SECTION 23 00 00 – HEATING VENTILATION AND AIR CONDITIONING (HVAC)

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS, COMPLIANCE, UNIVERSITY GUIDELINES AND STANDARDS

A. Code Rules and Safety Orders:

1. Construction as called out on working drawings shall be in full accordance with the rules and regulations of all ten parts of the California Code of Regulations, Title 24 (The California Building Standards Code) per University administrative policy. Title 24 includes amended versions of the Uniform Building Code, Uniform Mechanical Code, Uniform Plumbing Code, National Electric Code and the Uniform Fire Code. Also included is the California Energy Code (Title 24, Part 6).

2. Location of Underground Utilities: Refer to 01 14 00,1.8, A.

B. Additional government codes and regulations shall be complied with as applicable to the project.

1. The regional air quality management district with jurisdiction over the Cal Poly Campus is the San Luis Obispo County Air Pollution Control District ((805) 781-5912) with headquarters in San Luis Obispo, California. Mechanical systems regulated by the district include: fume exhaust systems, cooling towers, fuel burning equipment (depending on size & fuel type), paint spray booths, incinerators, and dust handling equipment. A "Permit to Construct" must be obtained from the District prior to beginning construction or modification on any system regulated by the District. The Design Professional shall be responsible for identifying project impacts requiring compliance with Air Pollution Control District regulations Alternatives for compliance shall be discussed with the Cal Poly Project Manager. The Design Professional shall provide Cal Poly with all information required to obtain a "Permit to Construct". Permit applications, and related correspondence shall be channeled through the Cal Poly Environmental Health & Safety Office (Environmental Programs Manager).

2. Systems discharging to the campus sewer system shall be in compliance with the requirements of the City of San Luis Obispo Waste Water Treatment Plant (Industrial Waste Inspector (805) 781-7215). Mechanical systems discharging unusual wastes may require special provisions or may not be allowed. Triggers include high or low pH, oil, grease, chemical contamination, biological contamination, and rain water to the sewer. Mechanical systems typically

impacted include commercial kitchen waste, elevator sump pump discharge, lab process waste, and water purification system waste. The Design Professional shall be responsible for confirming impacts to the project due to the City Waste Water Discharge Ordinance. Alternatives for compliance shall be discussed with the University's Representative. Negotiations involving specific project issues shall be channeled through the CAL POLY Environmental Health & Safety Office (Director).

3. Chillers over 50lbs not used for general HVAC require inclusion in the campus leak detection and repair program and must be registered in California Air Resources Board (CARB) tracking system.
4. Contractor Quality Assurance. Refer to Milestones for Trade Shop Observation Walk-Downs in section 01 45 00, 1.6 Quality of Work, F., 1
5. Modification to the Campus Standards Specification or Details: Refer to 01 41 00 Regulatory Requirements, 1.3, 5. 5.

1.02 RELATED WORK

A. Division 01 - General Requirements
B. Section 07-84-00 – Firestopping
C. Division 14 - Conveying Equipment
D. Division 25 - Integrated Automation
E. Division 26 – Electrical
F. Division 27 - Communications
G. Division 33 – Utilities
H. Campus Standard Details - 3000 - Drainage
I. Campus Standard Details - 6000 - Utilities

1.03 BASIC DESIGN PRIORITIES:

A. Program Requirements / Design Guidelines / Government Codes: Mechanical systems shall be designed to meet the more stringent of: the user requirements as identified in the Program, the requirements these Design Guidelines, or applicable government codes and regulations. The Design Professional shall be responsible for notifying the University's Representative of conflicting requirements. The University's Representative shall provide the final decision as to how conflicts will be resolved.

B. Ease of Maintenance / Operation: Mechanical systems shall be designed to be easily maintained and operated. Access and service space shall be key considerations of the design. All Fixtures, Equipment, and Valves locations shall be designed and Installed to be Accessible, Readily (Readily Accessible). Capable of being reached quickly for

operation, renewal, or inspections without requiring those to whom ready access is requisite to take actions such as to use tools (other than keys), to climb over or under, to remove obstacles, or to resort to portable ladders, and so forth.

C. Factory-installed single gang toggle switch on the exterior of the VAV controls box for disconnecting line voltage power prior to opening the control panel. The VAV power supply (for example 115V) shall be separate from the 24V control power in the VAV panel.

1.04 EQUIPMENT REPLACEABILITY:

A. Mechanical equipment shall be located such that replacement is possible without building demolition. Buildings shall be provided with special provisions (oversized doors, removable louvers, access plates, etc.) as required to meet this requirement.

1.05 SYSTEM LIFE:

A. Mechanical systems shall be designed to last the life of the building. Components shall typically be institutional grade. With approval of the University's Representative, an exception to this requirement may be granted for systems to support specialized applications with a short life expectancy.

1.06 WATER CONSERVATION:

A. Mechanical system shall be designed to minimize water use. Cal Poly has a long-standing tradition of frugal water use. Design decisions which significantly impact water use shall be brought to the attention of the University's Representative. The University's Representative shall provide the final decision on such matters.

1.07 UTILITY METERING:

A. All mechanical utilities serving a building shall be metered. This shall include Water, Natural Gas, Campus Heating Hot Water, Campus Chilled Water and Chilled Water (when produced at a plant outside the building). See applicable Sections Division 25 - Integrated Automation, for metering specifics. A complex of residential buildings may be master metered with approval of the University's Representative.

1.08 DESIGN DOCUMENTATION:

A. Design documentation shall be provided for all mechanical systems to assure efficiency in the mechanical design process and to serve as a reference after construction.

B. Conceptual Design Report / Mechanical Systems: At the Schematic Design phase, submit a "Conceptual Design Report" for the project's mechanical systems, covering each anticipated mechanical system in the project. A key element of the report shall be a discussion of the alternative systems available to meet the identified needs. Design Development work for the mechanical systems shall not begin until the University's Representative has approved a conceptual alternative for each mechanical system.

1. Conceptual Design Report shall include:

a. Identification of the mechanical services required in each type of space included in the project.

b. The base criteria to be used for capacity sizing each mechanical service to each space type within the project. Identify the source of the criteria (e.g., consultant recommendation, program requirement, building user interview, code requirement, campus standard, equipment manufacturer). State extent to which services will be oversized to accommodate future growth.

c. A discussion of the pro and cons of the design alternatives available for each mechanical system.

d. A recommended alternative for each mechanical system.

e. Space allocation required for each recommended alternative.

f. A description of access to be provided to each major piece of mechanical equipment.

C. Design Development Report / Mechanical Systems:

1. The Design Development submittal shall include a "Design Development Report" covering each mechanical system in the project. This report shall include:

a. Room by room documentation of required mechanical services.

b. A written description of each mechanical system covering system purpose, system type, utility inputs, and locations of all major equipment.

c. The criteria to be used in sizing and laying out each mechanical system and the source of the criteria (similar to Conceptual Design Report).

d. Rough schematics of the proposed systems indicating major equipment, points of connection to existing utilities, and the rooms served by each mechanical utility.

e. A description of the required space to accommodate each major element of the proposed mechanical systems, including mechanical rooms, exterior mechanical yards, roof mounted mechanical equipment, mechanical shafts,

and ceiling space provisions.

f. A complete description of access for maintenance and replacement to each piece of mechanical equipment.

g. Rough equipment sizing calculations.

h. Catalog cut sheets on all major mechanical equipment.

2. Title 24 Building Envelope Plan Check Compliance Documents: The Design Professional shall submit Title 24, Part 6; Building Envelope Plan Check Compliance Documentation no later than the 50% Working Drawing Submittal. This documentation shall include applicable portions of forms; ENV-1, ENV-2, & ENV-3.

3. Title 24 Mechanical Plan Check Compliance Documents: Title 24 The Design Professional shall submit Title 24, Part 6; Mechanical Plan Check Compliance Documentation no later than the 50% Working Drawing Submittal. This documentation shall include applicable portions of forms; MECH-1, MECH-2, MECH-3 and MECH-4.

4. Final Mechanical Calculations & Equipment Documentation: Final mechanical calculations shall be submitted no later than the 50% Working Drawing Submittal. These calculations shall document the final basis of design for all mechanical equipment and systems. Title 24 plan check documentation may be used to supplement the calculations where applicable. Also included shall be manufacturer's catalog cut sheet and sizing tables on all major mechanical equipment being used as the basis of design.

D. Working Mechanical Drawings

1. Maintenance access space as recommended by the manufacturer shall be indicated on the drawings for all mechanical equipment Designated access spaces shall include as a minimum: equipment access door swings, control panel access, tube pulls, coil removal space, fan shaft removal space, lubrication point access, and fire box access.

2. No abbreviation or symbol shall be used on the drawings unless included in the legend.

3. No work shall be called out in a manner which is not contractually enforceable.

4. Work shall not be called out in a design / build format on drawings intended for competitive bidding unless specifically approved by the University's Representative.

5. Mechanical Equipment shall have all important features specified. (Model number alone shall not be considered sufficient) Specifications for University Projects must be open to more than one bidder per Public Works Contract Law except in very specific situations. The specifications should be written in a manner which encourages competition among vendors of equivalent mechanical equipment yet precludes inferior products. To this end the quality level of all major features should be specified. See Part 1 of the Guidelines for further guidance on the method of calling out equivalent products for University contracts.
6. Natural and Mechanical Ventilation
    a. California Mechanical Code (CMC) requires that naturally ventilated space must also be provided with mechanical ventilation unless the system meets any of the following exceptions:
        1) Exception #1: An engineered natural ventilation system where approved by the AHJ need not comply with Section 402.2.
        2) Exception #2: A mechanical ventilation system is not required where natural ventilation openings comply with the requirements of Section
        402.2 and are permanently open or have controls that prevent the openings from being closed during occupancy.
        3) Exception #3: A mechanical ventilation system is not required where the zone is not served by heating or cooling equipment.

E. Energy Design Goals:

1. Energy Efficiency: Mechanical system shall be designed to minimize energy use. Cal Poly has a long-standing tradition of frugal energy use. Design decisions which significantly impact energy use or cost shall be brought to the attention of the University's Representative. The University's Representative shall provide the final decision on such matters.
2. Depending on the project size, the ER is responsible for performing the energy model to demonstrate a project's energy efficiency to meet requirements of 2013 Title 24 Part 6 Energy Code, LEED Gold, and the CSU Energy Policy.
3. The following systems may be considered to help reach sustainability goals:
    a. Cogeneration
    b. Condensing boilers

c. Solar thermal for domestic hot water

d. Photovoltaic panels

e. Phase Change Material

f. Wall insulation

g. Glazing performance

h. Sunshades

i. Variable air volume system for Make-up Air and Exhaust

j. Heat Pump Hot Water Systems implementation for smaller zones using hydronic heat from building systems, CO2 or refrigeration systems and electric heat pumps rather than natural gas-fired units.

4. Energy Modeling and Life Cycle Cost Analysis (LCCA)

a. Depending on the project size, the design team is responsible for the energy modeling and performing additional LCCAs associated with any of the sustainability options listed.

5. For LEED documentation, at least one year of data collection is required, consisting of:

a. Total plant building and equipment electricity used, in kWh.

b. Total plant building and equipment gas used, in therms for MBTU.

c. Total heating energy output, in pounds or MBTU.

F. Mechanical Load Basis of Design

1. Outdoor Design Conditions

a. Summer: 87°F db/65°F WB (ASHRAE 0.5%, San Luis Obispo, CA)

1) For Refrigeration condensers use 105°F db.

b. Winter: 33°F (ASHRAE 0.2%, San Luis Obispo, CA)

c. Elevation: 320 ft.

d. California Climate Zone: 5

2. Indoor Design Conditions

a. Lecture Halls: heat to 70°F, cool to 76°F

b. Lab Space: heat to 70°F, cool to 76°F

c. Other spaces: heat to 70°F, cool to 76°F

d. Bedroom: Heating only, 70°F +/-2°F

e. Living Room: Heating only, 70°F +/-2°F

f. Study Room: Heating only, 70°F +/-2°F

g. Laundry Room: Ventilation and Heating only

h. Entry/Lobby (in dorm buildings): Ventilation and Heating only

i. Admin Spaces: 76°F cooling, 70°F heating

j. Elec. Rooms: Cooling only, 85°F

k. Data/telecom rooms: Cooling only, 75°F

l. Elevator machine rooms: Cooling only, 85°F, 75°F if Controller located in the Room. Current adopted Elevator Code Requirements shall take precedence in event of conflict of requirements. Refer to elevator manufacturer cooling requirements for additional information.

G. Indoor Humidity Control

1. All areas, unless otherwise noted: no humidifiers required.

H. California Minimum Ventilation Criteria

1. All areas: 15 cfm/person or 0.15 cfm/sq. ft. minimum, whichever is greater.
2. Comply with 2013 California Building Energy Efficiency Standard.
3. Comply with Chapter 4 of 2013 CMC.

I. Exhaust to Outdoors (Minimum Rates)

1. Toilet rooms: 12 air changes per hour or 75 cfm/fixture, whichever is greater.
2. Janitor closet: 100 cfm or 10 air changes per hour, whichever is greater.
3. Shower rooms: 12 air changes per hour
4. Main trash rooms: 12-15 air changes per hour
5. Floor trash closets: 50 to 100 cfm per floor
6. Kitchenette: 0.3 cfm per sf or hood exhaust rate, whichever is greater.

J. Building Envelope

1. Glazing: glass/frame combination
2. Typical vertical:

a. Description: double pane, low-e, and thermal break frame

b. U= 0.26 (center-of-glass summer daytime)

c. = 0.45 (with frame)

d. Solar heat gain factor = 0.27 (center-of-glass)

3. Typical skylight:
   a. Description: double pane, low-e, and thermal break frame
   b. U= 0.26 (center-of-glass summer daytime)
   c. U = 0.45 (with frame)
   d. Solar heat gain factor = 0.27 (center-of-glass)
4. Wall construction
   a. Description: 4" metal framing at 16" O.C.
   b. Insulation: R-13 batt insulation and 1" continuous rigid insulation at R-5 per inch.
   c. Overall U-value = 0.105
5. Roof construction:
   a. Insulation: R-30
   b. Overall U-value = 0.030

K. Internal Heat Gains
1. Lighting (The D-B Team shall confirm and coordination the following values with the Lighting Designer):
   a. Bedroom: 1 W/sq. ft.
   b. Corridor: 0.6 W/sq. ft.
   c. Restroom: 0.6 W/sq. ft.
   d. Living Room: 1.1 W/sq. ft.
   e. Study Room: 1.2 W/sq. ft.
   f. Community Kitchen: 1.6 W/sq. ft.
2. Receptacle power:
   a. Bedroom: 2.5 W/sq. ft.
   b. Living Room: 1 W/sq. ft.
   c. Study Room: 1.5 W/sq. ft.
   d. Light Recreation Space: 1 W/sq. ft.
3. Occupant heat gain:
   a. All areas: 250 Btuh sensible/250 Btuh latent

b. Light Recreation Space: 275 Btuh sensible/475 Btuh latent

4. Electrical transformers: 2% loss
5. Elevator machine rooms: refer to elevator drawings.
6. Telecom/MDF/IDF rooms: refer to low-voltage drawings.

L. Ductwork Design Criteria (Maximum Allowable Values)

1. Air velocities above these maximum values require acoustical treatment.
2. Supply ducts:
   a. Exposed in occupied spaces: 0.08" wg/100 ft and 1500 ft/min velocity
   b. Above ceiling in occupied spaces: 0.08" wg/100 ft and 1800 ft/min velocity
   c. In shafts adjacent occupied spaces: 0.20" wg/100 ft and 2000 ft/min velocity
   d. In shafts adjacent unoccupied spaces: 0.30" wg/100 ft and 3000 ft/min velocity.
3. Return/exhaust ducts:
   a. Exposed in occupied spaces: 0.06" wg/100 ft and 1000 ft/min velocity
   b. Above ceiling in occupied spaces: 0.06" wg/100 ft and 1500 ft/min velocity
   c. In shafts: 0.10" wg/100 ft and 2000 ft/min velocity
   d. In mechanical rooms: 0.20" wg/100 ft and 3000 ft/min velocity
4. General building/toilet exhaust ducts: 0.10" wg/100 ft and 1500 ft/min velocity

M. Coils

1. The University Standard is copper/copper construction (copper tubes, copper fins), exceeding industry "standard" coils which are copper/aluminum construction. Aluminum fins are prone to corrosion and are not allowed for the campus's coastal environment.
2. Maximum face velocity: 450 fpm
3. Maximum fins per inch: 12
4. Maximum air pressure drop – heating coil: 0.25" wc
5. Maximum tube pressure drop: 10 ft. wg.
6. Minimum tube pressure drop: 2 ft. wg.
7. Minimum tube rows – heating coil in air handler: 1
8. Minimum tube rows – reheat coil in VAV terminal unit: 2

N. Hydronic Piping Design Criteria

1. Max water pressure drop: 4 ft. wg./100 ft.
2. Max water velocity: 6 ft/sec
3. Max allowable water velocity: 10 ft/sec in mechanical rooms
4. Provide shut-off valve for isolation of major areas, at each piece of equipment, and each air handling system. Provide ability to isolate floors and major piping branches, including vents to break vacuum and vent air as well as drains pipe to floor sinks or drains. Required isolation valves and other equipment shall be clearly identified on the Drawings.
5. For piping loops requirements for chemical treatment and passivation, see Section 23 25 00, HVAC Water Treatment.

O. Heating Hot Water Temperatures

1. Plant heating water supply/return temperatures: 180°F/140°F
2. Radiant heating panels supply/return water temperatures: 180°F/160°F
3. Fin-Tube Baseboard Heaters supply/return water temperatures: 180°F/160°F

P. Chilled Water (CHW) Temperatures

1. Plant chilled water supply temperature is 40°F.
2. Minimum water side Delta T is 20°F, but provide 26° where possible.

Q. Redundancy Assumptions

1. Boilers: provide N+1 boiler redundancy
2. Heating water pumps: provide N+1 pump redundancy
3. If Cogen is used, provide full back-up capacity with boilers.

R. Metering and Controls

1. Provide BTU meter at each building to monitor heating hot water usage and DHW usage.
2. Building Automation System (BAS) DDC control system for complete system optimization of major equipment. Refer to Section 23 05 19 for Metering.

S. Economizers:

1. Evaluate life cycle costs for using economizers on units smaller than 75,000 Btuh, especially on 24/7 loads.

T. 24-Hour Cooling:

1. Provide dedicated HVAC equipment/systems to spaces requiring 24-hour cooling

(allowing unoccupied parts of the building to be shut down).

2. Buildings or zones within buildings having different cooling requirements from the rest of the building shall have a separate cooling system from the rest of the building.
3. Types of Spaces: Review program to determine spaces requiring 24-hour cooling (such as main data frame rooms, server rooms, telephone equipment rooms, elevator equipment rooms, labs and other areas containing special equipment).
4. Equipment Function: Based upon critical functions of equipment, evaluate and analyze cooling options and redundancy -- DX Units verses Central Plant Chilled Water versus Hybrid CHW/DX units.

U. Equipment Access:

1. Provide clear access to equipment for inspection and maintenance.
2. Access Panels: Provide adequate, unobstructed access to equipment and ceiling access panels.
3. Volume/Balancing Dampers: Locate access panels within 18 inches of service point.
4. Pumps in Mechanical Rooms: Orient pumps with the motor end towards the wall, and pumps, strainers and isolation valves toward the center of the room, making sure suction strainer is accessible.
5. Building Isolation Valves: In addition to building isolation valves required to be located within the building, valves at the street or adjacent to the Utilidor need to be raised, accessible and housed in a covered box, flush with ground level.

END OF SECTION 23 00 00

SECTION 23 05 19 - METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.01 REFERENCE STANDARDS

A. ASME B40.100 - Pressure Gauges and Gauge Attachments 2013.

B. ASME MFC-3M - Measurement of Fluid Flow in Pipes Using Orifice, Nozzle and Venturi 2004 (Reaffirmed 2017).

C. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers 2014.

D. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers 2014, with Editorial Revision (2017).

E. AWWA C700 - Cold-Water Meters -- Displacement Type, Metal Alloy Main Case 2015.

F. AWWA M6 - Water Meters -- Selection, Installation, Testing, and Maintenance 2012, with Addendum (2018).

G. UL 393 - Indicating Pressure Gauges for Fire-Protection Service Current Edition, Including All Revisions.

1.02 SUBMITTALS

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

1.03 GENERAL INFORMATION AND DESIGN GUIDELINES

A. Requirements: Refer to CSU Building Metering Guide. Website: http://www.calstate.edu/cpdc/ae/gsf/documents/CSU_Metering_Guide.pdf

B. Intent: Metering to meet the performance-based LEED NC/EB Energy & Atmosphere Credit – Building-level energy metering standards for ongoing accountability and optimization of building energy and water consumption performance over time.

C. Refer to and coordinate with Section 25 00 00 – Integrated Automation.

D. Metering Equipment: Allow Campus the ability to identify problems and achieve improved system performance. Select meters for future connection to a remote-read automated metering network.

E. BTU meter shall be installed at each building and for each system (heating, cooling and domestic water), Onicon System 10, F-3200 mag BTU Meter, or approved equal. Provide on the return side as well.

F. Flow Meters:

1. Onicon F-3200 to connect to Campus Building Management System (BMS) by Siemens.

2. Execution: Locate on straight run of pipe with no flow interruptions such as valves or direction change. Installed location shall typically have straight uninterrupted pipe for 10 diameters upstream and 5 diameters downstream. Consult manufacturer's installation instructions for specific installation requirements and other piping configurations. Install on the building return side, with BTU Meter to follow downstream. Do not use strap on types of meters. Use inline magmeters for flow meters.

G. Keys for Cabinets and Padlocks:

1. Cabinets and Equipment: Provide 2 keys per panel. Coordinate with Section 08 06 05 – Key Schedule.

2. Padlocks: Coordinate with Section 08 06 05 – Key Schedule.

3. Closeout Submittal: Provide panel keys separated and labeled. Provide location, room number, quantity, manufacturer name and model numbers of keys, and coordinate closeout submittal with Section 08 06 05 – Key Schedule.

PART 2 - PRODUCTS

2.01 POSITIVE DISPLACEMENT METERS (LIQUID)

A. AWWA C700, positive displacement disc type suitable for fluid with metal alloy main case and cast-iron frost-proof, breakaway bottom cap, hermetically sealed register, remote reading.

B. Provide so to be measure and monitored, with totalizer tied to the Building Management System (BMS).

C. Meter: Brass body turbine meter with magnetic drive register.

1. Service: Cold water, 122 degrees F (50 degrees C).
2. Service: Hot water, 200 degrees F (93 degrees C).
3. Accuracy: 1-1/2 percent.

2.02 HEAT CONSUMPTION METERS

A. Meter: Brass body turbine meter with magnetic drive register, platinum temperature sensors.

1. Maximum Service Temperature: 200 degrees F (93 degrees C).
2. Accuracy: 1-1/2 percent.

2.03 LIQUID FLOW METERS

A. Calibrated ASME MFC-3M Venturi orifice plate and flanges with valved taps, chart for conversion of differential pressure readings to flow rate, with pressure gauge in case.

B. Annular element flow stations with meter set.

1. Measuring Station: Type 316 stainless steel pitot type flow element inserted through welded threaded couplet, with safety shut-off valves and quick coupling connections, and permanent metal tag indicating design flow rate, reading for design flow rate, metered fluid, line size, station or location number.
   a. Pressure rating: 275 psi (1896 kPa).
   b. Maximum temperature: 400 degrees F (204 degrees C).
   c. Accuracy: Plus, 0.55 percent to minus 2.30 percent.

2.04 PRESSURE GAUGES

A. Pressure Gauges: ASME B40.100, UL 393 stainless steel case internals and connection, no brass or bronze, with no calibration adjustment, black scale on white background.

1. Mid-Scale Accuracy: Grade 1A or better. Accuracy shall be uniform throughout scale.

2. Scale: PSI or inches of mercury, or a combination.

2.05 PRESSURE GAUGE TAPPINGS

A. Gauge Cock: Tee or lever handle, brass for maximum 150 psi (1034 kPa).

B. Needle Valve: Brass, 1/4-inch (6 mm) NPT for minimum 150 psi (1034 kPa).

C. Pulsation Damper: Pressure snubber, brass with 1/4-inch (6 mm) connections.

D. Syphon: Steel, Schedule 40, 1/4-inch (6 mm) angle or straight pattern.

2.06 DIAL THERMOMETERS

A. Thermometers - Fixed Mounting: Dial type bimetallic actuated; ASTM E1; stainless steel case, adjustable, minimum 3" diameter, white with black markings and black pointer, hermetically sealed lens, stainless steel stem.

1. Accuracy: 1 percent.
2. Calibration: Degrees F.

B. Thermometer: ASTM E1, stainless steel case, adjustable angle with front recalibration, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed lens, stainless steel stem.

1. ASME B40.3 Grade A.
2. Accuracy: 1 percent.
3. Calibration: Degrees F.
4. Provide by Miljoco, Ashcroft, or approved equivalent.

C. Provide DDC sensor at dry wells.

2.07 STATIC PRESSURE GAUGES

A. 3-1/2-inch (90 mm) diameter dial in metal case, diaphragm actuated, black figures on white background, front recalibration adjustment, 2 percent of full-scale accuracy.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install positive displacement meters with isolating valves on inlet and outlet to AWWA M6. Provide full line size valved bypass with globe valve for liquid service meters.

B. Provide instruments with scale ranges selected according to service with largest appropriate scale.

END OF SECTION 23 05 19

SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT PART 1 GENERAL

1.01 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Adhesive-backed duct markers.

D. Stencils.

E. Pipe labeling and markers.

F. Ceiling tacks.

1.02 REFERENCE STANDARDS

A. Current Office of State Fire Marshal adopted Edition of the California Mechanical Code (CMC)

B. ANSI/ASME A13.1 - Scheme for the Identification of Piping Systems

1.03 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements for submittal procedures.

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

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

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

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

F. Project Record Documents: Record actual locations of tagged valves.

G. ANSI/ASME A13.1 Pipe Labeling Product Submittal.

H. Access Panels and ACT Tiling Grid Labeling

1.04 University Guidelines and Requirements

A. All piping shall be identified per ANSI/ASME A13.1 - Scheme for the Identification of Piping Systems. Provide labels every 50 feet including common name of fluid, gas, or chemical in pipe with concentration and GHS pictogram for hazard, direction of flow, place labels near valves and flanges. Submit proposed labeling for review and approval by Cal Poly Representative in consultation with Facility Services and the Campus Engineer.

B. Access Panels shall be labeled using P-Touch labels. P-Touch labels shall be: TZES141 ~3/4" Black Print on Clear Extra Strength label tape.

C. ACT Ceiling Tile Grid shall be labeled using P-Touch labels. P-Touch labels shall be: TZES141~3/4" Black Print on Clear Extra Strength label tape

D. Volume/Balancing Dampers:

1. Plan Notations: Clearly identify on plans.
2. Field Identification: Provide visible, accessible identification. Example: Bright-colored streamers.

E. Property ID Labels for Equipment:

F. Submittals:

1. List of Equipment for Property ID Labels:

2. Submit list of equipment for Property ID Labels, including location, function, equipment manufacturer's name, and model and serial numbers for verification by Engineer.
3. After acceptance by Engineer: Submit hard and electronic copies for assignment of bar-coding identification numbers by Campus Facility Services.
4. Samples: Submit two Property ID Labels.
5. Closeout Submittals: Project Record Documents: Record actual locations of labeled items; include bar-code numbers, and provide as-built electronic copy of list of equipment with location, function, equipment manufacturer's name, and model and serial numbers.

G. Pre-Installation Meetings:
1. Convene minimum two weeks prior to commencing work of this section.

H. Labels:
1. Description: Property ID Labels.
2. Material: Anodized Aluminum.
3. Size: 2 x 0.875 inches.
4. Attachment: Adhesive backed.
5. Message:
6. Printed identification:
7. First Line: "[University Name] MEP"
8. Second Line: "Facility Services"
9. Bar code: Code numbers shall be provided by the University Facility Services via the Trustees Representative.

PART 2 PRODUCTS

2.01 IDENTIFICATION APPLICATIONS

A. Air Handling Units: Nameplates.

B. Air Terminal Units: Tags.

C. Automatic Controls: Tags. Key to control schematic.

D. Control Panels: Nameplates.

E. Ductwork: Nameplates.

F. Heat Transfer Equipment: Nameplates.

G. Instrumentation: Tags.

H. Major Control Components: Nameplates.

I. Piping: Tags.

J. Pumps: Nameplates.

K. Relays: Tags.

L. Small-sized Equipment: Tags.

M. Tanks: Nameplates.

N. Thermostats: Nameplates.

O. Valves: Tags and ceiling tacks where located above lay-in ceiling.

P. Water Treatment Devices: Nameplates.

2.02 NAMEPLATES

A. Manufacturers:

B. Letter Color: White.

C. Letter Height: 1/4 inch (6 mm).

D. Background Color: Black.

2.03 TAGS

A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2-inch (40 mm) diameter.

B. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2-inch (40 mm) diameter with smooth edges.

2.04 ADHESIVE-BACKED DUCT MARKERS

2.05 STENCILS

A. Stencils: With clean cut symbols and letters of following size:

1. 3/4 to 1-1/4 inch (20-30 mm) Outside Diameter of Insulation or Pipe: 8 inch (200 mm) long color field, 1/2 inch (15 mm) high letters.

2.06 PIPE MARKERS

A. Color: Comply with the most current edition of ANSI/ASME A13.1 for the Primary Identification, the Additional Means of Identification ASME A13.1, the Secondary Identification,

Placement, the ANSI / ASME A13.1 Size Chart (Pipe Overall Diameter, the Marker Size & Letter Height), and the Abandoned Piping identification. The Contractor shall provide and install all of the aforementioned requirements per the most current edition of ANSI/ASME A13.1.

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

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

D. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches (150 mm) wide by 4 mil (0.10 mm) thick, manufactured for direct burial service.

E. Color code as follows:

1. Heating, Cooling, and Boiler Feedwater: Green with white letters.
2. Toxic and Corrosive Fluids: Orange with black letters.
3. Compressed Air: Blue with white letters.

2.07 CEILING TACKS

A. Description: Steel with 3/4-inch (20 mm) diameter color coded head.

PART 3 EXECUTION

3.01 INSTALLATION

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

B. Install ductwork with plastic nameplates. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

END OF SECTION 23 05 53

SECTION 23 08 00 – MECHANICAL SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. System specific commissioning

B. Related Sections:
   1. 01 91 15, "General Commissioning Requirements"
      a. To be provided on a project-by-project basis, where required
   2. 01 33 00, "Submittal Procedures"
   3. 01 77 00, "Contract Closeout Procedures"
   4. 01 78 23, "Operation and Maintenance Data"
   5. Coordinate with Division 27 Requirements and the Campus ITS Department.

1.2 DESCRIPTION OF WORK – refer to Section 01 91 15

1.3 SUBMITTALS – refer to Section 01 91 15

PART 2 – PRODUCTS – refer to Section 01 91 15

PART 3 – EXECUTION

3.1 COMMISSIONING PROCESS AND PROCEDURES – refer to Section 01 91 15

3.2 PRE-FUNCTIONAL CHECKLISTS

A. Pre-Functional Test is defined under Section 01 91 15. Only the sample checklists are provided in this section as **Exhibit 23 08 00-A** as an indication of the format and rigor of the required pre-functional checklists and documentation. Though not developed specifically for this project, they show the extent of checks involved associated with typical installations. Actual Pre-Functional Checklist shall be prepared by the CA upon review of all the contractor submittals, including manufacturer's installation instructions and O&M manuals.

B. These checklists do not take the place of the manufacturer's recommended checkout and start-up procedures or report.

C. Regardless of whether the CA includes them or not, checks, inspections, safety measures, quality control measures and start-up procedures recommended by the manufacturer shall be implemented by the Contractor prior to initiation of the commissioning activity.

D. The Commissioning Coordinator (CC) employed by the Contractor shall be responsible for directing all Pre-Functional Check lists provided by the CA. The CC shall engage subcontractors and vendors service representatives with expertise in the specific equipment or system to determine whether the equipment or system passes the checks detailed in the Pre-Functional Checklist.

E. CC shall communicate the actual schedule for the execution of the Pre-Functional Checks to the CA as provided under Section 01 91 15.

F. The Commissioning Authority (CA) may choose to participate in the inspection of items along with the Contractor and specialty subcontractors and vendors. In addition, CA reserves the right to inspect any or all of the items on his own in order to satisfy that the installation conforms to the design objectives and the system is ready for Functional Testing.

G. For additional information on how the Pre-Functional Checklists fits within the overall framework of Commissioning as well as the Contractor's obligations under the same, please see Section 01 91 15.

3.3 FUNCTIONAL PERFORMANCE TEST PROCEDURES (FPTs)

A. Contractor shall assist the Commissioning Authority (CA) in developing the Working Functional Performance Test (FPT) Procedures as specified in Section 01 91 15. For any given equipment or system subcontractors and equipment suppliers associated with and specializing in the specific equipment are required to participate in developing the working procedures for the indicated FPTs. It is conceivable that for certain equipment and systems, multiple subcontractors and specialties may be required to participate to contribute to the development of the Functional Test. Contractor shall extend his full cooperation to the CA in securing the subcontractor or supplier resources necessary to develop and implement the Functional Tests.

B. The Contractor's Commissioning Coordinator is required to manage the subcontractors in developing the Working FPT Procedures and Data Forms, and in performing all FPT's.

C. Though not developed specifically for this project, the sample Functional Test

Procedures shown under **Exhibit 23 08 00-B** are provided as an indication of the format and rigor of the required Functional Testing procedures and documentation.

D. CA may approve certain equipment performance tests to be conducted at the factory. If so, Contractor shall make arrangements and pay for travel costs for Owner and the CA to visit the factory and witness such tests at the factory.

E. Contractor shall be responsible for demonstrating the successful testing of 100% of the systems to be commissioned per the Functional Test plans and procedures provided by the CA.

F. CA shall develop the Functional Test following review of all contractor submittals. The Functional Test documents shall be made available immediately upon the successful completion of the Pre-Functional Check Lists and correction of all issues identified in the Pre-Functional Checklist.

G. Contractor shall allow a reasonable time frame after the completion of TAB activities to schedule and conduct the Functional Tests. Functional tests shall commence only upon completion of the TAB activities and all flows and measurement data established through the TAB process are available for the Commissioning Agent's review. In no event shall the commissioning Functional Test duration be less than four weeks, plus what is reasonably required to correct issues identified and time required for retest and back-check. Noted duration is general guidance and will vary on a project-by-project basis. Contractor shall coordinate the work of other disciplines so that commissioning test procedures are not interrupted as a result of work that needs to be performed inside or outside the building.

H. Refer to Section 01 91 15 for additional requirements regarding Functional Tests.

END OF SECTION 23 08 00

EXHIBIT 23 08 00 - A – Pre-Functional Checklist Sample

Pre-functional Checklist

System Type: Makeup Air Units

PFC Form ID: M.01

A. Submittal/Approval

Submittal. The above equipment and systems integral to them are complete and ready for functional testing. The checklist items are complete and have been checked off only by parties having direct knowledge of the event, as marked below, respective to each responsible contractor. This prefunctional checklist is submitted for approval, subject to an attached list of outstanding items yet to be completed. A Statement of Correction will be submitted upon completion of any outstanding areas. None of the outstanding items preclude safe and reliable functional tests being performed.

General Contractor	Date	Electrical Contractor	Date
Mechanical Contractor	Date	Controls Contractor	Date

Pre-functional checklist items are to be completed as part of start-up & initial checkout, preparatory to functional testing.

- Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).
- If this form is not used for documenting, one of similar rigor shall be used.
- General contractor shall assign checklist sections to the respective sub-contractors.
- General Contractor shall be responsible to see that the checklist items by their sub-contractors are completed and checked off.

Approvals. This filled-out checklist has been reviewed. Its completion is approved with the exceptions noted in the issues log.

Commissioning Authority	Date

B. Model Verification

Enter nameplate information; Verify installed units match approved submittals:

Unit ID:	MUA-1
Manufacturer:	
Model:	
Serial Number:	
CFM:	
Cooling Capacity (MBH):	
Heating Capacity (MBH):	

Unit ID:	MUA-2
Manufacturer:	
Model:	
Serial Number:	
CFM:	
Cooling Capacity (MBH):	
Heating Capacity (MBH):	

C. Installation Checks

Check if Okay. Enter "N/A" if not applicable. Enter note number if deficient.

		Equipment Tag		
Tag	**Inspection Item**	**MUA-1**	**MUA-2**	**Comments**
1.00	DOCUMENTATION			
	Verify if the following items have been submitted:			
1.01	Manufacturer's cut sheets including performance data (if available)			
1.02	Installation and startup manual / plan			
1.03	O&M manuals			
1.04	Control sequences			
2.00	CABINET AND GENERAL INSTALLATION			
2.01	Permanent labels affixed - indoor and outdoor units			
2.02	Casing condition good: no dents, leaks, door gaskets installed			
2.03	Access doors close tightly - no leaks			
2.04	Boot between duct and unit tight and in good condition			
2.05	Vibration isolation equipment installed & released from shipping locks			
2.06	Maintenance access acceptable for unit and components			
2.07	Sound attenuation installed (if applicable)			
2.08	Thermal insulation properly installed according to specifications			
2.09	Instrumentation installed according to specifications (temperature gauges, pressure gages, flow meters, etc.)			
2.10	All the duct connections to the cabinet are air tight and insulated			
2.11	Filters installed and replacement type and efficiency label permanently affixed to housing - construction filters removed			
3.00	FANS AND DAMPERS			
3.01	Supply fan and motor alignment appear correct			
3.02	Supply fan belt tension and condition appear OK (if applicable)			
3.03	Supply fan protective shrouds for belts in place and secure (if applicable)			
3.04	Supply fan area clean			
3.05	Supply fan and motor properly lubricated			
3.06	Smoke and fire dampers installed properly per contract documents (proper location, access doors, appropriate ratings verified)			
3.07	All dampers close tightly			

Tag	Inspection Item	MUA-1	MUA-2	Comments
3.08	All damper linkages have minimum play			
4.00	DUCTING			
4.01	Duct joint sealant properly installed			
4.02	No apparent severe duct restrictions			
4.03	Turning vanes installed in square elbows (if applicable)			
4.04	OSA intakes located away from pollutant sources & exhaust outlets			
4.05	Pressure leakage tests completed (if applicable)			
4.06	Branch duct control dampers operable (if applicable)			
4.07	Ducts cleaned as per specifications			
4.08	Balancing dampers installed as per drawings and TAB company site visit			
4.09	Sound attenuators installed (if applicable)			
8.00	ELECTRICAL			
8.01	Power disconnects in place and labeled			
8.02	All electric connections tight			
8.03	Proper grounding installed for unit and components			
8.04	Safeties in place and operable			
8.05	Breaker size and type correct			
8.06	Power disconnect located within sight of unit controller (per electrical code)			
9.00	CONTROLS			
9.01	Control system interlocks hooked up and functional			
9.02	Related thermostats are installed			
9.03	Related building automation system points are installed			
9.04	All control devices and wiring complete			
9.05	Sensors calibrated (per specifications)			
9.06	Specified sequences of operation and operating schedules have been implemented with all variations documented			
10.00	OPERATIONAL			
10.01	Supply fan rotation correct			
10.02	Supply fan - No unusual vibration or noise			
10.03	Condenser fan rotation correct			
10.04	Condenser fan noise and vibration acceptable			

Tag	Inspection Item	MUA-1	MUA-2	Comments
10.05	**Compressor** - Measure line-to-line voltage imbalance *(% Imbalance = 100 x (max. deviation from avg.) / avg.)* Fan motor (line-to-line voltage): a) Ph 1: _____ b) Ph 2: _____ c) Ph 3: _____ d) Average voltage: e) % Imbalance: f) Is imbalance less than 2%? (Yes/No)	a)_____ b)_____ c)_____ d)_____ e)_____ f)_____	a)_____ b)_____ c)_____ d)_____ e)_____ f)_____	
10.06	**Compressor** - Verify full load running amps a) Rated Amps: _____ Rated FL amps x _____srvc factor = _____ (Max amps) b) Measured Amps: _____ c) Running less than max? (Yes/No)	a)_____ b)_____ c)_____	a)_____ b)_____ c)_____	
10.07	If **supply** fan is > 5 HP, measure line-to-line voltage imbalance. (If VFD-equipped, measure upstream of VFD). *(% Imbalance = 100 x (max. deviation from avg.) / avg.)* Fan motor (line-to-line voltage): a) Phase 1 (V) = b) Phase 2 (V) = c) Phase 3 (V) = d) Average Voltage (V) = e) Percent Imbalance (%) = f) Is imbalance less than 2% (Yes/No)?	a)_____ b)_____ c)_____ d)_____ e)_____ f)_____	a)_____ b)_____ c)_____ d)_____ e)_____ f)_____	
10.08	If **supply** fan is > 5 HP - Verify full load running amps. (If VFD-equipped, measure upstream of VFD). (Rated FL amps x srvc factor = Max amps) a) Rated Amps = b) Measured Amps (A) = c) Running less than Max (Yes/No) =	a)_____ b)_____ c)_____	a)_____ b)_____ c)_____	

END OF EXHIBIT

EXHIBIT 23 08 00 - B – Functional Test Procedure

Sample

Functional Test Procedures

Project Name

System: Rooftop Unit
Date: Click or tap to enter a date.

FTP **M.01**

A. Objectives

1. Confirm satisfactory operation of airside system(s).

B. Equipment

	EQUIPMENT ID	DESCRIPTION OF EQUIPMENT
1.		
2.		
3.		
4.		

C. Participants

	NAME	COMPANY	FUNCTION	ROLE
1.				Party filling out this form and witnessing the test.
2.				Party operating the equipment and executing the test.

D. Prerequisite Checklist

	ITEM	☑
1.	Pre-functional checks completed.	☐
2.	TAB complete and zone design lows previously verified.	☐
3.	All safety devices (such as high pressure switches) have been checked.	☐
4.	VFD start-up and testing is complete.	☐
5.	Occupants (if any) notified that testing in progress and zone temperatures will be significantly out of normal range.	☐
6.	No interior dust or fumes in the building.	☐
7.	BAS system able to display real time measured condition in the air handler and in all zones.	☐
8.	All fire dampers open.	☐
9.	Condensate trap at the air handler is primed.	☐

E. Test Procedure

SEQ. #	SEQUENCE/TEST	EXPECTED RESPONSE	ACTUAL RESPONSE	PASS ☑
1.	<u>AHU Disable</u> With AHU initially enabled, command the AHU off by BAS. Re-enable the AHU. Simulate a condition where the programmed schedule turns the AHU off.	*Verify by visual inspection that:* Supply fan on AHU slowly ramps down (through VFD) and comes to a stop. OSA & relief dampers are closed. Return damper is open AHU is disabled.	Supply Fan Off: ☐ YES ☐ NO OSA & Relief Dampers are Closed: ☐ YES ☐ NO Return Damper is Open: ☐ YES ☐ NO AHU is disabled via schedule: ☐ YES ☐ NO	☐ YES ☐ NO ☐ N/A
2.	<u>AHU Enable</u> Operation check with AHU commanded on by BAS. Verify that the programmed schedule can also enable the unit	*Verify by visual inspection that:* OSA & return dampers are opened. Supply fan on AHU slowly ramp up to min speed (through VFDs). Supply fan speed control loop is enabled after supply fan status is confirmed. Supply air temperature (SAT) control loop is enabled. AHU shall enable based on scheduled occupancy. Programmed schedule per SOO.	OSA & Return Dampers Open: ☐ YES ☐ NO Supply Fan On: ☐ YES ☐ NO Supply fan speed control loop is enabled: ☐ YES ☐ NO SAT Control Loop is Enabled: ☐ YES ☐ NO AHU shall enable with schedule: ☐ YES ☐ NO Schedule per SOO: ☐ YES ☐ NO	☐ YES ☐ NO ☐ N/A

SEQ. #	SEQUENCE/TEST	EXPECTED RESPONSE	ACTUAL RESPONSE	PASS ☑
3.	Basic VFD Operation (Supply Fans) Check the rotation of the fans in drive mode. Check the rotation of the fans in by-pass mode. Document basic VFD programmed parameters. Verify speed output at VFD (%) is same as the speed output command at BAS.		Fan speed rotation correct in drive mode: ☐ YES ☐ NO Fan speed rotation correct in by-pass: ☐ YES ☐ NO ☐ N/A Motor speed low/high limit: ## / ## Hz Ramp up/down time: ## / ## s Min/Max reference: ## / ## % Min/Max speed ref: ## / ## Hz Speed at BAS matches VFD: ☐ YES ☐ NO ☐ N/A	☐ YES ☐ NO ☐ N/A

SEQ. #	SEQUENCE/TEST	EXPECTED RESPONSE	ACTUAL RESPONSE	PASS ☑
4.	VFD Response to Zone Air flow Demand & Minimum OSA For this test, disable (a) DCV and (b) economizer, if installed. *Minimum Flow*: Adjust cooling and heating setpoints such that zone temperature is __3__ °F above heating setpoint and __3__ °F below cooling setpoint. *Design Flow*: Adjust cooling and heating setpoints such that zone temperature is __3__ °F below heating setpoint OR __3__ °F above cooling setpoint.	VFD shall modulate supply fan to its min programmed speed of __15__ (%). The OSA damper shall modulate to its programmed *Lo Flow Vent Limit* of __30__ (%). VFD shall ramp up fan speed to its max programmed speed of __100__ (%). The OSA damper shall modulate to its programmed *Vent Limit* of __15__ (%). For all temperature demand conditions, fan speed shall stabilize after some time without hunting.	Supply Fan Speed: __##__ (%), or __##__ (Hz) OSA CFM: ## OSA Damper: __##__ (%) Return Damper: __##__ (%) Supply Fan Speed: __##__ (%), or __##__ (Hz) OSA CFM: ## OSA Damper: __##__ (%) Return Damper: __##__ (%) VFD speed modulates to maintain the required flow at the zones: ☐ YES ☐ NO	☐ YES ☐ NO ☐ N/A
5.	Supply Fan Speed (PID Loop) Gather 24-hour trend data for the following control points: - *Supply Fan Speed* - *Zone Temp & Setpoint* Also, a separate trend for: - *Supply Fan Speed* - *OAD Position*	Trend data shall demonstrate stable and responsive controls	Trend data attached to this FTP as a graphic in Exhibit 1A & 1B ? ☐ YES ☐ NO Trend data shows stable and responsive controls? ☐ YES ☐ NO	☐ YES ☐ NO ☐ N/A

SEQ. #	SEQUENCE/TEST	EXPECTED RESPONSE	ACTUAL RESPONSE	PASS ☑
6.	Economizer Control *Warm OSA Condition (i.e., Economizer Off)*: Set the system to cooling mode with a SAT setpoint of 65 °F. Simulate a condition such that: 1) OSA temperature is greater than return air temperature, OR *Cool OSA Condition (i.e., Economizer On)*: Simulate a condition where all the following are true: 1) OSA temperature is below return air temperature, AND Lower the SAT setpoint to 55 °F.	Economizing remains disabled. OSA damper shall modulate to maintain minimum OSA while CHW cooling operates to maintain supply air setpoint. OAD damper shall modulate open to 100%. RAD shall close. CHW cooling shall remain off until RAD is fully closed and the economizing alone is not able to meet supply air setpoint.	Economizing disabled: ☐ YES ☐ NO OAD modulates to maintain min OSA: ☐ YES ☐ NO RA damper inverse to OSA damper: ☐ YES ☐ NO OSA damper 100% open: ☐ YES ☐ NO RAD closes: ☐ YES ☐ NO CHW cooling off (initially): ☐ YES ☐ NO OSA damper 100% Open: ☐ YES ☐ NO RAD closes fully: ☐ YES ☐ NO CHW cooling on to maintain SAT setpoint: ☐ YES ☐ NO	☐ YES ☐ NO ☐ N/A
7.	Economizer (PID Loop) Gather 24-hour trend data for the following control points: - *OSA Damper* - *Temperature (SAT, RAT, OAT)* - *CHW valve*	Trend data shall demonstrate stable and responsive controls	Trend data attached to this FTP as a graphic in Exhibit 2 ? ☐ YES ☐ NO Trend data shows stable and responsive controls? ☐ YES ☐ NO	☐ YES ☐ NO ☐ N/A

SEQ. #	SEQUENCE/TEST	EXPECTED RESPONSE	ACTUAL RESPONSE	PASS ☑
8.	Basic Heating Valve Control Heating coil shall be enabled whenever all conditions are true: - AHU is enabled. - Zone temp < Zone setpoint Simulate a test with all conditions true to enable heating. Test shall be performed during a cold morning. Temporarily disable SAT setpoint reset (if programmed). Override the system and set SAT setpoint to 75 °F. Increase supply air temperature setpoint to 95 °F to simulate a higher load. Test each false condition (above) and verify heating is disabled.	Heating coil shall be enabled with all conditions true. While active, the controller shall measure the supply air temperature (SAT) and modulate the heating coil valve to maintain a SAT setpoint. Heating coil valve shall modulate open to maintain the higher load. Heating shall be disabled with any false condition.	Heating coil enabled? ☐ YES ☐ NO Supply Fan Speed: ## %. OAT / MAT / SAT: ## / ## / ## °F HW Valve %: ## % Heating valve modulates more open? ☐ YES ☐ NO Supply Fan Speed: ## %. OAT / MAT / SAT: ## / ## / ## °F HW Valve %: ## % In lieu of the above, insert a screenshot of the AHU below. Heating is disabled with each of the stated false conditions? ☐ YES ☐ NO ☐ N/A	☐ YES ☐ NO ☐ N/A

SEQ. #	SEQUENCE/TEST	EXPECTED RESPONSE	ACTUAL RESPONSE	PASS ☑
9.	Basic Cooling Valve Control Cooling coil shall be enabled whenever all conditions are true: - AHU is enabled. - Zone temp < Zone setpoint Simulate a test with all conditions true to enable cooling. Test shall be performed during a hot day. Temporarily disable SAT setpoint reset (if programmed). Override the system and set SAT setpoint to 65 °F. Decrease supply air temperature setpoint to 55 °F to simulate a higher load. Test each false condition (above) and verify cooling is disabled.	Cooling coil shall be enabled with all conditions true. While active, the controller shall measure the supply air temperature (SAT) and modulate the cooling coil valve to maintain a SAT setpoint. Cooling coil valve shall modulate open to maintain the higher load. Cooling shall be disabled with any false condition.	Cooling coil enabled? ☐ YES ☐ NO Supply Fan Speed: ## %. OAT / MAT / SAT: ## / ## / ## °F CHW Valve %: ## % Cooling valve modulates more open? ☐ YES ☐ NO Supply Fan Speed: ## %. OAT / MAT / SAT: ## / ## / ## °F CHW Valve %: ## % In lieu of the above, insert a screenshot of the AHU below. Cooling is disabled with each of the stated false conditions? ☐ YES ☐ NO ☐ N/A	☐ YES ☐ NO ☐ N/A

SEQ. #	SEQUENCE/TEST	EXPECTED RESPONSE	ACTUAL RESPONSE	PASS ☑
10.	Pre-Occupancy 1-Hr Purge Mode Operation check with AHU commanded to Pre-Occupancy 1-Hr Purge Mode by BAS	*Verify by visual inspection that:* AHU is enabled OSA damper maintains min OSA flow setpoint AHU is enabled in minimum ventilation or economizer mode 1-hr before occupancy to satisfy the Title-24 required pre-occupancy purge.	AHU enabled: ☐ YES ☐ NO OSA Damper Open: ☐ YES ☐ NO Purge duration adequate: ☐ YES ☐ NO	☐ YES ☐ NO ☐ N/A
11.	Hight Duct Pressure Failure Test the static pressure switch by artificially increasing the static duct pressure at the sensor. Manually reset the switch to resume normal function.	At 4.0 in. w.c., (adjustable) the high static pressure switch will stop the supply fan. A critical alarm shall be generated at the operator workstation. Unit shall re-enabled when switch is reset, and alarm shall be cleared.	High static pressure switch stops the supply fan? ☐ YES ☐ NO ☐ N/A Critical alarm generated in BAS? ☐ YES ☐ NO ☐ N/A Unit can be re-enabled when switch is reset? ☐ YES ☐ NO ☐ N/A	☐ YES ☐ NO ☐ N/A

END OF EXHIBIT

SECTION 23 09 13 - INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating 2018.

B. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings 2018.

C. ASTM B32 - Standard Specification for Solder Metal 2008 (Reapproved 2014).

D. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2016.

E. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric) 2018.

F. ASTM B819 - Standard Specification for Seamless Copper Tube for Medical Gas Systems 2018.

G. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2018.

1.02 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide description and engineering data for each control system component. Include sizing as requested. Provide data for each system component and software module.

C. Shop Drawings: Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences. Submit schedule of valves indicating size, flow, and pressure drop for each valve. For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.

D. Manufacturer's Qualification Statement.

E. Installer's Qualification Statement.

F. Project Record Documents: Record actual locations of control components, including panels, thermostats, and sensors. Accurately record actual location of control components, including panels, thermostats, and sensors.

1.03 WARRANTY

A. Correct defective work within a five-year period after Substantial Completion.

B. Provide five-year manufacturer's warranty for control air compressors.

PART 2 PRODUCTS

2.01 EQUIPMENT - GENERAL

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

2.02 UNIVERSITY GUIDELINES AND REQUIREMENTS

A. TEMPERATURE SENSORS:

1. Resistance Temperature Detectors (RTD's):

a. Standard: Siemens 1000 Ohm Platinum RTD, Model Number PTM6.2P1K.

b. Exception: Thermistors are required in some zone applications such as VAV boxes, and may only be used in those areas.

c. Function: Use for air handlers, Hot Water (HW) and Chilled Water (CHW). Do not install in piping tee. Connect to Building Management System (BMS) by Siemens.

B. DIFFERENTIAL PRESSURE SENSORS:

a. Siemens Sitrans 7MF4433 with 3-valve manifold and local display.

b. Standard: Emerson Process Management, Rosemount Model #1151 Pressure Transmitter. Connect to Building Management System (BMS) by Siemens. Specify pressure range for 150% of maximum expected differential pressure.

c. Function: Measure differential pressure for monitoring and control of variable speed pumps.

d. Website: http://www.emersonprocess.com/rosemount/Products/Pressure/m1151.html

C. MOTOR CONTROLS:

1. Campus Standard: ABB ACH580. Enclosure: UL. Integral disconnect. No bypass. Or approved equal by Siemens or Danfoss.

2. Function: Connect to Campus Building Management System (BMS) by Siemens as a Field Level Network (FLN) or BACnet device (minimum requirement to be FLN capable) to provide direct communication for monitoring drive. With FLN communication Stop/Start and Speed command are acceptable. With BACnet

Stop/Start and Speed command must be hardwired. Proof through drive and via current switches. Siemens drives are acceptable.

2.03 CONTROL PANELS

A. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gauges, pilot lights, push buttons and switches flush on cabinet panel face.

B. NEMA 250, general purpose utility enclosures with enameled finished face panel.

2.04 CONTROL VALVES

A. Globe Pattern:

1. Up to 2 inches (50 mm): Bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with backseating capacity repackable under pressure.
2. Over 2 inches (50 mm): Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.
3. Hydronic Systems:
    a. Rate for service pressure of 125 psig at 250 degrees F (860 kPa at 121 degrees C).
    b. Replaceable plugs and seats of stainless steel.
    c. Size for 3 psig (20 kPa) maximum pressure drop at design flow rate.
4. Steam Systems:
    a. Rate for service pressure of 125 psig at 250 degrees F (860 kPa at 121 degrees C).
    b. Replaceable plugs and seats of stainless steel. Pressure drop across any steam valve at maximum flow; as indicated on drawings.
    c. Size for 10 psig (70 kPa) inlet pressure and 5 psig (35 kPa) pressure drop.
    d. Valves shall have modified linear characteristics.

B. Butterfly Pattern:

1. Iron body, bronze disc, high performance seat for service to 250 degrees F (137 degrees C) wafer or lug ends, extended neck.
2. Hydronic Systems:

a. Rate for service pressure of 125 psig at 250 degrees F (860 kPa at 121 degrees C).

b. Size for 1 psig (7 kPa) maximum pressure drop at design flow rate.

C. Pneumatic Operators:

1. Rolling diaphragm, spring loaded, piston type with spring range as indicated.
2. Valves shall spring return to normal position as indicated on freeze, fire, or temperature protection.
3. Select operator for full shut off at maximum pump differential pressure.

D. Electronic Operators:

1. Valves shall spring return to normal position as indicated on freeze, fire, or temperature protection.
2. Select operator for full shut off at maximum pump differential pressure.

E. Radiation Valves:

1. Bronze body, bronze trim, 2 or 3 port as indicated, replaceable plugs and seats, union and threaded ends.
2. Rate for service pressure of 125 psig at 250 degrees F (860 kPa at 121 degrees C).

2.05 DAMPERS

A. Performance: Test in accordance with AMCA 500-D.

B. Frames: Galvanized steel, welded or riveted with corner reinforcement, minimum 12 gage, 0.1046 inch (2.66 mm).

C. Blades: Galvanized steel, maximum blade size 8 inches (200 mm) wide, 48 inches (1200 mm) long, minimum 22 gage, 0.0299-inch (0.76 mm), attached to minimum 1/2-inch (13 mm) shafts with set screws.

2.06 DAMPER OPERATORS

A. General: Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two position control and for fail safe operation.

1. Provide sufficient number of operators to achieve unrestricted movement throughout damper range.

B. Pneumatic Operators:

1. Rolling diaphragm piston type with adjustable stops.
2. Pilot Positioners: Starting point adjustable from 2 to 12 psig (15 to 83 kPa) and operating span adjustable from 5 to 13 psig (35 to 90 kPa).

C. Electric Operators:

1. Spring return, auxiliary end switch.

D. Inlet Vane Operators:

1. High pressure with pilot positioners and sufficient force to move vanes when fan is started with vanes in closed position. Return vane operator to closed position on fan shutdown.

2.07 HUMIDISTATS

A. Room Humidistats:

1. Wall mounted, proportioning type.

B. Limit Duct Humidistats:

1. Insertion, two position type.

2.08 INPUT/OUTPUT SENSORS

A. Temperature Sensors:

1. Use thermistor or RTD type temperature sensing elements with characteristics resistant to moisture, vibration, and other conditions consistent with the application without affecting accuracy and life expectancy.

B. Carbon Dioxide Sensors, Duct and Wall:

1. General: Provide non-dispersive infrared (NDIR), diffusion sampling CO2 sensors with integral transducers and linear output.

2.09 THERMOSTATS

A. Pneumatic Room Thermostats:

B. Electric Room Thermostats:

C. Line Voltage Thermostats:

D. Airstream Thermostats:

2.10 LEVEL SWITCHES

A. Float Sensors:

1. Boiler Water Level Control:

END OF SECTION 23 09 13

SECTION 23 09 93 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS PART 1 GENERAL

1.01 SECTION INCLUDES

A. This section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other sections.

B. Sequence of operation for:

1. Air terminal units.
2. Cabinet heaters.
3. Central refrigeration systems.
4. Central fan systems.
5. Fan coil units.
6. Heating coils.
7. Heating water zone control.
8. Humidifiers.
9. Induction units.
10. Unit heaters.

1.02 RELATED REQUIREMENTS

A. Section 23 09 13 - Instrumentation and Control Devices for HVAC.

B. Section 23 09 23 - Direct-Digital Control System for HVAC.

C. Coordinate with Division 27 requirements and Campus ITS Department.

1.03 SUBMITTALS

A. Sequence of Operation Documentation: Submit written sequence of operation for entire HVAC system and each piece of equipment.

B. Control System Diagrams: Submit graphic schematic of the control system showing each control component and each component controlled, monitored, or enabled.

C. Points List: Submit list of all control points indicating at least the following for each point.

D. Designer's Qualification Statement.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION – NOT USED

END OF SECTION 23 09 93

SECTION 23 11 23 - FACILITY NATURAL-GAS PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pipe, pipe fittings, valves, and connections for natural gas piping systems.

1.02 RELATED REQUIREMENTS

A. Section 23 05 53 - Identification for HVAC Piping and Equipment.

B. Section 33 52 16 - Gas Hydrocarbon Piping.

1.03 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

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

C. Project Record Documents: Record actual locations of valves.

PART 2 PRODUCTS

2.01 NATURAL GAS PIPING, BURIED BEYOND 5 FEET (1500 MM) OF BUILDING

A. Steel Pipe: ASTM A53/A53M, Schedule 40 black.

1. Fittings: ASTM A234/A234M, wrought steel welding type, with AWWA C105/A21.5 polyethylene jacket or double layer, half-lapped 10 mil (0.25 mm) polyethylene tape.
2. Joints: ASME B31.1, welded.

B. Polyethylene Pipe: ASTM D2513, SDR 11.

1. Fittings: ASTM D2683 or ASTM D2513 socket type.
2. Joints: Fusion welded.

2.02 NATURAL GAS PIPING, BURIED WITHIN 5 FEET (1500 MM) OF BUILDING

A. Steel Pipe: ASTM A53/A53M, Schedule 40 black.

1. Fittings: ASTM A234/A234M, wrought steel welding type.
2. Joints: ANSI Z223.1, welded.
3. Jacket: AWWA C105/A21.5 polyethylene jacket or double layer, half-lapped 10 mil (0.25 mm) polyethylene tape.

2.03 NATURAL GAS PIPING, ABOVE GRADE

A. Steel Pipe: ASTM A53/A53M, Schedule 40 black.

1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, wrought steel welding type.
2. Joints: Threaded or welded to ASME B31.1.

2.04 FLANGES, UNIONS, AND COUPLINGS

A. Unions for Pipe Sizes 3 Inches (80 mm) and Under:

1. Ferrous pipe: Class 150 malleable iron threaded unions.

2.05 PIPE HANGERS AND SUPPORTS

A. Provide hangers and supports that comply with MSS SP-58.

1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
2. Overhead Supports: Individual steel rod hangers attached to structure or to trapeze hangers.
3. Trapeze Hangers: Welded steel channel frames attached to structure.
4. Vertical Pipe Support: Steel riser clamp.

2.06 BALL VALVES

A. Construction, 4 Inches (100 mm) and Smaller: MSS SP-110, Class 150, 400 psi (2760 kPa) CWP, bronze or ductile iron body, 304 stainless steel or chrome plated brass ball, regular port, Teflon seats and stuffing box ring, blow-out proof stem, lever handle with balancing stops, threaded or grooved ends with union.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Pipe Hangers and Supports:

1. Install in accordance with ASME B31.9.

3.02 SERVICE CONNECTIONS

A. Provide new gas service complete with gas meter and regulators in accordance with Section 33 52 16. Gas service distribution piping to have initial minimum pressure of 7-inch wc (1.75 kPa). Provide regulators on each line serving gravity type appliances, sized in accordance with equipment.

END OF SECTION 23 11 23

SECTION 23 21 13 - HYDRONIC PIPING

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing and Fusing Operators 2019.

B. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300 2016.

C. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings 2018.

D. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings 2018.

E. ASME B31.9 - Building Services Piping 2017.

F. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless 2018.

G. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service 2018a.

H. ASTM B32 - Standard Specification for Solder Metal 2008 (Reapproved 2014).

I. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2016.

J. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric) 2018.

K. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120 2015, with Editorial Revision (2018).

L. ASTM D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series) 2015.

M. ASTM D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40 2017.

N. ASTM D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80 2015.

O. ASTM D2855 - Standard Practice for the Two-Step (Primer & Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets 2015.

P. ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications 2007 (Reapproved 2013).

Q. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding 2011 (Amended 2012).

R. AWS D1.1/D1.1M - Structural Welding Code - Steel 2015, with Errata (2016).

S. AWWA C105/A21.5 - Polyethylene Encasement for Ductile-Iron Pipe Systems 2010.

T. AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings 2012.

U. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings 2017.

V. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast 2017, with Errata (2018).

W. AWWA C606 - Grooved and Shouldered Joints 2015.

X. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018.

1.02 QUALITY ASSURANCE

A. Date stamp all castings used for coupling housings, fittings, valve bodies, etc. for quality assurance and traceability.

B. Welder Qualifications: Certify in accordance with ASME BPVC-IX.

PART 2 PRODUCTS

2.01 HYDRONIC SYSTEM REQUIREMENTS

A. Comply with ASME B31.9 and applicable federal, state, and local regulations.

B. Piping: Provide piping, fittings, hangers and supports as required, as indicated, and as follows:

1. Where more than one piping system material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized. Do not use couplers or nipples.

2. Use non-conducting dielectric connections whenever jointing dissimilar metals. Dielectrics are to be union type or Flange kits. No threaded dielectric pipe nipples allowed.

3. Use threaded or welded joints only. Grooved mechanical joints are not permitted.

4. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.

C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use flanges, unions or press fitting couplings to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.

D. Valves: During the design phase and also in shop drawings preparation, coordinate with Cal Poly Facilities to identify locations for isolation valves.

E. Welding Materials and Procedures: Conform to ASME BPVC-IX.

2.02 HEATING WATER AND GLYCOL PIPING, BURIED

A. Steel Pipe: ASTM A53/A53M, Schedule 40, black, with AWWA C105/A21.5 polyethylene jacket, or double layer, half-lapped polyethylene tape.

B. Steel Pipe Sizes 12-inch (305 mm) and Greater: ASTM A53/A53M, 3/8-inch (9.5 mm) wall, black with AWWA C105/A21.5 polyethylene jacket, or double layer, half-lapped polyethylene tape.

1. Fittings: ASTM A234/A234M, wrought steel welding type with double layer, half-lapped polyethylene tape.
2. Joints: Welded in accordance with AWS D1.1/D1.1M.
3. Casing: Closed glass cell insulation.

C. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), annealed.

1. Fittings: ASME B16.22, wrought copper.
2. Joints: Braze, AWS A5.8M/A5.8 BCuP copper/silver alloy.
3. Casing: Closed glass cell insulation.

2.03 HEATING WATER AND GLYCOL PIPING, ABOVE GRADE

A. Steel Pipe: ASTM A53/A53M, Schedule 40, black, using one of the following joint types:

1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D1.1/D1.1M welded.
2. Threaded Joints: ASME B16.3, malleable iron fittings.
3. Press fittings: Viega MegaPress.
4. Flange bolted connections.

B. Steel Pipe Sizes 12 Inch (305 mm) and Greater: ASTM A53/A53M, 3/8-inch (9.5 mm) wall, black, using one of the following joint types:

1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D1.1/D1.1M welded.

C. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), drawn, using one of the following joint types:

1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings.
    a. Solder: ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
    b. Braze: AWS A5.8M/A5.8 BCuP copper/silver alloy.
2. Press fittings: Viega ProPress
3. Tee Connections: Mechanically extracted collars with notched and dimpled branch tube.

2.04 CHILLED WATER PIPING, BURIED

A. Steel Pipe: ASTM A53/A53M, Schedule 40, black with AWWA C105/A21.5 polyethylene jacket, or double layer, half-lapped polyethylene tape.

1. Fittings: ASTM A234/A234M, wrought steel welding type with double layer, half-lapped polyethylene tape.
2. Joints: Welded in accordance with AWS D1.1/D1.1M.
3. Casing: Closed glass cell insulation.

B. Steel Pipe Sizes 12 Inch (305 mm) and Greater: ASTM A53/A53M, 3/8-inch (9.5 mm) wall, black with AWWA C105/A21.5 polyethylene jacket, or double layer, half-lapped polyethylene tape.

1. Fittings: ASTM A234/A234M, wrought steel welding type with double layer, half-lapped polyethylene tape.
2. Joints: Welded in accordance with AWS D1.1/D1.1M.
3. Casing: Closed glass cell insulation.

C. Copper Tube: ASTM B88 (ASTM B88M), Type K (A) annealed.

1. Fittings: ASME B16.22, wrought copper.
2. Joints: Brazed, lead free, ASTM B32 HB alloy (95-5 tin-antimony), or tin and silver.
3. Casing: Closed glass cell insulation.

D. Ductile Iron Pipe: AWWA C151/A21.51.

1. Fittings: AWWA C110/A21.10, ductile iron, standard thickness.
2. Joints: AWWA C111/A21.11, Styrene butadiene rubber (SBR) or vulcanized SBR gasket with 3/4-inch (19 mm) diameter rods.

E. PVC Pipe Sizes 6 inch (150 mm) and Smaller: ASTM D1785, Schedule 40, or ASTM D2241, SDR 21 or 26.

1. Fittings: ASTM D2466, or ASTM D2467, PVC.
2. Joints: Solvent welded in accordance with ASTM D2855.

F. PVC Pipe Sizes 8 Inch (200 mm) and Larger: ASTM D1785, Schedule 80, or ASTM D2241, SDR 21 or 26.

1. Fittings: ASTM D2466, or ASTM D2467, PVC.
2. Joints: Solvent welded in accordance with ASTM D2855.

2.05 CHILLED WATER PIPING, ABOVE GRADE

A. Steel Pipe: ASTM A53/A53M, Schedule 40, black; using one of the following joint types:

1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D1.1/D1.1M welded.
2. Threaded Joints: ASME B16.3, malleable iron fittings.

B. Steel Pipe Sizes 12 Inch (305 mm) and Greater: ASTM A53/A53M, 3/8-inch (9.5 mm) wall, black; using one of the following joint types:

1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D1.1/D1.1M welded.

C. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), hard drawn; using one of the following joint types:

1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22, solder wrought copper fittings.
    a. Solder: ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
2. Tee Connections: Mechanically extracted collars with notched and dimpled branch tube.

D. PVC Pipe: ASTM D1785, Schedule 40, or ASTM D2241, SDR 21 or 26.

1. Fittings: ASTM D2466 or ASTM D2467, PVC.
2. Joints: Solvent welded in accordance with ASTM D2855.

E. PVC Pipe Sizes 8 Inch (203 mm) and Larger: ASTM D1785, Schedule 80, or ASTM D2241, SDR 21 or 26.

1. Fittings: ASTM D2466 or ASTM D2467, PVC.
2. Joints: Solvent welded in accordance with ASTM D2855.

2.06 CONDENSER WATER PIPING, BURIED

A. Steel Pipe: ASTM A53/A53M, Schedule 40, black with AWWA C105/A21.5 polyethylene jacket, or double layer, half-lapped polyethylene tape.

1. Fittings: ASTM A234/A234M, wrought steel welding type with double layer, half-lapped polyethylene tape.
2. Joints: Threaded for pipe 2 inch (50 mm) and under; AWS D1.1/D1.1M, welded for pipe over 2 inch (50 mm).

B. Steel Pipe Sizes 12 Inch (305 mm) and Greater: ASTM A53/A53M, 3/8-inch (9.5 mm) wall, black with AWWA C105/A21.5 polyethylene jacket, or double layer, half-lapped polyethylene tape.

1. Fittings: ASTM A234/A234M, wrought steel welding type with double layer, half-lapped polyethylene tape.
2. Joints: Welded in accordance with AWS D1.1/D1.1M.

C. Copper Tube: ASTM B88 (ASTM B88M), Type K (A) annealed.

1. Fittings: ASME B16.22, wrought copper.
2. Joints: Solder, lead free, 95-5 tin-antimony, or tin and silver.

D. Ductile Iron Pipe: AWWA C151/A21.51.

E. PVC Pipe: ASTM D1785, Schedule 40, or ASTM D2241, SDR 21 or 26.

1. Fittings: ASTM D2466 or ASTM D2467, PVC.
2. Joints: Solvent welded in accordance with ASTM 2855.

F. PVC Pipe sizes 8 inch (200 mm) and larger: ASTM D1785, Schedule 80, or ASTM D2241, SDR 21 or 26.

1. Fittings: ASTM D2466 or ASTM D2467, PVC.
2. Joints: Solvent welded in accordance with ASTM D2855.

2.07 CONDENSER WATER PIPING, ABOVE GRADE

A. Steel Pipe: ASTM A53/A53M, Schedule 40, black.

1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings with finish matching piping; AWS D1.1/D1.1M welded.
2. Threaded Joints: ASME B16.3, malleable iron fittings with finish matching piping.

B. Steel Pipe Sizes 12 Inch (305 mm) and Greater: ASTM A53/A53M, 3/8-inch (9.5

mm) wall, black; using one of the following joint types:

1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D1.1/D1.1M welded.

C. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), drawn; using one of the following joint types:

1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings.
    a. Solder: ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
2. Tee Connections: Mechanically extracted collars with notched and dimpled branch tube.

D. PVC Pipe: ASTM D1785, Schedule 40, or ASTM D2241, SDR 21 or 26.

1. Fittings: ASTM D2466 or ASTM D2467, PVC.
2. Joints: Solvent welded in accordance with ASTM D2855.

E. PVC Pipe Sizes 8 Inch (200 mm) and Greater: ASTM D1785, Schedule 80, or ASTM D2241, SDR 21 or 26.

1. Fittings: ASTM D2466 or ASTM D2467, PVC.
2. Joints: Solvent welded in accordance with ASTM D2855.

2.08 RADIANT HEATING PIPING

A. Copper Tube: ASTM B88 (ASTM B88M), Type K (A) annealed.

1. Fittings: ASME B16.22, wrought copper.
2. Joints: Braze, AWS A5.8M/A5.8 BCuP copper/silver alloy.
3. Press Fittings: Viega ProPress

2.09 PIPE HANGERS AND SUPPORTS

A. Provide hangers and supports that comply with MSS SP-58.

1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.

2.10 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

A. Unions for Pipe 2 Inches (50 mm) and Less:

B. Flanges for Pipe 2 Inches (50 mm) and Greater:

2.11 FLEXIBLE HOSE FOR USE ON HEATING AND COOLING HYDRONICS

A. Basis of Design: Hose Master GM100SHMU120.

B. Or Approved Equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. PVC Pipe: Make solvent-welded joints in accordance with ASTM D2855.

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

D. Install piping to conserve building space and to avoid interfere with use of space.

E. Group piping whenever practical at common elevations.

F. Slope piping and arrange to drain at low points.

END OF SECTION 23 21 13

SECTION 23 21 23 - HYDRONIC PUMPS

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports 2013.

B. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

C. UL 778 - Standard for Motor-Operated Water Pumps Current Edition, Including All Revisions.

1.02 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements.

PART 2 PRODUCTS

2.01 HVAC PUMPS - GENERAL

A. Provide pumps that operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

B. Products Requiring Electrical Connection: Listed and classified by UL or testing agency acceptable to Authority Having Jurisdiction as suitable for the purpose specified and indicated.

2.02 SYSTEM LUBRICATED CIRCULATORS

A. Type: Horizontal shaft, single stage, direct connected with multiple speed wet rotor motor for in-line mounting, for 140 psi (965 kPa) maximum working pressure, 225 degrees F (107 degrees C) maximum water temperature.

B. Casing: Cast iron with flanged pump connections.

C. Impeller, Shaft, Rotor: Stainless Steel.

D. Bearings: Metal Impregnated carbon (graphite) and ceramic.

E. Motor: Impedance protected, multiple speed, with external speed selector.

2.03 IN-LINE CIRCULATORS

A. Type: Horizontal shaft, single stage, direct connected, with resiliently mounted motor for in-line mounting, oil lubricated, for 175 psi (1200 kPa) maximum working pressure.

B. Casing: Cast iron, with flanged pump connections.

C. Impeller: Non-ferrous keyed to shaft.

D. Bearings: Oil-lubricated bronze sleeve.

E. Shaft: Alloy steel with bronze sleeve, integral thrust collar.

F. Seal: Mechanical seal, 225 degrees F (107 degrees C) maximum continuous operating temperature.

G. Drive: Flexible coupling.

H. Electrical Characteristics:

1. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

2.04 VERTICAL IN-LINE PUMPS

A. Type: Vertical, single stage, close coupled, radially or horizontally split casing, for in-line mounting, for 175 psi (1200 kPa) working pressure.

B. Casing: Cast iron, with suction and discharge gauge port, casing wear ring, seal flush connection, drain plug, flanged suction and discharge.

C. Impeller: Bronze, fully enclosed, keyed directly to motor shaft or extension.

D. Shaft: Carbon steel with stainless steel impeller cap screw or nut and bronze sleeve.

E. Seal: Mechanical seal, 225 degrees F (107 degrees C) maximum continuous operating temperature.

F. Electrical Characteristics:

1. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

2.05 CLOSE COUPLED PUMPS

A. Type: Horizontal shaft, single stage, close coupled, radially split casing, for 125 psi (860 kPa) maximum working pressure.

B. Casing: Cast iron, with suction and discharge gauge ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.

C. Impeller: Bronze, fully enclosed, keyed to motor shaft extension.

D. Shaft: Stainless steel.

E. Seal: Mechanical seal, 225 degrees F (107 degrees C) maximum continuous operating temperature.

F. Electrical Characteristics:

1. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

2.06 BASE-MOUNTED PUMPS

A. Type: Horizontal shaft, single stage, direct connected, radially or horizontally split casing, for 125 psi (860 kPa) maximum working pressure.

B. Casing: Cast iron, or ductile iron with suction and discharge gauge ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.

C. Impeller: Bronze, fully enclosed, keyed to shaft.

D. Bearings: Oil lubricated roller or ball bearings.

E. Shaft: Alloy steel with copper, bronze, or stainless-steel shaft sleeve.

F. Seal: Mechanical seal, 225 degrees F (107 degrees C) maximum continuous operating temperature.

G. Drive: Flexible coupling with coupling guard.

H. Baseplate: Cast iron or fabricated steel with integral drain rim.

I. Electrical Characteristics:

1. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

2.07 DUAL DRIVE PUMPING SYSTEM

A. Pumping System: Horizontal split case, base-mounted pump with two motors, operating at 1750 rpm and 1150 rpm, assembled on integral base with control cabinet.

B. Control Cabinet: NEMA OS 1, UL approved enclosure with individual circuit breakers, magnetic starters with overload protection, running lights, separate 115V fused control circuit, hands-off-automatic switches, motor failure alarm with manual reset, pre-wired.

C. Electrical Characteristics:

1. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

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

C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close-coupled or base-mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches (102 mm) and over.

D. Check, align, and certify alignment of base-mounted pumps prior to start-up, including a Pre-alignment check, alignment when full of water, and alignment at operating temperature.

END OF SECTION 23 21 23

SECTION 23 25 00 - HVAC WATER TREATMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Filtered canister, stainless-steel

B. Conductivity controller.

C. Water meter.

D. Solenoid valves.

E. Test equipment.

1.02 RELATED REQUIREMENTS

A. Section 23 09 13 - Instrumentation and Control Devices for HVAC.

B. Section 23 21 13 - Hydronic Piping.

C. Coordinate with the campus water treatment provider and Campus Facilities for testing procedures.

D. Follow campus discharge procedures as outlined in permits.

E. Closed hydronic loops shall use soft water for make-up water.

1.03 REFERENCE STANDARDS

A. UL (DIR) - Online Certifications Directory Current Edition.

1.04 SUBMITTALS

A. Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.

B. Shop Drawings: Indicate system schematic, equipment locations, and controls schematics, electrical characteristics and connection requirements.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

A. Comply with applicable codes, Campus Standards, and EH&S requirements for addition of non-potable chemicals to building mechanical systems and to public sewage systems. Submit Detailed Workplan with Narrative and Material/Chemical Data sheets for review and approval by Cal Poly Representative and EH&S and prior to commencement of water treatment. Refer to https://afd.calpoly.edu/ehs/waterquality

B. Comply with UL (DIR) requirements.

C. Provide certificate of compliance from Authority Having Jurisdiction indicating approval of installation.

2.02 FILTERED CANISTER

A. Stainless Steel.

B. Size according to the volume of the system, minimum five (5) gallons.

2.03 CONDUCTIVITY CONTROLLER

A. Packaged monitor controller with solid state circuiting, five percent accuracy, linear dial adjustment, built-in calibration switch, on-off switch and light, control function light, output to control circuit and recorder.

2.04 WATER METER

A. Displacement type cold water meter with sealed, tamper-proof magnetic drive, impulse contact register, single pole, double throw dry contact switch.

2.05 SOLENOID VALVES

A. Forged brass body globe pattern, normally open or closed as required, explosion-proof and watertight solenoid enclosure, and continuous duty coil.

2.06 TEST EQUIPMENT

A. Provide white enamel test cabinet with local and fluorescent light, capable of accommodating 4 - 10 ml zeroing titrating burettes and associated reagents.

END OF SECTION 23 25 00

SECTION 23 40 00 - HVAC AIR CLEANING DEVICES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Disposable panel filters.

B. High efficiency particulate air (HEPA) filters.

C. Washable permanent panel filters.

D. Electronic air cleaners.

1.02 REFERENCE STANDARDS

A. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size 2017.

B. UL 586 - High Efficiency, Particulate, Air Filter Units Current Edition, Including All Revisions.

C. UL 867 - Electrostatic Air Cleaners Current Edition, Including All Revisions.

D. UL 900 - Standard for Air Filter Units Current Edition, Including All Revisions.

1.03 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements for submittal procedures.

B. Product Data: Provide data on filter media, filter performance data, filter assembly and filter frames, dimensions, motor locations and electrical characteristics and connection requirements.

PART 2 PRODUCTS

2.01 DISPOSABLE, EXTENDED AREA PANEL FILTERS

A. Media: UL 900 Class 1, pleated, lofted, non-woven, reinforced cotton fabric; supported and bonded to welded wire grid by corrugated aluminum separators.

B. Minimum Efficiency Reporting Value (MERV): 13, when tested in accordance with ASHRAE Std 52.2.

2.02 DISPOSABLE PANEL FILTERS

A. Media: UL 900 Class 2, fiber blanket, factory sprayed with flameproof, non-drip, non-volatile adhesive.

1. Thickness: Per manufacturer requirement

B. Performance Rating:

1. Coordinate Performance Rating per manufacturer requirements and with Cal Poly Facilities.
2. Face Velocity: Verify per above.
3. Initial Resistance: Verify per above.
4. Recommended Final Resistance: 0.50 inches WG (125 Pa). Verify per above.

C. Casing: Cardboard or plastic frame.

2.03 HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTERS

A. Media: UL 586, pleated, water-resistant glass fiber with separators of aluminum:

B. Minimum Efficiency Reporting Value (MERV): 15, when tested in accordance with ASHRAE Std 52.2.

2.04 WASHABLE PERMANENT PANEL FILTERS

A. Media: 14 mesh steel screen, zinc electroplated, alternate layers of flat and herringbone crimp, four layers per inch (25 mm); rod reinforced.

2.05 ELECTRONIC AIR CLEANERS

A. Assembly: UL 867; galvanized steel assembly containing electronic agglomerator and disposable panel filters.

B. Electronic Agglomerator: Independently supported and nested collection cells of aluminum construction including ionizing section consisting of alternately spaced grounded struts and charged ionizing wires, and collecting section consisting of alternately grounded and charged plates, with insulators located out of air stream.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install air cleaning devices in accordance with manufacturer's instructions.

B. Prevent passage of unfiltered air around filters with felt, rubber, or neoprene gaskets.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with clean set.

END OF SECTION 23 40 00

SECTION 23 54 00 - FURNACES

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. ANSI Z21.47 - American National Standard for Gas-Fired Central Furnaces 2016.

B. NFPA 54 - National Fuel Gas Code 2018.

C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

D. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2018.

E. NFPA 211 - Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances 2016.

F. UL (DIR) - Online Certifications Directory Current Edition.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

A. Comply with NFPA 70 and NFPA 70E.

B. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified and indicated.

2.02 GAS FIRED FURNACES

A. Annual Fuel Utilization Efficiency (AFUE): 0.95 ("condensing").

B. Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heating element, controls, air filter, humidifier, and accessories; wired for single power connection with control transformer.

1. Safety certified by CSA in accordance with ANSI Z21.47.
2. Venting System: Direct.
3. Combustion: Sealed.
4. Air Flow Configuration: Upflow.
5. Heating: Natural gas fired.

C. Performance:

D. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner. If not certified for combustible flooring, please provide additional steel base.

E. Primary Heat Exchanger:

1. Material: Hot-rolled steel.
2. Shape: Tubular type.

F. Secondary Heat Exchanger:

1. Material: Aluminized steel.
2. Shape: [_____].

G. Gas Burner:

1. Atmospheric type with adjustable combustion air supply.
2. Gas valve, two stage provides 100 percent safety gas shut-off; 24 volt combining pressure regulation, safety pilot, manual set (On-Off), pilot filtration, automatic electric valve.
3. Electronic pilot ignition, with electric spark igniter.
4. Combustion air damper with synchronous spring return damper motor.
5. Non-corrosive combustion air blower with permanently lubricated motor.

H. Gas Burner Safety Controls:

1. Thermocouple sensor: Prevents opening of gas valve until pilot flame is proven and stops gas flow on ignition failure.
2. Flame rollout switch: Installed on burner box and prevents operation.
3. Vent safety shutoff sensor: Temperature sensor installed on draft hood and prevents operation, manual reset.
4. Limit Control: Fixed stop at maximum permissible setting, de-energizes burner on excessive bonnet temperature, automatic resets.

I. Supply Fan: Centrifugal type rubber mounted with direct drive with adjustable variable pitch motor pulley.

J. Motor:

1. 1750 rpm single-speed, permanently lubricated, hinge mounted.

K. Air Filters: 1 inch (25 mm) thick urethane, washable type arranged for easy replacement.

L. Operating Controls:

1. Room Thermostat: Cycles burner to maintain room temperature setting.
2. Supply Fan Control: Energize from bonnet temperature independent of burner controls, with adjustable timed off delay and fixed timed on delay, with manual

switch for continuous fan operation. Provide continuous low speed fan operation.

2.03 ELECTRIC FURNACES

A. Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heating element, controls, air filter, humidifier, and accessories; wired for single power connection with control transformer.

1. Air Flow Configuration: Upflow.
2. Heating: Electric.

B. Cabinet: Steel with baked enamel finish, easily removed and secured access doors, glass fiber insulation and reflective liner.

C. Supply Fan: Centrifugal type rubber mounted with direct drive motor.

D. Motor:

1. 1750 rpm single-speed, permanently lubricated, hinge mounted.

E. Electric Heater: Helix wound bare nichrome wire heating elements arranged in incremental states of 5 kW each, with porcelain insulators.

F. Electric Heater Operating Controls:

1. Low voltage adjustable room thermostat energized heater stages in sequence with pre-determined delay between heating stages.
2. High limit temperature control de-energizes heating elements, automatic resets.

G. Air Filters: 1 inch (25 mm) thick urethane, washable type arranged for easy replacement.

H. Performance:

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions and requirements of authorities having jurisdiction.

B. Install in accordance with NFPA 90A.

C. Install gas fired furnaces in accordance with NFPA 54.

D. Provide vent connections in accordance with NFPA 211.

END OF SECTION 23 54 00

SECTION 23 73 13 - MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS PART 2 PRODUCTS

1.01 REGULATORY REQUIREMENTS

A. Comply with NFPA 70 and NFPA 70E.

B. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified and indicated.

1.02 CASING CONSTRUCTION

A. Full Perimeter Base Rail:

1. Construct of galvanized steel.
2. Provide base rail of sufficient height to raise unit for external trapping of condensate drain pans.

B. Casing:

1. Construct of one piece, insulated, double wall panels.
2. Provide mid-span, no through metal, internal thermal break.
3. Construct outer panels of galvanized steel and inner panels of galvanized steel.
4. Casing Air Pressure Performance Requirements:
    a. Able to withstand up to 8 inches w.g. (2 kPa) positive or negative static pressure.
    b. Not to exceed 0.0042 inches per inch (0.0042 mm/mm) deflection at 1.5 times design static pressure up to a maximum of plus 8 inches w.g. (2 kPa) in positive pressure sections and minus 8 inches w.g. (2 kPa) in negative pressure sections.

C. Access Doors:

1. Construction, thermal and air pressure performance same as casing.
2. Provide surface mounted handles on hinged, swing doors.

D. Outside Air and Exhaust Air Weather Hood:

1. Fabricate from same material as casing outer panel.

2. Extend hood past perimeter of unit casing opening so as not to instruct airflow path.
3. Paint hoods with same finish as external surface of outdoor units.
4. Provide inlet hood for each fresh air damper with a sine wave moisture eliminator to prevent entrainment of water into the unit from outside air.
5. Provide exhaust hoods for each exhaust air opening.
6. Size each hood for 100 percent of nominal fresh air damper capacities.
7. Protect each hood with bird screen to prevent nesting at intake or exhaust air flow paths.

E. Unit Flooring: Construct with sufficient strength to support expected people and equipment loads associated with maintenance activities.

F. Casing Leakage: Seal joints and provide airtight access doors so that air leakage does not exceed one percent of design flow at the specified casing pressure.

G. Insulation:
1. Provide minimum thermal thickness of 12 R (2.29 RSI) throughout.
2. Completely fill panel cavities in each direction to prevent voids and settling.
3. Comply with NFPA 90A.

H. Drain Pan Construction:
1. Provide cooling coil and humidifier sections with an insulated, double wall, galvanized steel drain pan complying with ASHRAE Std 62.1 for indoor air quality and sufficiently sized to collect all condensate.
2. Slope in two planes to promote positive drainage and eliminate stagnate water conditions.
3. Locate outlet of sufficient diameter at lowest point of pan to prevent overflow at normal operating conditions.
4. Provide threaded drain connections constructed of drain pan material, extended sufficient distance beyond the base to accommodate field installed, condensate drain trapping.

I. Louvers: Stationary, of galvanized steel, 4-inch (100 mm) deep with plenum, nylon bearings, 1/2-inch (13 mm) mesh, 0.04 inch (1.0 mm) galvanized wire bird screen in

aluminum frame, and bearing AMCA Certified Ratings Seal in accordance with AMCA 500-L. Furnish adjustable louvers with hollow vinyl bulb edging on blades and foam side stops to limit leakage to maximum 2 percent at 4-inch wg (1 kPa) differential pressure when sized for 2000 fpm (10 m/s) face velocity.

J. Finish:

1. Indoor Units:

a. Provide exterior, galvanized steel panels without paint.

b. Color: Manufacturer's standard color.

1.03 FAN SECTION

A. Type: Forward curved, single width, single inlet, centrifugal plug type fan, in compliance with AMCA 99. Refer to Section 23 3413.

B. Performance Ratings: Determined in accordance with AMCA 210 and labeled with AMCA Certified Rating Seal.

C. Sound Ratings: AMCA 301; tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.

D. Bearings: Self-aligning, grease lubricated, with lubrication fittings extended to exterior of casing with plastic tube and grease fitting rigidly attached to casing.

E. External Motor Junction Box: Factory mount NEMA 4 external junction box and connect to extended motor leads from internally mounted motors.

F. Motor Wiring Conduit: Factory wire fan motor wiring to the unit mounted starter-disconnect, variable frequency drive, external motor junction box and [_____].

G. Fan Accessories:

H. Flexible Duct Connections:

1. For separating fan, coil, and adjacent sections.

I. Drives:

1. Comply with AMCA 99.

2. Bearings: Heavy duty pillow block type, ball bearings, with ABMA STD 9 L-10 life at 50,000 hours.

3. Shafts: Solid, hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

4. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, bored to fit shafts, and keyed. Variable and adjustable pitch sheaves for motors 15 hp and under selected so required rpm is obtained with sheaves set at mid-position; fixed sheave for 20 hp and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of the motor. Once the system is balanced and approved by the commissioning agent, remove variable and adjustable pitch sheaves and replace with fix pitch sheaves.
5. Belt Guard: Fabricate to SMACNA (DCS); 0.106-inch (2.6 mm) thick, 3/4-inch (20 mm) diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

1.04 COIL SECTION

A. Casing: Provide access to both sides of coils. Enclose coils with headers and return bends exposed outside casing. Slide coils into casing through removable end panel with blank off sheets and sealing collars at connection penetrations.

B. Drain Pans: 24 inch (600 mm) downstream of coil and down spouts for cooling coil banks more than one coil high.

C. Eliminators: Three break of galvanized steel, mounted over drain pan.

D. Air Coils:

1. Certify capacities, pressure drops, and selection procedures in accordance with AHRI 410.

E. Fabrication:

1. Tubes: 5/8-inch (16 mm) OD seamless copper expanded into fins, brazed joints.
2. Fins: Copper.
3. Casing: Die formed channel frame of galvanized steel.

1.05 FILTER AND AIR CLEANER SECTION

A. General: Provide filter sections with filter racks, minimum of one access door for filter removal, and filter block-offs to prevent air bypass.

B. Differential Pressure Gauge:

1. Provide factory installed dial type differential pressure gauge, flush mounted with casing outer wall, and fully piped to both sides of each filter to indicate status.
2. Maintain plus/minus 5 percent accuracy within operating limits of 20 degrees F (minus 6.7 degrees C) to 120 degrees F (48.9 degrees C).

1.06 DAMPER SECTION

A. Mixing Section: Provide a functional section to support the damper assembly for modulating the volume of outdoor, return, exhaust and [_____] air.

B. Damper Blades:

1. Double-skin airfoil design with metal, compressible jamb seals and extruded-vinyl blade-edge seals on each blade.
2. Self-lubricating stainless steel or synthetic sleeve bearings.
3. Comply with ASHRAE Std 90.1 for rated maximum leakage rate.
4. Provide leakage testing and pressure ratings in compliance with AMCA 500-D test methods.
5. Arrange in parallel or opposed-blade configuration.

C. Barometric Relief Dampers:

1. Frame: Roll formed galvanized steel.
2. Blades: Roll formed galvanized steel.
3. Blade Seals: Extruded vinyl, mechanically attached to the blade edge.
4. Material:

1.07 FAN CONTROL CABINET

A. If a fan control cabinet is installed on the unit and exposed to heat elements, the fan control cabinet needs to be cooled.

END OF SECTION 23 73 13

SECTION 23 74 13 - PACKAGED OUTDOOR CENTRAL-STATION AIR-HANDLING UNITS PART 2 PRODUCTS

1.01 MANUFACTURED UNITS

A. General: Roof mounted units with hydronic heating and cooling systems tied into the Campus Utilidor system, or with specific approval or beyond the campus system Utilidor system having gas burner and electric refrigeration.

B. Description: Self-contained, packaged, factory assembled and prewired, consisting of cabinet and frame, supply fan, return fan, heat exchanger and burner, heat recovery coil, controls, air filters, refrigerant cooling coil and compressor, condenser coil and condenser fan.

1.02 FABRICATION

A. Cabinet: Steel with baked enamel finish, including access panels with screwdriver operated flush cam type fasteners. Structural members shall be minimum 18 gage, 0.0478 inch (1.21 mm), with access doors or panels of minimum 20 gage, 0.0359 inch (0.91 mm).

B. Heat Exchangers: Aluminized steel, of welded construction.

C. Supply and Return Fan: Forward curved centrifugal type, resiliently mounted with V-belt drive, adjustable variable pitch motor pulley, and rubber isolated hinge mounted high efficiency motor or direct drive as indicated. [____] . Refer to Section 22 05 48. Once the system is balanced and approved by the commissioning agent, remove variable pitch motor pulley and replace with a fixed pitch motor pulley.

1.03 BURNER

A. Gas Burner: Atmospheric type burner with adjustable combustion air supply, pressure regulator, gas valves, manual shut-off, intermittent spark or glow coil ignition, flame sensing device, and automatic 100 percent shut-off pilot.

B. Gas Burner Safety Controls: Energize ignition, limit time for establishment of flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, energize blower motor, and after air flow proven and slight delay, allow gas valve to open.

1.04 EVAPORATOR COIL

A. Provide copper tube copper fin coil assembly with galvanized drain pan and connection. Provide with a 20°F minimum Delta T.

B. Provide capillary tubes or thermostatic expansion valves for units of 6 tons (21 kw) capacity and less, and thermostatic expansion valves and alternate row circuiting for units 7.5 tons (26 kw) cooling capacity and larger.

1.05 COMPRESSOR

A. Provide hermetic compressors, 3600 rpm maximum, resiliently mounted with positive lubrication, crankcase heater, high- and low-pressure safety controls, motor overload protection, suction and discharge service valves and gauge ports, and filter drier.

1.06 CONDENSER COIL

A. Provide copper tube aluminum fin coil assembly with subcooling rows and coil guard.

B. Provide direct drive propeller fans, resiliently mounted with fan guard, motor overload protection, wired to operate with compressor. Provide high efficiency fan motors.

1.07 HEAT RECOVERY COIL

A. Provide copper tube copper fin coil assembly with multiple circuits arranged to provide heat recovery.

1.08 FAN CONTROL CABINET

A. If a fan control cabinet is installed on the unit and exposed to heat elements, the fan control cabinet needs to be cooled.

END OF SECTION 23 74 13