ADDENDUM NO. 02
AUGUST 16, 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. Add the following new specification sections to the project manual issued August 16, 2017 as Addendum #2:

1. 225000 – STEAM FIRED DOMESTIC WATER HEATERS
2. 238219 – FAN COIL UNITS

B. Replace the following specifications sections in their entirety with revised sections issued August 16, 2017 as Addendum #2:

1. 230620 – HYDRONIC SPECIALTIES
2. 230923 – DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC
3. 232223 – STEAM CONDENSATE RETURN UNITS (formerly entitled STEAM CONDENSATE PUMPS)
4. 233100 – DUCTWORK
5. 235700 – HEAT EXCHANGERS FOR HVAC
6. 237323 – AIR HANDLING UNITS

C. Revise the following specification with replacement paragraphs issued August 18, 2018 as Addendum #2:

1. 261116 – SECONDARY UNIT SUBSTATIONS, page 5, paragraph 2.4 Dry-type Transformer Section

PART 2 - CHANGES TO DRAWINGS

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

1. M301 – ENLARGED PLAN TYPICAL 2ND-10TH FLOOR LOBBY TEMPORARY AHU INSTALLATION DETAILS
2. M706 – CONTROLS POINTS

E. Revise the following drawing sheets with drawing revisions issued August 16, 2017 as Addendum #2:
1. MEP100 - ROOF FLOOR PLAN - MEP – PROPOSED
2. M001 - NOTES AND LEGEND
3. M002 - SCHEDULES
4. M003 - SCHEDULES
5. M004 - SCHEDULES
6. M101 - BASEMENT FLOOR PLAN - HVAC - DEMO
7. M102 - 2ND FLOOR PLAN - HVAC - DEMO
8. M103 - 3RD FLOOR PLAN - HVAC - DEMO
9. M104 - 4TH FLOOR PLAN - HVAC - DEMO
10. M105 - 5TH FLOOR PLAN - HVAC - DEMO
11. M106 - 6TH FLOOR PLAN - HVAC - DEMO
12. M107 - 7TH FLOOR PLAN - HVAC - DEMO
15. M110 - 10TH FLOOR PLAN - HVAC - DEMO
16. M200 - BASEMENT FLOOR PLAN - HVAC - NEW
17. M201 - FIRST FLOOR PLAN - HVAC - PROPOSED
18. M202 - 2ND FLOOR PLAN - HVAC - PROPOSED
19. M203 - 3RD FLOOR PLAN - HVAC - PROPOSED
20. M204 - 4TH FLOOR PLAN - HVAC - PROPOSED
21. M205 - 5TH FLOOR PLAN - HVAC - PROPOSED
22. M206 - 6TH FLOOR PLAN - HVAC - PROPOSED
23. M207 - 7TH FLOOR PLAN - HVAC - PROPOSED
24. M207A - 7TH FLOOR PLAN - AIR FLOW DIAGRAM
25. M208 - 8TH FLOOR PLAN - HVAC - PROPOSED
26. M209 - 9TH FLOOR PLAN - HVAC - PROPOSED
27. M210 - 10TH FLOOR PLAN - HVAC - PROPOSED
28. M211 - PENTHOUSE - HVAC – PROPOSED
29. M300 - ENLARGED PLAN - TYPICAL 2ND-10TH FLOOR LOBBY – TEMPORARY AHU INSTALLATION
30. M400 - ENLARGED CENTRAL PLANT - BASEMENT FLOOR PLAN - DEMO
31. M401 - ENLARGED CENTRAL LANT - BASEMENT FLOOR PLAN - PROPOSED
32. M402 - ENLARGED BASEMENT FLOOR PLAN - MECHANICAL ROOMS
33. M403 - ENLARGED PLAN - 2ND FLOOR - MECHANICAL ROOM - DEMO
34. M404 - ENLARGED PLAN - 2ND FLOOR - MECHANICAL ROOM - PROPOSED
35. M405 - ENLARGED PLAN - 3RD FLOOR - MECHANICAL ROOM - DEMO
36. M406 - ENLARGED PLAN - 3RD FLOOR - MECHANICAL ROOM - PROPOSED
37. M407 - ENLARGED PLAN - TYPICAL 4TH-7TH FLOOR - MECHANICAL ROOM - DEMO
38. M408 - ENLARGED PLAN - TYPICAL 4TH-7TH FLOOR - MECHANICAL ROOM - PROPOSED
39. M409 - ENLARGED PLAN - TYPICAL 8-10TH FLOOR - MECHANICAL ROOM - DEMO
40. M410 - ENLARGED PLAN - TYPICAL 8TH-10TH FLOOR - MECHANICAL ROOM - PROPOSED
41. M411 – ALTERNATE #1 - ENLARGED PLAN - TYPICAL 8th-10th FLOOR- MECHANICAL ROOM - PROPOSED
42. M501 – SECTIONS – BASEMENT MECHANICAL ROOMS
43. M502 – SECTIONS – 2ND FLOOR MECHANICAL ROOM
44. M503 – SECTIONS – 3RD THRU 10TH FLOOR MECHANICAL ROOMS
45. M504 – ALTERNATE #1 SECTIONS – 8TH THRU 10TH FLOOR MECHANICAL ROOMS
46. M505 - CUSTOM AHU CONFIGURATIONS
47. M506 - CUSTOM AHU CONFIGURATIONS
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- END -
SECTION 22 50 00

STEAM FIRED DOMESTIC WATER HEATERS

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. Division 22 Plumbing
C. Section 232000A Piping, Valves and Fittings

1.2 SUMMARY
A. This Section includes packaged tankless water heaters utilizing indirect steam heat exchange.

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 where applicable.

D. All internal potable water surfaces shall comply with NSF61 standard for no lead.

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 TANKLESS STEAM FIRED DOMESTIC WATER HEATERS

A. Manufacturers:
1. ThermaFlo Engineering Company.
2. Maxi-Therm, Inc.
3. Cemline, Inc.
4. PVI Watts, Inc..
5. AO Smith, Inc..

B. Description: Pre-packaged, manufacturer assembled, pre-piped, domestic water heater system incorporating shell-and-tube type steam to water heat exchanger(s), safety relief valve, steam regulator valve(s), steam trap(s), integral digital temperature controller, instrumentation & sensors, and support frame.

C. Heat Exchanger
1. Configuration: Horizontal or vertical oriented heat exchanger as indicated
2. Pressure Class: as indicated
3. ASME Code constructed in accordance with Section VIII, Division 1
4. Shell: 304 or 316L stainless steel
5. Steam Head: Removable cast iron or steel confirming with requirements of pressure classification.
6. Tubes: 0.75” double wall seamless copper or 304 stainless steel
7. Tube Sheet: 0.75” brass
8. Insulation: Minimum 2” high-density insulation meeting the minimum requirements of ASHRAE 90.1 current version. Provide insulation with removable stainless steel jacketing.

D. Safety Relief Valves: Combination pressure-temperature ASME Code stamped bronze bodied.
E. Piping: Refer to Section 232000A Piping, Valves and Fittings

F. Temperature Regulator Valve
1. Cast iron or steel body as required by indicated pressure class requirements.
2. Stainless steel trim with renewable seals
3. Single soft-seat construction
4. Class VI shutoff rated
5. Electrically actuated with failsafe spring closure.
6. Manufacturer installed and pre-piped

G. Steam Trap
1. Float & thermostatic type
2. Cast iron body with renewable internals
3. Size for minimum 2:1 safety factor at not more than 1.0 psi differential pressure
4. Rated for maximum anticipated condensate temperature

H. Controls
1. UL listed digital microprocessor temperature controller with graphical interface, adjustable temperature controls, operating temperature indication, status indication, and over-temperature warning indication.
2. Manufacturer pre-programmed and tested.
3. Manufacturer installed in NEMA 4 enclosure with single point, 120 VAC power connection.
4. Manufacturer installed and prewired inlet and outlet platinum RTD temperature sensors with stainless steel thermal wells
5. Manufacturer prewired to steam regulator valve.

I. Frame: Galvanized or epoxy coated carbon steel with flanged footings.

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.
1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 UNIT INSTALLATION
A. Install units on concrete housekeeping pads.
B. Concrete Bases: Anchor unit 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 22 and 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 units.

C. Install shutoff valves at 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. Sterilize potable water surfaces Section 220500 Common Work Results for Plumbing

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 06 20

HYDRONIC SPECIALTIES

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 WORK INCLUDED
   A. Expansion Tanks
   B. Air Vents
   C. Air Separators
   D. Strainers
   E. Gauges and Gauge Connections
   F. Pump Suction Fittings
   G. Relief Valves
   H. Water Flow Measuring and Balancing System

1. 3 RELATED WORK
   A. Section 22 13 16 - Plumbing Piping.
   B. Section 23 21 00 - Hydronic Piping.

1. 4 REFERENCES

1. 5 REGULATORY REQUIREMENTS
   A. Conform to ANSI/ASME Boilers and Pressure Vessels Code Section 8D for manufacture of tanks.

1. 6 QUALITY ASSURANCE
   A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1. 7 SUBMITTALS
   A. Submit shop drawings and product data under provisions of Section 23 00 00.
   B. Submit shop drawings and product data for manufactured products and assemblies required for this project.
C. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.

D. Submit manufacturer's installation instructions under provisions of Section 23 00 00.

1. 8 OPERATION AND MAINTENANCE DATA
   A. Submit operation and maintenance data under provisions of Section 23 00 00.
   B. Include installation instruction, assembly views, lubrication instructions, and replacement parts list.

1. 9 DELIVERY, STORAGE, AND HANDLING
   A. Deliver products to site under provisions of Section 23 00 00.
   B. Store and protect products under provisions of Section 23 00 00.

PART 2 - PRODUCTS

2. 1 EXPANSION TANKS
   A. Construction: Closed, welded steel, tested and stamped in accordance with Section 8D of ANSI/ASME Code; 125 psi rating; cleaned, prime coated, and supplied with steel support saddles; with tappings for installation of accessories.
   B. Gauge Glass Set: Brass compression stops, guard, and 3/4 inch red line glass, maximum 24 inches length, long enough to cover tank for 2 inches above bottom to 2 inches below top.
   C. Quick Connect Air Inlet: Automotive tire valve type, manual air vent, tank drain, and pressure relief valve.
   D. Automatic Cold Water Fill Assembly: Pressure reducing valve, reduced pressure double check back flow preventer, test cocks, strainer, vacuum breaker, and valved by-pass.
   E. Hot Water Heating System: Set expansion tank pressure relief valve at 125 psi maximum and pressure reducing valve at 100 psi.
   F. Chilled Water System: Set expansion tank pressure relief valve at 125 psi maximum and pressure reducing valve at 100 psi.
   G. Size: Refer to drawings for capacity.

2. 2 AUTOMATIC AIR VENTS:
   A. Provide at the highest points of the chilled water system and on the chilled water coils as shown on the Drawings, an automatic air vent, Armstrong No. 21AR or approved equal, with a pressure rating of 250 psig. Provide shut-off valve to facilitate maintenance of air vent. Locate all air vents and their discharge lines in accessible locations, preferably clustered.

2. 3 AIR SEPARATORS
   A. Dip Tube Fitting: For 150 psig operating pressure; to prevent free air collected in boiler from rising into system.
   B. In-line Air Separators: Cast iron for sizes 1-1/2 inch and smaller, or steel for sizes 2 inch and larger; tested and stamped in accordance with Section 8D of ANSI/ASME Code; for 150 psig operating pressure.
C. Selection shall be based upon system flow with pipe size as a minimum in accordance with the basis of design. In no case shall entering velocity exceed 10 feet per second. Separator shall be fabricated steel, rated for 150 psig working pressure, stamped and registered in accordance with ASME Section VIII, Division 1 for unfired pressure vessels, and include two equal chambers above and below the inlet / outlet nozzles.

D. Air separator Unit shall include internal Spirotube® elements filling the entire vessel to suppress turbulence and provide air elimination efficiency of 100% free air, 100% entrained air, and 99.6% dissolved air at the installed location. Dirt separation efficiency shall be a minimum of 80% of all particles 30 micron and larger within 100 passes. The elements must consist of a copper core tube with continuous wound copper wire medium permanently attached and followed by a separate continuous wound copper wire permanently affixed.

E. Basis of design for the air eliminator / dirt separator shall be the Spirovent® VDN or VHN Series as manufactured by Spirotherm, Inc., Glendale Heights, Illinois or approved equal. Unit shall include removable lower head for internal inspection. Alternate manufacturers such as Armstrong DAS – 150 PSI Model or Amtrol ADS – 150 PSI Model shall be acceptable, if the they comply with the specifications and performance.

F. Air Elimination Valve: Bronze, float operated, for 125 psig operating pressure.

G. Combination Air Separators/Strainers: Steel, tested and stamped in accordance with Section 8D of ANSI/ASME Code, for 150 psig operating pressure, with galvanized steel integral strainer with 3/16 inch perforations, tangential inlet and outlet connections, and internal stainless steel air collector tube.

2. 4 STRAINERS:

A. Each control valve for chilled water and heating water, and each pressure reducing valve assembly regardless of its size shall be preceded by a sediment strainer. The arrangement of these sediment strainers shall be such that the screens may be removed for cleaning with ease through a gasketed plug. Monel or stainless steel shall be used to fabricate the non-collapsible, lapped screens, which shall contain no soldered joints.

B. Sediment strainers shall be placed in piping systems wherever shown on the Drawings and at such other points as may be required for the removal of foreign material from the piping systems.

C. Strainers for water piping 2-1/2" and larger shall be Crane No. 989-1/2 Sediment Separators or approved equal. In piping two inches (2") and smaller, they shall be Crane No. 988-1/2, or approved equal.

D. Strainers, 2" and smaller, bronze body, screwed ends, No. 10 mesh strainer, screwed cap with bronze blow-off valve (size to be determined by standard tap size in cap). Cast iron body, 2 1/2" and larger, isolating type flanged ends where installed in copper lines, No. 7 perforated monel strainer, flanged cap with bronze ball blow-off valve (size of blow-off valve shall be determined by standard tap size in cap). Special Note: All strainers 6" and larger shall have studs mounted in the body flange in lieu of bolts for removal of cap. Baskets for strainers 6" and larger shall have stainless steel reinforcing bands at ends to prevent collapsing.

E. Full sized blow off valves shall be installed on all strainers in steam, condensate, chilled and hot water lines and a drain shall be installed from each valve to the nearest floor drain.

2. 5 GAUGES AND GAUGE CONNECTIONS:

A. Furnish and install Ashcroft No. 1279A Dura-gauges on both suction and discharge sides of pumps, complete with Ashcroft No. 1095 lever handle shut-off cocks, and Ashcroft No. 1106B pulsation piston type dampeners, or approved equal. Porous type will not be accepted. See pump Specifications. Gauges shall have stainless steel movement and 1/2 of 1% accuracy. Gauges shall have back connection when used on a panel;
otherwise they shall have bottom connections. The graduation of the dials and the arrangement of the mechanisms shall conform to the pressure range details shown on the Drawings.

B. Combination pressure or vacuum gauges shall be Ashcroft Dura-gauges No. 1279AC, or approved equal. The accessories for these gauges shall conform to those prescribed for pressure gauges.

C. Furnish and install, where noted or indicated on the accompanying Drawings or called for elsewhere in these Specifications, gauge connections complete with Ashcroft No. 1095 lever handle union shutoff cocks, or approved equal. All gauge connections shall be made up with brass pipe, nipples and brass screw fittings.

### 2.6 THERMOMETER AND THERMOMETER WELLS:

A. Furnish and install thermometers of not less than 9" scale complete with brass separable sockets with extension neck to allow for insulation of piping. These thermometers shall be mercury red reading type in one piece glass tubes extending from top of scale to sensor, and shall be located so that they may be easily read. Field adjustable angle thermometers are acceptable. Thermometers shall in all cases be installed upright or at the proper angle to be read while standing on the floor. The wells for thermometers shall be located in vertical pipes where possible and when necessary in horizontal pipes they shall be installed in the side and not on the top of the pipe. They shall be Weksler Industrial Thermometers, or approved equal, with range of 0 to 100 degrees F. for chilled water, and 0 to 220 degrees F for hot water.

B. Thermometer wells and thermometers shall be located where noted on the accompanying Drawings and where called for in other sections of the Specifications. Thermometer test wells only shall be installed in a vertical position in horizontal lines and at 45 degrees, in vertical lines to hold a fluid in the well.

C. Thermometer test wells shall be 3/4" Weksler Thermal Wells, brass with stem of minimum length to extend beyond the mid-diameter of the pipe, 2-1/2" extension neck, and brass screw plug. Wells shall be suitable for use of industrial type thermometers.

D. Indicating thermometers shall be placed in lines wherever shown on the Drawings. These thermometers shall be Weksler Industrial Thermometers having stainless steel separable sockets and scales of the range shown on the Drawings.

### 2.7 PUMP SUCTION FITTINGS:

A. Fitting: Angle pattern, cast-iron body, threaded for 2 inch and smaller, flanged for 2-1/2 inch and larger, rated for 175 psig working pressure, with inlet vanes, cylinder strainer with 3/16 inch diameter openings, disposable fine mesh strainer to fit over cylinder strainer, and permanent magnet located in flow stream and removable for cleaning.

B. Suction diffusers shall be Paco or approved equal, cast iron body and cover, steel diffuser, and stainless steel strainer, 125 pound ASA (flat face) flange for a working pressure of 175 psi and temperature of 300°F.

C. Accessories: Adjustable foot support, blowdown tapping in bottom, gauge tapping in side.

### 2.8 WATER RELIEF VALVES:

A. The pressure relief valves installed for the protection of the water circulating circuits shall be McAlear No. 307 single seated diaphragm and spring type valves with screwed connections or approved equal. They shall be 3/4" size of bronze construction with bronze seat, composition shut-off disc and rubber diaphragm.
2.9 BUILDING MAIN HOT WATER, CHILLED WATER and STEAM CONDENSATE INTEGRATING METERS:

A. Furnish and install complete transit time Controlotron Metering systems. Flow element shall be installed in a straight run of pipe in accordance to manufacturer's guidance for the specific installation in order to maintain rated accuracy.

B. Each flow station shall consist of dual flow sensor and carriers mounted in the 'transverse' arrangement with laminated or metal identification tag on chain giving pipe size, meter series, and station identification. Flow stations shall be of steel construction, welded in place.

C. Wall mounted meter shall be complete with adequate lengths of flow cables attached sensors, and installation and operating instructions. Meter shall operate on 115 VAC. Meter shall be backlit LCD, dual channel (one for chilled water, for hot water, the other for steam condensate. Each channel shall indicate:
   1. Instantaneous flow rate in GPM, and total Gallons
   2. Each channel shall have dual outputs for each of the displayed values. Out puts shall be 4-20 mA and TTL pulse rate, each proportional to display values, compatible and connected with building EMS.
   3. Building EMS shall be programmed and capable of M & V protocol as required by LEED.
   4. Meter shall have positive zero flow indication.

D. Unit shall accommodate the following fluid operating ranges:
   1. Temperature: 36° to 250° F.
   2. Pressure: 0 to 150 psi.

2.10 DELETED

2.11 AUTOMATIC FLOW-CONTROL VALVES:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Flow Design Inc.
   b. Griswold Controls.

2. Body: Brass or ferrous metal.

3. Piston and Spring Assembly: Stainless steel, tamper proof, self cleaning, and removable.

4. Combination Assemblies: Include bowne or brass-alloy ball valve.

5. Identification Tag: Marked with zone identification, valve number, and flow rate.

6. Size: Same as pipe in which installed.

7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.

8. Minimum CWP Rating: 175 psig or 300 psig.

9. Maximum Operating Temperature: 200 deg F or 250 deg F.

2.12 - DELETED -
PART 3 - EXECUTION

3. 1 INSTALLATION AND APPLICATION

A. Install specialties in accordance with manufacturer's instructions to permit intended performance.
B. Support tanks inside building from building structure in accordance with manufacturer's instructions.
C. Provide manual air vents at system high points and as indicated.
D. Provide manual air vents at entrance to all heating hot water coils, with a "cane" shaped discharge tube, positioned to permit draining to a portable receptacle.
E. For automatic air vents in ceiling spaces or other concealed locations, extend vent tubing to nearest drain.
F. Provide air separator on suction side of system circulation pump and connect to expansion tank.
G. Provide valved drain and hose connection on strainer blow down connection.
H. Provide pump suction fitting on suction side of base mounted centrifugal pumps. Remove temporary strainers after cleaning systems. Clean all permanent strainers after circulating systems for a minimum of 48 hours at full capacity.
I. Support pump fittings with floor mounted pipe and flange supports.
J. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.
K. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.
L. Pipe relief valve outlet to nearest floor drain.
M. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

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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. Not Used

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/aut 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:
2. 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 ensuring primary air flow condition shall be controlled and maintained 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 and insuring 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 or as indicated otherwise. 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 or linear characterized ball 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 or as required otherwise for pressure class compliance. 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 as indicated. Valves for low-pressure steam shall be sized for 80% pressure drop of inlet pressure or as indicated. 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 or as indicated.

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 or as indicated.

7. Valve Constant (Cv) Charts: Shop drawings shall indicate the valve constant (Cv rating) of all valves provided 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: JCI, 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.

   b. Manufacturers: JCI Standard Premium RTD or equal.

   c. 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 SENSERS
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°C 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°F 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:
         JCI, 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 ve-
locity 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 JCI or 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: JCI, 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 JCI or 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 JCI, 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 it 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 conjunction 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 modulates 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 it's 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>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 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.
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.
      i. Cougar Systems
   2. Receiver: welded steel, min 3/16” thick; galvanized inside & outside with magnesium anode or 300 series stainless steel, externally adjustable float switch connections, and flanges for pump mounting.
   3. Pumps: Centrifugal single stage or vertical multi-stage turbine type, close coupled, permanently aligned, stainless steel shaft, bronze fitted; with replaceable bronze case ring (centrifugal type) and mechanical seal; mounted on receiver flange. Select pumps for non-
STEAM CONDENSATE PUMPS

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 31 00

DUCTWORK

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 WORK INCLUDED

A. Low Pressure Ducts
B. Medium and High Pressure Ductwork
C. Duct Cleaning

1.3 RELATED WORK

A. Division 09 Section, Painting, priming or coating of metal ductwork exposed to view.
B. Section 23 05 48 - Vibration Isolation
C. Section 23 07 13 - Duct Insulation
D. Section 23 33 00 - Ductwork Accessories
E. Section 23 36 00 - Air Terminal Units
F. Section 23 37 00 - Air Inlets and Outlets
G. Section 23 05 93.A - Testing, Adjusting and Balancing

1.4 REFERENCES

A. ASHRAE - Handbook of Fundamentals; Duct Design
B. ASHRAE - Handbook of HVAC Systems and Equipment; Duct Construction
C. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
D. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
E. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
F. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality
G. ASTM B209 - Aluminum and Aluminum Alloy Sheet and Plate
H. NFPA 45 – Laboratory Ventilating Systems and Hood Requirements
I. NFPA 90A - Installation of Air Conditioning and Ventilating Systems
J. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems
K. NFPA 96 - Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooling Equipment
L. SMACNA – HVAC Duct Construction Standards, 1995
M. UL 181 - Factory-Made Air Ducts and Connectors
N. SMACNA Round Industrial Duct Construction Standards,
P. Assembly and Installation of Spiral Duct and Fittings, IMC.
Q. Engineering Report No. 132 (Spacing of Duct Hangers), IMC.
R. AWSD1.1 American Welding Society Structural Welding Code

1.5 DEFINITIONS
A. Duct Sizes: Inside clear dimensions. For lined ducts, maintain sizes inside lining.
B. Low Pressure: 3 inch WG positive or negative static pressure and velocities less than 1,500 fpm.
C. Medium Pressure: 6 inch WG positive static pressure and velocities greater than 1,500 fpm.
D. High Pressure: 10 inch WG positive static pressure and velocities greater than 2,500 fpm.

1.6 SUBMITTALS
A. Product Data
   1. Provide product data for all ductwork systems to be used on project. Product data submittals shall include the following as a minimum:
      a. System name and type
      b. Duct system design pressure
      c. Hangers and supports, including materials, fabrication, methods for duct and building attachment.
      d. Sealant type.
B. Shop Drawings shall be submitted on all items of sheet metal work specified herein. Shop Drawings of ductwork at air units shall be submitted at a minimum scale of 3/8” equal to one foot. Shop drawings of ductwork located at all other locations shall be prepared at a scale of not less than ¼” = 1'-0". Reproduction and submittal of the construction documents is not acceptable. Shop drawings shall include the following:
   1. Clearance dimensions between ducts and dimensions above finished floors for bottom and tops of ducts.
   2. Call out of duct materials other than galvanized including but not limited to stainless steel, aluminum, or prefabricated fire rated ductwork.
3. Shop Drawings shall indicate location of all supply, return, exhaust and light fixtures from the approved reflected ceiling plans.

4. Shop drawings shall identify all duct sizes, reinforcement and spacing.

5. Penetrations through fire rated and other partitions.

6. Show major equipment with ductwork connections.

C. Show all dampers, turning vanes, access doors, fire dampers and all other ductwork accessories to be provided. Submit shop drawings and product data under provisions of Section 23 00 00.

D. Submit two samples of stainless steel welded duct joint to Engineer and Owner for approval. After approval, sample shall remain at job site for reference. [NOTE TO ENGINEER: Discuss with owner to understand if other types of ductwork samples are required for project].

E. Welding Certificates. Provide for all welders including procedures and standards of acceptance.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 23 00 00.

B. Store and protect products under provisions of Section 23 00 00.

PART 2 - PRODUCTS

2.1 DUCTWORK GENERAL:

A. All ductwork indicated on the Drawings, specified or required for the air conditioning and ventilating systems shall be of materials as hereinafter specified unless indicated otherwise. All air distribution ductwork shall be fabricated, erected, supported, etc., in accordance with all applicable standards of SMACNA Duct Manuals where such standards do not conflict with NFPA 90A and where class of construction equals or exceeds that noted herein. All exhaust ductwork including toilet room exhausts shall be constructed and leak tested as specified for medium pressure supply ducts at negative pressure.

B. All ductwork shown on the Drawings, specified or required for the heating, ventilating and air conditioning systems shall be constructed and erected in a first class workmanlike manner. The work shall be guaranteed for a period of one (1) year from and after the date of acceptance of the job against noise, chatter, whistling, vibration, and free from pulsation under all conditions of operation. After the system is in operation, should these defects occur, they shall be corrected as directed by the Architect.

C. All duct sizes shown on the Drawings are air stream sizes. Allowance shall be made for internal lining where required, to provide the required cross sectional area.

D. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched), and shall not be any larger than necessary. All duct openings shall be provided with sheet metal caps if the openings are to be left unconnected for any length of time.

E. Except for special ducts specified elsewhere herein, all sheet metal used on the project shall be constructed from prime galvanized steel sheets and/or coils up to 60" in width. Each sheet
shall be stenciled with manufacturer's name and gauge. Coils of sheet steel shall be stenciled throughout on ten foot (10') centers with manufacturer's name and must be visible after duct is installed. Sheet metal must conform to SMACNA sheet metal tolerances as outlined in SMACNA's "HVAC Duct Construction Standards."

F. Where ducts that are exposed to view (including equipment rooms), pass through walls, floors or ceilings, furnish and install sheet metal collars around the duct.

2.2 DUCTWORK LOW PRESSURE:

A. The scope of low pressure ductwork is defined as all ductwork downstream of terminal units. Construction of all low pressure duct shall be in accordance with Low Velocity Duct Construction Standards as published by Sheet Metal and Air Conditioning Contractors National Association (SMACNA) and shall be sealed and tested at 3" static with the same test procedures as medium pressure ductwork.

B. Spiral wound round duct shall be as manufactured by United McGill Sheet Metal Company or approved equal.

C. The metal gauges listed in the 1995 SMACNA HVAC Duct Construction Standards for Metal and Flexible Duct are the minimum which shall be used for this project. It shall be noted that the Contractor is responsible that the metal gauge selected is heavy enough to withstand the physical abuse of the installation.

D. Elbows shall be radius type and have a centerline radius of 1-1/2 times the duct diameter or width. Elbows in round ducts may be smooth radius as described above or 5-piece 90 degree elbows and 3-piece 45 degree elbows. Joints in round ducts shall be slip type with a minimum of three sheet metal screws. Joints in sectional elbows shall be sealed as specified for duct sealing. 90˚ mitered elbows are not acceptable unless approved by the Architect/Engineer or Project Manager.

E. SEALANT: All ductwork (except welded exhaust duct) shall be sealed with either "MP" (Multi-Purpose), Hardcast "Iron-grip 601", Polymer Adhesive "Airseal #11", or "United Duct Seal" (United McGill Corp.) water base, latex or acrylic type sealant. Note that, except as noted, oil or solvent based sealants are specifically prohibited for use on this project. For exterior applications, "Uni-Thane " (United McGill Corp.) polyurethane based sealant shall be used. No other sealants may be used. All seams and joints in shop and field fabricated ductwork shall be sealed by applying one layer of sealant, then immediately spanning the joint with a single layer of 3" wide open weave fiberglass tape. Sufficient additional sealant shall then be applied to completely imbed the cloth. All sealants shall be UL rated at no more than flame spread of 5 and smoke developed of 0. At contractor's option, Hardcast 1602 sealant tape may be used in lap joints and flat seams.

2.3 DUCTWORK MEDIUM PRESSURE

A. The scope of medium pressure ductwork is defined as all ductwork downstream of all air handlers, up to and including terminal units, plus all return air ductwork, plus all general toilet room exhaust ductwork. Construction of all ducts shall be in accordance with High Velocity Construction Standards as published by SMACNA. All round and rectangular duct construction, duct fittings, dampers, etc., are covered in this manual and it is to be adhered to.

1. Spiral wound round duct shall be as manufactured by United McGill Sheet Metal Company or approved equal.

2. The metal gauges are listed herein for round duct and for rectangular duct.
B. All ductwork (except welded exhaust duct) shall be sealed with either "MP" (Multi-Purpose), Hardcast "Iron-grip 601", or "United Duct Seal" (United McGill Corp.) water base, latex or acrylic type sealant. Note that, except as noted, oil or solvent based sealants are specifically prohibited for use on this project. For exterior applications, "Uni-Thane" (United McGill Corp.) polyurethane based sealant shall be used. No other sealants may be used. All seams and joints in shop and field fabricated ductwork shall be sealed by applying one layer of sealant, then immediately spanning the joint with a single layer of 3" wide open weave fiberglass tape. Sufficient additional sealant shall then be applied to completely imbed the cloth. At contractor’s option Hardcast 1602 sealant tape may be used in lap joints and flat seams.

C. Oval ducts shall be spiral flat oval or welded flat oval equal to those of United McGill Sheet Metal Company with gauges and reinforcing as recommended by the manufacturer for medium pressure or the ducts may be Shop fabricated of completely welded construction of the following gauge:

1. Major Axis 12 to 20 No. 24 gauge
2. Major Axis 20 to 30 No. 22 gauge
3. Major Axis 30 to 46 No. 20 gauge
4. Major Axis 46 to 50 No. 18 gauge
5. Major Axis 50 and Up No. 16 gauge

D. Oval fittings shall be equal to those of United McGill Sheet Metal Company with requirements, sealing, etc., similar to that specified for round medium pressure work.

E. Oval duct reinforcing methods shall be submitted as Shop Drawings for approval. Reinforcing galvanized angles shall be of sizes specified for same size rectangular ducts. Galvanized angles shall be used where standing seams are specified for rectangular ducts. Attaching methods shall be shown on Shop Drawings and submitted for approval.

F. Testing of Medium Pressure Ductwork: (Includes from fan discharge through to the discharge of terminal units.)

1. All medium pressure ducts shall be pressure tested according to SMACNA Chapter 10 test procedures. Design pressure for testing ductwork shall be six inches (6") of water. Total allowable leakage shall not exceed 1% of the total system design air flow rate. When partial sections of the duct system are tested, the summation of the leakage for all Sections shall not exceed the total allowable leakage.

2. The entire system of medium pressure ductwork shall be tested, including the VAV/Constant Volume Terminal Units (i.e. The ductwork shall be capped immediately prior to the Terminal Units, and tested as described above). After testing has proven that the ductwork is installed and performs as specified, the terminal units shall be connected to the ductwork and the connections sealed with extra care. The contractor shall inform the project inspector when the joints may be visually inspected for voids, splits, or improper sealing of the joints. If any leakage in the terminal unit connections/joints after the systems have been put into service, the leaks shall be repaired by: 1) complete removal of the sealing materials, 2) thorough cleaning of the joint surfaces, and 3) installation of multiple layers of sealing materials.
3. At the option of the Owner, the Contractor may be allowed to eliminate the terminal units from testing by capping the supply ductwork prior to the terminal units, then inspecting the connection to the terminal units when complete. This option may only be exercised by the Resident Construction Manager, and then only if documented in writing prior to testing.

G. All exhaust ductwork, including toilet room exhausts, shall be constructed as for medium pressure ducts and shall be tested for leaks in the same manner as for medium pressure supply ducts.

H. Contractor may use DUCTMATE or Ward flanged Duct Joint system, reference SMCNA FIG. 1-4 “Transverse Joints” T-25a or T-25b on rectangular ductwork. Slip-on duct flanges are not acceptable. Contractor may at his option (where space permits) use rectangular ductwork with DUCTMATE or Ward system in lieu of oval ductwork.

I. Rectangular 90 degree elbows shall be constructed with single thickness turning vanes mounted on an integral rail. Mitered 90 degree elbows are not allowed unless approved by the Engineer and Construction Manager. Radius type rectangular elbows shall have a centerline radius of 1-1/2 times the duct diameter or width. Elbows in round or oval ducts may be smooth long radius as described above or 5-piece 90 degree elbows and 3-piece 45 degree elbows. Joints in round ducts shall be slip type with a minimum of three sheet metal screws. Joints in sectional elbows shall be sealed as specified for duct sealing.

2.4 ELBOWS:

A. Where rectangular elbows are shown, or are required for good air flow, contractor shall provide and install turning vanes. Turning vanes shall be factory fabricated with integral support rail. Radius elbows shall have a centerline radius of not less than one and one-half (1-1/2) times the duct width. Submit Shop Drawings on factory fabricated and job fabricated turning vanes. Provide turning vanes in all rectangular radius elbows and offsets.

B. All turning vanes shall be anchored to the cheeks of the elbow in such a way that the cheeks will not breathe at the surfaces where the vanes touch the cheeks.

2.5 FLEXIBLE DUCTS:

A. Low Pressure Insulated Flexible Duct may be used where shown on the drawings. Duct shall be made with factory preinsulated duct supported by a corrosion resistant metal spiral, or a coated spring steel helix and solid inner liner mechanically interlocked or permanently bonded to the helix wire, covered with a minimum of 1-1/2" thick, 3/4 lb. density fiberglass blanket sheathed in a vapor barrier of fiberglass reinforced aluminum foil and Mylar laminate. The insulation shall have a minimum “K” factor of 0.29 at 60 degrees F. mean and a vapor barrier permeability rating of 0.05 per ASTM method E96-66, Procedure A. The C factor shall be 0.24 to meet HUD requirements. The duct shall be rated for a positive working pressure of 10" w.g. and a temperature of up to 250 degrees F. The duct shall comply with NFPA 90A and be listed and labeled by Underwriters Laboratories, Inc., as Class I Air Duct, Standard 181, and meet GSA, FHA and other U. S. Government standards; flame spread, not over 25; smoke developed, not over 50. Flexible ducts shall be not more than 5'-0" in length, shall be installed as indicated in the diffuser connection detail, and shall be Flexmaster Type 1M or approved equal.

1. The terminal ends of the duct core shall be secured by compression coupling or stainless steel worm gear type clamp equal to Ideal Series 56 Snaplock. The fittings on Air Devices and on sheet metal duct shall be coated with the sealant specified for low pressure ductwork, then flexible duct core slipped over duct and coupling or clamp tightened, then connection sealed with more sealant. Insulation of flexible duct shall be slipped over connection to point where insulation abuts mixing box or
insulation on duct. These insulation connections shall be sealed by imbedding fiberglass tape in the sealant specified for medium pressure ductwork and coating with more sealant to provide a vapor barrier. (This applies to all flex connections to diffusers, grilles, etc. when allowed on the drawings.)

2. Medium and High Pressure Insulated Flexible Duct shall be factory applied insulation of 1" minimum thickness, 3/4 lb. density with a permeability rating of 0.30. The duct shall be composed of dead soft, spiral wound, triple locked corrugated aluminum core covered with Ratings shall be as described for Low Pressure Duct above. Flexible ducts shall be not more than 2'-0" in length, used for alignment or sound/vibration purposes only, and may only be installed in straight runs. Flexible duct shall NOT be used for changes of direction of air flow and shall be Flexmaster Type TL-M or approved equal. Installation, clamps and sealing shall be the same as specified for rigid duct.

2.6 DUCT LINER:

NOTE: ALL DUCTWORK SHALL BE EXTERNALLY INSULATED UNLESS OTHERWISE INDICATED ON THE PROJECT DRAWINGS. (SEE SECTION 23 07 19, FOR THE APPLICABLE INSULATION SPECIFICATION.)

A. Where indicated on the Drawings, ducts shall have lining equal to Fiberglass Aeroflex No. 150 duct liner. Duct liner shall be one inch (1") thick unless otherwise indicated. The liner shall be applied to the inside of the duct with heavy density side to the air stream and shall be secured in the duct with fireproof 3M #37 or St. Clair R41B adhesive, completely coating the clean sheet metal. All joints in the insulation shall be "buttered" and firmly butted tightly to the adjoining liner using fireproof adhesive. Where a cut is made for duct taps, etc., the raw edge shall be accurately and evenly cut and shall be thoroughly coated with fireproof adhesive. On ducts over twenty-four (24") in width or depth, the liner shall be further secured with mechanical fasteners. The fasteners shall be A. J. Gerrard Company pronged straps, or approved equal, secured to the ducts by fireproof adhesive. The clips shall be eighteen inch (18") maximum spacing and shall be pointed up with fireproof adhesive. Liner shall be accurately cut and ends thoroughly coated with fireproof adhesive so that when the duct section is installed, the liner shall make a firmly butted and tightly sealed joint. Where ducts are lined exterior insulation will not be needed unless otherwise noted, except that the two insulations shall not lap less than twenty-four inches (24"). Dimensions given on the Drawings are metal sizes. Refer to Section 23 00 00 for Flame-Spread Properties.

B. Duct liner in medium pressure ducts shall be the same except a perforated metal liner shall be used over duct liner for securement in lieu of fasteners.

2.7 FACTORY LINED ACOUSTICAL DUCTS

A. Where indicated on the Drawings, furnish and install double wall internally insulated duct and fittings.

B. Duct shall consist of outer metal pressure shell, 1" thick glass fiber insulation and internal perforated metal liner.

C. Duct and fittings shall be equal to Acousti-K 27 as manufactured by United McGill Sheet Metal Company.
2.8 LABORATORY EXHAUST DUCTWORK

A. Applies to stainless steel ductwork indicated in specification application table for Laboratory Exhaust Systems.

B. Provide exhaust ductwork of minimum gages:

<table>
<thead>
<tr>
<th>DUCT SIZE</th>
<th>GAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>28-inch diameter or less</td>
<td>18</td>
</tr>
<tr>
<td>30-inch to 60-inch diameter</td>
<td>16</td>
</tr>
<tr>
<td>61-inch diameter or greater</td>
<td>14</td>
</tr>
<tr>
<td>Greater than 60 x 42 (rectangular or oval)</td>
<td>Comply with SMACNA</td>
</tr>
</tbody>
</table>

C. ALL LAB EXHAUST DUCTWORK SHALL HAVE LONGITUDINAL BUTT ("SOLID") WELD SEAMS WITH BUTT WELD JOINTS. Butt-weld all joints and fittings using Gas Tungsten Arc Welding ("TIG"). Welding procedures shall meet the requirements of AWSD1.1. Welds on exposed ductwork inside the building shall be ground and polished. Duct sealant shall not be used to seal ductwork.

D. Provide required transitions from duct to equipment and make connections to equipment.

E. Fittings:
   1. Refer to Round and Oval Ducts and Fittings General Requirements in this specification. Transverse and longitudinal seams shall be butt welded joints.
   2. Refer to drawings for additional information.

F. Submit certification of welder’s qualifications to perform the required welding operations and all project WPS for TIG welding sheet metal. All welder certifications shall be maximum 2 years prior to date of awarding contract.

2.9 ALUMINUM DUCTWORK:

A. Provide aluminum ductwork only where indicated on the drawings.

B. Duct joints shall be all soldered construction, one standard gauge heavier than for the same size galvanized steel ducts.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer also to requirements included in Part 2 of this specification.

B. Obtain manufacturer's inspection and acceptance of fabrication and installation of fiberglass ductwork prior to beginning of installation.

C. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

D. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
E. Slope underground ducts to plenums or low pump out points at 1:500. Provide access doors for inspection.

F. Coat buried, metal ductwork without factory jacket with one coat and seams and joints with additional coat of asphalt base protective coating.

G. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.

H. Connect terminal units to medium or high pressure ducts directly or with two feet maximum length of flexible duct. Do not use flexible duct to change direction. Allow for a minimum of 3 diameters of straight duct to the entrance of all terminal units.

I. Connect diffusers with 5'-0" maximum length or troffer boots with 2’ maximum length of flexible duct to low pressure ducts. Hold in place with strap or clamp, and seal as specified.

J. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for cleanout. Use stainless steel for ductwork exposed to view and stainless steel or galvanized steel for ducts where concealed.

K. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

3.2 LOW PRESSURE DUCT SUPPORTS:
A. See Section 23 05 29.

3.3 MEDIUM PRESSURE DUCT SUPPORTS:
A. See Section 23 05 29.

3.4 DUCTWORK APPLICATION SCHEDULE

<table>
<thead>
<tr>
<th>AIR SYSTEM</th>
<th>MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Outside Air Intake</td>
<td>316 Stainless Steel</td>
</tr>
<tr>
<td>Medium Pressure Supply</td>
<td>Galvanized Steel</td>
</tr>
<tr>
<td>Low Pressure Supply</td>
<td>Galvanized Steel</td>
</tr>
<tr>
<td>Return/Relief Air</td>
<td>Galvanized Steel</td>
</tr>
<tr>
<td>General Exhaust Air (Toilet Rooms)</td>
<td>Galvanized Steel</td>
</tr>
<tr>
<td>Lab Exhaust</td>
<td>316L Stainless Steel</td>
</tr>
<tr>
<td>Rooftop ductwork</td>
<td>316L Stainless Steel</td>
</tr>
<tr>
<td>Emergency Generator Exhaust</td>
<td>Double Wall or Black Steel</td>
</tr>
</tbody>
</table>
3.5 CLEANING OF SYSTEMS:

A. Before turning the installation over to the Owner, all ducts should be cleaned and blown free of all dust and dirt that has collected in the ducts.

END OF SECTION 23 31 00
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.
   6. Maxi-Therm

B. Configuration: U-tube with removable bundle.

C. Shell Materials: Steel.

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

E. Tube:
   1. Seamless steel or 90/10 copper-nickel SB-111 alloy 706.
   2. Tube diameter is determined by manufacturer based on service.

F. Tube sheet Materials: Steel or 304L stainless 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 (horizontal units):
   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 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. Nortek Air Solutions / Temtrol / Ventrol

F. Thermal Corporation

G. JCI York Custom

H. 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 or powder coating. 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 linter. 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 airside) 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

AIR HANDLING UNITS
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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 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.

I. Factory engineered fan wall array systems may be provided in lieu of single plenum fans. All engineering, materials, and labor required for provision of fan wall systems shall be provided by contractor at no additional cost to the owner and shall be subject to technical review by the engineer of record. Fan wall array total motor HP must not exceed scheduled value and individual fan motors must be factory pre-wired and provided with individual electrical disconnect switches and motor overload protection for use with a single variable speed drive.

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

D. 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 traceable flow measurement devices and shall be witnessed by a representative of the Owner’s Test & Balance firm.

E. Test each AHU scheduled at 12,000 cfm or greater airflow capacity.

F. 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
SECTION 23 82 16

AIR COILS AND HEAT PIPES

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. Water coils
   B. Heat Pipes

1.3 RELATED SECTIONS
   B. Section 23 07 19 - Piping Insulation
   C. Section 23 06 20.13 - Hydronic Specialties
   D. Section 23 22 00.A - Steam and Steam Condensate Specialties
   E. Section 23 31 00 - Ductwork: Installation of duct coils
   F. Section 23 09 00 - Controls and Instrumentation
   G. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
   H. Section 26 27 26 - Wiring Devices and Floor Boxes

1.4 REFERENCES

AIR COILS
23 82 16 - 1
A. ANSI/ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils
B. ANSI/NFPA 70 - National Electrical Code
C. ANSI/UL 1096 - Electric Central Air Heating Equipment
D. SMACNA - HVAC Duct Construction Standards, Metal and Flexible

1.5 SUBMITTALS
A. Submit shop drawings under provisions of Section 23 00 00.
B. Submit shop drawings indicating coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions.
C. Submit product data under provisions of Section 23 00 00.
D. Submit product data indicating coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions.
E. Submit manufacturer's installation instructions under provisions of Section 23 00 00.
F. Submit manufacturer's certificate under provisions of Section 23 00 00 that coils are tested and rated in accordance with ANSI/ARI 410.

1.6 APPLICATION
A. The specifications and all other requirements shall be applicable to all chilled water and hot water coils installed within the air-handling units and installed outside the AHU in ductwork or plenums etc.

1.7 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.

1.8 DELIVERY, STORAGE, AND HANDLING
A. Deliver products to site under provisions of Section 23 00 00.
B. Store and protect products under provisions of Section 23 00 00.
C. Protect coil fins from crushing and bending by leaving in shipping cases until installation, and by storing indoors.

D. Protect coils from entry of dirt and debris with pipe caps or plugs.

PART 2 PRODUCTS

2.1 CHILLED AND HOT WATER COILS:

A. Water coil capacities, pressure drops and selection procedures shall be certified for the capacity scheduled in accordance with ARI Standard 410. Non-certified coils will not be accepted.

B. Chilled and hot water coils shall be of the extended surface type meeting all conditions and having the minimum face area and pressure drops scheduled on the Drawings, and shall have same-end supply and return connections unless otherwise indicated. Coils shall be constructed of copper tubes 5/8" O.D. with .035" thick minimum wall thickness and copper fins permanently bonded to the tubes by mechanical expansion. Coils shall have a maximum of 8 fins per inch, and a maximum of 6 rows. If additional capacity is necessary, the additional capacity shall be provided by an additional coil, with an additional access section between the coils, and the coils shall be piped in series, counter flow to the direction of air flow. Copper fins on plate coils shall be .006" thick.

C. Coil headers and connections shall be of I.P.S. brass or heavy gauge seamless hard drawn copper tubing with penetrations for connection of core tubing by die-formed intrusion process with resulting contact depth between the header wall and core tubing of not less than .090". Joints between core tubing and header shall be of recess swage design to allow a large mating area for build up of brazing materials to give increased strength to the joint. Supply and return connection of brass or copper shall be terminated with National Pipe Threads with wrench flats.

D. Coils shall be designed and certified by the manufacturer to operate to scheduled face velocity plus 10% without moisture carry over. Each coil section shall be provided with a 316-L Stainless Steel frame/casing, including tube sheets, no lighter than 16 gauge. Frame members shall extend over the ends and edges of the coils and shall be constructed with formed holes for tubes, permitting free expansion and contraction of coil sections while supported by an extended surface of the frame. Intermediate tube support sheets of 316-L stainless steel shall be provided in all coils having tube lengths in excess of 48". on long coil sections the spacing of coil supports shall not exceed 48". All intermediate supports shall be welded to coil frame members and fabricated with formed tube holes to support the penetrating tubes.

E. Condensate from chilled water coils shall be piped to the nearest convenient floor drain. The pipe size shall be 1" minimum diameter, insulated as specified for chilled water piping. A trap of a minimum depth of 6 inches shall be provided in this drain line to prevent the escape or entry of air through the drain piping.
F. Where blow-through units are provided without internal heating coils in the hot deck position, a perforated plate shall be provided in place of the heating coils to simulate the air flow resistance of the absent coil.

G. Pressure test all coils to 350 psi under water.

H. Chilled water and hot water coils in ductwork and plenum (outside the air-handling units) shall be installed within the manufacturer’s supplied section / module with the casing as indicated in section 23 73 23 – air handling units.

2.2 WRAP-AROUND HEAT PIPE COIL

A. Heat pipe coil shall be of air-to-air heat transfer technology. Wrap-around heat pipe shall be “Colmac” or “Innergytech” heat pipe coils (heat exchangers) or equal and designed to efficiently transfer heat from a warm air stream to a colder one.

B. Heat pipe coil shall be Integral Fin Design with each heat pipe shall be made from one piece of material, with no discontinuities between fin and tube, to achieve the maximum heat transfer possible with minimum pressure drop. It also eliminates the possibility of corrosion at the tube and fin interface.

C. Integral fins will be fabricated from 1050 Aluminum Alloy. Heat pipes shall have a capillary wick structure integral to the heat pipe container wall.

D. The individual heat pipes coil shall consist of three elements: a sealed pipe, a capillary wick structure, and a refrigerant fluid, and all the pipes shall be sealed under a vacuum, with the working fluid is in equilibrium with its own vapor. The capillary wick shall distribute the working fluid over the inside of the pipe. Hot air flowing over one end of the pipe evaporates the working fluid. The vapor is then condensed at the cooler end, giving up its heat to the second air stream. The vapor flows back to the evaporator, completing the cycle.

E. The heat pipe coil shall be designed to be a sturdy, reliable unit. Individual “U” tubes shall be welded to each section of the heat pipe coil to ensure sound construction; individual tubes shall ensure that there is even distribution of working fluid in all heat pipes. Connections between the heat pipe sections shall be compact and located opposite to the dehumidification coil connections. The heat pipe coil shall be sized to closely wrap around the coil or to allow space between it and the cooling coil.

F. The heat pipe coils shall be sized in a manner similar to other heating/cooling coils, using a face velocity of 500 feet per minute. At this velocity, pressure drops across the heat pipe coil shall be modest when compared with other types of heat exchangers. If higher pressure drops can be tolerated, face velocities higher than 500 feet per minute can be used under proper conditions.

G. Heat pipe working fluids shall be R-134a, R-124, or be selected on the basis of heat pipe operating temperatures and compatibility with heat pipe container material.
H. Heat pipes shall be individually processed, charged, hermetically sealed and factory tested.

I. Heat pipe coil structural casing shall be fabricated from a minimum of Aluminum Alloy 5052, or 304 Stainless. The heat pipe coil shall be supplied with 4 flanges on the top and bottom along the front and back edges. Intermediate supports shall be furnished as required.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in ducts and casings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.

C. Support coil sections independent of piping on steel channel or double angle frames and secure to casings. Provide frames for maximum three coil sections. Arrange supports to avoid piercing drain pans. Provide airtight seal between coil and duct or casing.

D. Protect coils to prevent damage to fins and flanges. Comb out bent fins.

E. Make connections to coils with unions and flanges.

F. On water coils, provide shut-off valve on supply line and lock shield balancing valve on return line. Locate water supply at bottom of supply header and return water connection at top. Provide float operated automatic air vents at high points complete with stopvalve. Ensure water coils are drainable and provide drain connection at low points.

G. On water [and glycol] heating coils, and chilled water cooling coils, connect water supply to leaving air side of coil (counter flow arrangement).

H. For cooling coils where air velocity exceeds 550 ft./min provide three break moisture eliminators of 24 gauge (0.60 mm) copper.

I. Provide drain pan and drain connection for cooling coils. Fabricate drain pan from minimum 18-gauge 316L stainless steel. Extend 3 inches from face of coil entering air side, 18 inches from face of coil leaving air side and 4 inches from face of eliminators. Pipe drain pans individually to floor drain with water seal trap.

L. Insulate headers located outside air flow as specified for piping. Refer to Section 23 07 19.
M. Wire electric duct coils in accordance with ANSI/NFPA 70. Refer to Sections 26 05 19 and 26 27 26.

END OF SECTION
SECTION 238219

FAN COIL 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.

1.2 SUMMARY

A. This Section includes fan-coil units and accessories.

1.3 DEFINITIONS

A. BAS: Building automation system.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.


C. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

D. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. 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.
FAN COIL UNITS

1.6 COORDINATION

A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.7 WARRANTY

1. Warranty Period: One year from date of Substantial Completion.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: Furnish one spare fan belt for each unit installed.
2. Air Filters: One spare set for each unit installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

B. In the Fan-Coil-Unit Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
3. Basis-of-Design Product: The design for each fan-coil unit is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2 DUCTED FAN-COIL UNITS

A. Basis-of-Design Product: Trane or a comparable product by one of the following:

B. [ Manufacturers:

1. Carrier Corporation.
2. Engineered Air Ltd.
3. Environmental Technologies, Inc.
4. First Co.
7. Daikin McQuay.
8. Trane.
9. YORK International Corporation.

C. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

D. Coil Section Insulation: 1-inch thick matte elastomeric insulation complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
   1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.

E. Drain Pans: Stainless steel formed to slope from all directions to the drain connection as required by ASHRAE 62.

F. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panels.

G. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
   1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis.
   2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
   3. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.

H. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting MERV value as scheduled according to ASHRAE 52.2.

I. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig. Include manual air vent and drain.

J. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, electronically commutated (ECM) motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

K. Belt-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, electronically commutated (ECM) motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
   1. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

L. Control devices and operational sequence are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
M. Electrical Connection: Factory wire motors and controls for a single electrical connection.

N. Capacities and Characteristics as scheduled.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fan-coil units level and plumb.

B. Install fan-coil units to comply with NFPA 90A.

C. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste.
   a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

B. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23 Section "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
C.  Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D.  Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 DEMONSTRATION

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

END OF SECTION 238219
c. Spares: Include three fuses in use and three spare fuses in storage clips in each switch.

B. Surge Arresters: Comply with IEEE C62.11, Distribution class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.

2.4 DRY-TYPE TRANSFORMER SECTION


B. Enclosure: Indoor, ventilated, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy, with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.

C. Cooling System: Class AA, air cooled, complying with IEEE C57.12.01.

D. Insulation Materials: IEEE C57.12.01, rated 220 deg C.

E. Insulation Temperature Rise: 150 deg C, maximum rise above 40 deg C.

F. Basic Impulse Level: 440-10 kV LV and 30 kV HV.

G. Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps, 2 above and 2 below rated primary voltage.

H. Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps below rated primary voltage.

I. Sound level may not exceed 65 dBA level, without fans operating.

J. Impedance: 6.75 percent.

K. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

L. Energy efficient per DOE 2016.

2.5 SECONDARY DISTRIBUTION SECTION

A. Secondary Terminal Compartment: Bus for close coupling with busduct.

B. Secondary Distribution: Low-voltage switchboard as specified in Division 26 Section "Switchboards."

2.6 IDENTIFICATION DEVICES

A. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."
CONTRACTOR TO CLEAN ALL EXISTING MEDIUM PRESSURE SUPPLY AIR DUCTWORK
### Air Handling Unit Schedule (AHU/CAVU)

<table>
<thead>
<tr>
<th>Room</th>
<th>System</th>
<th>Location</th>
<th>Model</th>
<th>Btu/h</th>
<th>HSPF</th>
<th>Efficiency</th>
<th>Manufacturer</th>
<th>Notes</th>
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### Air Filter Schedule (AF)

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<th>System</th>
<th>Location</th>
<th>Model</th>
<th>Btu/h</th>
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### Chilled Water Precooling (PC) & Cooling (CC) Coil Schedule

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### Heat Pipe (HP) Coil Schedule

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### Hot Water Preheat (PH) & Heating (HC) Coil Schedule

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<th>Room</th>
<th>System</th>
<th>Location</th>
<th>Model</th>
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### Temporary Air Handling Unit Schedule

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<th>Room</th>
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<th>Location</th>
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<th>Btu/h</th>
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### Hot Water Heating Coil Schedule (Duct Mounted)

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<th>Room</th>
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TEMPORARY AHU INSTALLATION

NOTE

1. Green dot on top of pipe at 90 degrees clockwise from 12 o'clock.

2. Red dot on top of pipe at 90 degrees clockwise from 12 o'clock.

3. Black dot on top of pipe at 90 degrees clockwise from 12 o'clock.

4. Blue dot on top of pipe at 90 degrees clockwise from 12 o'clock.

5. White dot on top of pipe at 90 degrees clockwise from 12 o'clock.

6. Yellow dot on top of pipe at 90 degrees clockwise from 12 o'clock.

7. Orange dot on top of pipe at 90 degrees clockwise from 12 o'clock.

8. Pink dot on top of pipe at 90 degrees clockwise from 12 o'clock.

9. Purple dot on top of pipe at 90 degrees clockwise from 12 o'clock.

10. Brown dot on top of pipe at 90 degrees clockwise from 12 o'clock.

11. Gray dot on top of pipe at 90 degrees clockwise from 12 o'clock.

12. Silver dot on top of pipe at 90 degrees clockwise from 12 o'clock.

13. Gold dot on top of pipe at 90 degrees clockwise from 12 o'clock.

14. Clear dot on top of pipe at 90 degrees clockwise from 12 o'clock.

15. Green line on top of pipe at 90 degrees clockwise from 12 o'clock.

16. Red line on top of pipe at 90 degrees clockwise from 12 o'clock.

17. Black line on top of pipe at 90 degrees clockwise from 12 o'clock.

18. Blue line on top of pipe at 90 degrees clockwise from 12 o'clock.

19. White line on top of pipe at 90 degrees clockwise from 12 o'clock.

20. Yellow line on top of pipe at 90 degrees clockwise from 12 o'clock.

21. Orange line on top of pipe at 90 degrees clockwise from 12 o'clock.

22. Pink line on top of pipe at 90 degrees clockwise from 12 o'clock.

23. Purple line on top of pipe at 90 degrees clockwise from 12 o'clock.

24. Brown line on top of pipe at 90 degrees clockwise from 12 o'clock.

25. Gray line on top of pipe at 90 degrees clockwise from 12 o'clock.

26. Silver line on top of pipe at 90 degrees clockwise from 12 o'clock.

27. Gold line on top of pipe at 90 degrees clockwise from 12 o'clock.

28. Clear line on top of pipe at 90 degrees clockwise from 12 o'clock.

TEMPORARY AHU INSTALLATIONS DETAILS
SECTIONS - BASEMENT MECHANICAL ROOMS

SECTION A-A

SECTION B-B

SECTION C-C
SECTIONS - 3RD THRU 10TH FLOOR MECHANICAL ROOMS
SECTIONS - 8TH THRU 10TH FLOOR MECHANICAL ROOMS
HEAT EXCHANGER STEAM TO HOT WATER DIAGRAM

1. Notes for drawing:
   - Provide all 2" T/C lines in black plastisol for Type I/T categories:
     - Thermal Well, Condenser, Well, Requirements with Isolator Well.
   - Heat Exchanger cannot exist in horizontal, first type.
   - Provide working drawings before the actual drawings.
MONITOR AND DISPLAY AIR FILTER DIFFERENTIAL PRESSURES. ALARM ON PERSISTENT HIGH LIMITS.

ALARM AND OVERRIDE OPERATION TO ECONOMIZER MODE UPON FREEZE-STAT ACTIVATION.

OPEN MIXED AIR TEMPERATURE.

ENGAGE ECONOMIZER MODE WHEN OUTSIDE AIR TEMPERATURE DECREASES TO LESS THAN OWNER DEFINED SETPOINT.

CLOSE PRE-TREATED AIR DAMPER AND OPEN RELIEF DAMPER. MODULATE ECONOMIZER DAMPER INVERSELY PROPORTIONAL TO ECONOMIZER DAMPER.

ALARM ON PERSISTENT HIGH OR LOW OUTSIDE AIRFLOW.

ENGAGE ECONOMIZER MODE WHEN OUTSIDE AIR TEMPERATURE DECREASES TO LESS THAN OWNER DEFINED TEMPERATURE.

HOT-DECK TEMPERATURE.

MODULATE PRE-COOLING COIL TO MAINTAIN PRE-TREATED COLD DECK TEMPERATURE AT COOLING COIL PUMP AS OUTSIDE AIR DECREASES BELOW 35°F AND VISE VERSA.

ALARM ON PERSISTENT HIGH OR LOW COLD SUPPLY AIR TEMPERATURE.

COLD-DECK TEMPERATURE ACTS TO INCREASE CHW FLOW AND VISE VERSA.

ALARM ON PERSISTENT HIGH OR LOW COLD SUPPLY AIR TEMPERATURE.

MODULATE PRE-HEATING COIL TO MAINTAIN PRE-TREATED HOT-DECK TEMPERATURE.

AN INCREASE IN HOT DECK TEMPERATURE ACTS TO INCREASE RETURN AIR CO2 AND VISE VERSA.

ALARM ON PERSISTENT HIGH REHEAT TEMPERATURE.

MODULATE FAN SPEED TO MAINTAIN OUTSIDE AIRFLOW. AN INCREASE IN OUTSIDE AIRFLOW ACTS TO DECREASE FAN SPEED AND VISE VERSA.

RESET OUTSIDE AIRFLOW FROM MIN TO MAX AND RETURN AIR CO2 INCREASES FROM 700 TO 1100 PPM (ADJ).

MONITOR AND DISPLAY FINAL PRE-TREATED SUPPLY TEMPERATURE. ALARM ON PERSISTENT HIGH OR LOW LIMITS.

MONITOR AND DISPLAY AIR FILTER DIFFERENTIAL PRESSURES. ALARM ON PERSISTENT HIGH LIMITS.

ALARM AND DISENGAGE FAN, CLOSE INLET DAMPER, OPEN PRE-HEATING VALVE, OPEN PRE-COOLING VALVE, AND ENGAGE HW CIRCULATION PUMP UPON FREEZE-STAT ACTIVATION.

VALUES TO BE DETERMINED BY OWNER. ALARM ON PERSISTENT HIGH OR LOW HOT SUPPLY AIR TEMPERATURE.

HIGH OR LOW HOT SUPPLY AIR TEMPERATURE ACTS TO CLOSE THE HW CONTROL VALVE AND VISE VERSA.

RESET HOT DUCT TEMPERATURE SETPOINT PER OUTSIDE AIR TEMPERATURE LOOKUP SCHEDULE.

LOOKUP SCHEDULE VALUES TO DETERMINE THE OUTSIDE AIR TEMPERATURE ACTS TO OPEN THE CHW CONTROL VALVE AND VISE VERSA.

ALARM ON PERSISTENT HIGH STATUS FAILURE.

DISCRIMINATOR TO GRANT CONTROL AUTHORITY TO THE SENSOR INDICATING THE LOWEST PRESSURE.

SOFTWARE DISCRIMINATOR TO GRANT CONTROL AUTHORITY TO THE SENSOR INDICATING THE LOWEST PRESSURE.

MAINTAIN MINIMUM DUCT STATIC PRESSURE BETWEEN THE HOT AND COLD SUPPLY DUCTS. PROVIDE A SEQUENCE OF OPERATION:
The University of Texas Health Science Center at Houston
School of Public Health

UT HEALTH
SCIENCE
SCHOOL OF
PUBLIC HEALTH
1242 PRESSLEY ST.
HOUSTON, TX 77008

ISBD NUMBER 1

Sheet 4

Addendum 1

Addendum 2

Job Number

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08/16/2017

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LABORATORY CONTROLS WITH FUSE HOODS

TYPICAL LABORATORY CONTROL WITH FUSE HOODS

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Air Flow Station Installation

TYPICAL AIR VALVE & FUSE HEAD CONTROLS RETROFIT

DUAL DUCT SAV CONTROL DIAGRAM (NON LABORATORY APPLICATION)

HOT WATER SYSTEM CONTROL DIAGRAM
SEQUENCE OF OPERATION:

- **OPEN PRIMARY LAB EXHAUST FAN DAMPER AND ENGAGE PRIMARY LAB EXHAUST FANS CONTINUOUSLY.**
  - Interlock dampers to fans to delay fan operation until damper is fully open and vice versa.
  - Alarm on fan status failure.
  - Modulate primary lab fan speeds in tandem to maintain duct static pressure.
  - Provide software discriminator to grant control authority to the sensor indicating the highest pressure.
  - An increase in static pressure acts to increase fan speed and vice versa.

- **ENGAGE LEAD STACK EXHAUST FAN CONTINUOUSLY.**
  - Engage lag stack exhaust fan upon lead stack fan failure.
  - Automatically alternate lead and lag designations periodically to equalize fan run time.
  - Modulate bypass dampers in sequence to maintain stack discharge air velocity.
  - A decrease in stack velocity acts to open bypass dampers in sequence and vice versa.
  - Alarm on persistent low stack air velocity.

**SEQUENCE OF OPERATION:**

- **ENGAGE FAN TO RUN CONTINUOUSLY.**
  - Modulate fan speed to maintain space temperature.
  - An increase in space temperature acts to increase fan speed and vice versa.
  - Alarm and disengage fan on persistent fan status failure.
  - Modulate cooling coil to maintain cold deck temperature.
  - An increase in cold deck temperature acts to open CHW valve and vice versa.
  - Reset cold deck temperature in sequence with fan speed.
  - As fan speed decreases to min limit, increase cold deck setpoint temperature and vice versa.

- **ENGAGE ECONOMIZER SEQUENCE AS OUTSIDE AIR TEMPERATURE DECREASES BELOW SEPTION DEFINED BY OWNER.**
  - Disengage AHU fan in sequence with economizer.
  - Open economizer damper and engage exhaust fan.
  - Modulate exhaust fan speed to maintain space temperature.
  - An increase in space temperature acts to increase exhaust fan speed and vice versa.
  - Alarm and terminate economizer mode upon persistent exhaust fan status failure.
  - Monitor and display space temperature and filter differential pressure.
  - Alarm on high space temperature limit or high filter differential pressure limit.

**SEQUENCE OF OPERATION:**

- **ENGAGE FAN ON DEMAND, SCHEDULE, OR MANUAL OVERRIDE.**
  - Alarm and disengage fan on persistent fan status failure.
  - Modulate cooling coil to maintain space temperature (in sequence with terminal unit).
  - An increase in space temperature acts to open the CHW valve and vice versa.
  - Alarm on persistent high or low space temperature.
PROPOSED EMERGENCY ELECTRICAL RISER DIAGRAM
PROPOSED - 3RD FLOOR PLAN - POWER

- Locate and install new feeders in area of existing equipment.
- Check for possible changes in existing systems.
- New electrical conduits may be required.
- All work must be performed in accordance with local codes.
- Notify electrical contractor prior to installation.

PROPOSED - 3RD FLOOR MECHANICAL ROOM - POWER

- Check for possible changes in existing systems.
- New piping may be required.
- Notify mechanical contractor prior to installation.

PROPOSED - 3RD FLOOR ELEVATION OF NEW INSTALLATION

- Check for possible changes in existing systems.
- New structural elements may be required.
- Notify structural engineer prior to installation.
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}
THIRD FLOOR PLAN - PLUMBING

SCALE: 1/8" = 1'-0"
SIXTH FLOOR PLAN - PLUMBING

SCALE: 1/8" = 1'-0"
TENTH FLOOR PLAN - PLUMBING

SCALE: 1/8" = 1'-0"
1. Enlarged Basement Floor Plan - Plumbing

2. Water Softener Piping Detail