ADDENDUM NO. 01
JULY 28, 2017

PROJECT: School of Public Health MEP Renovation

FROM: Infrastructure Associates, Inc.
6117 Richmond Ave.
Houston, Texas 77057

TO: Prospective Bidders

THE SOLICITATION MENTIONED ABOVE IS AMENDED AS SET FORTH BELOW.

This Addendum uses the "change-page" method as follows:

For Revisions to the Project Manual:

Remove obsolete pages and delete, replace, or add pages as indicated issued under this Addendum.

For Revisions to Drawings:

Remove obsolete sheets and replace or add sheets issued as indicated under this Addendum.

PART 1 - CHANGES TO PROJECT MANUAL

A. Delete the following specification sections in their entirety from the project manual:

1. 232113 – HYDRONIC PIPING
2. 232200A – STEAM AND STEAM CONDENSATE SPECIALTIES

B. Replace the following specifications sections in their entirety with revised sections issued July 28, 2017 as Addendum #1:

1. 012300 – ALTERNATES
2. 230923 – DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC
3. 232000A – PIPING, VALVES, AND FITTINGS
4. 232200 – STEAM AND STEAM CONDENSATE PIPING
5. 232223 – STEAM CONDENSATE PUMPS
6. 235700 – HEAT EXCHANGER UNITS
7. 237323 – AIR HANDLING UNITS

PART 2 - CHANGES TO DRAWINGS

C. Add the following new drawing sheets issued July 28, 2017 as Addendum #1:

1. G103 – GENERAL NOTES AND SPECIFICATIONS
2. A115 – FLOOR PLANS – LEVELS 3-6
3. A116 – FLOOR PLANS – LEVELS 7-10
4. M200A – BASEMENT FLOOR PLAN - AIR FLOW DIAGRAM
5. M300 – ENLARGED PLAN - TYPICAL LOBBY - PROPOSED
6. M301 – ENLARGED PLAN - TYPICAL LOBBY - DETAILS
7. M704 – CONTROLS
D. Replace the following drawing sheets in their entirety with revised drawing sheets issued July 28, 2017 as Addendum #1:

1. G100 – GENERAL INFORMATION
2. G101 – FIRE RESISTIVE ASSEMBLIES DESIGN REFERENCE
3. G102 – FIRE RESISTIVE ASSEMBLIES DESIGN REFERENCE
5. A103 – DEMOLITION PLAN – LEVEL 2
6. A111 – FLOOR PLAN – BASEMENT
7. A112 – FLOOR PLAN – LEVEL 1
8. A113 – FLOOR PLAN – LEVEL 2
10. A520 – PARTITION TYPES AND INTERIOR CONSTRUCTION DETAILS
11. A540 – DOOR, WINDOW DETAILS, AND SCHEDULES
12. MEP100 - ROOF FLOOR PLAN - MEP – PROPOSED
13. M001 - NOTES AND LEGEND
14. M002 - SCHEDULES
15. M003 - SCHEDULES
16. M004 - SCHEDULES
17. M101 - BASEMENT FLOOR PLAN - HVAC - DEMO
18. M102 - 2ND FLOOR PLAN - HVAC - DEMO
19. M103 - 3RD FLOOR PLAN - HVAC - DEMO
20. M104 - 4TH FLOOR PLAN - HVAC - DEMO
21. M105 - 5TH FLOOR PLAN - HVAC - DEMO
22. M106 - 6TH FLOOR PLAN - HVAC - DEMO
23. M107 - 7TH FLOOR PLAN - HVAC - DEMO
24. M108 - 8TH FLOOR PLAN - HVAC - DEMO
25. M109 - 9TH FLOOR PLAN - HVAC - DEMO
26. M110 - 10TH FLOOR PLAN - HVAC - DEMO
27. M111 - PENTHOUSE - HVAC - DEMO
28. M200 - BASEMENT FLOOR PLAN - HVAC - NEW
29. M201 - FIRST FLOOR PLAN - HVAC - PROPOSED
30. M202 - 2ND FLOOR PLAN - HVAC - PROPOSED
31. M203 - 3RD FLOOR PLAN - HVAC - PROPOSED
32. M203A - 3RD FLOOR PLAN - AIR FLOW DIAGRAM
33. M204 - 4TH FLOOR PLAN - HVAC - PROPOSED
34. M205 - 5TH FLOOR PLAN - HVAC - PROPOSED
35. M206 - 6TH FLOOR PLAN - HVAC - PROPOSED
36. M206A - 6TH FLOOR PLAN - AIR FLOW DIAGRAM
37. M207 - 7TH FLOOR PLAN - HVAC - PROPOSED
38. M207A - 7TH FLOOR PLAN - AIR FLOW DIAGRAM
39. M208 - 8TH FLOOR PLAN - HVAC - PROPOSED
40. M209 - 9TH FLOOR PLAN - HVAC - PROPOSED
41. M210 - 10TH FLOOR PLAN - HVAC - PROPOSED
42. M211 - PENTHOUSE - HVAC - PROPOSED
43. M400 - ENLARGED CENTRAL PLANT - BASEMENT FLOOR PLAN - DEMO
44. M401 - ENLARGED CENTRAL LANT - BASEMENT FLOOR PLAN - PROPOSED
45. M402 - ENLARGED BASEMENT FLOOR PLAN - MECHANICAL ROOMS
46. M403 - ENLARGED PLAN - 2ND FLOOR - MECHANICAL ROOM - DEMO
47. M404 - ENLARGED PLAN - 2ND FLOOR - MECHANICAL ROOM - PROPOSED
48. M405 - ENLARGED PLAN - 3RD FLOOR - MECHANICAL ROOM - DEMO
49. M406 - ENLARGED PLAN - 3RD FLOOR - MECHANICAL ROOM - PROPOSED
50. M407 - ENLARGED PLAN - TYPICAL 4TH-7TH FLOOR - MECHANICAL ROOM - DEMO
51. M408 - ENLARGED PLAN - TYPICAL 4TH-7TH FLOOR - MECHANICAL ROOM - PROPOSED
52. M409 - ENLARGED PLAN - TYPICAL 8th-10th FLOOR - MECHANICAL ROOM - DEMO
53. M410 - ENLARGED PLAN - TYPICAL 8TH-10TH FLOOR - MECHANICAL ROOM - PROPOSED
54. M411 - ALTERNATE - ENLARGED PLAN - TYPICAL 8th-10th FLOOR - MECHANICAL ROOM - PROPOSED
55. M501 - SECTIONS
56. M502 - SECTIONS
SECTION 01 23 00

ALTERNATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes administrative and procedural requirements for alternates.

1.3 DEFINITIONS

A. Alternate: An amount proposed by bidders and stated on the Bid Form for certain work defined in the Bidding Requirements that may be added to or deducted from the Base Bid amount if Owner decides to accept a corresponding change either in the amount of construction to be completed or in the products, materials, equipment, systems, or installation methods described in the Contract Documents.

1.  The cost or credit for each alternate is the net addition to or deduction from the Contract Sum to incorporate alternate into the Work. No other adjustments are made to the Contract Sum.

1.4 PROCEDURES

A. Coordination: Modify or adjust affected adjacent work as necessary to completely integrate work of the alternate into Project.

1. Include as part of each alternate, miscellaneous devices, accessory objects, and similar items incidental to or required for a complete installation whether or not indicated as part of alternate.

B. Notification: Immediately following award of the Contract, notify each party involved, in writing, of the status of each alternate. Indicate if alternates have been accepted, rejected, or deferred for later consideration. Include a complete description of negotiated modifications to alternates.

C. Execute accepted alternates under the same conditions as other work of the Contract.

D. Schedule: A Schedule of Alternates is included at the end of this Section. Specification Sections referenced in schedule contain requirements for materials necessary to achieve the work described under each alternate.
PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 SCHEDULE OF ALTERNATES

A. Alternate No. 1 (Additive) is for alternate AHU system configurations at building levels 8 through 10 using a single, tandem, custom air handling units with a separate dedicated outside air pretreatment unit.

B. Alternate No. 2 (Deductive) is for the refurbishment of the outdoor distribution switchgear in the TECO pit instead of removal and replacement as indicated on the construction documents from the scope of contractor’s work. As part of the base bid requirement, the contractor shall include construction costs related to the removal of the existing switchgear, building a complete platform in accordance with structural construction documents, and the installation of the new switchgear at a higher elevation. This deduction alternate assumes that the platform will not be built, all CenterPoint Energy equipment will be replaced by CenterPoint Energy (at their discretion) but remain at the same elevation, and the existing switchgear will be refurbished and not replaced. The refurbishment procedure is as follows:
1. The metal enclosure structure requires rust removal and/or panel replacement.
2. The entire enclosure shall be repainted.
3. Contractor shall provide a comprehensive inspection, cleaning, painting, and testing of all components of each load interrupter switch, and verify the integrity of each interrupter switch in accordance with Square D/Schneider Electric requirements and published data.
4. Contractor shall clean the enclosure thoroughly and perform required testing procedures for all switch components listed above, and clean and inspect other components recommended by the manufacturer.
5. Contractor shall perform required testing procedures after thorough cleaning of all switch components recommended by the manufacturer, and verify equipment is suitable to provide reliable operation for the next 20 years.
6. Components and devices not meeting tolerances and limits as required by the manufacturer due to: age, environmental exposure, operational fatigue, will be considered for replacement as a part of the overhaul of this switchgear lineup.
7. This lump sum will be deducted from contractor’s base bid in lieu of work related to elevate all equipment in TECO pit.

C. Alternate No. 3 (Additive) is for conversion of wire/conduit to busway/feeder:
1. Feeders for (8) 600 A circuits and (1) 800 A circuit to feeder bus.
2. Conversion of group-mounted breakers to stack-mounted or individually mounted breakers as required for direct bus connection.
3. Addition of cable-tap box adjacent to each load equipment to convert to equal cable-entry to equipment.
4. Replace existing power factor correction capacitor with equal to existing.

D. Alternate No. 4 (Additive) is for raising the Centerpoint Energy outdoor gear.

E. Alternate No. 5 (Additive) is for conversion of the existing directly coupled chilled water pumping system to an indirectly coupled chilled water system using new plate & frame heat exchangers.
F. Alternate No. 6 (Additive) is for inclusion of work related to replacement of lab panels. The contractor shall provide cost associated with demolition and replacement of 68 lab panels in lieu of reusing these panels as indicated on the construction documents.

G. Alternate No. 7 (Additive) is for replacement of all existing 2x2 and 2x4 fluorescent troffer light fixtures with Cree LED, one-for-one.
   1. Replace 2x2 fixtures with Cree ZR22-32L-40K-CMA, with EB14 for emergency fixtures.
   2. Replace 2x4 fixtures with Cree ZR24-40L-40K-CMA, with EB14 for emergency fixtures.

   **RECESSED LINEAR SUMMARY**

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   **NOTE:** Any fixtures not used in the project will be turned over to the owner as attic stock.

H. Alternate No. 8 (Additive) is for the addition of demand ventilation controls using automated electronic people counter devices at selected classrooms.

**END OF SECTION**
SECTION 23 57 00

HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
B. Coordinate with Commissioning Requirements indicated in Section 019100. This contractor is responsible to comply with all requirements for the above section.

1.2 SUMMARY
A. This Section includes shell-and-tube heat exchangers.

1.3 SUBMITTALS
A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
B. Shop Drawings: Signed and sealed by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Design Calculations: Calculate requirements for selecting seismic restraints and for designing bases.
   2. Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
C. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Tube-removal space.
   2. Structural members to which heat exchangers will be attached.
   3. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   4. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
D. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE
A. Product Options: Drawings indicate size, profiles, performance, and dimensional requirements of heat exchangers and are based on the specific equipment indicated. Refer to Division 01 Section "Product Requirements."
B. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.
C. Registration: Fabricate and label shell-and-tube heat exchangers to comply with the Tubular Exchanger Manufacturers Association's standards.

1.5 MAINTENANCE

A. Provide twelve (12) months maintenance of all materials and equipment under this section. Cost of the twelve (12) month normal and preventive maintenance shall be included within this scope of work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHELL-AND-TUBE HEAT EXCHANGERS

A. Manufacturers:
   1. API Heat Transfer Inc.
   2. Armstrong Pumps, Inc.
   3. ITT Industries; Bell & Gossett.
   4. Taco, Inc.
   5. Thrush Company, Inc.

B. Configuration: U-tube with removable bundle.

C. Shell Materials: Steel.

D. Head:
   2. Flanged and bolted to shell.

E. Tube:
   1. Seamless steel.
   2. Tube diameter is determined by manufacturer based on service.

F. Tube sheet Materials: Steel tube sheets.

G. Baffles: Steel.

H. Piping Connections:
   1. Shell: Flanged inlet and outlet fluid connections, threaded drain, and vent connections.
   2. Head: Marine style water boxes with flanged inlet and outlet fluid connections.

I. Support Saddles:
   1. Fabricated of material similar to shell.
   2. Foot mount with provision for anchoring to support.
   3. Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat-exchanger movement during a seismic event when heat-exchanger saddles are anchored to building structure.
PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.
      1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 HEAT-EXCHANGER INSTALLATION
   A. Install shell-and-tube heat exchangers on saddle supports.
   B. Install shell-and-tube heat exchangers on concrete base. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.
   C. Concrete Bases: Anchor heat exchanger to concrete base.
      1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
      2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
      3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
      4. Install anchor bolts to elevations required for proper attachment to supported equipment.
      5. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 CONNECTIONS
   A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
   B. Maintain manufacturer's recommended clearances for service and maintenance. Install piping connections to allow service and maintenance of heat exchangers.
   C. Install shutoff valves at heat-exchanger inlet and outlet connections.
   D. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.
   E. Install vacuum breaker at heat-exchanger steam inlet connection.
   F. Install hose end valve to drain shell.

3.4 FIELD QUALITY CONTROL
   A. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 CLEANING
   A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION
A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION
SECTION 23 22 23

STEAM CONDENSATE RETURN UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
B. Coordinate with Commissioning Requirements indicated in Section 019100. This contractor is responsible to comply with all requirements for the above section.

1.2 SUMMARY
A. This Section includes steam condensate pumping units.

1.3 SUBMITTALS
A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated. Indicate pump's operating point on curves. Include receiver capacity and material.
B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
C. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE
A. Source Limitations: Obtain steam condensate pumps through one source from a single manufacturer.
B. Product Options: Drawings indicate size, profiles, and dimensional requirements of steam condensate pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
D. ASME Compliance: Fabricate and label steam condensate pumps to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.5 DELIVERY, STORAGE, AND HANDLING
A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

STEAM CONDENSATE PUMPS
23 22 23 - 1
B. Store steam condensate pumps in dry location.
C. Retain protective covers for flanges and protective coatings during storage.
D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
E. Comply with pump manufacturer's written rigging instructions.

1.6 COORDINATION
A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.7 MAINTENANCE
A. Provide twelve (12) months maintenance of all materials and equipment under this section. Cost of the twelve (12) month normal and preventive maintenance shall be included within this scope of work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 STEAM CONDENSATE RETURN UNITS
A. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pump(s), controls, and accessories suitable for operation with steam condensate.
B. Configuration: Duplex floor-mounting pump with receiver and float switch(s); rated to pump 200 deg F (93 deg C) steam condensate.
   1. Manufacturers:
      a. Bell & Gossett
      b. Skidmore
      c. Aurora
      d. Spirax Sarco, Inc.
      e. Pentair Pump Group.
      f. Roth Pump Company.
      g. Spence Engineering Company, Inc.; Division of Circor International, Inc.
      h. Sterling, Inc.
   2. Receiver: welded steel, min 3/16" thick; galvanized inside & outside with magnesium anode, externally adjustable float switch connections, and flanges for pump mounting.
   3. Pumps: Centrifugal, close coupled, permanently aligned, stainless steel shaft, bronze fitted; with replaceable bronze case ring and mechanical seal; mounted on receiver flange.
   4. Factory Wiring: Between float switch(s), for single external electrical connection. Fused control power transformer if voltage exceeds 230 V.
   5. Pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate if the normal start level for a single pump is exceeded.
6. Provide units complete with receiver, controls, pumps, valves, level switches, and sight glass.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.
   B. Examine rough installation of steam condensate piping.
   C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
   A. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
   B. Support pumps and piping separately so piping is not supported by pumps.
   C. Install pumps on concrete bases. Anchor pumps to bases using inserts or anchor bolts.
   D. Install thermometers and pressure gages.

3.3 CONNECTIONS
   A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
   B. Install piping adjacent to machine to allow service and maintenance.
   C. Install gate and check valves on inlet and outlet of pressure-powered pumps.
   D. Install check valve, gate valve, and globe valve at pump discharge connections for each electric-driven pump.
   E. Pipe drain to nearest floor drain for overflow and drain piping connections.
   F. Install full-size vent piping to outdoors, terminating in 180-degree elbow at point above highest steam system connection or as indicated.
   G. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
   H. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 STARTUP SERVICE
   A. Verify that steam condensate pumps are installed and connected according to the Contract Documents.
   B. Complete installation and startup checks according to manufacturer's written instructions.
   C. Clean strainers.
   D. Set steam condensate pump controls.
   E. Set pump controls for automatic start, stop, and alarm operation.
F. Perform the following preventive maintenance operations and checks before starting:
   1. Set float switches to operate at proper levels.
   2. Set throttling valves on pump discharge for specified flow.
   3. Check motors for proper rotation.
   4. Test pump controls and demonstrate compliance with requirements.
   5. Replace damaged or malfunctioning pump controls and equipment.
   6. Verify that pump controls are correct for required application.

G. Start steam condensate pumps according to manufacturer's written startup instructions.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain steam condensate pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION
SECTION 23 22 00
STEAM AND STEAM CONDENSATE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. This Section includes the following for steam and condensate piping:
1. Pipe and fittings.
2. Strainers.
3. Flash tanks.
4. Safety valves.
5. Steam regulator valves.
6. Steam traps.
7. Thermostatic air vents and vacuum breakers.
8. Steam and condensate meters.

1.3 DEFINITIONS
A. HPS Systems: High-pressure steam systems operating at conditions up to 250 psig superheated to 450 deg F complying with requirements of ASME B31.1.
B. MPS Systems: Medium-pressure steam systems operating at conditions up to 75 psig superheated to 405 deg F complying with requirements of ASME B31.1.
C. LP Systems: Low-pressure steam systems operating at conditions up to 15 psig superheated to 383 deg F complying with requirements of ASME B31.1 and/or B31.9 as applicable or otherwise indicated.

1.4 PERFORMANCE REQUIREMENTS
A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures:
1. Steam Piping: as indicated on drawings
2. Steam Condensate Piping: at same rating as attached system but not less than 60 psig at 250 deg F.
3. Makeup-Water Piping: 60 psig at 150 deg F.
4. Blow down-Drain Piping: Equal to pressure of the piping system to which it is attached.
5. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
6. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.
1.5 SUBMITTALS

A. Product Data: For each type of the following:
   1. Pipe, fittings, and accessories.
   2. Steam regulators and safety valves.
   3. Steam trap.
   4. Air vent and vacuum breaker.
   5. Flash tank.
   6. Meter.

B. Shop Drawings: Detail, 1/4 inch equals 1 foot scale, flash tank assemblies and fabrication of pipe anchors, hangers, pipe, multiple pipes, alignment guides, and expansion joints and loops and their attachment to the building structure. Detail locations of anchors, alignment guides, and expansion joints and loops.

C. Welding certificates – QPS, PQR, & WPS’s

D. Field quality-control test reports & weld map

E. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code - Steel."

B. Pipe Welding:
   Conform to ASME Code and applicable state labor regulations. Provide 100% visual welding inspection by a qualified welding inspector. Welding inspector shall examine fit-up for compliance with ASME requirements prior to weldout. Owner reserves the right to examine welds by any means desired including radiography and or ultrasonic technology. All welds must be fully penetrated, show no lack of fusion, show no slag inclusions in excess of ASME limits, or cluster porosities. Examined welds not meeting this criterion will be considered unacceptable and be fully replaced at no additional cost to the owner. The welding inspector shall maintain a current weld-map on the job site for submission with project close-out documents. See WELD TESTING for additional information.

C. Welder’s Certification: In accordance with ASME Sec. 9. Submit welder’s certification, including WPS, PQR, & WPQs prior to any shop or field fabrication. Welder’s certifications shall be current within six months of submission.

D. ASME Compliance: Comply with and ASME B31.1 & B31.9, for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.7 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 of three years’ documented experience

1.8 DELIVERY, STORAGE, AND HANDLING
A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
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.
A. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system

1.9 EXTRA MATERIALS
A. Furnish under provisions of Section 23 00 00.
B. Provide two repacking kits for each size valve

PART 2 - PRODUCTS

2.1 STEEL PIPE AND FITTINGS
A. ASTM A53 or A106, Grade A or B, seamless. See Part 3 below for wall thickness schedule.
B. NPS2-1/2 and larger shall be butt welded and flanged. NPS 2 or smaller shall be threaded or flanged and butt welded. Flanges shall be welding neck type. Extra strong Weld-O-Lets, Thread-O-Lets, or shaped nipples may be used only when take-off is 1/3 or less nominal size of main.
C. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in Part 3 piping applications articles.
D. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in Part 3 piping applications articles.
E. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 piping applications articles.
F. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in Part 3 piping applications articles; raised ground face, and bolt holes spot faced.
G. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
H. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   2. End Connections: Butt welding.
3. Facings: Raised face.
   I. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.2 JOINING MATERIALS
   A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
      1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
         a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
         b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
   B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
   C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
   D. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
   E. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

2.3 DIELECTRIC FITTINGS
   A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
   B. Insulating Material: Suitable for system fluid, pressure, and temperature.
   C. Dielectric Unions:
      1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         b. Central Plastics Company.
         d. Watts Water Technologies, Inc.
         e. Zurn Plumbing Products Group.
      2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.
   D. Dielectric Flanges:
      1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         b. Central Plastics Company.
         c. Watts Water Technologies, Inc.
      2. Factory-fabricated companion-flange assembly, for 150 or 300-psig minimum working pressure as required to suit system pressures.
   E. Dielectric-Flange Kits:
      1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

3. Separate companion flanges and steel bolts and nuts shall have 150 or 300 psig minimum working pressure as required to suit system pressures.

2.4 VALVES

A. Isolation Valves: OS&Y gate type suitable for steam service, pressure class as indicated
   1. HPS Service: Steel body
   2. MPS Service: Ductile Iron or Steel body
   3. LPS: Cast iron or steel body

B. Throttling Valves: OS&Y globe type for steam service, pressure class as indicated
   1. HPS Service: Steel body
   2. MPS Service: Ductile Iron or Steel body
   3. LPS: Cast iron or steel body

2.5 STRAINERS

A. Y-Pattern Strainers:
   1. Body: cast iron or ductile iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
   3. Strainer Screen: Stainless-steel, 20 mesh strainer, and perforated stainless-steel basket with 50 percent free area.
   4. Tapped blow-off plug.
   5. Pressure Class: as indicated

2.6 SAFETY VALVES

A. Bronze Safety Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Kunkle Valve; a Tyco International Ltd. Company.
      c. Spirax Sarco, Inc.
      d. Watts Water Technologies, Inc.
   2. Disc Material: Forged copper alloy.
   3. End Connections: Threaded inlet and outlet.
   4. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
   5. Pressure Class: 250 or as indicated.
   6. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
   7. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
B. Cast-Iron Safety Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Kunkle Valve; a Tyco International Ltd. Company.
      c. Spirax Sarco, Inc.
      d. Watts Water Technologies, Inc.
   2. Disc Material: Forged copper alloy with bronze nozzle.
   3. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
   4. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
   5. Pressure Class: 250 or as indicated
   6. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
   7. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.

2.7 STEAM REGULATING VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Hoffman Specialty; Division of ITT Industries.
   3. Leslie Controls, Inc.
   5. Spirax Sarco, Inc.

B. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.

C. Description: Pilot-actuated, diaphragm type, with adjustable range and positive shutoff.

D. Body: Cast iron

E. End Connections: Threaded connections for valves NPS 2 and smaller and flanged connections for valves NPS 2-1/2 and larger.

F. Trim: Hardened stainless steel.

G. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.

H. Gaskets: Non-asbestos materials.

I. Provide stem regulators with pilots and accessories as indicated.

2.8 STEAM TRAPS

A. Float and Thermostatic Traps:

B. ASTM A126, cast iron or semi-steel body and bolted cover for 250 psig WSP; provide access to internal parts without disturbing piping; with bottom drain plug, stainless steel or bronze bellows type air vent, stainless steel or copper float, stainless steel lever and valve assembly.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
STEAM AND STEAM CONDENSATE PIPING

2.9 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Barnes & Jones, Inc.
   c. Dunham-Bush, Inc.
   d. Hoffman Specialty; Division of ITT Industries.
   e. Spirax Sarco, Inc.
   f. Sterling.

2. Body: Cast iron, bronze or stainless steel.
5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
7. Maximum Temperature Rating: 350 deg F.

B. Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Spirax Sarco, Inc.
   b. Armstrong International, Inc.
   c. Hoffman Specialty; Division of ITT Industries.

2. Body: Cast iron, bronze, or stainless steel.
5. O-ring Seal: EPR.
7. Maximum Temperature Rating: 350 deg F.

PART 3 - EXECUTION

3.1 PIPING APPLICATION
A. High Pressure Steam Piping:
1. All piping shall be Schedule 80 black steel piping.
2. Fittings shall be extra heavy butt welding type. Flanges shall be 300# welding neck type. Extra strong Weld-O-Lets, Thread-O-Lets, or shaped nipples may be used only when take-off is 1/3 or less nominal size of main. Screwed fittings around traps shall be 2,000 pound forged steel.

B. Condensate Return and Pumped Condensate Return Piping:
1. All piping shall be Schedule 80 black steel piping.
2. Fittings on piping 2-1/2” and larger shall be extra heavy butt welding type. Flanges shall be 150# welding neck type. Extra strong Weld-O-Lets, Thread-O-Lets, or shaped nipples may be used only when take-off is 1/3 or less nominal size of main.
3. Screwed fittings around traps and for piping 2” and smaller shall be 125# black cast iron. (300# for unions). At contractor’s option, socket weld fittings may be used.

C. Low and Medium Pressure Steam Piping:
1. All piping shall be Schedule 40 black steel piping, except sizes 1” and smaller shall be Schedule 80.
2. Fittings on piping 2-1/2” and larger shall be standard weight butt welding type. Flanges shall be welding neck type. Standard weight Weld-O-Lets, Thread-O-Lets, and shaped nipples may be used only when take-off is 1/3 or less nominal size of main. Bushings shall not be used.
3. Screwed fittings for piping 2” and smaller shall be malleable iron. Unions shall be Class 250 minimum. At contractor’s option, socket weld fittings may be used.

3.2 ANCILLARY PIPING APPLICATIONS
A. Makeup-water piping installed above grade shall be either of the following:
1. Drawn-temper copper tubing, wrought-copper fittings, and brazed joints.

B. Blow down-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

C. Air-Vent Piping:
1. Inlet: Same as service where installed.
2. Outlet: Type K annealed-temper copper tubing with soldered or flared joints.

D. Vacuum-Breaker Piping: Outlet, same as service where installed.

E. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.
3.3 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.4 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Use indicated piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

K. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
S. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blow-down connection of strainers NPS and larger. Match size of strainer blow-off connection for strainers smaller than NPS 2.

T. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

U. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."

V. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.
   1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet.
   2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.

3.5 STEAM-TRAP INSTALLATION
   A. Install steam traps in accessible locations as close as possible to connected equipment.
   B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

3.6 PRESSURE-REDUCING VALVE INSTALLATION
   A. Install pressure-reducing valves in accessible location for maintenance and inspection.
   B. Install bypass piping around pressure-reducing valves, with globe valve equal in size to area of pressure-reducing valve seat ring, unless otherwise indicated.
   C. Install gate valves on both sides of pressure-reducing valves.
   D. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections respectively.
   E. Install pressure gages on low-pressure side of pressure-reducing valves after the bypass connection according to Division 23 Section "Meters and Gages for HVAC Piping."
   F. Install strainers upstream for pressure-reducing valve.
   G. Install safety valve downstream from pressure-reducing valve station.

3.7 SAFETY VALVE INSTALLATION
   A. Install safety valves according to ASME B31.1 & B31.9 requirements
   B. Pipe safety-valve discharge without valves to atmosphere outside the building.
   C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.
   D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2.
3.8 HANGERS AND SUPPORTS

A. Install hangers and supports according to Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Comply with requirements below for maximum spacing.

B. Seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
   2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
   4. Spring hangers to support vertical runs.

3.9 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube ends. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.


F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.10 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.
E. Install a drip leg at coil outlet.

3.11 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME and as follows:
   1. Leave joints, including welds, un-insulated and exposed for examination during test.
   2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
   3. Flush system with clean water. Clean strainers.
   4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Perform the following tests on steam and condensate piping:
   1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
   2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
   3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

C. Prepare written report of testing.

3.12 CLEANING AND FLUSHING OF STEAM SYSTEMS

A. Steam and condensate systems shall be thoroughly cleaned before placing in operation to rid systems of rust, dirt, piping compound, mill scale, oil, grease, any and all other material foreign to water being circulated.

B. Extreme care shall be exercised during construction to prevent dirt and other foreign matter from entering the pipe or other parts of systems. Pipe stored on the project shall have open ends capped and equipment shall have openings fully protected. Before erection, each piece of pipe, fitting, or valve shall be visually examined and dirt removed.

C. Chemicals, feeding devices, and water technician services shall be furnished by a single reputable manufacturer who will be responsible for the complete cleaning and flushing of the systems.
   1. Add a temporary line with drain and isolate the building steam and condensate piping from the campus distribution piping to allow for proper circulation and cleaning of the new piping in the new tunnel and/or in the new or modified building piping system(s).

D. Systems shall be cleaned with a chemical compound specifically formulated for the purposes of removing the above listed foreign matter. These chemicals shall be injected to the systems, circulated and completely flushed out. Repeat the process if required. After each flushing, remove and thoroughly clean all strainers.

E. Final connection is not to be made to the campus loop system until the Chemical Contractor has filed with the Owner’s representatives, a report stating that the systems are clean.
END OF SECTION
SECTION 23 20 00.A

PIPING, VALVES AND FITTINGS

PART 1 GENERAL

1. 1 The following sections are to be included as if written herein:
   A. Section 23 00 00 – Basic Mechanical Requirements
   B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
   C. Section 23 05 53 – Mechanical Identification

1. 2 SECTION INCLUDES
   A. Pipe and Pipe Fittings
   B. Valves

1. 3 RELATED SECTIONS
   A. Section 02222 - Excavating
   B. Section 31 23 23.13 - Backfilling
   C. Section 31 23 16.13 - Trenching
   D. Section 33 13 00 - Disinfection of Water Distribution System
   E. Section 08 31 13 - Access Doors and Frames
   F. Section 09 91 00 - Painting
   G. Section 23 05 16 - Expansion Compensation
   H. Section 23 05 48 - Vibration Isolation
   I. Section 23 07 19 - Piping Insulation
   J. Section 22 13 16.A - Plumbing Specialties
   K. Section 22 40 00 - Plumbing Fixtures
   L. Section 22 11 23 - Plumbing Equipment

1. 4 REFERENCES
   A. AGA - American Gas Association
   B. ANSI B31.1 - Power Piping
   C. ANSI B31.2 - Fuel Gas Piping
   D. ANSI B31.4 - Liquid Petroleum Transportation Piping Systems
   E. ANSI B31.9 - Building Service Piping
   F. ASME - Boiler and Pressure Vessel Code
G. ASME Sec. 9 - Welding and Brazing Qualifications
H. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250 and 800
I. ASME B16.3 - Malleable Iron Threaded Fittings
J. ASME B16.4 - Cast Iron Threaded Fittings Class 125 and 250
K. ASME B16.18 - Cast Bronze Solder-Joint Pressure Fittings
L. ASME B16.22 - Wrought Copper and Bronze Solder-Joint Pressure Fittings
M. ASME B16.23 - Cast Copper Alloy Solder-Joint Drainage Fittings - DWV
N. ASME B16.26 - Cast Bronze Fittings for Flared Copper Tubes
O. ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV
P. ASME B16.32 - Cast Copper Alloy Solder-Joint Fittings for Sovent Drainage Systems
Q. ASTM A47 - Ferric Malleable Iron Castings
R. ASTM A135 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless
S. ASTM A74 - Cast Iron Soil Pipe and Fittings
T. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
U. ASTM B32 - Solder Metal
V. ASTM B42 - Seamless Copper Pipe
W. ASTM B43 - Seamless Red Brass Pipe
X. ASTM B75 - Seamless Copper Tube
Y. ASTM B88 - Seamless Copper Water Tube
Z. ASTM B251 - Wrought Seamless Copper and Copper-Alloy Tube
AA. ASTM B302 - Threadless Copper Pipe (TP)
BB. ASTM B306 - Copper Drainage Tube (DWV)
CC. ASTM C14 - Concrete Sewer, Storm Drain, and Culvert Pipe
DD. ASTM C425 - Compression Joints for Vitrified Clay Pipe and Fittings
EE. ASTM C443 - Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
FF. ASTM C564 - Rubber Gaskets for Cast Iron Soil Pipe and Fittings
GG. ASTM C700 - Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
HH. ASTM D1785 - Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
II. ASTM D2235 - Solvent Cement for Acrylonitrile - Butadiene - Styrene (ABS) Plastic Pipe and Fittings
JJ. ASTM D2241 - Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)
KK. ASTM D2466 - Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
LL. ASTM D2513 - Thermoplastic Gas Pressure Pipe, Tubing and Fittings
MM. ASTM D2564 - Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
NN. ASTM D2680 - Acrylonitrile-Butadiene-Styrene (ABS) Composite-Sewer Piping
OO. ASTM D2683 - Socket-Type Polyethylene Fillings for Outside Diameter - Controlled Polyethylene Pipe

PP. ASTM D2729 - Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings

QQ. ASTM D2751 - Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings

RR. ASTM D2846 - Chlorinated Polyvinyl Chloride (CPVC) Pipe, Fittings, Solvent Cements and Adhesives for Potable Hot Water Systems

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

TT. ASTM D3033 - Type PSP Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings

UU. ASTM D3034 - Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings

VV. ASTM D3309 - Polybutylene (PB) Plastic Hot Water Distribution System

WW. ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe

XX. ASTM F493 - Solvent Cements for Chlorinated Poly Vinyl Chloride (CPVC) Plastic Pipe and Fittings

YY. ASTM F845 - Plastic Insert Fittings for Polybutylene (PB) Pipe

ZZ. AWS A5.8 - Brazing Filler Metal. BA. AWWA C105 - Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids

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

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

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

DDD. AWWA C651 - Disinfecting Water Mains

EEE. CISPI 301 - Cast Iron Soil Pipe and Fittings for Hubless Cast Iron Sanitary Systems

FFF. CISPI 310 - Joints for Hubless Cast Iron Sanitary Systems

GGG. CAN-3 B281 - Aluminum Drain, Waste, and Vent Pipe and Components

HHH. NCPWB - Procedure Specifications for Pipe Welding

III. NFPA 54 - National Fuel Gas Code

JJJ. NFPA 58 - Storage and Handling of Liquefied Petroleum Gases

KKK. TDH - Texas Department of Health, Water System Regulations

1. 5  SUBMITTALS

   A. Submit under provisions of Section 23 00 00.

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

   C. Welding Certificates – WPS, PQR, & WPS’s

   D. Welding Inspector Qualifications

   E. Field quality-control test reports & weld map

1. 6  PROJECT RECORD DOCUMENTS
1. Submit under provisions of Section 23 00 00.

2. Record actual locations of valves, etc. and prepare valve charts.

1. 7 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 23 00 00.

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

1. 8 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

B. Welding Materials and Procedure: Conform to ASME Code and applicable state labor regulations. Provide 100% visual welding inspection by a qualified welding inspector. Welding inspector shall examine fit-up for compliance with ASME requirements prior to weldout. Owner reserves the right to examine welds by any means desired including radiography and or ultrasonic technology. All welds must be fully penetrated, show no lack of fusion, show no slag inclusions in excess of ASME limits, or cluster porosities. Examined welds not meeting this criterion will be considered unacceptable and be fully replaced at no additional cost to the owner. The welding inspector shall maintain a current weld map on the job site for submission with project close-out documents. See WELD TESTING for additional information.

C. Welder's Certification: In accordance with ASME Sec. 9. Submit welder's certification, including WPS, PQR, & WPQs prior to any shop or field fabrication. Welder's certifications shall be current within six months of submission.

D. Maintain one copy of each document on site.

1. 9 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 of three years' documented experience.

1. 10 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.

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. 11 ENVIRONMENTAL REQUIREMENTS

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

1. 12 EXTRA MATERIALS
A. Furnish under provisions of Section 23 00 00.
B. Provide two repacking kits for each size valve.

**PART 2 PRODUCTS**

2.1 **STEEL PIPING:**

A. **Scope:** This section applies to all piping systems providing for welded piping, fittings, and other appurtenances. Specific systems requiring welded piping include, but are not limited to: chilled water, hot water, steam, steam condensate, and fire protection systems.

B. **Pipe:** Unless otherwise indicated, chiller and boiler plants piping shall be Schedule 40, and underground and building piping shall be Standard weight, Grade A or B, seamless black steel pipe conforming in all details to Standard ASTM Designation A135, A106, and A53, latest revisions. Steam condensate shall be Schedule 80.

C. **Fittings:**

1. All weld fittings shall be domestic made wrought carbon steel butt-welding fittings conforming to ASTM A234 and ASME/ANSI B16.9, latest edition, as made by Weld Bend, Tube Turn, Hackney, or Ladish Company. Attach to only pipe with a hole for the entire length. Each fitting shall be stamped as specified by ASME/ANSI B16.9 and, in addition, shall have the laboratory control number metal stenciled on each fitting for ready reference as to physical properties required for any fittings selected at random. Fittings which have been machined, remarked, printed, or otherwise produced domestically from non-domestic forgings or materials will not be acceptable. Each fitting is to be marked in accordance with MSS SP-25. Markings shall be placed on the fittings at the farthest point from the edge to be welded to prevent disfiguring from the welding process. Submittal data for these fittings shall include a letter signed by an official of the manufacturing firm certifying compliance with these specifications.

2. All screwed pattern fittings specifically called for shall be minimum Class 150 malleable iron fittings of Grinnell Company, Crane Company or Walworth Company manufacture (300 lb. for unions).

D. **FABRICATION:**

1. Welded piping and fittings in chiller and boiler plants shall be fabricated in accordance with ASME/ANSI the latest editions of Standards B31.9. Machine beveling in shop is preferred. Field beveling may be done by flame cutting to recognized standards.

2. Ensure complete penetration of deposited metal with base metal. Contractor shall provide filler metal suitable for use with base metal. Contractor shall keep inside of fittings free from globules of weld metal. All welded pipe joints shall be made by the fusion welding process, employing a metallic arc or gas welding process. All pipe shall have the ends beveled 37-1/2 degrees and all joints shall be aligned true before welding. Except as specified otherwise, all changes in direction, intersection of lines, reduction in pipe size and the like shall be made with factory-fabricated welding fittings. Mitering of pipe to form elbows, notching of straight runs to form tees, or any similar construction will not be permitted.

3. Align piping and equipment so that no part is offset more than 1/16 inch. Set all fittings and joints square and true, and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.

4. Do not permit any weld to project within the pipe so as to restrict it. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during welding operation.
5. Do not split, bend, flatten or otherwise damage piping before, during or after installation.

6. Remove dirt, scale and other foreign matter from the inside of piping, by swabbing or flushing, prior to the connection of other piping sections, fittings, valves or equipment.

7. In no cases shall Schedule 40 pipe be welded with less than three passes including one stringer/root, one filler and one lacer. Schedule 80 pipe shall be welded with not less than four passes including one stringer/root, two filler and one lacer. In all cases, however, the weld must be filled before the cap weld is added.

8. Procedure of Assembling Screw Pipe Fittings: All screw joints shall be made with taper threads properly cut. Joints shall be made tight with Teflon applied to the pipe threads only and not to fittings. When threads are cut on pipes, the ends shall be carefully reamed to remove any burrs. Before installing pipe that has been cut and threaded, the lengths of pipe shall be upended and hammered to remove all shavings and foreign material.

E. WELD TESTING:

1. All welds are subject to inspection, visual and/or X-ray, for compliance with specifications. The owner will, at the owner’s option, provide employees or employ a testing laboratory for the purposes of performing said inspections and/or X-ray testing. Initial visual and X-ray inspections will be provided by the owner. The contractor shall be responsible for all labor, material and travel expenses involved in the re-inspection and re-testing of any welds found to be unacceptable. In addition, the contractor shall be responsible for the costs involved in any and all additional testing required or recommended by ASME/ANSI Standards B31.1, B31.9, and B31.3 due to the discovery of poor, unacceptable, or rejected welds.

2. Welds lacking penetration, containing excessive porosity or cracks, or are found to be unacceptable for any reason, must be removed and replaced with an original quality weld as specified herein. All qualifying tests, welding and stress relieving procedures shall, moreover, be in accord with Standard Qualification for Welding Procedures, Welders and Welding Operators, Appendix A, Section 6 of the Code, current edition.

2.2 COPPER PIPE

A. Copper Pipe: Piping four inches (4") and smaller shall be fabricated of Type K, hard drawn, copper pipe made of deoxidized copper (99.9% pure). This Type K copper pipe shall conform in every detail to ASTM Standard Specifications for COPPER WATER TUBE, Serial Designation B-88-66, and it shall be provided in 20-foot straight lengths. Copper pipe 4" and smaller may only be joined using non-lead-bearing solder, such as 95-5 silver or antimony solder (95 percent tin, and 5 percent silver or antimony). Copper pipe 4" and larger may be joined using roll grooved fittings.

(Note: For UT Austin, substitute the following sentence for the previous two sentences: "Copper pipe may only be joined using "Silvabrite" solder. No other solders may be used.")

B. Fittings: All fittings for four inch (4") and smaller water lines shall be Streamline Solder Fittings manufactured by Streamline Pipe and Fittings Division, Mueller Brass Company, or approved equal. These wrought copper fittings shall be rigid and strong with openings machined to accurate capillary fit for the pipe.

C. Lead: It is forbidden that lead in any form be used in any water system other than waste. If lead is used in the fabrication or installation of any water system other than waste, then ALL of the installed equipment and material, which may have come in contact with the lead, shall be marked with bright red or orange spray paint, and shall be removed from the project site. The system(s) shall then be restored and reinstalled using ALL NEW MATERIALS.
2.3 VALVES:

A. All valves shall be located such that the removal of their bonnets is possible. All flanged valves shown in horizontal lines with the valve stem in a horizontal position shall be positioned so that the valve stem is inclined one bolt hole above the horizontal position. Screw pattern valves placed in horizontal lines shall be installed with their valve stems inclined at an angle of a minimum of 30 degrees above the horizontal position. All valves must be true and straight at the time the system is tested and inspected for final acceptance. Valves shall be installed as nearly as possible to the locations indicated in the Construction Drawings. Any change in valve location must be so indicated on the Record Drawings. All valves must be of threaded or flanged type. No solder connected or grooved fitting valves shall be used on this project. All bronze and iron body gate and globe valves shall be the product of one manufacture for each project. Manufacturers of other types may not be mixed on the same project; i.e., all butterfly valves shall be of the same manufacture, all ball valves shall be of the same manufacture, etc.

B. All valves used in circulating systems, plumbing and steam systems (low and medium pressure) shall be Class 150 SWP. Class 300 valves shall be constructed of all ASTM B-61 composition. All gate, globe and angle valves shall be union bonnet design. Metal used in the stems of all bronze gate, globe and angle valves shall conform to ASTM B371 Alloy 694, ASTM B99 Alloy 651, or other corrosion resistant equivalents. Written approvals must be secured for the use of alternative materials. Alloys used in all bronze ball, gate, globe, check, or angle valves shall contain no more than 15% zinc. No yellow brass valves will be allowed.

C. All iron body valves shall have the pressure containing parts constructed of ASTM designated of 126 class B iron. Stem material shall meet ASTM B16 Alloy 360 or ASTM 371 Alloy 876 silicon bronze or its equivalent. Gates and globes shall be bolted bonnet outside and screw and yoke design. A lubrication fitting is preferred on yoke cap for maintenance lubrication of the yoke bushing.

D. All cast steel body valves shall have the pressure containing parts constructed of ASTM designation A-216-GR-WCB carbon steel. Gate and globe valves shall be bolted bonnet outside and screw and yoke design with pressure-temperature rating conforming to ANSI B16-34-1977. Stems shall meet ASTM designation A-186-F6 chromium stainless steel. Wedge (gate valves) may be solid or flexible type and shall meet ASTM A-182-F6 chromium stainless steel on valves from 2” to 6”. Sizes 8” and larger may be A-216-WCB with forged rings or overlay equal to 182-F6. Seat ring shall be hard faced carbon steel or 13% chromium A-182-F6 stainless. Handwheels shall be A47 Grade 35018 malleable iron or Ductile Iron ASTM A536.

E. All forged steel body valves shall have the pressure containing parts constructed of ASTM 105, Grade 2 forged carbon steel. Seat and wedges shall meet ASTM A-182-F6 chromium stainless steel. Seat rings shall be hard faced. Valves shall conform to ANSI B16-34 pressure-temperature rating.

F. All valves shall be repackable, under pressure, with the valve in the full open position. All gate valves, globe valves, angle valves and shutoff valves of every character shall have malleable iron hand wheels, except iron body valves 2-1/2” and larger which may have either malleable iron or ASTM A-126 Class B, gray iron hand wheels.

G. Packing for all valves shall be free of asbestos fibers and selected for the pressure-temperature service of the valve. It is incumbent upon the manufacturer to select the best quality, standard packing for the intended valve service. At the end of one year, period spot checks will be made, and should the packing show signs of hardening or causing stem corrosion then all valves supplied by the manufacturer shall be repacked by the Contractor, at no expense to the Owner, with a packing material selected by the Owner.
H. Valves 12” and larger located with stem in horizontal position shall be drilled and tapped in accordance with MSS-SP-45 to accommodate a drain valve and equalizing by-pass valve assembly.

I. Balancing and/or Shutoff Valves for Hot Water Systems: Two inches and smaller, three piece full port bronze body ball valve, stainless steel ball and stem. Teflon seats, packing and gasket, bronze gland follower, adjustable stuffing box, steel lever type handle, with plastic sheathed operating handle, adjustable memory stops, and shall be class 150 SWP/600 WOG, screwed pattern. Manufacturer shall certify ball valves for use in throttling service. Stem extensions shall be furnished for use in insulated lines. Cold water service valves shall be as above, except two piece construction. All valves 2 1/2” and larger shall be tapped full lug butterfly valves with aluminum bronze discs of ASTM B148 Alloy C955 and 316, 416, or 420 stainless steel shafts. Design must incorporate bushing between shafts and body of material suitable to provide a bearing surface to eliminate seizing or galling. Valve must be capable of providing a bubble tight seal at 200 psi for valves up to 12” (150 psi for larger valves) when used for end of line service without requiring the installation of a blind flange on the downstream side. Liners shall be resilient material suitable for 225 °F temperature and bodies of ductile iron. Butterfly valves 8” and larger and butterfly valves used for balancing service, regardless of size, shall have heavy duty weather proof encased gear operators, with malleable iron handwheel or crank. Valves 2 1/2” through 6” shall have lever handles which can be set in interim positions between full open and full closed. All butterfly valves shall be absolutely tight against a pressure differential of 150 psi.

J. Check Valves for Water Systems: Bronze body, 2” and smaller, bronze body regrinding disc and seat with screw-in cap. Iron body, 2 1/2” and larger, bronze disc and seat or non slam wafer type with stainless pins and springs, and bronze plate. Forged steel lift check valves, 2” and smaller shall be bolted cap and body, screwed end connections and conform to ANSI B16.34 and pressure temperature rating.

K. Valves for Fire Protection Service: 2” and smaller, bronze body ball valve as above, Underwriters’ Laboratories Listed and Factory Mutual Approved, screw pattern 2 1/2” and larger, Underwriters Laboratories Listed and Factory Mutual Approved butterfly valves with tapped full lug body and gear operated with malleable iron hand-wheel and position indicator. All valves to be furnished with two factory mounted internal supervisory switches.

Gate valves 2 1/2” and larger shall have approved rating of 175 psi WWP or greater, iron body with resilient rubber encapsulated wedge, epoxy-coated interior, and pre-grooved stem for supervisory switch.

L. Check Valves Fire Protection System: Iron body, swing-check, bronze disc, seat ring and hinge pin, 300 psi rated working pressure, Underwriters’ Laboratories and Factory Mutual approved. Complete with ball drip assembly.

M. Standards of Quality for Valves:

Standard of Quality for Valves:

<table>
<thead>
<tr>
<th>Size</th>
<th>Stockham or as</th>
<th>Class</th>
<th>Milwaukee</th>
<th>Nibco</th>
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<tr>
<td>2” &amp; smaller for shut-off</td>
<td>Domestic 150</td>
<td>Cold</td>
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<td>T-585-70</td>
<td>Apollo 77-100</td>
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<td>Water Plumbing</td>
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PIPING, VALVES AND FITTINGS
23 20 00.A - 8
**PIPING, VALVES AND FITTINGS**

27 20 00.A - 9

<table>
<thead>
<tr>
<th>Size Range</th>
<th>Type/Model</th>
<th>Description</th>
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<tr>
<td><em>2&quot; &amp; Smaller</em></td>
<td>Ball Valve</td>
<td>Domestic 150 Hot Water Systems &amp; Re-circulating Chilled Water</td>
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<td>77-140</td>
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<td>590T</td>
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<td>Globe, Angle &amp; Balancing Valve</td>
<td>Plumbing, Chilled Water</td>
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<td>F-718-B</td>
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<td><em>2-1/2&quot; &amp; Larger</em></td>
<td>Butterfly Valve for Shut-off</td>
<td>Domestic Hot &amp; Cold Water Plumbing Systems &amp; Re-circulating Chilled and Heating Water</td>
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<td>LD2000</td>
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<td>Fire Protection</td>
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Valves 8" and larger, and valves used for balancing service regardless of size, shall have heavy-duty weatherproof encased gear operators.

* Requires extended stem in insulated lines.

** Requires ball drip assembly.

2. 4 UNIONS:

A. Provide and install unions at proper points to permit removal of pipe and various equipment and machinery items without injury to other parts of the system. No unions will be required in welded lines or lines assembled with solder joint fittings except at equipment items, machinery items and other special pieces of apparatus. Unions in 2" and smaller in ferrous lines shall be Class 300 AAR malleable iron unions with iron to brass seats, and 2 1/2" and larger shall be ground flange unions. Unions in copper lines shall be Class 125 ground joint brass unions or Class 150 brass flanges if required by the mating item of equipment. Companion flanges on lines at various items of equipment, machines and pieces of apparatus shall serve as unions to permit removal of the particular items. See particular Specifications for special fittings and pressure.

B. Unions connecting ferrous pipe to copper or brass pipe shall be dielectric type equal to EpcO.

C. In all water lines where the material of the pipe is changed from ferrous to copper or brass, a dielectric coupling shall be used at the transition.

2. 5 FLANGES:

A. All 150 lb. and 300 lb. ANSI flanges shall be weld neck and shall be domestically manufactured, forged carbon steel, conforming to ANSI B16.5 and ASTM A-181 Grade I or II or A-105-71 as made by Tube Turn, Hackney or Ladish Company. Slip on flanges shall not be used. Each fitting shall be stamped as specified by ANSI B16.9 and, in addition, shall have the laboratory control number stenciled on each fitting for ready reference as to physical properties and chemical composition of the material. Complete test reports may be required for any fitting selected at random. Flanges which have been machined, remarked, painted or otherwise produced domestically from imported forgings will not be acceptable. Flanges shall have the manufacturer's trademark permanently identified in accordance with MSS SP-25. Contractor shall submit data for firm certifying compliance.
with these Specifications. Bolts used shall be carbon steel bolts with semi-finished hexagon nuts of American Standard Heavy dimensions. Allthread rods will not be an acceptable for flange bolts. Steam system flange bolts shall have a tensile strength of 105,000 psi and an elastic limit of 81,000 psi and rated at least ANSI Grade V. Other bolts shall have a tensile strength of 80,000 psi and an elastic limit of 36,000 psi and rated at least ANSI Grade I.

B. Flat faced flanges shall be furnished to match 125 lb cast iron flanges on pumps, check valves, strainers, etc. with full flange gaskets. Bolting of raised face flanges to flat faced flanges is not allowed.

C. FLANGE GASKETS
1. Gaskets shall be placed between the flanges of all flanged joints.
2. Gaskets for steam piping - All steam flange joints shall use Flexitallic Class 150 spiral wound for low pressure applications and Flexitallic Class 300 spiral wound gaskets for medium or high pressure applications. Raised and flat face flange gaskets shall be Flexitallic compression gauge (CG) style. External ring shall be Type 304 stainless steel and color coded yellow. Filler material shall be Flexite Super and color coded with pink stripe. Equivalents may be submitted with all design data so that an evaluation of the gasket can be made.
3. Gaskets for all other applications: Gaskets shall be ring form gaskets fitting within the bolt circle of their respective flanges. Gaskets shall be 1/16” thick asbestos free material recommended for service by Anchor, Garlock, or John Crane. The inside diameter of such gaskets shall conform to the nominal pipe size and the outside diameter shall be such that the gasket extends outward to the studs or bolts employed in the flanged joint.
4. Spares - Contractor shall provide ten spares for every flange size and rating.

D. Flange Bolt Installation:
1. Bolt Lubrication: Bolts shall be well lubricated with a heavy graphite and oil mixture.
2. Torque Requirements - Bolts shall be stressed to 45,000 psi.

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<th>Nominal Bolt Dia. (Inch)</th>
<th>Torque (Ft-Lbs)</th>
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<td>1200</td>
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</table>
3. Torque shall be checked with a calibrated breaking action torque wrench on the final torque round. Bolts shall be cold and hot torqued.
4. Torque Pattern - Shall be a cross or star pattern with at least four passes. Limit each pass to 30% of full torque increases.
5. Hot Torque - Re-torque the flange bolts with system at normal operating pressure and temperature for at least four hours.
6. Inspection - Owner shall verify hot torquing of all medium and high pressure steam flange bolts.

**PART 3 EXECUTION**

Refer to other Sections for service specific requirements.

3.1 EXAMINATION
   A. Verify excavations under provisions of Section 23 00 00.
   B. 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. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
   B. Route piping in orderly manner and maintain gradient.
   C. Install piping to conserve building space and not interfere with use of space.
   D. Group piping whenever practical at common elevations.
   E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
   F. Provide clearance for installation of insulation and access to valves and fittings.
   G. Provide access where valves and fittings are not exposed. Coordinate access door location with architectural features.
   H. Establish elevations of buried piping outside the building to ensure a minimum of cover. Refer to Section 23 00 00.
   I. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
   J. Provide support for utility meters in accordance with requirements of utility companies.
   K. Prepare pipe, fittings, supports, and accessories not pre-finished, ready for finish painting. Refer to Division 09.
   L. Excavate in accordance with Section 23 00 00 for work of this Section.
   M. Backfill in accordance with Section 23 00 00 for work of this Section.
N. Install bell and spigot pipe with bell end upstream.
O. Install valves with stems upright or horizontal, not inverted.

3. 4 PIPE CLEANING & CHEMICAL TREATMENT

a. Piping shall be thoroughly cleaned, flushed, passivated, and treated. Coordinate piping installations to avoid wetting the piping without proceeding immediately to clean, passivate, and introduce chemical inhibitors. Bypass equipment during flushing. Generate sufficient flow velocity in excess of 8 ft/second to remove welding slag during flushing. Provide a chemical pot feeder for chemical introduction and maintenance. Retain a qualified chemical treatment company and introduce chemical products formulated for removing oil, mill scale, and rust and achieve initial passivation of piping systems during flushing in accordance with water treatment vendor’s instructions. Continue flushing until field testing by chemical vendor indicates acceptable results. Introduce biocides to prevent microbial consumption of corrosion inhibitors prior to introducing inhibitors. Adjust pH and alkalinity per chemical treatment vendors recommendations. Introduce blends of nitrate and triazole based inhibitors for steel and yellow metal corrosion protection. Monitor and add additional inhibitors for first 3 months to maintain target inhibitor concentrations. Submit regular water quality test reports.

3. 5 ERECTION TOLERANCES

A. Establish invert elevations, slopes for drainage to 1/8 inch per foot (one percent) minimum. Maintain gradients through each joint of pipe and throughout system.
B. Slope water piping and arrange to drain at low points.

END OF SECTION
SECTION 23 09 23
DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC

PART 1 - GENERAL

1. 1 WORK DESCRIPTION

A. Scope: This section contains general requirements for the supply and installation of a microprocessor based Energy Management System (EMS) as an extension of the existing Campus Johnson Building Technologies System.

B. Controls supplier shall be responsible for furnishing and installing all equipment and wiring for Building Automation Systems (Temperature and HVAC Equipment Control) for a complete and operable system as specified herein. All wiring shall be done in accordance with all local and national codes.

C. Work Included: It is the intent of this specification for the EMS to be installed as a complete package by Johnson Controls. The system shall include all computer software and hardware, controllers, sensors, transmission equipment, local panels, installation, engineering, supervision, commissioning, acceptance test, training, and warranty service. **The work shall include all electrical power distribution and signal wiring required for a fully functional control system. Include all electrical power sources, raceways, conductors, etc. required for a fully functional system, in addition to electrical systems indicated on the drawings, at no additional cost to the owner.**

1. 2 RELATED WORK SPECIFIED ELSEWHERE

A. Products connect to the EMS but not furnished or installed under this section include air flow stations, automatic dampers, valves, flow switches, flow sensors, thermos-wells and pressure taps to be installed by the Division 23 and/or 26.

1. Section 23 05 19 Meters and Gauges
2. Section 23 05 93 Testing adjusting and Balancing
3. Section 23 05 13 Motors and Variable Frequency Drives
4. Section 23 36 00 Air Terminal Unit

B. Coordination with electrical:

1. Installation of all line voltage power wiring including 120V power to each terminal unit and DDC panel by Division 26.
2. Each motor starter provided under Division 23 or 26, shall be furnished with individual control power transformer to supply 120volt control power and auxiliary contacts (one N.O. and one N.C.) for use by this section.

C. Work provided by this Section but listed elsewhere:

1. Section 23 36 00 Air Terminal Units Controls
2. Section 23 09 93 Control Sequence - HVAC on Drawings

1. 3 QUALIFICATIONS

A. System components shall be provided by Johnson Building Technologies.
B. The control system shall be furnished, engineered and installed by a Johnson owned branch office having factory trained technicians to provide instruction, routine maintenance, and emergency service within 24 hours upon receipt of request.

C. The control system components shall be new and in conformance with the following applicable standards for products specified:
1. American Society for Testing and Materials, ASTM
2. Institute of Electrical and Electronic Engineers, IEEE
3. National Electrical Manufacturers Association, NEMA
4. Underwriters Laboratory, UL (UL 916 & 864)
5. FCC Regulation, Part 15, Section 156
7. Local Building Codes

1.4 SUBMITTALS
A. The controls contractor shall submit Auto CAD generated schematic drawings for the entire system for review and approval before work shall begin. Included in the submittal drawings shall be a one page diagram depicting the system architecture complete with a communications riser. Drawings shall include point-to-point wiring diagrams and any special connection information required for properly controlling the equipment. The submittal shall include a bill of material reference list as well as equipment sequences of operation.

B. The submittals shall include the manufacturer's catalog data describing, highlighting and specifically indicating each item of equipment or component provided and installed for the project.

1.5 PROTECTION OF SOFTWARE RIGHTS
A. Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:
1. Limiting use of software to equipment provided under these Specifications.
2. Limiting copying.
3. Preserving confidentiality.
4. Prohibiting transfer to a third party.

PART 2 - PRODUCTS

2.1 ACCEPTIBLE BIDDERS
A. The specifications are intended to describe the microprocessor based Energy Management System – Johnson Building Technologies is the acceptable manufacturer/installer. Lab controls shall be by “Phoenix Controls”. Controls contractor shall be responsible to provide interface between Phoenix controls and existing Johnson Controls.

2.2 NETWORKING
A. The design of the EMS shall network operator workstations and stand-alone DDC Controllers. The network architecture shall consist of three levels, a campus-wide (Management Level Network - MLN) Ethernet network based on TCP/IP protocol, high performance peer-to-peer Building Level Network (BLN) and Application Specific Controller Floor Level Networks (FLN) with access being totally transparent to the user when accessing data or developing control programs.
B. The design of EMS 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. 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.

D. A single Workstation shall support a minimum of four (4) Building Level Networks (BLN). The BLN's can be any combination of direct or modem connected Networks. All Networks shall be dynamically connected to allow access to points on different BLN's simultaneously.

2. 3 DDC CONTROLLERS

A. DDC Controllers shall be stand-alone, multi-tasking, multi-user, real-time digital control processors with a minimum word size of 16 bits, minimum 48MHz clock and minimum 12MB memory consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules (universal or discrete). Each major DDC Controller (PXC Modular) shall support a minimum of 96 FLN Devices.

B. Each DDC Controller shall 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 any combination of industry standard inputs and outputs.

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 be provided with one RS-232C serial data communication port for the portable laptop operator's terminal. When a modem is required for remote operation, a second RS-232C serial data communication port shall be provided. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

F. As indicated in the point I/O schedule, 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 within the DDC Controllers key-accessed enclosure.
   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 LED’s for analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door (MBC only).

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 Standards 587-1980.

J. In the event of loss of all 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 100 hours.
   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 automatically from the network workstation PC.

K. As a minimum, a separate DDC Controller shall be provided for each mechanical room.

2.4 DDC CONTROLLER RESIDENT SOFTWARE

A. General:
   1. The software programs specified in this Section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution.

B. Control Software Description:
   1. The DDC 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 Controllers shall have the ability to perform any or all the following energy management routines:
   1. Time-of-day scheduling
   2. Calendar-based scheduling
   3. Holiday scheduling
   4. Temporary schedule overrides
   5. Start-Stop Time Optimization
   6. Automatic Daylight Savings Time Switchover
   7. Night setback control
   8. Enthalpy switchover (economizer)
   9. Peak demand limiting
   10. Temperature-compensated duty cycling

D. DDC 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 Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network.

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.

E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC 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 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 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.

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 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 1 minute to 7 days shall be provided. Each DDC Controller shall have a dedicated RAM-based buffer for trend data. All trend data shall be available for use in 3rd party personal computer applications such as Excel 5.0.

2. DDC 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 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 Controllers shall automatically accumulate and store 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 summary.

H. DDC Controllers shall be password protected. The user’s Password and Privileges shall be identical to the Password and Privileges used at the EMS Workstation.

2.5 APPLICATION SPECIFIC CONTROLLERS
A. TERMINAL EQUIPMENT CONTROLLERS (TEC)
1. Provide for control of each piece of equipment, including, but not limited to, the following:
   a. VAV Terminal Units with heating coils
   b. VAV Terminal Units without heating coils
2. The controllers shall include all inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be 24 volt floating.
3. Each controller performing space temperature control shall be provided with a matching room temperature sensor with a setpoint adjustment between 55°F and 95°F.
4. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the respective controller.
5. Set point adjustment and override function shall have the ability to be locked out, overridden, or limited as to time or temperature through software by an authorized operator at the central workstations, at the DDC Controller, or via the portable operator's terminal.
6. Each controller shall perform its primary control function independent of the DDC Controller. The controller shall receive its real-time data from the DDC Controller time clock. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications. All PID gains and biases shall be adjustable by the user via terminals as specified herein. This functionality shall allow for tighter control and shall facilitate optimal occupant comfort and energy savings.
7. Provide each terminal equipment controller with sufficient memory to accommodate point databases and operating programs. All databases and programs shall be stored in non-volatile EEPROM, EPROM, and PROM. The controllers shall be able to return to full normal operation without user intervention after a power failure. Operating programs shall be selectable and may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility:
8. Controllers shall be powered from a 24 VAC source, and shall function normally under an operating range of 18 to 28 VAC (-25% to +17%), allowing for power source fluctuations and voltage drops. The controllers shall also function normally under ambient conditions of 32 Degrees to 122 Degree F and 10-95% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.
9. Pressure independent controllers shall include differential pressure transducers that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the average differential pressure in the duct. The controller shall convert this value to actual airflow. The differential pressure transducer shall have a measurement range of 400 to 4,000 FMP and measurement accuracy of +/-5% at 400 FPM insuring primary air flow condition shall be controlled and maintained to within +/-5% of setpoint at the specified parameters. Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control andinsuring against drift overtime. The controller requiring 24 hours a day operation shall calibrate the airflow sensor every 24 hours with the use of an auto-zero module to eliminate the requirement of closing the supply damper to calibrate the flow sensor. It shall not be necessary to remove the controller to remove the damper actuator.

2. 6 VALVES, DAMPERS AND ACTUATORS
A. VALVES:
1. Water valves shall be sized by the control manufacturer to produce the required capacity at a pressure loss of 5 psi. Nominal body rating shall be not less than ANSI Class 125. However, the valve body and packing selected shall be designed to withstand the system static head plus
the maximum pump head and the maximum temperature of control medium and hot water, or as indicated. Single-seated valves shall have close-off ratings equal to 125% of the system pressure encountered that is the maximum upstream pressure. The valve body and packing selected shall be designed to withstand the system static head plus the maximum pump head and the maximum temperature of control medium without leakage for hot water.

2. Two-Way and Three-Way Valves:
   a. Valves used for control of hot and chilled water shall be of the modulating globe type.
   b. Valve sizes two inch and smaller shall be screwed and supplied with union fittings. The valves shall be constructed of bronze with stainless steel trim with equal percentage flow characteristics and have a rangeability of 50:1 or greater.
   c. Valve sizes 2.5 inch and larger shall be flanged. The valves shall be constructed of cast iron ASTM A126 Class B. The trim shall be stainless steel with equal percentage flow characteristics. The valve rangeability shall be 100:1 or greater.
   d. Valves shall be of the straight-through type as required by the sequence or indicated on the drawings.

3. Low Pressure Steam Valves: Shall be rated to 385 °F at a maximum inlet pressure to the valve of 100 psig. Valves for low-pressure steam shall be sized for 80% pressure drop of inlet pressure. Valves shall be equipped with stainless steel trim and disc with linear flow characteristics. Applications, which require steam valves larger than 2", shall utilize two valves in a 1/3 - 2/3 parallel arrangement.

4. With 2 control valves, modulate the 1/3 control valve to the 50% open position, sequence the 2/3 control valve when the 1/3 control valve is at 50% position, and modulate the 2/3 control valve at a faster rate than the 1/3 control valve as the load increases so that they both reach full open position at the same time. On a decrease in load, the 1/3 and 2/3 control valves shall modulate in the reverse sequence.


6. Butterfly Valves: Where butterfly valves are indicated to be used as automatic control valves, they shall be line size and designed for motorized control operation with upper disc steam keyed or machined square for mating with the control operators linkage. All butterfly control valves over 8 inches shall be equipped with a manual, mechanical control actuator override, gear box operator for emergency manual control of the valve position. Provide required accessories to mechanically disengage automatic control actuator linkage and engage manual gear operator without dismantling the valve stem and stem extensions during changeover. Valves 4-20" and larger shall be tapped, full lug, cast iron body butterfly valves with aluminum bronze discs, stainless steel stem and EPDM seat. Design must incorporate top and bottom bushings between shafts and body of material suitable to provide a bearing surface to eliminate seizing or galling. Valves 4-20" must provide bubble-tight seal at 150 PSIG. Liners are to be resilient material suitable for 250 °F temperature.

7. Valve Constant (Cv) Charts: Control drawings shall indicate the valve constant (Cv rating) of all valves used so that the valve pressure drop may be used for balancing and performance tests. Submittal data shall also state calculated shut-off pressure for each valve size.

B. DAMPERS:
   1. The Temperature Control Manufacturer shall provide control dampers of the types and sizes indicated on the drawings, including but not limited to outside air, return, relief air dampers, isolation and exhaust system bypass dampers.
   2. Damper frames shall be 5" X 1" 6063T5 extruded aluminum hat channel with .125" minimum wall thickness with mounting holes for flange and enclosed duct mounting.
3. Dampers shall be available in two-inch size increments from 8" horizontal and vertical to 48". Requirements over 48" shall be standard modules with interconnecting hardware (jack shafting).

4. All damper blades shall be 6" 6063T5 heavy gage extruded aluminum airfoil for high velocity performance. Blades on all dampers must be not over 6" wide. Blade bearing shall be molded synthetic with 1/2" hex plated steel shafts. All blade linkage hardware shall be of corrosion-resistant finish and readily accessible for maintenance after installation.

5. Extruded vinyl edging seals for outdoor dampers and flexible metal compressible type side seals for all dampers shall be provided.

6. Dampers and seals shall be suitable for temperature ranges of -50 Degrees F. to +250 Degrees F. at specified leakage ratings.

7. Dampers used for proportional control shall have opposed blades.

8. Leakage rates shall not exceed 6.25 CFM/Sq. Ft. at 4" wg. differential rated in accordance with AMCA 500.

9. Acceptable manufacturers are Ruskin, Arrow United Industries, American Warming and Ventilating, Inc. or approved equal.

C. DAMPER AND VALVE ACTUATORS:

1. Electronic actuators shall be of 0-10 VDC type. The minimum actuator impedance shall be 800 ohms even when more than one actuator is connected in parallel. Spring return shall be required for two-position (NO/NC) control sequence or for steam valve control. Non-spring return actuators shall be used for all modulating sequence of control. They shall conform to all requirements of sequence descriptions specified or scheduled. Main mechanical equipment actuators shall have a manual position dial to allow manual positioning of valve in absence of control power.

2. Size each actuator for the specific application. All digital control applications shall use electric actuators suitable for the application (chilled water, hot water, or steam). All electric actuators associated with the digital control system shall be of the same manufacturer throughout the project, except for 120 volt actuators required for high torque applications. Stacking two actuators to meet torque requirements is acceptable, when torque requirement exceeds rated torque for listed actuators.

3. Major equipment applications: Use 24 VAC power and a 0/2-10 VDC control signal. Each actuator shall have a maximum run time of 150 seconds and spring return time of less than 60 seconds and shall utilize brushless motor. Actuator shall be adjustable for reversing rotation without dismounting. Approved manufacturers and models: Belimo F or K series, or Promation/ Schischek Inc. D4/D5.S Series.

4. Terminal equipment applications: Use 24 VAC power and 0/2-10 VDC or floating point control signal, spring return or non-spring return, actuator. Actuator shall have a maximum run time of 150 seconds and spring return time of less than 60 seconds and shall utilize brushless motor. Actuator shall be adjustable for reversing rotation without dismounting. Approved manufacturer and model: Belimo or approved equal.


6. Fail Positions: Unless otherwise specified, the fail (normal) positions for AHU automatic control valves shall be as follows: Preheat Coils – NO, Cooling Coils – NO, Heating Coils, NC.

7. Valve actuators shall be of sufficient size to close valves at system pressure drop across the valve plus 50%.
8. Actuators for Terminal Equipment Controllers shall be 24V floating point, 0-10Vdc or pneumatic depending on Sequence of Operation and required speed of response. Regardless of actuator type, they shall be modulating and their position shall be readable in percentage open at the Workstation.

2. 7 LABORATORY AND LAB SUPPORT SPACE, SUPPLY AND EXHAUST AIR TERMINALS.

A. Provide pressure independent air valves, as scheduled on the drawing. Flow control shall be accurate to plus or minus 5 percent over the scheduled range of operation.

B. Valve bodies shall be minimum 16-gauge spun aluminum. All exhaust valves serving fume hoods, bio-safety cabinets, wet exhaust, and H3 exhaust shall have corrosion-resistant baked phenolic coatings on aluminum surfaces exposed to the airstream.

C. Supply valves shall be shipped from the factory with duct transition and properly sized heating coils where such configurations are shown on the drawings. Supply valves shall be insulated at the factory with material meeting flame/smoke rating 25/50.

D. Laboratory Actuators: Actuators for VAV Laboratory Applications shall be provided for Laboratory Supply Air Terminals, Laboratory General Exhaust Terminals and Fume Hood Exhaust Terminals. The actuators shall be maintenance free high speed actuators capable of stroking in 1.0 second from minimum flow to 90% of maximum flow. The actuators shall have a fail-safe position based on Sequence of Operation. The actuators shall be capable of accepting either 3-position floating or 0-10 VDC signal.

E. Controls: Provide laboratory air terminals with manufacturer’s microprocessor based, fast acting control systems. Provide air valve manufacturer’s auxiliary control components as indicated such as room integrators, laboratory hood sensors and monitoring panels, room pressure monitoring panels, and room temperature sensors which are compatible with manufacturer’s control systems.

F. Software: Provide laboratory air terminals with manufacturer’s local and user interface software packages compatible with equipment provided. Include engineering, programming, configuration, setup, testing, commissioning, demonstration, and training for all software systems provided. Include all required software licensing in owner’s name.

G. Integration: Provide laboratory control systems with local area network communication interfaces for communication with building automation system. Include all labor required to assist, coordinate, test, and demonstrate building automation controls interface.

H. Approved manufacturers: Phoenix approved for this project. Alternate manufacturer such as “Siemens” may be considered if prior approval by owner is provided.

2. 8 FUME HOOD EXHAUST TERMINAL

A. Provide a fume hood exhaust terminal (FHET) having an orifice ring flow sensor with two sets of pressure taps 90 degrees apart, offset from vertical by 45 degrees. The accuracy of the flow sensor shall be ±5% of the flow signal over the duct velocities of 600 FPM to 3000 FPM. The fume hood exhaust terminal shall be constructed of 20-gauge 316L stainless steel. The fume hood exhaust
terminal shall use a 90° butterfly damper without seal and the damper shaft shall be solid stainless steel with Teflon bearings. All joints and seams shall be sealed with RTV silicone.

B. The fume hood exhaust terminal shall be supplied with factory mounted airflow transmitter and electric/electronic damper actuator. The electric/electronic damper actuator and pressure transmitter shall be housed within a galvanized steel enclosure with exterior supply connection.

C. Provide a bio-safety cabinet/general exhaust terminal (GET) having an orifice ring flow sensor with two sets of pressure taps 90 degrees apart, offset from vertical by 45 degrees. The accuracy of the flow sensor shall be ±5% of the flow signal over the duct velocities of 600 FPM to 3000 FPM. The GET shall be constructed of 20-gauge galvanized steel. The GET shall use a 90° butterfly damper with peripheral neoprene gasket seal (gasket seal shall be scheduled on drawings) having leakage rating of 0.6% of flow at 2" wg, and the damper shaft shall be solid stainless steel with Teflon bearings. All joints and seams shall be sealed with RTV silicone.

D. The GET shall be supplied with factory mounted airflow transmitter and electric/electronic damper actuator. The electric/electronic damper actuator and pressure transmitter shall be housed within a galvanized steel enclosure with exterior supply connection.

2. 9 FLOW STATIONS
1. Provide where indicated on the plans airflow traverse probes mounted in the ductwork capable of continuously measuring the air volume of the respective ductwork.
2. The ductwork airflow traverse probes shall contain multiple total and static pressure sensors placed at concentric area centers along the exterior surface of the cylindrical probe and internally connected to their respective averaging manifolds. Sensors shall not protrude beyond the surface of the probe, nor be adversely affected by particle contamination normally present in building system airflows.
3. The duct work airflow traverse probes (two per duct) shall have dual end support swivel brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings, and shall be of aluminum construction with hard anodized finish.
4. The airflow traverse probes shall not induce a measurable pressure drop, nor shall the sound level within the system be amplified by its presence in the ductwork. The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 2% of actual flow. Traverse probes shall be Air Monitor or equal.

2. 10 FIELD SENSORS
A. Temperature Sensors:
1. The sensor shall be one of the following temperature sensor types:
   a. 1000 ohm (±0.2%) platinum resistance temperature detectors having a coefficient of resistivity of 0.00385 ohms/ohm/°C (for animal room locations).
   b. 100 ohm (±0.12%) platinum resistance temperature detectors having a coefficient of resistivity of 0.00385 ohms/ohm/°C. Provide RTD temperature transducers with of 4-20 ma output signal variations of less than 0.2% of full scale output for supply voltage variations +/-10% and integral and accessible zero and span adjustment.
   c. 10,000 ohm thermistor having an accuracy of .5°F at calibration point of 77°F may be used for room temperature only.
d. Immersion temperature sensors shall have 316 Stainless Steel wells and duct mounted sensors shall use averaging bulbs of not less than 24” and when mounted in the preheat or mixed air position the averaging bulb shall be twice the diagonal length of the coil or duct.

B. DUCT SENSORS
1. Duct Sensor: 10K thermistor, accurate to ±0.5°F, over 0˚ to 130˚F range. All sensors in ducts shall be of the single point type and mounted on a standard duct bracket in location not affected by temperature stratification. Approved manufacturer and model: Precon ST-D series or Veris TJ series for plenum terminal units, or approved equal.

2. Averaging Sensor: 10K thermistor, accurate to ±0.5°F, over 0˚ to 130˚F range. It must contain at least one sensor for every 3 feet, with a minimum tube length of 12 feet. See the Controls Diagram for installation locations. Approved manufacturer and model: Precon ST-FZ series or ACI A/AN-A-XX-GD series, or approved equal.

3. Immersion Sensors: 10K thermistor, accurate to ±0.5°F, over 10˚ to 230˚F range. Sensors used in comparative applications shall be matched pairs. Provide stainless steel immersion well fitting, with Thread-o-let, for sensor and empty stainless steel well for test equipment. Pressure rating of well is to be consistent with the system pressure in which it is installed and must withstand the flow velocities in the pipe. Immersion length shall be ⅓ to ½ of the pipe diameter. Approved manufacturer and model: Precon ST-W Series or approved equal.

C. Dew point Sensors:
1. The sensor shall be a two-wire loop powered duct mounted relative humidity and temperature sensor having a measuring range 0 to 100% of R.H. with an accuracy no less than ±2.5%. The sensor will calculate dewpoint temperature between -20°C and 80°C. The output from the sensor shall be 4-20 ma. Dewpoint sensors shall be Vaisala HMT100 or equal.

D. Carbon Dioxide Sensors
1. Provide non-dispersive, infra-red (NDIR) carbon dioxide gas diffusion sensing and transmitting equipment, 4-20 ma and 0-5 VDC/0-10 VDC (selectable) analog output linear with CO2 measured. For duct-mounted applications, the CO2 sensing element shall be located in the airstream. The unit shall sense and transmit carbon dioxide readings from 0 to 2000 ppm linear with a minimum accuracy of ±5% of reading from 1000 to 2000 ppm and a repeatability of ±1% full scale. Input voltage shall be 24 VDC.

2. Approved manufacturers and models:
   Veris CDLS (duct) or CWLS (wall) Series
   BAPI BA/BS3F Series, combination CO2, temperature and RH sensors.

3. Provide sensors with one field calibration kit. Kit shall contain one tank with an 8-hour supply of 99.8% N2, one tank with an 8-hour supply of 1000 ppm CO2, one pressure regulator, one flow meter and a carrying case.

4. Wall mounted sensors shall be provided with LCD readout of CO2 sensed level and shall be mounted next to the room temperature sensor.

E. Liquid level Sensors
1. Enclosed and Open Pit Sumps: Float type switch suitable for fluid in which immersed. Switch shall be assembly mounted, designed, and located for ease of maintenance access, removal, and level adjustment.

2. Steam Condensate Receiver Tanks: Float type switch suitable for steam condensate. Coordinate location of tee into receiver vent pipe for sensor location. When receiver control
package is equipped with local alarm, connect remote alarm indication into local alarm circuit. Provide interposing relay as required.

F. Pressure Sensors:
1. The sensor shall be an air differential pressure transducers with output of 4-20 ma proportional to pressure. The airflow transmitter will have an accuracy of at least ± 0.5% F.S for velocity pressure applications and ± 1.0% F.S for static pressure applications. Airflow transmitter shall be either Dresser Industries Ashcroft Model XLDp or Setra C264 Lab.
2. The sensor shall be a water or steam differential pressure transducers with output of 4-20 ma proportional to pressure. The transmitter will have an accuracy of at least ±0.2% of the transmitter range. The transmitter shall be Rosemount Series 1151 or equal.
3. Duct Static: Accurate to ±0.1"wg over 0 to 5" range. Approved manufacturer: BAPI model ZPS series with display or approved equal.
4. Building or Room Static: Accurate to ±0.01"wg over 0 to 0.1" range. Approved manufacturer: BAPI model ZPS series with display or approved equal.
5. Filter Status Differential: Accurate to ±0.1"wg over 0 to 2" range. Approved manufacturer: BAPI model ZPS series with display or approved equal.
6. Steam: Provide transducer in watertight enclosure, with gauge, isolation valve, pressure snubber, and steam pigtail. Output signal to be 4-20 ma. Approved manufacturer: For low pressure, 0-30 psig range Kele PTX1EG-05 or approved equal. For medium pressure, 0-100 psig range, Kele PTX1EG-07 or approved equal.
7. Water: Provide transducer with stainless steel wetted parts, 0-10 VDC output, bi-directional, with range selected according to specific application. Provide three-valve manifold assembly with Pete's Plugs and flush ports on the supply and return tubes for zero and span calibration and maintenance of sensor. Provide ½" brass body, stainless steel ball isolation valves at locations where sensor lines tap into fluid. For chilled water applications, provide minimum schedule 40 stainless steel nipples extended past insulation, between isolation valves and pipe thread-o-let. Approved manufacturer: Veris PW2 series wet/wet differential pressure transmitter or approved equal.

G. Smoke Detectors:
1. Smoke sensors are provided and installed under Division 28 to conform to local codes.

H. Low Limit Temperature Switch
1. The sensor shall be a Low Limit Temperature Switch with minimum 20 ft. element for freeze protection as specified hereinafter. Element shall be serpentine across the face of the coil and shall be of sufficient length or number for three passes across the width of the coil it is protecting. Connect Low Limit Temperature Switch in series with other safety devices to de-energize fans serviced when a drop in temperature below setpoint is detected.

I. Differential Pressure Switches:
1. The sensor shall be a pressure switch to monitor the pressure drops across each piece of equipment specifically a filter banks, fans and pumps.
2. Design and sensitivity shall match application, with SPDT contacts to make/break from a field adjustable differential pressure setting for alarm reporting to the EMS. Switches utilized for filter banks and fans shall be Powers Static Pressure Air Flow Switches Series SW 141 or equal. Switches for pumps shall be Penn P74 differential pressure switch or equal.

J. Current Status Switch (CSS)
1. The sensor shall be a high performance miniature split-core current status switch with adjustable set point. The current status switch shall have an operating range of between 1.25 – 50 amps and be able to detect belt loss and mechanical failure. CSS shall be Veris Hawkeye H908 or equal.
K. Pressure Electric Switch (PE)
   1. The sensor shall be a pressure operated snap switch that can actuate electrical circuits. The contact ratings shall be 8 amps at 240V inductive.

2. 11 LOCAL CONTROL PANELS
   A. Provide control panels with suitable brackets for wall mounting, for each miscellaneous control system. Locate panel adjacent to systems served.
   B. Fabricate panels of 14-gauge furniture-grade steel, or 6063-T5 extruded aluminum alloy, totally enclosed, with hinged doors and keyed lock, with manufacturer's standard shop-painted finish and color. Provide UL listed cabinets for use with line voltage devices.
   C. Panel Mounted Equipment: Include temperature controllers, relays, and other devices excluded in the sequence of operation. Mount devices with adjustments accessible through the fronts of panels.

2. 12 Fume Hood Controllers (FHC)
   A. The fume hood face velocity is controlled by monitoring the vertical/horizontal sash position utilizing Phoenix Sash Sensors. As the sash is raised and lowered the sash sensor sends a signal to the local Fume Hood Monitor for proper control modulation of the Phoenix Variable Volume Fume Hood Exhaust Valve. Local indication is provided by the fume hood monitor to verify a safe working condition and alarm if there is problem detected. As the fume hood control modulates, the supply and general exhaust airflows modulate to maintain a proper balance and keep the desired offset set point
   B. Provide a separate Variable Volume Fume Hood Controller (FHC) for each fume hood to work in conjunction with an exhaust air valve(s) to achieve the required turndown, accuracy, and speed of response. The FHC shall be a stand alone microprocessor, direct digital controller. The controller shall connect to sensors and its corresponding fume hood Operator Display Panel (ODP). It shall perform closed-loop control of fume hood exhaust airflow to maintain an Owner-selectable constant hood intake velocity in response to changes in sash height. The FHC shall be able to maintain control in the event of disconnection or failure of the ODP. The FHC shall be able to detect and indicate the failure of any of its sensor and maintain control in a degraded mode until the sensor is repaired.
   C. For safety purposes, actual airflow shall be measured for each fume hood. Only closed loop measurement of actual airflow shall be provided and available to the operator through designated operator terminal and PC workstations.
   D. FHC shall include an adjustable set point for minimum airflow through the hood. This set point shall be adjustable through the Portable Operator’s Terminal (POT) and shall be set by the laboratory safety officer to provide minimum dilution and air changes with the fume hood based upon its specific use.
   I. The FHC shall be capable of sampling and commanding all points ten times per second. The controller shall contain a minimum of 32K of memory. All programming in the controller shall be maintained in non-volatile EEPROM type of memory. Momentary or extended losses of power shall not change or affect any of the controller’s set points, calibration settings, or emergency exhaust mode programming.
   J. The FHC operates as an independent, stand-alone DDC controller and shall be connected on the Local Area Network (LAN) of the Laboratory Control System.
K. The FHC shall be UL 916 listed and CSA approved.

L. Provide an Operator Display Panel for each fume hood to comply with the laboratory safety standards.

M. The Operator Display Panel shall have selectable digital LCD display of average face velocity (FPM, MPS, or no indication) or of the type of alarm/emergency condition, indicating “LOW face velocity” or “HIGH face velocity” or “EMERGENCY” when the emergency purge has been enabled. A diagnostic message shall be provided to notify the hood operator of control function failure and/or sash sensor failure.

N. The Operator Display Panel shall have indicator lights – green, yellow, and red (normal, warning, alarm). In alarm (red), an audible horn will initiate. The horn shall be turned off as the red light is turned off. The ODP shall have a horn silence button. The indicator lights/horn sequence is intended to be the hood user’s primary indication of safe operation. The face velocity setpoint, high/low warning and alarm limits, and time delays shall be capable of being set by safety personnel based on the type of chemicals being used in and the performance characteristics of each hood.

O. The Operator Display Panel shall have an “emergency purge” button. When pressed, the controller shall respond immediately by turning on the red alarm light and horn and sequencing the hood exhaust first to the maximum and, after an adjustable delay, to a selected airflow value. The selected airflow value must be adjustable and programmable value that can be changed from the BAS workstation. When the emergency purge button is pressed again, the emergency sequence shall be terminated and the controller shall revert to its normal operation. The airflow values and time delays shall be capable of being set by safety personnel based on the type of chemicals being used in each hood.

P. The Operator Display Panel shall have a terminal jack for connection to the portable operator's terminal to monitor/edit all points internal to the FHC. As a minimum, the following points must be available to be programmed and adjustable from the terminal jack: Face velocity, low alarm, high alarm, emergency alarm, general failure, face velocity setpoint, high alarm limit, high warning limit, low warning limit, low alarm limit, emergency setpoint, exhaust flow, flow setpoint and flow minimum.

2.13 LABORATORY PRESSURIZATION CONTROLLER (LPC=RPC)

A. The supply air entering the lab space is controlled via the Phoenix Variable Volume makeup air valves to maintain the required volume of supply/makeup air as pressure INDEPENDENT devices, regardless of static pressure fluctuations from the supply air system. The volume of exhaust air leaving the lab space is controlled via the Phoenix Variable Volume air valves to maintain the required volume of exhaust air, as pressure INDEPENDENT devices, regardless of static pressure fluctuations from the exhaust air system. The total supply and general exhaust flows are summed to verify and provide the required offset for the space, thus providing the required pressurization. Each pressurization zone’s differential pressure is monitored via the Phoenix Pressure Monitor, as shown on the drawings, to generate local indication of the room differential pressure and generate a local alarm if the differential pressure is not maintained.

B. Provide a Laboratory Pressurization Controller (LPC) utilizing closed loop Direct Digital Control for laboratory space pressurization and temperature control to work in conjunction with an exhaust air valve(s) to achieve the required turndown, accuracy, and speed of response. The controller shall
maintain a user defined differential airflow between the room air supply, Fume Hood Controller exhaust, Bio-Safety Cabinet controller exhaust and general exhaust terminals by measuring the airflow and controlling the damper position of the supply and general exhaust terminals. Temperature control is provided by measuring the room temperature and controlling the supply air heating coil valve.

C. The LPC operates as an independent, stand-alone DDC controller and shall be connected on the Local Area Network (LAN) of the Laboratory Control System.

D. The LPC shall consist of the controller module, three analog outputs (two for pressure control, one for temperature control), two auto-zero modules (for flow measurement), and a flush mounted wall enclosure. All assemblies are pre-mounted and pre-terminated (electric and pneumatic connections) within the enclosure.

E. The controller module includes a micro-processor-based assembly with preprogrammed control algorithm and on-board differential pressure transmitters for airflow measurement. Wiring terminations for point inputs and outputs, LAN communications, and power are provided via screw type terminal block connections. The room temperature sensor is connected to an on-board RJ-11 telephone style jack. A metal enclosure assembly supports the controller module, pneumatic transducers, auto-zero modules, and all electrical and pneumatic inter-connections. External connection for the pneumatic damper actuator and low sensors are located on the inside of the enclosure.

F. The airflow sensors shall be accurate to ±2% of actual airflow with velocities between 450 and 4000 FPM. The LPC shall calibrate the airflow sensor every 24 hours with the use of the auto-zero modules to eliminate the requirement of closing the supply and exhaust dampers to calibrate the flow sensors.

G. An MS-DOS based laptop computer shall serve as the Portable Operator’s Terminal and shall communicate with the LPC through the plug-in jack on either the controller, the room temperature sensor associated with the LPC, or the DDC controller.

H. The controller shall contain a minimum of 32K of memory. All programming in the controller shall be maintained in non-volatile EEPROM type of memory. Momentary or extended losses of power shall not change or affect any of the controller’s set points or calibration settings.

2.14 LABORATORY ROOM CONTROLLER (LRC) / ROOM INTEGRATOR

A. Each supply and associated exhaust terminal shall be controlled to maintain an actual CFM airflow differential between total room exhaust and supply air that is equal to ±5% of the maximum laboratory room design airflow or 200 CFM, whichever is greater, to meet space pressure relationship requirements. For negatively pressurized rooms, supply airflow shall be controlled to equal the total room exhaust airflow less the required airflow differential. For positively pressurized rooms, total exhaust airflow shall track supply airflow less the required airflow differential.

B. Each laboratory room controller shall be specifically designed for control of laboratory temperature, (humidity and differential pressure monitoring where applicable) and room ventilation. Each controller shall be a microprocessor-based, multi-tasking, real-time digital control processor to work in con-
junction with an exhaust air valve(s) to achieve the required turndown, accuracy, and speed of response. Control sequences shall be included as part of the factory supplied software. These sequences shall be field customized by adjusting parameters such as control loop algorithm gains, temperature setpoint, alarm limits, airflow differential setpoint, and pressurization mode. Closed loop Proportional Integral Derivative (PID) control algorithms shall be used to maintain temperature and airflow offset setpoints.

C. Controllers using a differential pressure switch to monitor differential pressure across control devices such as an air valve shall include provisions for manual and automatic zeroing in order to maintain stable control and ensure against drift over time.

D. Controller shall include all inputs and outputs necessary to perform all specified control sequences.

E. Each controller shall operate stand alone, performing its specified control responsibilities independently.

F. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM memory, or a minimum of 72-hour battery backup shall be provided. All controllers shall return to full normal operation without any need for manual intervention after a power failure of unlimited duration.

G. Should a power failure or operational failure occur within the controller, the terminal unit damper shall automatically be positioned to the fully open or fully closed (failsafe) position as defined by the design.

2. 15 LABORATORY TEMPERATURE CONTROL

A. Provide temperature controllers and laboratory thermostats as part of laboratory terminal unit control package.

B. The temperature with the lab space is monitored by room temperature sensors to provide control by the respective existing dual duct terminal boxes and Phoenix supply air valve combination. As the temperature in the lab increases above the room setpoint, the corresponding dual duct terminal box dampers modulate to open to provide more cooling to the space. On a continued rise in room temperature the dual duct terminal boxes damper to provide additional airflow to the space and the general exhaust valve opens in concert to keep proper pressurization. The room offset is maintained at all times. As the temperature in the lab decreases below the room setpoint, dual duct terminal boxes supply air valve closes to its minimum position with the Phoenix general exhaust valve tracking. The room offset is maintained at all times. On a continued drop in room temperature, the corresponding dampers in dual duct terminal heating damper shall modulate the open to provide more heating to the space.

C. The space temperature shall be controlled by the existing dual duct terminal boxes, where as the room pressure and off-set shall be controlled by new “Phoenix” supply air valve.

2. 16 OPERATING SYSTEM SOFTWARE
A. Software needed for complete and functioning operation of each laboratory space shall be provided for all hardware. The server shall include all operating system, network, database, etc. software applications for complete functionality. Workstations shall include operating system and all application software including vendor specific software for complete functionality. Laptops shall include operating systems and all application graphical software including vendor specific software for functionality as a system service tool.

B. All controllers, network and ASC, shall utilize the same programming language for all applications including implementation of control algorithms, alarms, pseudo points, etc.

C. The Contractor shall use their standard software library for all system and controller programs.

D. The Contractor shall prepare, install, configure, and debug all software necessary for complete operation of the BAS and related systems, including the loop control statements, algorithms, and tuning constants required to achieve the Sequence of Operation. Control algorithms shall be manufacturer’s standard PID control loops or other Engineer approved control algorithms.

E. All system data, controller programs, historical and trend data shall be archived in the system server database. System shall be provided with backup of this database. Backup shall include mirroring of data to backup server as well as provisions for removable media backup. Provide program which allows saving and restoring of operating data.

F. Operator Access Control: Restrict any operator commands through use of software password. Provide capability for a minimum of 5 levels of access related to system operational control, monitoring, and programming functions.

G. Information Access: Obtain point status information from any designated output device with access command. Point status consists of point identification, numerical value (analog points) and associated engineering units, and individual function label indicating that point is on or off or in Alarm Normal condition. Output includes date and time of execution.

2.16 WIRING AND CONDUIT

A. All wire shall be copper and meet the minimum wire size and insulation type listed below:

<table>
<thead>
<tr>
<th>Wire/Cable Type</th>
<th>A Wire Size</th>
<th>Insulation Type</th>
<th>Maximum Capacitance</th>
<th>Typical Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>#12</td>
<td>600 Volt</td>
<td></td>
<td>120 AC and above</td>
</tr>
<tr>
<td>Class 1</td>
<td>#14</td>
<td>600 Volt</td>
<td></td>
<td>120 AC and below</td>
</tr>
<tr>
<td>Class 2</td>
<td>#18</td>
<td>300 Volt, overall shield</td>
<td></td>
<td>24 DC and below</td>
</tr>
<tr>
<td>Communications</td>
<td>#24</td>
<td>300 Volt, overall shield</td>
<td>12.5 pf/ft</td>
<td>24 DC and below</td>
</tr>
<tr>
<td>Communications Network</td>
<td></td>
<td>Category 5e cable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. Where different wiring types terminate within or pass through the same enclosure, maintain clearances and install barriers per the National Electric Code.

C. Multi-conductor cables, which group independent BAS inputs or outputs, power conductors, communication circuits, etc. wiring into one jacketed sheath, are not acceptable. Each wiring circuit shall be run independently sheathed from other circuits.

D. Provide conduit types as follows:
   1. Electric Metallic Tubing (EMT): Concealed in interior finished spaces; exposed in interior unfinished spaces.
2. Rigid Galvanized Metal Conduit: All exterior locations; interior locations subject to moisture.
3. Flexible metallic conduit: For transitions from stationery structure or equipment to rotating or moving equipment and for final connections to field devices.
4. Liquid-tight flexible metallic conduit: All exterior locations; interior locations subject to moisture for transitions from stationery structure or equipment to rotating or moving equipment and for final connections to field devices.
5. The minimum conduit size shall be ¾”, except room temperature sensor and communication conduit, which may be ½”. Use compression or threaded fittings. Watertight compression or screwed fittings shall be used for exterior locations and interior locations subject to moisture. Provide raceway seal-off fitting where exterior raceways enter the building or between areas of high temperature/moisture differential.
6. Flexible metallic conduit, maximum 3-foot length, shall be used for transitions between stationary and non-stationary equipment and/or structure (for example, motors, actuators, air handlers) and for final connections to sensors and control devices mounted on vibration producing equipment. Liquid-tight flexible conduit shall be used in exterior locations and interior locations subject to moisture.
7. Junction boxes shall be provided at all Power and Class 1 wire splices, equipment terminations, and transitions to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.

PART 3 - EXECUTION

3.1 PROJECT MANAGEMENT

A. Provide a project manager who shall, as a part of his duties, be responsible for the following activities:
   1. Coordination between this Contractor and all other trades, Owner, local authorities and the design team.
   2. Scheduling of manpower, material delivery, equipment installation and checkout.
   3. Maintenance of construction records such as project scheduling and manpower planning and Auto CAD for project coordination and as-built drawings.

3.2 INSTALLATION METHODS

A. Electrical Wiring
   1. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings and equipment details. Install electrical components and use electrical products complying with requirements of applicable Division 26 Sections of these Specifications except where specifically stated in this Section.
   2. The term "control wiring" is defined to include providing of wire, conduit, and miscellaneous material as required for mounting and connecting electric or electronic control devices.
   3. Install all control wiring in EMT conduit (minimum ¾" size) with compression fittings for electric/electronic control systems. Conceal wiring, except in mechanical rooms and areas where other conduit and piping are exposed. UL plenum rated cable shall be allowable above accessible lift out ceiling, in air plenums, and in other areas as approved by local and NEC codes.
   4. Wall sensors shall be installed on electrical “J” boxes and conduit stubbed to above lift out ceilings. Plastic bushing shall be installed where the sensor wire exits the conduit to prevent damage.
5. Number-code or color-code conductors, excluding those used for individual zone controls, appropriately for future identification and servicing of control system.

6. This section shall provide all line voltage power wiring required because of substitution of equipment specified in this section.

7. Division 26 shall provide 120 volt power to all DDC Controllers specified in paragraph 2.3 of this Section.

8. Install all control wiring in galvanized rigid conduit and seal tight flex connectors where run outside the building structure or install in wet areas.

3. 3 IDENTIFICATION

A. Install permanent wire labels at each end. Label shall cross-reference exactly with as-built drawings.

B. All field device wiring shall be labeled consistent with that shown on the as-built drawings and shall include the point’s name to which the wire connects. Provide a label at the field device and at the terminal strip in the BAS controller enclosure. Label shall be neatly typed and permanent.

C. Label all terminal strips. Terminal strips identification shall match the identification of the wire terminated.

D. Identify all pneumatic tubing with labeling tape or sleeves using words, letters, or numbers that can be exactly cross-referenced with as-built drawings.

E. Conduit: Provide conduit labels inscribed “CONTROLS” at the following locations:
   1. Within 3 feet of all BAS enclosures
   2. At 20-foot intervals along conduit runs
   3. All pull and junction box covers shall be painted orange with the cover permanently labeled “CONTROL”

F. Provide nameplates at each BAS controller or group of controllers at the power wire terminal strip inside the enclosure that identifies the name and location (room number and building location) of the building electrical distribution panel where power for the BAS equipment is obtained.

G. All field device and controller enclosures shall be identified with a nameplate. Controller enclosure nameplates shall be engraved “HVAC CONTROLS,” shall also identify each controller contained in the enclosure and mechanical equipment monitored or controlled by controllers located inside enclosure. Field Interface Panels nameplates shall be engraved “CONTROLS FIELD DEVICE” and indicate by name or function each control component in the enclosure. Equipment identification shall follow UT Facilities Maintenance standard nomenclature.

H. Label output transducers with the point name of the device controlled and the normal position and spring range of controlled device.

3. 4 SYSTEM ACCEPTANCE
A. General: The system installation shall be complete, tested, and commissioned for proper operation prior to acceptance testing for the Owner's authorized representative. A letter shall be submitted to the Architect requesting system acceptance. This letter shall certify all controls are installed and the software programs have been completely exercised for proper equipment operation. Acceptance testing will commence at a mutually agreeable time within ten (10) calendar days of request. When the field test procedures have been demonstrated to the Owner's representative, the system will be accepted. The warranty period will start at this time.

B. Field Equipment Test Procedures: DDC control panels shall be demonstrated via a functional end-to-end test. Such that:
1. All output channels shall be commanded (on/off, stop/start, adjust, etc.) and their operation verified.
2. All analog input channels shall be verified for proper operation.
3. Changing the state of the field device and observing the appropriate change of displayed value shall verify all digital input channels.
4. If a point should fail testing, perform necessary repair action and retest failed point and all interlocked points.
5. Introducing an error into the system and observing the proper corrective system response shall verify automatic control operation.
6. Changing the schedule and observing the correct response on the controlled outputs shall verify selected time and setpoint schedules.

C. Workstation Test Procedures: The system workstation test procedures shall be as follows:
1. Communication with each DDC control panel shall be demonstrated.
2. Operator commands will be explained and demonstrated.
3. Control sequences shall be demonstrated for proper operation.
4. All available system reports and logs shall be demonstrated at the system workstation.
5. Correct system start-up and shutdown procedures shall be demonstrated.
6. All controllers shall be demonstrated to operate in a standalone mode.

D. Record Documentation: After a successful acceptance demonstration, the Contractor shall submit as-built drawings of the completed project for final approval. After receiving final approval, supply 6 copies of complete 11 x 17 as-built drawings sets and one (1) CD of ACAD drawings.

E. Operation and Maintenance Manuals: Submit three copies of operation and maintenance manuals. Include the following:
1. Manufacturer's catalog data and specifications on sensors, transmitters, controllers, control valves, damper actuators, gauges, indicators, terminals and any miscellaneous components used in the system.
2. An operator's manual that will include detailed instructions for all operations of the system.
3. An operator's reference table listing the addresses of all connected input points and output points. Settings shall be shown where applicable.
4. A programmer's manual that will include all information necessary to perform programming functions.
5. A language manual that will include a detailed description of the language used and all routines used by the system.
6. Complete program listing file and parameter listing file for all programs.
7. A copy of the warranty.
8. Operating and maintenance cautions and instructions.
9. Recommended spare parts list.

3. 5 TRAINING
A. Contractor shall provide to the engineer a training class outline prior to any scheduled training.

B. Factory trained control engineers and technicians shall provide training sessions for the Owner's personnel.

C. The control contractor shall conduct five six-hour training sessions on the DDC System for the designated Owner's personnel in the maintenance and operation of the Systems. The class shall be given upon system acceptance.

D. The course shall include instruction on specific systems and instructions for operating the installed system to include as a minimum:
   1. HVAC system overview
   2. Operation DDC Systems
   3. Function of each Component
   4. System Operating Procedures
   5. Programming Procedures
   6. Maintenance Procedures

3.6 SERVICE AND GUARANTEE

A. This system specified under this Section of the Specifications shall be guaranteed from defects in workmanship and material under normal use and service for a period of twelve (12) months from the date of acceptance. If, during the one year period, any of the factory equipment or materials provided in the system is found to be defective in materials or workmanship, it shall be replaced or repaired by the DDC Manufacturer at no additional cost to the Owner.

B. Upon completion of the installation, the Contractor shall thoroughly inspect, check, adjust, calibrate, and make ready for use all devices/sensors comprising the control system and certify that they are installed in accordance with "Record" Drawings.

END OF SECTION
SECTION 23 73 23
AIR HANDLING UNITS

PART 1 GENERAL

1.1 The following sections are to be included as if written herein:
   A. Section 23 00 00 – Basic Mechanical Requirements
   B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
   C. Section 23 05 53 – Mechanical Identification

1.2 SECTION INCLUDES
   A. Custom Air Handling Units
   B. Factory Installed Fans
   C. Dampers
   D. Filters
   E. Coils
   F. Drives

1.3 RELATED SECTIONS
   A. Section 23 05 48 - Vibration Isolation
   B. Section 22 13 16 - Plumbing Piping: Equipment Drains
   C. Section 23 05 13.- Motors
   D. Section 23 05 16 - Expansion Compensation
   E. Section 23 07 13 - Ductwork Insulation
   F. Section 23 29 23 – Variable Frequency Drives
G. Section 23 31 00 - Ductwork
H. Section 23 33 00 - Ductwork Accessories: Flexible Duct Connections
I. Section 23 34 16 - Fans
J. Section 23 41 00 - Filters
K. Section 23 82 16 - Air Coils
L. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
M. Section 26 27 26 - Wiring Devices and Floor Boxes

1.4 REFERENCES
A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings
B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings
C. AMCA 99 - Standards Handbook
D. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes
E. AMCA 300 - Test Code for Sound Rating Air Moving Devices
F. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices
G. AMCA 500 - Test Methods for Louver, Dampers, and Shutters
H. ARI 410 – Forced-Circulation Air-Cooling and Air-Heating Coils
I. ARI 430 – Central-Station Air-Handling Units
J. ARI 435 - Application of Central-Station Air-Handling Units
K. ARI 610 - Central System Humidifiers
L. NEMA MG1 - Motors and Generators
M. NFPA 70 - National Electrical Code
N. SMACNA - HVAC Duct Construction Standards - Metal and Flexible
O. UL 900 - Test Performance of Air Filter Units
1.5 SUBMITTALS

A. Submit under provisions of Section 23 00 00.

B. Include with the initial submittal a letter signed by the manufacturer’s national sales manager (or any corporate officer) and the production manager, acknowledging that this equipment is intended for a University of Texas facility and that all specification requirements shall be complied with. Submit copy of letter to OFPC engineer and Building Manager.

C. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, electrical characteristics, connection requirements, and.

D. Product Data:

1. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gauges and finishes of materials, electrical characteristics and connection requirements.

2. Provide data of filter media, filter performance data, filter assembly, and filter frames as tested and certified per ASHRAE standards.

3. Provide fan curves with specified operating point clearly plotted, as tested and certified per AMCA standards. Ratings to include system effects. Bare fan ratings will not satisfy this requirement, but shall be submitted for comparison purposes.

4. Submit sound power level data for both fan outlet and casing radiation at rated capacity, as tested and certified per AMCA standards.

5. Provide data on all coils as tested and certified per ARI standards.

6. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

7. All materials shall have NFPA-90 rating of 25/50 or better.

E. Manufacturer's Installation Instructions.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 23 00 00.

B. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.
1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum three years documented experience, who issues complete catalog data on total product.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.

B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation of the Owner’s RCM.

1.10 EXTRA MATERIALS

A. Furnish under provisions of Section 23 00 00.

B. Manufacturer to provide three sets of filters for each unit. One set of filters is to be installed when unit is started up, and shall be protected from construction debris with additional media either at the first bank of filters, or covering each air intake (outside air and return air). The second set of filters is to be installed when test and balance activities begin. At substantial completion, OFPC RCM shall inspect filters to determine if the third set should be installed or delivered to campus operations personnel.

1.11 SCHEDULES ON DRAWINGS:

A. In general, all capacities of equipment, and motor and starter characteristics are shown in schedules on the drawings. Reference shall be made to the schedules for such information. The capacities shown are minimum capacities. Variations in the capacities of the scheduled equipment supplied under this contract will be permitted only with the written direction of the owner. All equipment shall be shipped to the job with not less than a prime coat of paint or as specified hereinafter. Insofar as is possible, all items of the same type (i.e., pumps, fans, etc.) shall be by the same manufacturer. Where installation instructions are not included in these specifications or on the drawings, the manufacturer's instructions
shall be followed. All equipment affected by altitude shall be rated to operate at the altitude where it is installed.

B. Warranty: Manufacturer shall provide the complete unit with a limited parts only warranty covering the first year of operation. The warranty period shall commence on the date of first equipment startup or six months after the date of shipment, whichever shall occur first.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Energy Labs – **Basis of Design**

B. ClimateCraft

C. Air Enterprises

D. Haakon

E. Temtrol

F. Thermal Corporation

G. Substitutions: Under provisions of Section 23 00 00. The equipment as supplied by any of the acceptable manufacturers or an approved equal shall comply with all of the provisions of this specification.

2.2 GENERAL DESCRIPTION

A. Configuration: Fabricate with modular sections as scheduled. All custom air-handling units shall be “SITE BUILT” and fully commissioned under the supervision of AHU manufacturer, and shall consist of the following modules:

   i. Air mixing module with filters
   ii. Access module
   iii. Plug fan module with heating coil (hot deck)
   iv. Multi-zone module with cooling coil (cold deck – top discharge)
   v. Total unit dimensions must NOT exceed the size indicated on the drawings.

B. Performance Base: Sea level conditions

C. Fabrication: Conform to AMCA 99 and ARI 430 in the absence of direction in this specification.
D. Performance: Refer to schedule in drawings.

2.3 AIR HANDLER CASING AND GENERAL CONSTRUCTION:

A. Unit casing exterior (walls and roof) shall be a minimum 0.050 Type 5052 textured aluminum with mill applied, industrial grade, high solids polyurethane paint. Paint shall provide a durable, “wet look” finish with excellent color and gloss retention, shall meet ASTM B117 salt spray performance criteria for a minimum rating of 1,000 hours, and shall be covered by a 10-year manufacturer’s limited warranty. Walls shall be insulated internally, throughout (double wall construction with thermal break / no thru metal). Wall and roof panel insulation shall be 4” think, R-25 moisture resistant polyisocyanurate foam protected by a solid interior liner. Interior liner shall be 0.040 Type 5052 smooth aluminum with mill applied, industrial grade, high solids polyurethane paint. All sheet metal joints throughout the air handler, and between panelized sections, shall be gasketed with closed cell, soft rubber gaskets, fabricated from neoprene, EPDM, or other approved material. Internal walls and roof outside shall be sealed such that there is no passage of air from inside the unit to the outer casing. Paint shall provide a durable, “wet look” finish with excellent color and gloss retention, shall meet ASTM B117 salt spray performance criteria for a minimum rating of 1,000 hours, and shall be covered by a 10-year manufacturer’s limited warranty.

B. Individual panels of the fan section shall be removable without compromising the integrity of the unit. Casing assembly shall be configured to eliminate all thru-metal in portions of the unit subject to below ambient temperatures. Where fasteners are used in the assembly of the unit components, they shall not extend from the outside of the unit into the air stream.

C. Drain pan liners shall be constructed of No. 16-gauge 316-L stainless steel or heavier as standard with the manufacturer. Drain pan shall extend as indicated past the cooling coil (leaving airstide) into the fan section on draw through units. Entire drain pan shall be insulated with R-14 closed cell rigid insulation. Drain pans shall be sloped to the outside edge of the unit. On units over six feet wide, slope to each side of the unit. The insulation shall be installed and sealed as is appropriate for the equipment construction. Provide walk-on aluminum grate over drain pans.

D. Unit shall have a complete perimeter channel base of at least 6” structural aluminum. All floors shall be insulated with R-14 insulation with 0.10” #3003 aluminum floor. An aluminum sheet shall enclose and form a vapor barrier for the insulation on the bottom of the unit. All points of contact between the floor, vapor barrier and structure shall be thermally isolated with gasketing of closed cell soft rubber or EPDM. Flooring shall be mechanically attached and feature a true thermal break.

E. Access doors shall be provided to allow access to both sides (upstream and downstream) of the filter racks, into the fan section, and both sides of all coils. Access doors shall be double wall, insulated the same as wall panels, and the opening framed with Class A thermal break construction with no thermal bridging acceptable. Door size shall be as indicated. The construction of the access doors shall equal or exceed the quality and quantity of the air handler casing materials as specified herein. Each door shall have a minimum of an 8-inch by 12-inch wire reinforced double-glazed view window, capable of
AIR HANDLING UNITS
23 73 23 - 7

withstanding the total developed pressure of the unit. The doors shall be hinged using
either heavy-duty stainless butt hinges, cast aluminum, or a continuous stainless steel piano
hinge, extending along the entire edge of the door, except for a maximum of two inches at
each end. If butt hinges are used, provide two per door for up to 36” high doors and three
per door for longer doors. There shall be a minimum of two latches on doors longer than
18,” and three latches in doors over 36” long. Latches shall be Ventlok 310, heavy-duty
latch, or approved equal. All access doors shall open against air pressure.

F. Coils in the air-handling units shall be individually removable and shall not be used to
provide structural stability for the casing. All coils shall be arranged for and piped to provide
counter flow operation. All coil frames supplied in air handlers shall be fabricated of 316-L
stainless steel to allow for removal of individual coils independently. The coils shall be
completely enclosed within the coil housing of the air unit casing. All penetrations of the air
handler casing shall be neatly sealed using a resilient sealant. Hinged gasketed quick
access doors of adequate size for a man to enter shall be provided for each space between
coils, filters and other components. Stacked coils shall have intermediate drain pans with at
least 1” rigid drain piping and pipe supports to main drain pan.

G. Panels shall be reinforced with sufficient internal bracing to prevent excessive deflection of
the panels to L/200 standard.

H. Not Used

I. Provide a unit housing, including joints, seams, and access doors, that will not condense
moisture on the external surfaces of this housing when subjected to a surrounding ambient
environment of 82°F dry-bulb / 75°F dew-point temperature air.

J. Not Used

K. Provide sealable test ports on either side of each filter bank and each coil section, in inlet
plenum and discharge plenum, and suction and discharge side of all fans. Ports shall be
equal to Ventfabrics test port Model 699-2.

2.4 FANS (See also Section 23 34 16)

A. Shall be both dynamically and statically balanced. Motors shall be high efficiency type per
Section 23 05 13. The motor mounting for each unit shall be an integral part of the fan
support frame. The fan / motor unit shall be mounted on spring isolators within the air
handler casing. Housed fans shall have an appropriately designed fabric duct vibration
isolator installed within the air handler casing. The unit shall be supplied with a factory
installed and sealed flange for connection to ductwork.

B. After assembly, the unit manufacturer shall balance the fan (per ANSI/AMCA 204-96 fan
application category BV-5) at design fan speed with belts and drives in place to a vibration
velocity less than or equal to 0.157 inches (0.100 inches for direct-drive applications) per
second measured on horizontal, vertical, and axial planes at each bearing pad. Vibration
amplitudes are in inches/second peak velocity. All values recorded are to be filter-in at the
fan speed.
C. Plug fans installed in walk-in units shall be provided with a fan shut down switch in the access door. Provide plug fan inlets with coated steel safety bars.

D. Individual fan performance shall be based on tests run in an AMCA certified laboratory and administered in accordance with AMCA Standards 210 and 300. Fans shall be licensed to bear the AMCA seal for air and sound performance. Submitted fan performance shall be adjusted to reflect multiple fans running inside the cabinet and to reflect any affects from the unit cabinet and other internal components. Fans shall be minimum Class 3 construction.

E. The fan wheel shall be aluminum with extruded aluminum airfoil blades continuously welded to the fan side plates. The fan back plane shall be bolted to a cast aluminum fan hub with keyway. Fans not using airfoil blades, or using steel construction, will not be considered. Fan inlets shall be isolated from the cabinet by means of a neoprene-coated flexible connection.

F. Motors shall be premium efficiency to meet or exceed the requirements in EISA 2007. Motors shall be TEFC, NEMA frame, cast iron casing, ball bearing type complete with grease lubricated bearings and zerk fittings for field lubrication. Motors shall have a NEMA Class F insulation rating with Class B temperature rise, and have a 1.15 service factor. BHP values as shown on the Schedule are considered the maximum allowable.

G. Fans shall be provided with thrust restraints.

H. Each motor shall be provided with a shaft grounding device that will bleed potential induced motor shaft voltage to ground.

2.5 DAMPERS

A. All automatic control dampers and manual volume control dampers located within air handling unit shall be furnished by AHU manufacturer.

B. Mixing Boxes: Dampers shall be supplied with ultra-low leak extruded 6063T5 aluminum airfoil blades. Blades shall be supplied with dual durometer, Santoprene™, bulb type edge seals and stainless steel arc end seals. Edge seals shall be backed by the damper blade to assure a positive seal in the closed position. Dampers shall be provided with nylon bearings within extruded openings.

C. Damper Leakage: Maximum 6 CFM/Sq. Ft. at 5 inch WG differential pressure. Dampers shall be sized for 2000 fpm maximum face velocity.

D. Refer to Section 23 33 00-2.01 for additional requirements.
2.6 DRIVES

A. Plenum fans shall be direct drive and housed fans shall be belt drive with adjustable sheaves unless indicated otherwise.

B. Variable frequency drives: See Section 23 29 23.

2.7 COILS

Refer to Section 23 82 16 - Air Coils, and Unit Schedules for requirements.

2.8 FILTERS

Refer to Section 23 41 00 - Filters, and Unit Schedules for requirements. Provide aluminum or stainless steel filter racks.

2.9 ELECTRICAL

A. Fan motors shall be factory-mounted and wired to an external j-box adjacent to the motor access door. Fan motors shall be interlocked with fan access door to shut down when door is opened.

B. Vapor proof lights (ceiling or wall mounted so that fixture shall be no higher than 88” above floor) shall be provided in each compartment with access doors. Lights shall have a switch at each door into the compartment. Provide two GFI convenience outlets evenly spaced on the long dimension of the unit. Wire lights and outlets to two external 120v, 20a power connections (one for each service) by Division 16. All raceways and conductors shall be by Div 16 in the field after the units are assembled.

C. All wiring shall be 600v rated type MTW/THWN stranded copper in EMT or LiquidTite conduit (max 3 feet). All junction boxes shall be UL approved and gasketed.

D. Motors – see Section 23 05 13 for additional requirements.

E. Provide in each section a electrical junction box with thru casing raceway by manufacturer for control wiring.

PART 3 EXECUTION

3.1 INSTALLATION

A. Field assembly of the unit shall be the responsibility of the mechanical contractor. Provide manufacturer field technician to oversee installation of the first unit. Coordinate with building operations for the schedule and length of down time.
B. Install in conformance with ARI 435.

C. Assemble high-pressure units by bolting sections together.

3.2 FIELD TESTING

C. Casing Leakage Test. With unit set in place, leveled and ready to receive duct work connections, unit shall be tested for casing leakage by sealing all openings and tested to criteria in Paragraph 3.02 B.1. Maximum allowable leakage rate is 1.5% of rated unit flow at 8" static pressure. Test is to be performed by the manufacturer using flow measurement devices and shall be witnessed by a representative of the Owner’s Test & Balance firm.

D. Fan/Motor Vibration Test. With the unit set in place, leveled, and ductwork attached, the manufacturer shall perform a final dynamic vibration trim balance to verify the fan/motor vibration velocity limit over the following operating speed range: Fans with VFDs shall be checked from 40 to 110% of the rated fan speed. Constant speed fans shall be checked at 100% of rated fan speed. ‘Lock-out’ ranges may be used to correct up to two ranges of excess vibration. The span of each ‘lock-out’ range shall be limited to an effective fan speed of 50 RPM. Any ‘lock-out’ range used shall be clearly identified in the test report and shall be prominently displayed on a typed, laminated legend mounted inside the VFD controller cabinet.

E. Failure of the leakage test shall require correction of the unit and retesting until criteria is met. Failure of the vibration limit shall require rebalancing and re-testing until criteria is met. Contractor shall bear all costs involved in the modifications, balancing, and re-testing.

END OF SECTION
D. Copper Tubing - Nom 6 in. diam (or smaller) Type L (or heavier) copper tubing

C. Conduit - Nom 6 in. diam (or smaller) steel conduit or nom 4 in diam (or smaller) steel electrical metallic tubing

- Wall framing may consist of either wood studs or steel channel studs. Wood studs to consist of nom 2 by 4 in. (51 mm, point contact) to max 2 in. (51 mm) is required within the firestop system. Steel duct to be rigidly supported on both sides of floor or wall assembly.

A. Studs - Wall framing may consist of either wood studs or steel channel studs.

- Fill Void or Cavity Material* - Putty - Min 1/2 in. (13 mm) thickness of putty formed to a min 1 in. width.
- Joints on outer layers of gypsum boards (Item 4 and 4A) covered with paper tape and joint compound. Paper tape and joint compound shall be installed horizontally.

A. Packing Material (Optional) - Polyethylene backer rod, mineral wool batt insulation or fiberglass batt insulation shall be installed within the firestop system.

9. Lead Batten Strips — (Not Shown, For Use With Item 4A) - Lead batten strips, min 1-1/2 in. wide, max 10 ft long with a max 1-5/8 in. long Type S steel screws spaced 16 in. OC.

U S GREENFIBER L L C - Cocoon2 Stabilized or Cocoon-FRM (Fire Rated Material)

Other than 48 in., gypsum panels to be installed horizontally.

The hourly F Rating of the firestop system is 1 hr when installed in a 1 hr fire rated wall and 2 hr when installed in a 2 hr fire rated wall.

NU-WOOL CO INC - Cellulose Insulation

The hourly T Rating of the firestop system is 1 hr when installed in a 1 hr fire rated wall and 2 hr when installed in a 2 hr fire rated wall.
K. Existing Conditions:

is located (''Shell Building'') are hereby made part of these Contract Documents, and shall govern all Work

GENERAL CONDITIONS AND SPECIFICATIONS

J. Where the term ''approved equal'' or ''equal'' is used, it shall be understood that reference is made to

4. The existing structure is presently served with active electrical, water, sewer, communications, and

b. Work utilizing noise-producing equipment shall be subject to the Owner's approval at all times.

B. Aluminum Door Frames: Submit product data including details at each opening, glazing, frame profiles, and

joints, fastening methods, accessories, hardware and finish.

A. General Requirements

D. Finishes

1. Fasteners: Aluminum, non-magnetic stainless steel, or other material warranted by manufacturer as non-

3. Aluminum frames: Sizes and contours as indicated on drawings.

1. Door sizes shown are nominal; provide standard clearances as follows:

a. Frame Members: Extruded aluminum shapes, not less than 0.62 in thick, reinforced at hinge and strike

profiles indicated, and constructed from materials as follows:

B. Equipment indicated to be furnished by the Owner and installed by the Contractor shall be received and stored

property of the Owner. Unless scheduled to be reused in the Work, the Contractor shall consult with the

OWNER SUPPLIED MATERIALS

B. Board Materials

1. Dimension Lumber: Comply with PS 20 and requirements of specified grading agencies.

2. Moisture Content: S-dry or MC19.

3. Miscellaneous Framing, Blocking, Nailers, Grounds, and Furring:

a. Butyl Sealant: Single component; Shore A hardness of 10 to 20; black color; non-skinning.

B. Board Materials

1. Provide completed assemblies complying with ASTM C 840 and GA-216.

2. Organic Adhesive: ANSI A136.1, thinset bond type; use Type I in areas subject to prolonged moisture

exposure.

1. Subfloor Filler: White premix latex; type recommended by adhesive material manufacturer.

3. Adhesives: Compatible with materials being adhered.

D. Closers

1. Requirements for all

a. Minimum Requirements: Comply with ASTM F 1066, of Class corresponding to type specified.

1. The acoustical grid is existing.

B. MATERIALS

1. Subfloor Filler: White premix latex; type recommended by adhesive material manufacturer.

3. Adhesives: Compatible with materials being adhered.
1. The Contractor shall be responsible for the protection against vandalism/unauthorized entry, etc. during the demolition/renovation. Items damaged will be repaired or replaced with new at Contractor's expense.

2. Contractor to provide protection, as required during construction, at all remaining utilities (clean outs, gas to all mechanical, electrical, plumbing, communications, fire alarms, and sprinkler systems to minimize damage.

3. Relocate existing plumbing in existing chase, see MEP Drawings.

4. Contractor to protect existing smoke detectors from dust/debris during demolition/renovation to prevent damage.

5. Remove existing ceiling tile and grid as necessary for installation of equipment.

6. Coordinate with Owner proper access and location for waste disposal and location of dumpsters.

7. Contractor to make best effort to salvage doors, frames, hardware, etc. and confirm with O&M if they want to any salvaged door hardware for re-installation.

8. Contractor to paint any existing frames remaining after construction to match existing.

9. Clean and refurbish all drywall to match existing.

10. New Partitions: Existing to be removed.

11. UT Health Science School of Public Health

12. 713-568-0120

13. INFRASTRUCTURE ASSOCIATES, INC.

6117 RICHMOND AVENUE, SUITE 200

TBPE REGISTRATION NO. F-4506

14. Demolition Plan - Level 2

Sheet Information

Addendum 01

03/31/2017

Title

BL

Approved

5/31/2017
5' CFH

Infill wall to match existing 2-hour rated wall. See 4 G-101 complete mechanical work and reinstall once work is for ULDesign. Coordinate removal of mechanical

Legend - Floor and Demolition Plan

New Partitions
Existing to remain
Existing to be removed

Key Map

1/4" = 1'-0"

Floor Plan - Basement

07/20/2017
School of Public Date
Drawn

UT Health Science

INFRASTRUCTURE ASSOCIATES, INC.
Houston, TX 77030
www.pwarch.com
(832) 554-1130

Houston, Texas 77031
Suite 200

UT Health Science
School of Public Health
1300 Pressler St.
Houston, TX 77008

www.IAHOUSTON.com

Title
DS
BL
BL

Addendum 01
07/20/2017

1. The Contractor shall be responsible for the protection against vandalism/unauthorized entry, etc. during the demolition process, but not limited to scratches, cracks, and dents.

2. Coordinate with Owner proper access and location for waste disposal and location of dumpsters.

3. Contractor to demolish and dispose of all items shown/noted to be removed, verify with owner items to be removed.

4. Contractor responsible to inspect existing conditions for all window frames and sills for damage including scratches, cracks, and dents. Contractor to paint any existing frames remaining after construction to match existing.
ceiling to match existing ceiling work. Reinstall as required for above.

Remove existing ceiling.
Remove existing louvers to allow delivery of mechanical equipment. Seal off the opening existing. See MEP for scope of work. Patch and repair to match complete scope of work. Patch and repair to match existing. 1/16" = 1'-0"
New gypsum board ceiling
New 1" aluminum faced insulating
8' - 0" Conduit and concrete encasement
Open to structure
A-520 corridor ceiling
to be 6" above existing
PH (713) 622-0557 FAX
General Notes - Reflected Ceiling Plan
2. See Interior Elevations for furr down heights and dimensions.
otherwise. See Finish Schedule for types.
New partition to structure. See 1 A-520 for partition schedule.

UT Health Science School of Public Health
1200 Pressler St.
Houston, TX 77030
(713) 622-0120
INFRASTRUCTURE ASSOCIATES, INC.
www.pwarch.com
(832) 554-1130
Houston, Texas 77031
WWW.IAHOUSTON.COM
216-159
Sheet Information
07/20/2017
HOUSTON, TEXAS 77057
Sheet
Sheet
Title
Rev
Job Number
Checked
Approved
Issue for Bid

Appendix B7

Reflected Ceiling Plan - Level 2

A-160
MECHANICAL SYMBOLS LEGEND

- **Page Information**
  - Page Dimensions: 2160.0x3024.0
  - Sheet Information

- **Issued For Bid**
  - Date: 05/31/2017
  - Revision: ADDENDUM 1
  - Issued For Bid: 07/28/2017

- **Notes and Legend**
  - Items marked with an asterisk (*) are subject to change.
  - Items marked with a dagger (†) require detailed information.
  - Items marked with a double dagger (‡) must be referenced.
  - Items marked with a triple dagger (§) are for notification.
  - Items marked with a square (□) are for information.
  - Items marked with a circle (○) are for instruction.
  - Items marked with a triangle (△) are for caution.
  - Items marked with a diamond (◇) are for action.

- **Pressure-Temperature Operating Requirements**

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<th>Service</th>
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<td>Hot Water</td>
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<td>Cold Water</td>
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- **Additional Notes**
  - All items not listed are included.
  - Items marked with an asterisk (*) are subject to change.
  - Items marked with a dagger (†) require detailed information.
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  - Items marked with a circle (○) are for instruction.
  - Items marked with a triangle (△) are for caution.
  - Items marked with a diamond (◇) are for action.

- **Project Details**
  - Address: 1200 Pressler St.
  - Phone: 713-798-5555
  - Fax: 713-798-5555
  - Email: info@uthealth.edu

- **Contact Information**
  - Project Manager: Jane Doe
  - Project Engineer: John Smith

- **Project Location**
  - University of Texas Health Science Center at Houston
  - School of Public Health
  - 1200 Pressler St.
  - Houston, TX 77030
### Temporary Air Handling Unit Schedule

<table>
<thead>
<tr>
<th>PLAN</th>
<th>ROOM</th>
<th>LEVEL</th>
<th>BUILDING</th>
<th>SYSTEM</th>
<th>COIL TYPE</th>
<th>SERIES</th>
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### Hot Water Heating Coil Schedule (Duct Mounted)

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### Notes:
- Plan and schedule items may not match existing systems, and should be reviewed for accuracy.
- Temperature and pressure values are approximate and may vary.
- Carbon filter specifications should be checked for compliance.
- All items should be verified before installation.
### STEAM TO HOT WATER HEAT EXCHANGER SCHEDULE (H4)

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### STEAM TEMP SCHEDULE

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### EXHAUST FAN SCHEDULE

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### COALESING AIR SEPARATOR SCHEDULE (A32)

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### VARIABLE AIR VOLUME TERMINAL SCHEDULE

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### AIR HANDLING UNIT SCHEDULE (AHU/GRU) - ALTERNATE

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### AIR VALVE SCHEDULE

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### AIR HANDLING UNIT FAN SCHEDULE (FP) - ALTERNATE

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<th>UNIT</th>
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<th>MAKE</th>
<th>MODEL</th>
<th>DCI</th>
<th>POWER (Kw)</th>
<th>DLS</th>
<th>VAV</th>
<th>PRIORITY</th>
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### CHILLED WATER PRECOOLING (PC) & COOLING (CC) COIL SCHEDULE - ALTERNATE

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### HOT WATER PREHEAT (PH) & HEATING (HC) COIL SCHEDULE - ALTERNATE

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### CONTROL POINT & FIELD DEVICE SCHEDULE - MISC VAV TERMINAL UNITS

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10TH FLOOR PLAN - HVAC - DEMO
BASEMENT FLOOR PLAN - AIR FLOW DIAGRAM
TEMPORARY AHU INSTALLATION

NOTE

1. Connect 2" to 3" flex hose to AHU and 3" pipe to LF-AHU

2. Connect 3" pipe to LF-AHU and 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details

3. Connect 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details and 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details

4. Connect 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details and 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details

5. Connect 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details and 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details

6. Connect 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details and 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details

7. Connect 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details and 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details

8. Connect 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details and 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details

9. Connect 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details and 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details

10. Connect 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details and 3" pipe to LF-Typical 2nd-10th Floor - Lobby - Temporary AHU Installation Details
1. ENLARGED PLAN - TYPICAL 4TH-7TH FLOOR - MECHANICAL ROOM - DEMO

REV 0 07/20

SCHEDULE:
- ENLARGED PLAN - TYPICAL 4TH-7TH FLOOR - MECHANICAL ROOM - DEMO

NOTES:
- [List of notes related to the mechanical room demo, including details about equipment, insulation, and mechanical systems]

SCALE: 3/8" = 1'-0"
1  ENLARGED PLAN - TYPICAL 8TH-10TH FLOOR - MECHANICAL ROOM - DEMO
SECTIONS - BASEMENT MECHANICAL ROOMS
SECTIONS - 3RD THRU 10TH FLOOR MECHANICAL ROOMS
HEAT EXCHANGE TO HOT WATER DIAGRAM

NOTE:
1. NOTE TIME FOR E/I AT 90.
2. LOCATE AT: 7.1.0.0.0 or 8.1.0.0.0 FOR SHOT FLOW - PROVIDE ELEMENTS THERMAL WALL - CONDUCTIVE THERMAL WALL - REQUIREMENTS WITH INDICATOR MILL.
3. NOTE TIMING BANDS FOR CONSOL.
4. PROVIDE Timers & System Timer - CONSUL.
5. PROVIDE VACUUM BREAKER & CONDUIT - CONSUL.
6. PROVIDE GROUND - CONSUL.
7. PROVIDE GROUND - CONSUL.

M603
MEASURE FOR BID
ISSUED FOR BID
07/28/2017
ADDENDUM 1
HEAT EXCHANGER
PIPING DIAGRAM
HEAT EXCHANGER STEAM TO HOT WATER DIAGRAM
SCALE: N.T.S.
ALL COLD WATER PIPING AND PIPING SHALL BE INSULATED WITH 1" FIBERGLASS INSULATION, ALL HOT AND HOT WATER RETURN PIPING SHALL BE INSULATED AS FOLLOWED {1 1/4" AND BELOW 1" FIBERGLASS INSULATION SHALL BE USED} AND {1 1/2" AND ABOVE 2" FIBERGLASS INSULATION SHALL BE USED}