any application specific controller:

1. Provide connection capability at either the Floor Level Network Controller or a related room sensor to access controller information.

2. Provide status, setup and control reports.

3. Modify, select and store controller data base.

4. Command, change setpoint, enable/disable any controller point.

D. Connection of a POT to a DDC or HVAC & Mechanical Equipment Controller, or ASC Controller shall not interrupt nor interfere with normal network operation in any way, prevent alarms from being transmitted or preclude centrally-initiated commands and system modification.

E. Portable operator terminal access to controller shall be password-controlled. Password protection shall be configurable for each operator based on function, points (designating areas of the facility), and edit/view capability.

2.8 LOCAL USER DISPLAY

The controllers on the peer to peer building level network shall have a display and keypad for local interface. A keypad shall be provided for interrogating and commanding points in the controller.

A. The display shall use the same security password and access rights for points in the display as is used in the associated controller.
B. The LCD display shall be a minimum of a 2 line 40 character display.

C. The LCD display shall include the full point name, value (numeric, digital or state text),
D. point priority and alarm status on one screen.
E. The LCD shall dynamically update the value, priority, and alarm status for the point being displayed.
F. The display shall be mounted either on the door of the enclosure or remote from the controller

2.9 PERSONAL COMPUTER OPERATOR WORKSTATION HARDWARE

A. Personal computer operator workstations shall be provided for command entry, information management, network alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater fault tolerance and reliability.

1. Workstation shall consist of an SVGA 17" color monitor, personal computer with minimum 512 MB RAM, 20.0 GB hard drive and controller, 3-l/2" diskette drive, 20X CD ROM drive, tape or zip storage device, mouse and 101-key enhanced keyboard. Personal computer shall be an IBM Compatible PC and shall include a minimum 850 MHZ Pentium II processor.

2. The minimum display resolution of no less than 1024 X 768 pixels. Separate controls shall be provided for color, contrasts and brightness. The screen shall be non-reflective.

B. Provide an Epson FX-870 or equivalent printer at each workstation location or on the network (Ethernet) for recording alarms, operator transactions and systems reports.

C. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.

2.10 WORKSTATION OPERATOR INTERFACE

A. Basic Interface Description

1. Operator workstation interface software shall minimize operator training through the use of English language prompting, 30 character English language point identification, on-line help, and industry standard PC application software. Interface software shall simultaneously communicate with up to 4 Building Level

Networks and share data between any of the 4 networks. The software shall provide, as a minimum, the following functionality:

a. Real-time graphical viewing and control of environment
b. Scheduling and override of building operations
c. Collection and analysis of historical data
d. Point database editing, storage and downloading of controller databases.
e. Alarm reporting, routing, messaging, and acknowledgment
f. Display dynamic data trend plot.
   - Must be able to run multiple plots simultaneously
   - Each plot must be capable of supporting 10 pts/plot minimum
   - Must be able to command points directly off dynamic trend plot application.
g. Definition and construction of dynamic color graphic displays.
h. Program editing
i. Transfer trend data to 3rd party software
j. Scheduling reports
k. Operator Activity Log
l. Open communications via OPC Server
m. Open communications via BACnet Client & Server

2. Provide a graphical user interface which shall minimize the use of keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection.

3. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BAS software shall run on a Windows NT 32 bit operating. These Windows applications shall run simultaneously with the BAS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information.

   a. Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via user-sized windows. Operator shall be able to drag and drop information between applications, reducing the number of steps (i.e. Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend).

1. Dynamic color graphics and graphic control

2. Alarm management, routing to designated locations, and customized messages

3. Year in advance event and report scheduling

4. Dynamic trend data definition and presentation

5. Graphic definition and construction

6. Program and point database editing on-line.

b. If the software is unable to display several different types of displays at the same time, the BAS contractor shall provide at least two operator workstations.

c. Report and alarm printing shall be accomplished via Windows Print Manager, allowing use of network printers.

4. Operator specific password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported).

5. Reports shall be generated on demand or via pre-defined schedule and directed to either CRT displays, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:

a. A general listing of all or selected points in the network
b. List of all points currently in alarm
c. List of all points currently in override status
d. List of all disabled points
e. List of all points currently locked out
f. List of user accounts and access levels
g. List all weekly schedules
h. List of holiday programming
i. List of limits and deadbands
j. Custom reports from 3rd party software

k. System diagnostic reports including, list of DDC panels on line and communicating, status of all DDC terminal unit device points
l. List of programs

6. Scheduling and override

Provide a calendar type format for simplification of time-of-day scheduling and overrides of building operations. Schedules reside in the PC workstation, DDC Controller, and HVAC Mechanical Equipment Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection or function key. Provide the following spreadsheet graphic types as a minimum:

a. Weekly schedules
b. Zone schedules, minimum of 200 unique zones
c. Scheduling for up to 365 days in advance
d. Schedule reports to print at PC.

7. Collection and Analysis of Historical Data

a. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.

b. Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of at least six points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred on-line to Microsoft Excel. DDC contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions. DDC contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.

c. Provide additional functionality that allows the user to view real-time trend data on trend graph displays. A minimum of ten points may be graphed, regardless of whether they have been predefined for trending. The dynamic graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. Exact point values may be viewed and the graphs may be printed. A minimum of 8 true graphs shall run simultaneously. Operator shall be able to command points directly on the trend plot by double clicking on the point.

B. Dynamic Color Graphic Displays

1. Create color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems and hot water boiler systems, and room level terminal units, shall be provided by the BAS contractor as indicated in the point I/O schedule of this specification to optimize system performance, analysis and speed alarm recognition.

2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of Autocad or scanned pictures for use in the system.

3. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
   a. Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.
   b. Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.
   c. Equipment state can be changed by clicking on the point block or graphic symbol and selecting the new state (on/off) or setpoint.

d. State text for digital points can be defined up to eight characters.

4. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.

5. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

6. Off the shelf graphic software, Microgafx Designer or Coral Draw software shall be provided to allow the user to add, modify or delete system graphic displays.

7. A clipart library of HVAC and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and laboratory symbols. The user shall have the ability to add custom symbols to the clipart library.

8. A dynamic display of the site specific architecture showing status of controllers, PC workstations and networks shall be provided.

C. System Configuration & Definition

1. Network wide control strategies shall not be restricted to a single DDC Controller or HVAC Mechanical Equipment controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.

2. Provide automatic backup and restore of all DDC controller and HVAC Mechanical Equipment controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller or HVAC Mechanical Equipment Controller. Changes made at the DDC Controllers or HVAC Mechanical Equipment Controllers shall be automatically uploaded to the workstation, ensuring system continuity.

3. System configuration, programming, editing, graphics generation shall be performed on-line. If programming and system back-up

must be done with the PC workstation off-line, the BAS contractor shall provide at least 2 operator workstations.

D. Alarm Management

1. Alarm Routing shall allow the user to send alarm notification to selected printers or PC location based on time of day, alarm severity, or point type.

2. Alarm Notification shall be provided via two alarm icons, to distinguish between routine, maintenance type alarms and critical alarms. These alarm icons shall be displayed when user is working in other Windows programs. The BAS alarm display screen shall be displayed when the user clicks on the alarm icon.

3. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.

4. Alarm messages shall be customizable for each point to display detailed instructions to the user regarding actions to take in the event of an alarm.

E. Workstation Communications

(**Note: 1,1.a and 1.b are optional for use in dial-up applications**)

1. Provide automatic dial-up communications for buildings as specified. Automatic dial-up communications shall include the following features as a minimum:

   a. Dial-Out

      1) Manual dial-out from the workstation to remote networks shall be accomplishable using only a mouse to select and request the desire remote connection.

   b. Dial-In

      1) Alarms shall automatically dial into the workstation for display at the terminal and for hard copy printout at the associated event printer.

2) Alarms shall, at the operator's option, dial into a stand-alone modem-printer to provide for real-time alarm printouts even when the workstation is off-line (such as when it is being used to run operator-selected 3rd party software).

3) Trend data shall be scheduled for automatic updating to the workstation at operator-selected times. The operator shall also have the option of manually collecting trend data at any time.

2.11 FIELD DEVICES

A. Provide instrumentation as required for monitoring, control or optimization functions.

B. Room Temperature Sensors

1) Digital room sensors shall have LCD display, day / night override button, and setpoint slide adjustment override options. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room adjustment.

Temperature monitoring range +20/120°F -13° to 49°C)
Output signal Changing resistance
Accuracy at Calibration point ±0.5°F (+/- 0.3°C)
Set Point and Display Range 55° to 95° F (13° to 35°C)

2) Liquid immersion temperature:
Temperature monitoring range +30/250°F (-1°/121°C)
Output signal Changing resistance
Accuracy at Calibration point ±0.5°F (+/-0.3°C)

3) Duct (single point) temperature:
Temperature monitoring range +20/120°F (-7°/49°C)
Output signal Changing resistance
Accuracy at Calibration point ±0.5°F (+/-0.3°C)

4) Duct Average temperature:
Temperature monitoring range +20° ±120°F(-7°/+49°C)
Output signal 4 – 20 mA DC
Accuracy at Calibration point ±0.5°F (±03°C)
Sensor Probe Length 25’ L (7.3m)

5) Outside air temperature:
Temperature monitoring range -58°±122° F(-50ºC to +50ºC)

Output signal 4 – 20 mA DC
Accuracy at Calibration point ±0.5°F (+/-0.3°C)

C. Liquid Differential Pressure Transmitter

Ranges	0-5/30 inches H20 0-25/150 inches H20 0-125/750 inches H20
Output	4 – 20 mA DC
Calibration Adjustments	Zero and span
Accuracy	±-0.2% of span
Linearity	±-0.1% of span
Hysteresis	±-0.05% of span

D. Differential pressure:

1. Unit for fluid flow proof shall be Penn P74.

Range	8 to 70 psi
Differential	3 psi
Maximum differential pressure	200 psi
Maximum pressure	325 psi

2. Unit for air flow.
   Set point ranges:
   0.5” WG to 1.0” WG (124.4 to 248.8 Pa)
   1.0” WG to 12.0” WG (248.8 to 497.6 Pa)

E. Static pressure sensor:

Range	0 to .5” WG (0 to 124.4 Pa) 0 to 1” WG (0 to 248.8 Pa) 0 to 2” WG (0 to 497.7 Pa) 0 to 5” WG (0 to 1.2 kPa 0 to 10” WG (0 to 2.5 kPa)
Output Signal	4 – 20 mA VDC
Combined static error	0.5% full range
Operating Temperature	-40º to 175º F (-40C to 79.5ºC)

F. Air Pressure Sensor:

Range:	0 to 0.1 in. water (0 to 24.9 Pa) 0 to 0.25 in. water (0 to 63.2 Pa) 0 to 0.5 in. water (0 to 124.5 Pa) 0 to 1.0 in. water (o to 249 Pa) 0 to 2.0 in water 90 to 498 Pa) 0 to 5.0 in. water (0 to 1.25 kPa) 0 to 10.0 in.water (0 to 2.49 kPa)

Output signal	4 to 20 mA
Accuracy	±1.0% of full scale

G. Humidity Sensors:

Range	0 to 100% RH
Sensing Element	Bulk Polymer
Output Signal	4 – 20 mA DC
Accuracy	At 77°F(25ºC) ± 2% RH

H. Control Valves (all control valves shall have electric actuators).

1. Electric Control

Rangeability	40:1
Flow Characteristics	Modified. Equal percentage
Control Action	Normal open or closed as selected
Medium	Steam, water, glycol
Body Type	Screwed ends 2" and smaller, flanged Valves 2½" and larger
Body Material	Bronze
Body Trim	Bronze
Stem	Stainless Steel
Actuator	0-10 VDC, 4-20 MA or 2 position 24 VAC/120VAC

2. All automatic temperature control valves in water lines shall be provided with characterized throttling plugs and shall be sized for minimum 25% of the system pressure drop or 5 psi, whichever is less.

   a) Positive positioning relays shall be provided on pneumatic control when required to provide sufficient power for sequencing.

   b) Two position valves shall be line size.

K . Damper Actuators

1. Damper actuators shall be Brushless DC Motor Technology with stall protection, bi-directional, fail safe spring return, all metal housing, manual override, independently adjustable dual auxiliary switch.

   a) The actuator assembly shall include the necessary hardware and proper mounting and connection to a standard ½" diameter shaft or damper blade.

2. Actuators shall be designed for mounting directly to the damper shaft without the need for connecting linkages.

3. All actuators having more than 100 lb-in torque output shall have a self-centering damper shaft clamp that guarantees concentric alignment of the actuator's output coupling with the damper shaft. The self-centering clamp shall have a pair of opposed "v" shaped toothed cradles; each having two rows of teeth to maximize holding strength. A single clamping bolt shall simultaneously drive both cradles into contact with the damper shaft.

4. All actuators having more than a 100 lb-in torque output shall accept a 1" diameter shaft directly, without the need for auxiliary adapters.

5. All actuators shall be designed and manufactured using ISO900 registered procedures, and shall be Listed under Standards UL873 and CSA22.2 No. 24-93 l.

2.12 MISCELLANEOUS DEVICES

A. Thermostats

1. Room thermostats shall be of the gradual acting type with adjustable sensitivity.
2. They shall have a bi-metal sensing element capable of responding to a temperature change of one-tenth of one degree. (Provide all thermostats with limit stops to limit adjustments as required.)
3. Thermostats shall be arranged for either horizontal or vertical mounting.
4. In the vertical position thermostat shall fit on a mullion of movable partitions without overlap.
5. Mount the thermostat covers with tamper-proof socket head screws.

B. Freezestats:

1. Install freezestats as indicated on the plans and provide protection for every square foot of coil surface area with one linear foot of element per square foot of coil.

   a) Upon detection of low temperature, the freezestats shall stop the associated supply fans and return the automatic dampers to their normal position. Provide manual reset.

C. Electronic Airflow Measurement Stations and Transmitters (At Duct Locations).

1. Stations – each insertion station shall contain an array of velocity sensing elements and straightening vanes. The velocity sensing elements shall be of the RTD or thermistor type. The sensing elements shall be distributed across the duct cross section in a quality to provide accurate readings. The resistance to airflow through the airflow measurement station shall not exceed 0.08 inches water gage at an airflow of 2,000 fpm. Station construction shall be suitable for operation at airflow of up to 5,000 fpm over a temperature range of 40 to 120 degrees F, and accuracy shall be plus or minus 3 percent over a range of 125 to 2,500 fpm scaled to air volume. Each transmitter shall produce a linear, temperature compensated 4 to 40 mA DC, output corresponding to the required velocity pressure measurement.

D. Fan Inlet Airflow Measuring Station

1. Each station shall contain parallel air straightener, total and static pressure sensing manifolds, internal piping and external pressure transmission ports with flexible tubing and quick-connect fittings. Fabricate of galvanized steel, size for fan inlet in which mounted. Maximum pressure loss through station of 0.08 inches water gage at 1500 fpm. Station shall have accuracy of 2%. Identify by model number, size, area, and specified airflow capacity.

E. Current Sensing Relay:

1. Provide solid-state, adjustable, current operated relay. Provide a relay which changes switch contact state in response to an adjustable set point value of current in the monitored A/C circuit.
2. Adjust the relay switch point so that the relay responds to motor operation under load as an “on” state and so that the relay responds to an unloaded running motor as an “off” state. A motor with a broken belt is considered an unloaded motor.
3. Provide for status device for all fans and pumps.

PART 3 - EXECUTION

3.1 PROJECT MANAGEMENT

Provide a designated project manager who will be responsible for the following:

Construct and maintain project schedule

On-site coordination with all applicable trades, subcontractors, and other integration vendors
Authorized to accept and execute orders or instructions from owner/architect
Attend project meetings as necessary to avoid conflicts and delays
Make necessary field decisions relating to this scope of work
Coordination/Single point of contact

3.2 SEQUENCE OF OPERATION

See Mechanical Plans

3.3 START-UP AND COMMISSIONING

A. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting and final field tests shall be completed by the manufacturer. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power.

B. Provide any recommendation for system modification in writing to owner. Do not make any system modification, including operating parameters and control settings, without prior approval of owner.

C. After manufacturer has completed system start-up and commissioning.

3.4 ELECTRICAL WIRING AND MATERIALS

A. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings, and related wiring accessories. All wiring shall be installed in conduit.

B. Provide wiring between thermostats, aquastats and unit heater motors, all control and alarm wiring for all control and alarm devices for all Sections of Specifications.

C. Provide 120 volt, single phase, 60 hertz emergency power to every B.M.S. DDC Controller panel, HVAC/Mechanical Equipment Controller, PC console, power supply, transformer, annunciator, modems, printers and to other devices as required. It is the intent that the entire building management system except terminal equipment shall be operative under emergency power conditions in the building. The power supplies are to be extended in conduit and wire from emergency circuit breakers.

D. Provide status function conduit and wiring for equipment covered under this Section.

E. Provide conduit and wiring between the B.M.S. panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring in conduit.

F. Provide conduit and control wiring for devices specified in this Section.

G. Provide conduit and wiring between the PC workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contractors, and B.M.S. panels, as shown on the drawings or as specified.

H. All wiring to be compliant to local building code and the NEC.

I. Provide electrical wall box and conduit sleeve for all wall mounted devices.

3.7 PERFORMANCE

A. Unless stated otherwise, control temperatures within plus or minus 2^{o}F humidity within plus or minus 3% of the set point and static pressure within 10% of set point.

3.8 COMMISSIONING, TESTING AND ACCEPTANCE

A. Perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets which shall be submitted prior to acceptance testing. Commissioning work which requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the owner and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the owner and construction manager are present throughout the commissioning procedure.

1. Prior to system program commissioning, verify that each control panel has been installed according to plans, specifications and approved shop drawings. Test, calibrate and bring on line each control sensor and device. Commissioning to include, but not be limited to:

a. Sensor accuracy at 10, 50 and 90% of range.

b. Sensor range.

c. Verify analog limit and binary alarm reporting.

d. Point value reporting.

e. Binary alarm and switch settings.

f. Actuator ranges.

g. Fail safe operation on loss of control signal, electric power, network communications.

B. After control devices have been commissioned (i.e. calibrated, tested and signed off), each BMS program shall be put on line and commissioned. The contractor shall, in the presence of the owner and construction manager, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy's. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and retested.

C. After all BMS programs have been commissioned, the contractor shall verify the overall system performance as specified. Tests shall include, but not be limited to:

1. Data communication, both normal and failure modes.
2. Fully loaded system response time.

3. Impact of component failures on system performance and system operation.

4. Time/Date changes.

5. End of month/ end of year operation.

6. Season changeover.

7. Global application programs and point sharing.

8. System backup and reloading.

9. System status displays.

10. Diagnostic functions.

11. Power failure routines.

12. Battery backup.

13. Smoke Control, stair pressurization, stair, vents, in concert with Fire Alarm System testing.

14. Testing of all electrical and HVAC systems with other division of work.

D. Submit for approval, a detailed acceptance test procedure designed to demonstrate compliance with contractual requirements. This Acceptance test procedure will take place after the commissioning procedure but before final acceptance, to verify that sensors and control devices maintain specified accuracy's and the system performance does not degrade over time.

E. Using the commissioning test data sheets, the contractor shall demonstrate each point. The contractor shall also demonstrate all system functions. The contractor shall demonstrate all points and system functions until all devices and functions meet specification.

F. The contractor shall supply all instruments for testing and turn over same to the owner after acceptance testing.

1. All test instruments shall be submitted for approval.

Test Instrument Accuracy:

Temperature:	1/4F or 1/2% full scale, whichever is less.
Pressure:	High Pressure (psi): ½ psi or 1/2% full scale, whichever is less.
Low Pressure:	1/2% of full scale (in w.c.)
Humidity:	2% RH
Electrical:	1/4% full scale

G. After the above tests are complete and the system is demonstrated to be functioning as specified, a thirty day performance test period shall begin. If the system performs as specified throughout the test period, requiring only

routine maintenance, the system shall be accepted. If the system fails during the test, and cannot be fully corrected within eight hours, the owner may request that performance tests be repeated.

3.9 TRAINING

A. The manufacturer shall provide factory trained instructor to give full instruction to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The manufacturer shall provide all students with a student binder containing product specific training modules for the system installed. All training shall be held during normal working hours of 8:00 am to 4:30 PM weekdays.

B. Provide 16 hours of training for Owner's designated operating personnel. Training shall include:

Explanation of drawings, operations and maintenance manuals
Walk-through of the job to locate control components
Operator workstation and peripherals
DDC controller and ASC operation/function
Operator control functions including graphic generation and field panel programming
Operation of portable operator's terminal
Explanation of adjustment, calibration and replacement procedures
Student binder with training modules

C. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Manufacturer. If such training is required by the Owner, it will be contracted at a later date.

END OF SECTION 15970

SECTION 15982 - FABRIC DUCTWORK

PART 1 GENERAL

1.1 SECTION INCLUDES (SUBMITTAL REQUIRED FOR EACH ITEM):

A. Extent of non-metal ductwork and related appurtenances is indicated on drawings and by requirements of this section.

B. Types of non-metal ductwork required for this project include the following:
   1. Fabric Air Dispersion Products.

1.2 RELATED SECTIONS:

A. Section 15010 - General Mechanical Requirements

1.3 REFERENCES

A. Underwriter’s Laboratories 25/50

B. NFPA 90A – Installation of Air Conditioning and Ventilating Systems

C. NFPA 90B – Installation of Warm Air Heating and Air Conditioning Systems

D. UL 2518 - AIR DISPERSION SYSTEM MATERIALS

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer’s specifications on materials and manufactured products used for work of this section.

B. Building Code Data: Submit UL file number under which product is Classified by Underwriters Laboratories NFPA 90, ICC AC167 and UL 2518.

1.5 WARRANTY

A. Manufacturer must provide a 5 Year Product Warranty for products supplied for the fabric portion of this system as well as a Design and Performance Warranty.

1.6 DELIVERY, STORAGE AND HANDLING:

A. Protect fabric air dispersion systems from damage during shipping, storage and handling.

B. Store products inside and protect from weather.

1.7 QUALIFICATIONS:

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with a minimum of 3 years documented experience.

B. Installer: Company specializing in performing the work of this section with a minimum of five years experience.

PART 2 - PRODUCTS

2.1 MATERIALS:

A. Verona Fabric: Air diffusers shall be constructed of a woven fire retardant fabric complying with the following physical characteristics:
   1. Fabric Construction: 100% Flame Retardant
   2. Weight: 6.2 oz. /yd^2 per ASTM D3776
   3. Color: (MUST SPECIFY- red, white, blue, green, gray, tan or black)
   4. Fabric Porosity: 2 (+2/-1) cfm/ft^2 per ASTM D737, Frazier. Custom Porosity 6, 13 & 29 CFM cfm/ft^2 available.
   5. Temperature Range: 0 degrees F to 180 degrees F
   6. Fire Retardancy: Classified by Underwriters Laboratories in accordance with the requirements of NFPA 90-A.

B. Systems Fabrication Requirements:
   1. Air dispersion accomplished by linear vent and permeable fabric. Linear vents must be sized in 1 CFM per linear foot increments (based on .5" SP), starting a 1 CFM through 90 CFM per linear foot. Linear vent is to consist of an array of open orifices rather than a mesh style vent to reduce maintenance requirements of mesh style vents. Linear vents should also be designed to minimize dusting on fabric surface.
   2. Size of and location of linear vents to be specified and approved by manufacturer.
   3. Inlet connection to metal duct via fabric draw band with anchor patches as supplied by manufacturer. Anchor patches to be secured to metal duct via zip screw fastener – supplied by contractor.
   4. Inlet connection includes zipper for easy removal / maintenance.
   5. Lengths to include required zippers as specified by manufacturer.
   6. System to include Adjustable Flow Devices to balance turbulence, airflow and distribution as needed. Flow restriction device shall include ability to adjust the airflow resistance from 0.06 – 0.60 in w.g. static pressure.
   7. Fabric system shall include connectors to accommodate suspension system listed below.
   8. Any deviation from a straight run shall be made using a gored elbow or an efficiency tee. Normal 90 degree elbows are 5 gores and the radius of the elbow is 1.5 times the diameter of the DuctSox.

C. Design Parameters:
1. Fabric air diffusers shall be designed from 0.25" water gage minimum to 3.0" maximum, with 0.5" as the standard.
2. Fabric air diffusers shall be limited to design temperatures between 0 degrees F and 180 degrees F (-17.8 degrees C and 82 degrees C).
3. Design CFM, static pressure and diffuser length shall be designed or approved by the manufacturer.
4. Do not use fabric diffusers in concealed locations.
5. Use fabric diffusers only for positive pressure air distribution components of the mechanical ventilation system.

D. Suspension Hardware:

1. Tension Cable: System shall be installed using a tension cable system including a single (1 Row) or double strands (2 Row) of cable located 3" above top-dead-center (1 Row) or 3" above the 10 and 2 o'clock locations of the Fabric Duct system. 2 Row supports are required for systems of 32" diameter and larger. Hardware to include cable, eye bolts, thimbles, cable clamps and turnbuckle(s) as required. System attachment shall be made using nylon cable clips spaced 24 inches.

Component options include (must specify per area if multiple on same project):
a. Galvanized Steel Cable
b. Stainless Steel Cable
c. Plastic Coated Stainless Steel Cable
d. Adjustable Gripple Mid-Supports – Available lengths: 5', 10', 15', 20' and 30'

2. Cylindrical Tensioning System with Suspended H-Track: System shall tension fabric in both the length and circumference of the Fabric Duct. Full 360 degree cylindrical rings with quick connection spacer tubes in the interior of the system. Fittings and end cap rings to be adjustable. Inlets and fittings to have tensioning anchor clips. Metal to metal safety connection device required from ring tube to track. System shall be installed used a suspended H-Track systems with 1 row hanging located 1.5" above top-dead-center. Hardware to include 10' sections of track, splice connectors, track end caps and vertical cable support kits – consisting of a length of cable with a locking stud end and Gripple quick cable connectors.

2.2 QUALITY ASSURANCE:

A. Building Codes and Standards:

1. Product must be Classified by Underwriters Laboratories in accordance with the 25/50 flame spread / smoke developed requirements of NFPA 90-A and are also classified in accordance with ICC Evaluation Service AC167 and UL 2518.. Product must meet UL-C (Canada), BS 5867, part 2, 1980 and GB8624-2006 B-s1, d0, t1 level.

2. All product sections must be labeled with the logo and classification marking of Underwriters Laboratories.

B. Design & Quality Control
   1. Manufacturer must have documented design support information including duct sizing, vent and orifice location, vent and orifice sizing, length, and suspension. Parameters for design, including maximum air temperature, velocity, pressure and fabric permeability, shall be considered and documented.

PART 3 - INSTALLATION

3.1 INSTALLATION OF FABRIC AIR DISPERSION SYSTEM:

A. Install chosen suspension system in accordance with the requirements of the manufacturer. Instructions for installation shall be provided by the manufacturer with product.

3.2 CLEANING AND PROTECTION:

A. Clean air handling unit and ductwork prior to the fabric duct system unit-by-unit as it is installed. Clean external surfaces of foreign substance which may cause corrosive deterioration of facing.

B. Temporary Closure: At ends of ducts which are not connected to equipment or distribution devices at time of ductwork installation, cover with polyethylene film or other covering which will keep the system clean until installation is completed.

C. If Fabric Duct systems become soiled during installation, they should be removed and cleaned following the manufacturers standard terms of laundry.

END OF SECTION 15982

SECTION 15990 - TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Testing, adjustment, and balancing of air systems.

B. Testing, adjustment, and balancing of hydronic systems.

1.2 RELATED SECTIONS

A. Section 15010 - General Mechanical Requirements.

1.3 REFERENCES

A. AABC - National Standards for Total System Balance.

B. ADC - Test Code for Grilles, Registers, and Diffusers.

C. ASHRAE 111 - Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-conditioning, and Refrigeration Systems.

D. NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

E. SMACNA - HVAC Systems Testing, Adjusting, and Balancing.

1.4 SUBMITTALS

A. Submit under provisions of Section 15010.

B. Submit name of adjusting and balancing agency for approval within 30 days after award of Contract.

C. Field Reports: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance to be submitted 21 days before any installation work.

D. Prior to commencing work, submit report forms or outlines indicating adjusting, balancing, and equipment data required. Include detailed procedures, agenda, and sample report forms.

E. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect/Engineer and for inclusion in operating and maintenance manuals.

F. Provide reports in letter size, 3-ring binder manuals, complete with index page and

indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

G. Test Reports: Indicate data on AABC National Standards for Total System Balance forms or NEBB.

H. Submit second test report for the second test which is to be done approximately 6 months after the first for opposite season operation.

1.5 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 15010.

B. Record actual locations of flow measuring stations balancing valves and rough setting.

1.6 QUALITY ASSURANCE

A. Perform total system balance in accordance with AABC National Standards for Field Measurement and Instrumentation, Total System Balance or NEBB Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

B. The test and balance contractor shall schedule a meeting at the site with the design engineer and spot check 10 to 15% of the readings. If the readings are off by more than 7% the complete building test and balance shall be redone and a new report submitted.

1.7 QUALIFICATIONS

A. Agency: Company specializing in the testing, adjusting, and balancing of systems specified in this section with minimum three years documented experience and certified by AABC, NEBB or Register Professional Engineer with a minimum of 5 year experience in Test and Balance.

B. Perform Work under supervision of AABC Certified Test and Balance Engineer or NEBB Certified Testing, Balancing and Adjusting Supervisor or Register Professional Engineer with a minimum of 5 year experience in Test and Balance.

1.8 SEQUENCING

A. Sequence work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

B. The Test and Balance Contractor shall work with Controls Contractor as required to adjust the dampers to provide the air flows as required.

1.9 SCHEDULING

A. Schedule work as required to perform the work required.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
   1. Systems are started and operating in a safe and normal condition.
   2. Temperature control systems are installed complete and operable.
   3. Proper thermal overload protection is in place for electrical equipment.
   4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
   5. Duct systems are clean of debris.
   6. Fans are rotating correctly.
   7. Fire and volume dampers are in place and open.
   8. Air coil fins are cleaned and combed.
   9. Access doors are closed and duct end caps are in place.
   10. Air outlets are installed and connected.
   11. Duct system leakage is minimized.
   12. Hydronic systems are flushed, filled, and vented.
   13. Pumps are rotating correctly.
   14. Proper strainer baskets are clean and in place.
   15. Service and balance valves are open.

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

C. Beginning of work means acceptance of existing conditions.

3.2 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect/Engineer to facilitate spot checks during testing.

B. Provide additional balancing devices as required.

3.3 INSTALLATION TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 5 percent of design.

C. Hydronic Systems: Adjust to within plus 5 percent or minus 0 percent of design.

3.4 ADJUSTING

A. Ensure recorded data represents actual measured or observed conditions.

B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

E. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

F. Check and adjust systems approximately six months after final acceptance and submit report for opposite season operation.

3.5 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to provide design supply, return, and exhaust air quantities.

B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

C. Measure air quantities at air inlets and outlets.

D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

E. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.

F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

I. Adjust outside air, return air, and exhaust dampers for design conditions.

J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

K. Where modulating dampers are provided, take measurements and balance at extreme conditions.

L. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure.

3.6 WATER SYSTEM PROCEDURE

A. Adjust water systems to provide required or design quantities.

B. Use calibrated fittings and pressure gages to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.

C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

D. Effect system balance with automatic control valves fully open to heat transfer elements.

E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

3.7 SCHEDULES

A. Equipment Requiring Testing, Adjusting, and Balancing

HVAC Pumps
Packaged Boiler
Air Cooled Water Chillers
Packaged Roof Top Heating/Cooling Units
Unit Air Conditioners
Computer Room Air Conditioning Unit
Terminal Heat Transfer Units
Air Handling Units, Include Sound Testing

Fans
Duct Sound Attenuator
Air Inlets and Outlets
Outside Air Unit

END OF SECTION 15990