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Bid # 2062 Prop 39 HVAC Modernization Project
Addendum # 1
April 09, 2018

To: All Prospective Bidders

THE FOLLOWING REVISIONS AND/OR CLARIFICATIONS SHALL BE MADE TO THE BIDDING REQUIREMENTS AND CONTRACT DOCUMENTS. REVISE AND AMEND THE DOCUMENTS FOR THE ABOVE NAMED PROJECT IN ACCORDANCE WITH THIS ADDENDUM. THE BID SHALL REFLECT THESE ADDENDUM CHANGES AND EACH BIDDER SHALL MAKE REFERENCE IN
THEIR BID TO THIS ADDENDUM ALL BIDDING REQUIREMENTS AND CONTRACT DOCUMENTS SHALL APPLY TO THIS ADDENDUM AS ORIGINALLY INDICATED IN THE APPLICABLE PORTIONS OF THE CONTRACT DOCUMENTS, UNLESS OTHERWISE MODIFIED BY THIS ADDENDUM.

Acknowledge receipt of this Addendum # 1 in the space provided on Bid Form. Failure to do so may result in the bid being deemed non-responsive.

The Addendum consists of the following change:

1. SPECIFICATION:

1.1 **REMOVE Scope of Work/Specification and REPLACE with attached Revised Scope of Work/Specification**

1.2 **ADD Exhibit 1 Contractor Cost Table**

1.3 **ADD Exhibit 2 Valve Schedule Final**

END OF ADDENDUM NO. 01

Enclosures:

- **REPLACE: Scope of Work/Specification (64 pages)**
- **ADD: Exhibit 1 Contractor Cost Table (2 pages)**
- **ADD: Exhibit 2 Valve Schedule (16 pages)**

Rio Hondo College Prop 39 HVAC Modernization Scope of Work

Contents

PART 1 - GENERAL

1.1 SUMMARY

A. This document provides the owner's requirements for the scope of work being funded by Proposition 39. It is based on investigations of the central plant and connected buildings conducted by kW Engineering. The Bidder shall provide all labor, materials, supplies, tools, parts and equipment (new and replacements) to do the work as described in the scope of work. Bidder shall be registered with the DIR and shall have the license (if required by law) to do the work.

B. This is a turn-key project with third-party commissioning. The bidding contractor is responsible for all required design documentation, permits, scheduling, project management, and other associated tasks.

C. All associated work, including new controllers, sensors, actuators, programming, and graphics must be seamlessly integrated into the existing Alerton building automation system (Campus BAS), which currently controls the central plant and other buildings on campus. It is the contractor's responsibility to make sure that the existing control system has the capacity to handle the new points, trending requirements, and all other relevant work described in this solicitation.

D. The Bidder will break out the bid cost as shown in the costing sheet (see attached Exhibit 1 – Prop 39 HVAC Modernization Contractor Cost Table). Failure to do so will cause Bidder's proposal to be deemed as Non-Responsive. Labor rates of Bidder and subcontractor(s) (including lower tier subcontractor) will comply with SB 854/SB 96. Clearly indicate all sub-contractors that will be used on this project and their work scope. See attached costing sheet.

1.2 SCOPE OF WORK

A. Replace (Furnish and Install) 3-way chilled water valves and actuator with 2-way – Science Building

1. Replace 3-way chilled water valves and actuator with 2-way chilled water valves and actuators.
2. Includes all material, labor, piping modifications, wiring and disposal.
3. Include new balancing valves in retrofit.
4. Use existing BAS controller for integration into Campus BAS. (These buildings are DDC already.)
5. Total of five (5) valve replacements at Science Building (AHU-1,2,3,4,6).
6. Includes all software mapping and modifications required for fully automated valve control by existing Campus BAS. Use existing control sequence to control valves.
7. See Exhibit 2 – Prop 39 Valve Replacement Schedule for valves schedule.
8. See Products section 2.4 ACTUATORS - 2-way chilled and hot water and 2.5 WATER CONTROL VALVES – 2-way chilled and hot water.

B. Controls Modifications and New/Replaced Sensors – Chilled Water Plant

1. Furnish and install new differential pressure (DP) sensors to measure pressure drop across chilled water coils with 3-way valves at Science (AHU-5), Technology (AHU-2C), and LRC (AHU-1)
2. Connect DP sensors to the BAS and implement new programming to automatically reset pump speed according to DP sensor readings and control the SCHWP to satisfy the loop with the lowest differential pressure reading.
3. Furnish and install three key central plant temperature sensors to replace existing.

   a. Bridge de-coupler temperature sensor (EXP 0 AI 02).
   b. Return Temperature sensor (EXP 0 AI 01).
   c. Supply Temperature sensor (AI 3) that measures temperature of the chilled water going to the buildings.
4. Reprogram chilled water plant control sequences:
   a. Chilled water plant enabled and disabled based on chilled water valve position.
   b. Implement original controls sequences for primary chilled water pump speed control.
   c. Revise secondary pump speed control to include new building pressure sensors.
   d. Implement chilled water reset control strategy. Reset to maintain max valve position.
   e. Implement condenser water reset control strategy. Linear OATwb reset.
   f. Verify cooling tower VFD speed staging controls. Suggest revisions if appropriate.
   g. Budget 16 hours for on-site commissioning and functional performance tests with Cx Agent.
5. Modify chilled water plant graphics.
   a. Create new chilled water valve summary graphic that shows all Fan Coils and Air Handlers served by central plant.
   b. Modify each chilled water plant graphic to reflect changes in sequences.
   c. Proposed graphics shall be reviewed with Cx Agent before changeover.
   d. Budget 8 hours for on-site graphics modifications/clean-up with Cx Agent (this is after initial review).
6. See Products section 2.9 DIFFERENTIAL PRESSURE TRANSMITTERS (Liquid DP) – Central Plant DP control and 2.13 TEMPERATURE TRANSMITTERS (CENTRAL PLANT) – CHW Plant
7. See Sequences section 4.3 CHILLED WATER PLANT.
8. See Graphics section 3.12 Chilled Water Plant Graphics.
9. Exhibit 3 – Central Plant Mechanical and Control Drawings.

C. Controls Modifications and New/Replaced Sensors – Hot Water Plant

1. Furnish and install new differential pressure (DP) sensors to measure pressure drop across AHU-Photo Lab)
2. Connect DP sensors to the BAS and implement new programming to automatically reset pump speed according to DP sensor readings and control the SHWPs to satisfy the loop with the lowest differential pressure reading.
3. Create new hot water valve summary graphic that shows all fan coils and air handlers served by central plant.
4. Reprogram hot water plant control sequences:
   a. Hot water plant enabled and disabled based on hot water valve position.
   b. Revise secondary pump speed control to maintain new building dP sensors at setpoint.
   c. Implement hot water temperature setpoint reset control strategy. OAT reset.
5. Modify hot water plant graphics.
   a. Proposed graphics shall be reviewed with Cx Agent before changeover
   b. Budget 8 hours for on-site graphics modifications/clean-up with Cx Agent (this is after initial review).
6. See Products section 2.9 DIFFERENTIAL PRESSURE TRANSMITTERS (Liquid DP) – Central Plant DP control and 2.13 TEMPERATURE TRANSMITTERS (CENTRAL PLANT) – CHW Plant
7. See Sequences section 4.4 Hot Water Plant.
8. See Graphics section 3.53 Hot Water Plant Graphics.
9. See Exhibit 3 – Central Plant Mechanical and Control Drawings.

D. Motor, Pully and Belt Replacements - Science Building
    1. Replace motor, pully and belts on AHU-1 SF (40hp), AHU-3 SF (25hp), AHU-4 SF (40hp), AHU-6 SF (7.5hp)
    2. Replace input and output contactors for AHU-6 Supply fan, AHU-1 RF VFD, AHU-3 RF VFD
        a. One (1) NC aux contact for output.
    3. Replace Belt on AHU-5 RF
    4. See Products section 2.14 MOTORS.
    5. See Exhibit 4 – Science Building Mechanical Drawings

E. Economizer Damper Repairs and Control Modifications - Science Building
    1. Hardware (all damper actuators 24volt, 0-10 Volt control)
        a. Replace OSA damper actuator (AHU-6, AHU-1, AHU-3, AHU-4)
        b. Replace RA damper actuator (AHU-2, AHU-3, AHU-4, AHU-5)
        c. Replace EA damper actuator (AHU-2, AHU-4)
        d. Repair linkage RA damper (AHU-3, AHU-4, AHU-5)
        e. Replace AIM1 board for OSA and RA actuators (AHU-3, AHU-4, AHU-5)
    2. Software (All AHUs)
        a. Revise economizer control sequence to dry-bulb control (existing RH sensors used in enthalpy control have failed).
    3. See section 2.4 ACTUATORS for specifications.

F. AHU Repair and Maintenance - Science Building
    1. For All Six (6) AHU Units
        a. Vacuum unit and condensate pan.
        b. Clean chilled water coil and hot water coil (if exists).
    2. Specified Air Handlers only
        a. Grease supply and return fan bearings and check tubing for clogs. Make correction as needed on AHU-1, AHU-3, AHU-4, AHU-5.
        b. Replace canvas for supply fan (AHU-1, AHU-2, AHU-3, AHU-4).
        c. Replace handles on Supply fan door on (AHU-1, AHU-3, AHU-4).
        d. Replace chilled water valve AIM board (AHU-5, AHU-6)
        e. Install 2 filter blank off (AHU-6)
        f. Repair tubing for high static switch (AHU-5)

G. Replace Existing AHU Controllers and VAV Box Controllers, Reheat Valves, and Thermostats - Science Building
    1. Upgrade all existing DDC VAV box controllers and reheat valves with new controllers and valves. Replace existing thermostats. Total of 108 VAV zones. 16 cooling only, 92 with re-heat coils. *Note: RHC is seeking a fully working air distribution system upon completion of this project. It is the contractor's responsibility to insure that all VAV boxes are able to maintain flow and temperature setpoints*.
    2. Replace (6) six existing AHU controllers.
    3. Provide full integration into existing campus BAS.
    4. Sequences are based on ASHRAE Guideline 36. VAV control sequences are dual-max. AHUs have trim and respond sequences.
        a. See Sequences section 4.7 VAV COOLING-ONLY TERMINAL UNITS and 4.8 VAV REHEAT TERMINAL UNIT
    5. Graphics Modifications
        a. Proposed graphics shall be reviewed with Cx Agent before changeover.
            i. Each type of graphic page shall be reviewed.

b. VAV Summary Page Required. Table must be exportable as CSV file.
c. Budget 16 hours for on-site graphics modifications/clean-up with Cx Agent (this is after initial review).
d. See Graphics section 3.5 SOFTWARE INTEGRATION - Graphics

6. See Products sections 2.2 SUPERVISORY CONTROLLER, 2.3 AHU CONTROLLER, 2.4 TERMINAL UNIT CONTROLLERS
7. See Products section 2.5 WATER CONTROL VALVES – 2-way chilled and hot water
8. See Exhibit 5 – Science Building 2015 Tab Report.

H. Pneumatic to DDC Retrofit – Wray Building

1. Pneumatic to DDC retrofit for pneumatically controlled HVAC equipment (three constant volume multizone air handlers, one single zones air handler, and 12 Exhaust fans) including full integration into existing Campus BAS. Note: *The Wray building has a local hot water system that is integrated into the campus BAS and is controlled by two Alerton controllers (VLC-1188).*
   a. Remove and replace three (3) existing pneumatically controlled 2-way chilled water valves with DDC controlled 2-way valves (Campus Inn (AHU-2), Music (AHU-4), Wray (AHU-5)).
   b. Remove and replace one (1) existing 3-way chilled water with 3-way valves AHU-TV Studio (AHU-3).
   c. Remove four (4) existing pneumatically controlled chilled water valve actuators and replace with DDC actuator of sufficient capacity.
   d. Remove and replace three (3) existing pneumatically controlled 2-way hot water valves with DDC controlled 2-way valves (Campus Inn (AHU-2), Music (AHU-4), Wray (AHU-5)).
   e. Remove and replace one (1) existing 3-way hot water with 3-way valves AHU-TV Studio (AHU-3).
   f. Remove four (4) existing pneumatically controlled hot water valve actuators and replace with DDC actuator of sufficient capacity.
   g. Include new balancing valves with all valve replacements.
   h. Furnish and install three (3) new cold deck supply (CD) air temperature (SAT) sensor downstream of cooling coil.
   i. Remove fourteen (14) existing pneumatically controlled zone mixing actuators and replace with DDC actuators of sufficient capacity.
   j. For all air handlers
      i. Repair outside air and return air damper hardware so that full range of motion is restored. (linkages and rods connecting dampers to actuator motors)
      ii. Remove and replace existing outdoor air damper actuators with an actuator of sufficient capacity
      iii. Furnish and install new seals on all outside air, return air, and exhaust dampers.
      iv. Remove and replace existing return air damper actuators with an actuator of sufficient capacity).
      v. Install new DDC thermostats in a total of 15 zones.
      vi. See Part 2 Products section for required speculations.
   k. For the three, constant volume multizone air handlers (AHU-2 (6 zones), AHU-4 (6 zones), AHU-5 (4 zones)
      i. Remove and dispose of all pneumatic controls
      ii. Install I/O points and virtual points per list in Section 3.4.A.2
   l. For the single zone air handler AHU-3
      i. Remove and dispose of all pneumatic controls

ii. Install I/O points per points list in Section 3.4.A.3

m. For the twelve (12) exhaust fans
   i. Remove and dispose of all pneumatic controls
   ii. Install I/O points per points list in Section 3.4.A.3
   iii. See Section 4.13 INDEPENDENT EXHAUST FANS for programming details.

2. Reprogram control sequences, highlighted controls sequences include:
   a. Program all air handlers to include hot deck and cold deck resets (multi-zone air handlers only).
   b. Program economizer to support most demanding deck (multi-zone air handlers only).
   c. See Section 4.12 and 4.13 for highlighted controls sequence.
3. See Exhibit 6 – Wray Building Mechanical Drawings.
4. See Exhibit 7 – Wray Building Pneumatic Controls Diagram.

I. Pneumatic to DDC Retrofit – Business Building (Bus/Art)

1. Pneumatic to DDC retrofit for HVAC equipment, <u>excludes</u> zone level mixing boxes. Includes installation of all required sensors and actuators (see points list) and full integration into existing Campus BAS.
   a. Building HVAC equipment to be controlled includes:
      i. Two (2) variable volume dual duct air handlers (AC-1B and AC-2B)
      ii. Single zone air handler (Photo Lab)
      iii. Three exhaust fans.
   b. Replace existing pneumatically controlled 3-way chilled water valves with Campus BAS controlled 2-way valves (AHU-1B, AHU 3B).
   c. Replace existing pneumatically controlled 3-way chilled water valve with Campus BAS controlled 3-way valves (AHU-Photo).
   d. Replace existing pneumatically controlled 3-way hot water valves with Campus BAS controlled 2-way valves (AHU-1B, AHU 3B, AHU-Photo).
   e. Replace existing pneumatically controlled 3-way hot water valve with Campus BAS controlled 3-way valves (AHU-Photo).
   f. Include new balancing valves with all valve replacements.
   g. For all air handlers
      i. Repair outside air and return air damper hardware so that full range of motion is restored. (linkages and rods connecting dampers to actuator motors)
      ii. Remove and replace existing outdoor air damper actuators with an actuator of sufficient capacity
      iii. Furnish and install new seals on all outside air, return air, and exhaust dampers.
      iv. Remove and replace existing return air damper actuators with an actuator of sufficient capacity).
      v. See Part 2 Products section for required specifications.
   h. For the two VAV DD (AHU-1B, AHU 3B)
      i. Remove and dispose of all pneumatic controls
      ii. Install I/O points and virtual points per list in Section 3.4.A.2
   i. For the single zone air handler AHU-Photo
      i. Remove and dispose of all pneumatic controls
      ii. Install I/O points and virtual points per list in Section 3.4.A.3
   j. For the three (3) exhaust fans
      i. Remove and dispose of all pneumatic controls

ii. Install I/O points and virtual points per list in Section 3.4.A.4
iii. See Section 4.13 INDEPENDENT EXHAUST FANS for programming details.

2. Reprogram control sequences, highlighted controls sequences include:
   a. Program all air handlers to include hot deck and cold deck resets (multi-zone air handlers only).
   b. Program economizer to support most demanding deck (multi-zone air handlers only).
   c. See Section 4.12 MULTIZONE AIR HANDLING UNIT for programming details.
   d. See Exhibit 8 – Business Building Mechanical Drawings.

J. Test and Balance - Chilled Water Distribution System
1. Balanced chilled water distribution system to insure all connected chilled water coils receive design flow when valves are at 100% open position (40 coil/valve combinations).
2. Determine required DP setpoints for newly installed DP sensors specified in Section 1.2.C.1.
3. See Exhibit 10 – RHC Prop 39 Valve Schedule Details for valve schedule. BAB Box re-heat coils not in scope unless specifically described in SOW.
4. See Product Section 3.9 for TAB specifications.

K. Test and Balance - Hot Water Distribution System (not including zone level coils)
1. Balanced hot water distribution system to insure all connected air handler coils and receive design flow when valves are at 100% open position (33 coil/valve combinations).
2. Determine required DP setpoints for newly installed DP sensors specified in Section 1.2.D.1.
3. See Exhibit 9 – RHC Prop 39 Valve Schedule Details.
4. See Product Section 3.9 for TAB specifications.

L. Test and Balance - Hot Water Distribution – Science Building
1. Balanced hot water distribution system to insure all 92 zones are receiving design flow when re-heat valve is 100% open.
2. Determine required DP setpoints for newly installed DP sensors specified in Section 1.2.D.1.
3. See Exhibit 5 – Science Building Mechanical Drawings for valve design flows and valve schedule.
4. See Product Section 3.9 for TAB specifications.

M. Test and Balance - Air Side Distribution – Science Building
1. Balanced air distribution system to insure all 108 zones are receiving design flow.
2. Determine required air handler duct static pressure setpoints for all air handlers.
3. See attached air handler and VAV box schedule.
4. See section 3.9 for TAB specifications.
5. See Exhibit 6 – Wray Building Mechanical Drawings.

N. Test and Balance - Air Side Distribution – Wray Building
1. Balanced air distribution system to insure all 15 zones are receiving design flow.
2. See section 3.9 for TAB specifications.
3. See Exhibit 6 – Science Building 2015 Tab Report for min and max CFM setpoint schedule.

O. Add-Alt #1: Staging Isolation Valves and Controls - Cooling Tower
1. Install six new automated isolation valves on the inlet side (11-inch lines) of the three cooling towers.
2. Connect the new isolation valve actuators to the cooling tower controller, install additional controller as necessary to handle six new binarity outputs.
3. Modify control sequence to allow for automated staging of the cooling towers based on central plant load.

4. Modify control sequence for cooling tower fans.
5. Modify control sequence for condenser water pump.

P. Add-Alt #2: Test and Balance - Cooling Tower
   1. Install six new automated isolation valves on the inlet side (11-inch lines) of the three cooling towers.
   2. Balance condenser flow to cooling tower using six existing balancing valves to ensure that condenser water is evenly distributed to all nozzles under design conditions.

Q. Add-Alt #3: Replace Existing pneumatic zone level VAV Dual Duct Box Controllers, and Thermostats – Business Building
   1. Replace existing pneumatic VAV dual duct box controllers
   2. Install new DDC Dual Duct VAV box controllers and thermostats. Total of 31 zones: AC-1B has 22 zones and AC-2B has 9 zones).
   3. Provide full integration into existing campus BAS.
   4. See Exhibit 9 - Business Mechanical Drawings

R. Add-Alt #4: Install DDC Controlled Building Isolation Valves – Chilled Water – Various Buildings
   1. Total of 18 valves; nine buildings, isolation valves installed on chilled water supply and chilled water return line. Assume 12-inch pipe.
   2. Provide full integration into existing campus BAS using new or existing controllers.
   3. Provide updated diagram of campus chilled water flow
   4. Provide and install wrap-around flow direction arrow stickers

S. Add-Alt #5: Install DDC Controlled Building Isolation Valves – Hot Water – Various Buildings
   1. Total of 16 valves; eight buildings, isolation valves installed on hot water supply and hot water return line. Assume 12-inch pipe.
   2. Provide full integration into existing campus BAS using new or existing controllers.

T. Furnish and Install network cabling, routers, and hubs required to provide a **fully functional network**. New communication network shall use new, dedicated cabling, routers, and hubs.
   1. Supervisory network shall be **BACnet/IP** between supervisory controllers and server.
   2. Owner's IT LAN shall not be used.
   3. Use existing pre-drilled holes in slabs. Reseal any new penetrations with fire-stop material.

U. Furnish and install all instrumentation specified in the **sequence of operations** and control schematics as required for a complete and operating system.
   1. Sequences of operation based on ASHRAE Guideline 36, including trim and respond control algorithms for DSP and SAT setpoint resets.
   2. Sequences specified in Part 4.

V. Furnish and install **new transformers and all associated wiring, conduit, and tubing** for all new DDC controls. Remove existing transformers, control wiring, and tubing where controls are being replaced. **Reuse existing enclosures** (panels) only where existing enclosures are suitably sized.

W. The Contractor shall be responsible for **providing power** from the control power distribution to all control devices per latest NEC code. Contractor to conduct field survey and provide construction documents, including power floor plans and panel schedules, for electrical work for affect panels.
   1. Updated panel loads
   2. Update panel schedule

X. The contractor shall be responsible for **system integration**.

Y. This project will be commissioned by a third party.

1. **30% of proposed contractor cost to be withheld** until Commissioning authority has signed off on the project.

QUALITY ASSURANCE

Z. The Contractor shall be regularly engaged in the installation and maintenance of DDC systems and shall have a minimum of five (5) years of demonstrated technical expertise and experience in the installation and maintenance of HVAC control systems similar in size and complexity to the project and have a maintained service organization.

AA. Any equipment purchased by the Contractor and billed to the Owner shall become the property of the Owner, even if the purchased equipment is not installed.

1.3 SUBMITTALS

A. Submit complete sets of documentation for approval before starting any work.

B. Engineering Submittals for new work are to consist of the following:

1. Product Information on all proposed hardware items.
2. Proposed installation locations for all equipment for review and approval.
3. Operating Manuals for all proposed hardware and software items.
4. Valve Schedules (if applicable) with Cv, sizes, model, body type.
5. System Architecture Diagram showing all network controllers, equipment controllers (if applicable), zone controllers, network wiring, and power wiring.
6. 24 Vac transformer Load Table
7. Detailed Control Diagrams of each system controlled. Diagrams shall include all I/O, point names, interlocks, wiring, and tubing required to meet the sequence of operations.
8. Sample Startup Forms and Startup Procedures submitted prior to switchover and startup.
9. Each graphic page shall be submitted for review and requires approval by the Cx agent.
10. Detailed sequence of operations for all systems included in PART 4.
11. Commissioning submittals as specified, below:
    a. Sensor Calibration
    b. Point-to-Point System Check-out forms.
    c. Programming Logic.

C. The Contractor shall submit a construction schedule prior to the beginning of construction. The Contractor shall submit a 2-week look ahead during construction, updated weekly.

1.4 CLOSE-OUT AND TURNOVER

A. Upon completing installation, the Contractor shall submit a close-out document specifying the following information:

1. List of all equipment furnished
2. Completed commissioning checklists, as specified in Section 3.2.

B. Upon final project completion, the Contractor shall submit the following information to the Owner's Representative to close out the project.

1. Notice of Completion – Letter to state that the Contractor considers the work completed and to list all final deliverables that have been submitted. Final deliverables include:
    a. One Physical Project Binder and 3 Digital Project Binders, containing the following:
        i. Operating and Maintenance manuals for installed equipment.
        ii. As-built Engineering Submittals, per Section 1.5.
        iii. Training Materials, per Section 3.3.
    b. Completed close-out documentation, as specified above in Section 1.6 A.

c. Final warranty letters. Warranty terms are specified in Section 3.4.
d. Delivery of any leftover equipment to the Owner.

PART 2 – PRODUCTS

2.1 GRAPHICAL USER INTERFACE (GUI)

A. Basic Interface Description

1. The GUI share be web based and integrated into the existing Alerton building automation system
2. The GUI shall provide, at a minimum, the following functionality:
    a. Real-time graphical viewing and control of environment.
    b. Time-based scheduling and override of building operations.
    c. Collection of historical data, minimum 12-month retention
        i. The system shall be setup to automatically archive trends older than a month to a building automation system server, stored by calendar year, on a weekly basis.
    d. Alarm reporting, routing, messaging, and acknowledgment.
    e. Program editing.
    f. Transfer trend data to third-party software, including through .CSV and/or .XLS files
    g. Operator Activity Log.
3. Operator specific password access protection shall be provided for each application to allow the administrator to limit access to point control, display and database manipulation capabilities as deemed appropriate for each user, based upon an assigned password. There shall be 4 access levels as defined below.
    a. Administrator – Full access. Can set passwords and add users.
    b. Programmer – Same access level as Administrator except cannot set passwords and add users. Can change own user name, password and email address.
    c. Operator –View all graphics and override points only, no set point access, can acknowledge alarms. Can change own user name, password and email address.
    d. Read Only – Read only remote access. Can change own user name, password and email address.
        i. Need to provide one remote login to consultant during project commissioning.
4. Reports shall be generated on demand. At a minimum, the system shall allow the user to easily obtain the following types of reports:
    a. A general listing of all or selected points in the network and their values.
    b. List of all points currently in alarm
    c. List of communication failures
    d. List of all points currently in override status
5. Scheduling and schedule override: Provide a calendar type format for simple time-of-day scheduling and overrides of building operations. Provide the following graphic types as a minimum:
    a. Scheduling for up to 365 days in advance, allows for holiday scheduling.
    b. Weekly schedules
    c. Zone schedules
    d. Schedule overrides allows for unique scheduling events
        i. All overrides are globally limited to a maximum of 96 hours (4 days).

2.2 SUPERVISORY CONTROLLER

A. The Network Controller (NC) shall be a fully user-programmable supervisory controller. The NC shall monitor and communicate with the network of air handling units, distributed zone controllers, and exhaust fan.

B. NC size and capability shall be sufficient to fully meet the requirements of this Specification and the associated Sequences of Operation.

C. The NC shall include at least one Ethernet port and at least one serial port (RS-232 or USB) for operation of operator I/O devices.

2.3 AHU CONTROLLER

A. The AHU controllers shall be fully programmable, native BACnet controllers.

B. Controllers shall have available IO for all points included in the control schematics including the add/alternates whether or not the owner chooses to include the add/alternate in the scope of work.

C. The controller shall have one spare universal input (UI) and one spare analog output (AO).

2.4 TERMINAL UNIT CONTROLLERS

A. Terminal unit controllers shall be a fully programmable, native BACnet Controller.

B. Terminal unit controllers shall have an integrated damper actuator and air flow sensor.

C. Each terminal unit controller shall support airflow measurement using the existing terminal unit flow cross(es).

D. Controllers shall have available IO for all points included in the control schematics including the add/alternates whether or not the owner chooses to include the add/alternate in the scope of work. Each controller shall include an occupancy-sensor input terminal (BI).

E. Each controller shall be capable of holding 48 hours of trend activity for all supported points at 5-minute intervals.

2.5 ACTUATORS

A. Common

1. 0-10 vDC, 4 – 20 mA, proportional (modulating) only.
2. Electric control shall be by Belimo, TAC, Johnson, Siemens, or approved equivalent
3. Actuators shall be Brushless DC Motor Technology with stall protection, bi-directional, fail safe spring return.
4. Actuator must be accessible for routine scheduled service.
5. Install in strict accordance with the manufacturer's recommendation.
6. Provide actuators, sized by the Contractor, with adequate torque for the applications.
7. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered.
8. Spring return actuators with more than 7 N*m (60 in-lbs) torque capacity shall have a manual crank to allow manual positioning.

B. Valve Actuators

1. Close-off Ratings
   a. 2-way valves shall close against 125 percent of the maximum differential to which they are subjected.
   b. 3-way valves shall close-off against double the maximum pressure differential to which they are subjected.
2. Use NEMA 4 housing.

2.6 WATER CONTROL VALVES – 2-WAY CHILLED AND HOT WATER

A. Manufacturers: Belimo or approved equivalent

B. Control valves shall be characterized ball valves.

C. Select valves to provide tight shut-off against maximum system temperatures and pressure encountered.

D. Characteristics:

1. Turn down ratio 40:1
2. Flow Characteristics ....Modified. Equal percentage
3. Control Action........................Normal open, closed, or fail in place as required per application.
4. Body Type ... .Threaded ends 2 inch and smaller, flanged 2½ inch and larger
5. Body Material ....Bronze, or Stainless Steel as required by service
6. Body Trim ....Bronze, or Stainless Steel as required by service.
7. Stem ....Stainless Steel

E. General

1. Valves shall be 2-way unless otherwise noted.
2. Control valves for each application shall be from the same manufacturer.

2.7 CHILLED WATER INTERFACE CONTROL VALVE - FOR BUILDING ISOLATION VALVES?

A. The chilled water interface control valve shall be line sized with near zero pressure drop, normally closed (N.C.) and able to shut off against sixty (60) PSI differential pressure with no more than 0.1% of maximum flow leakage.

B. The chilled water interface valve controller shall be capable of receiving a digital input from the campus utilities interface panel that will serve to command the valve closed in case of a utility distribution emergency.

C. Manufacturer: Belimo or approved equivalent

D. Shall be a characterized ball valve for valves up to 6". For valves larger than 6", contact Stanford's Energy Operations department for job specific requirements.

E. Characteristics:

1. Turndown ratios... ....40:1
2. Flow Characteristics ....Modified equal percentage
3. Body Type ....Threaded ends 2" and smaller, flanged 2.5" and larger
4. Body Material ....Stainless Steel
5. Stem ....Stainless Steel

F. Valve Actuator

1. Actuators shall have fail closed return.
2. Actuator shall close against 125 percent of the maximum differential to which they are subjected.
3. Modulating actuator input signals shall be 4-20ma.
4. Actuators shall be Brushless DC Motor Technology with stall protection.
5. Actuators shall be protected from weather (water) as needed.

2.8 SUPPLY, RETURN, AND AVERAGING AIR TEMPERATURE SENSORS

1. Accuracy: ± 0.9°F between 32°F and 150°F.
2. Order with junction box for wire connections, or wires long enough to terminate directly to controller without splices.

2.9 TEMPERATURE SENSORS (OUTDOOR AIR

1. 100 Ohm platinum RTD with a 4500H 2 wire, 4-20 mA current output signal proportional to specified temperature span of transmitter
   a. Accuracy: ± 0.12% at 32°F (Class B)
   b. Temperature Operating Range: -20 to 170°F
   c. Humidity Operating Range: 0 to 99% RH

d. Conformance: DIN-IEC 751

2. Suggested Manufacturers: Ultra Electronics (Model 733)

2.10 TEMPERATURE SENSORS (GENERAL)

A. Tier 2 temperature sensors use a 100 Ohm platinum RTD with a 4500H 2 wire, 4-20 mA current output signal proportional to specified temperature span of transmitter
   1. Accuracy:........…......................± 0.12% at 32°F (Class B)
   2. Temperature Operating Range…..-20 to 170°F
   3. Humidity Operating Range:............ 0 to 99% RH
   4. Conformance:. .... DIN-IEC 751
   5. Range: ....Consult with Owner before ordering

2.11 TEMPERATURE TRANSMITTERS (CENTRAL PLANT) – CHW PLANT

A. Manufacturers: Weed (by Ultra Electronics) or approved equivalent

B. Use 100 Ohm platinum RTD with a 4500H 2 wire, 4-20 mA current output signal proportional to specified temperature span of transmitter
   1. Accuracy:….........± 0.12% at 32°F (Class B)
   2. Temperature Operating Range for Chilled Water…..-20 to 170°F
   3. Humidity Operating Range:............ 0 to 99% RH
   4. Conformance:...... .... DIN-IEC 751
   5. Range: ....Consult with Owner before ordering

C. Include thermowell with spring loaded sensor

D. Calibration and Sizing
   1. Calibrated range for chilled water service is 30 to 80^{o}F
   2. Calibrated range for hot water service is 80 to 220^{o}F

E. Weed Part Numbers:
   1. Head: 5A00A1
   2. Spring Loaded Sensor: 305-01B-A-4-C-xxx.x-z006 (xxx.x equals length to nearest 0.1")
   3. Thermowell: ¾-S260-Ux.x0-Tx-316SS (x.x equals insertion length, x=lagging dimension)
   4. Transmitter: 4HQT4U+030+0080F (chilled water), 4HQT4U+080+0220F (hot water)

2.12 MOTORS

A. Provide premium efficiency, three-phase, 460-volt motors.

B. Motors connected to VFDs shall be inverter duty and compatible with the drive unit. Additionally, motors shall incorporate a design to prevent arcing through the motor bearings such as: insulated bearings, grounded motor shafts, or add-on devices such as those manufactured by AEGIS Ground Shafting Ring, Shaft Grounding Systems, or approved equal. Whenever possible, the ring shall be factory-installed.

2.13 ROOM TEMPERATURE SENSORS (THERMOSTATS)

A. Temperature accuracy at calibration point: ± 0.5°F

B. Units shall not display the temperature reading to occupants.

2.14 CONTROL POWER TRANSFORMER - DELETE

A. Unit shall be RIB Functional Devices, Inc., PSH A Series, 120-24V power supplies, or approved equal.

B. The unit shall be complete with 120 VAC convenience outlet, On/Off switch and breaker, LED indicator light.

2.15 BTU METER - DELETE

1. Recommended Manufacturer: Onicon (System 10), Kamstrup
2. Include flow meter and remote transmitter with NIST Traceable Calibration with Certifications.
3. Include communications card (BACnet).
4. Minimum Performance:
   a. Output — Linear, 4-20 mA (2-wire loop)
   b. Temperature Accuracy — ± .15 percent from 32-200 Deg F.
   c. Water Flow Accuracy — ± 1.0 percent of reading.

PART 3- EXECUTION

3.1 CONTRACTOR RESPONSIBILITIES

A. Construction Management

1. Contractor shall attend on-site or phone-in construction meetings as requested by the Owner. Meetings will not take place more often than once each week.
2. The Contractor shall provide a 2-week look ahead during construction with a list of construction impacts for occupants.

B. Control System Changeover

1. Switch-over from the existing control system to the new system shall be fully coordinated with the Owner.

3.2 HARDWARE INSTALLATION

A. Supply Air Temperature Sensors

1. The Contractor shall install all supply air temperature (SAT) sensors in accordance with the manufacturer's specifications.
2. Mount the SAT sensor in the supply air duct as follows:
   a. Air Handler sensor: at least 2 feet downstream of the supply air shaft joint.
3. If the SAT sensor is mounted such that it cannot be wired with the included wiring alone, the Contractor shall extend the length of wire using the following requirements:

Wiring from Sensor to Terminal Strip	Length <100 ft	22 AWG, unshielded
	Length >100 ft	22 AWG, shielded
Maximum Length	500 ft	

B. Outside Air Temperature Sensor

1. The Contractor shall install the outside air temperature sensor in accordance with the manufacturer's specifications.
2. The sensor shall be mounted in the outside air intake of the AHU, within the unit.
3. If the sensor is mounted such that it cannot be wired to the controller with the included wiring alone, the Contractor shall extend the length of wire using the following requirements:

Wiring from Sensor to Terminal Strip	Length <100 ft	22 AWG, unshielded
	Length >100 ft	22 AWG, shielded
Maximum Length	500 ft	

C. Mixed air temperature sensors

1. Mounting shall be across entire AHU width in order to incorporate both outside air and return air streams.

D. Controller(s) and Gateway(s).

1. Install according to manufacturer's recommendations.
2. Install, connect and wire the Controller(s) and Gateway(s). Design-build contractor shall submit proposed installation location for final review and approval. All controllers, gateways, and material necessary to complete the dedicated network shall be provided and installed by the installing contractor.
3. Controller(s) and Gateway(s) shall be installed in an enclosed control panel.
   a. The contractor shall use the existing control panels where there is adequate room to accommodate the new devices
   b. For devices requiring additional or new enclosures, the control panel shall have a hinged door and be NEMA 1 rated for indoor applications and NEMA 4 for outdoor applications. All voltage over 50 volts within the panel shall be guarded for safe access per NEC. The panel shall be sized for twenty percent spare mounting space.

c. Any keyed locks included in the enclosures shall be keyed identically.

E. Room temperature sensors (thermostats)
   1. Install new thermostats in location of existing thermostat.
   2. Any damage or holes in the wall due to installing wiring shall be patched and painted by the Contractor in order to reasonably mask the damage to the wall.
   3. Recess mounting box unless otherwise indicated, or required by the building construction materials.
   4. Label the units with tag number(s) of equipment serving the room.

3.3 ELECTRICAL AND WIRING MATERIALS

A. Work includes providing required wire, fittings, conduit, and related wiring accessories in the scope.

B. Supply and install all necessary transformers/power supplies as required to power instrumentation.

C. All communication wiring within the mechanical room shall be in conduit.

D. All control wire terminations shall be made at a terminal strip.

E. Control wiring shall be labeled with machine printed wire sleeve labels showing panel, controller, I/O, and point name.

F. Wiring must be pulled through existing conduit where applicable.

G. The Contractor shall sleeve and caulk all connections through fire rated walls.

H. The Contractor shall perform all wiring in accordance with all local and national codes.

I. Where practical, the Contractor shall make sure of the existing, pre-drilled slab penetrations between floors for new vertical conduit runs. The fire stop material shall be replaced upon the completion of the project, in compliance with local safety requirements.

3.4 SOFTWARE INTEGRATION – TRENDING

A. The point lists below are required for each listed piece of equipment. The contractor is required to specify controllers that are capable of providing the specified level of I/O and have sufficient memory to process the trend intervals. The points listed below shall be trended at minute intervals for a two-week duration during commissioning and continuously trended at 10 minute intervals.

1. VAV Terminal Unit (with reheat) and Fan Powered Terminal Units. Exclude points as required for cooling only terminal unit.

Point Description	**Hardware Points**	**Software Points**	**Network Point**	**Cx Trend**	**Continuous Trend**	**Show On Graphic**
Zone Temperature	AI			×	10 min.	×
Zone Setpoint		AV		×	10 min.	×
Zone Local Setpoint	AI			×	COV	×
Zone Pressure Request Multiplier		AV				×
Zone Cooling Request Multiplier		AV				×
Discharge Air Temperature	AI			×	10 min.	×
Damper Position	AO			×	10 min.	×
Heating Valve Position (excluded for cooling only terminal units)	AO			×	10 min.	×
Occupied Heating Setpoint		AV				×
Occupied Cooling Setpoint		AV				×
Effective Occupied Heating Setpoint		AV		×	10 min.	×
Effective Occupied Cooling Setpoint		AV		×	10 min.	×
Unoccupied Heating Setpoint		AV		×		×
Unoccupied Cooling Setpoint		AV		×		×
Heating Demand		AV		×	10 min.	×
Cooling Demand		AV		×	10 min.	×
Discharge Air Flow (CFM)	AI			×	10 min.	×
Discharge Air Flow Setpoint		AV		×	10 min.	×
VAV Mode (Heating/Deadband/Cooling)		AV		×	COV	×
Zone Group Mode (Occupied, Setup, Setback, Warm-up, Cool-Down, Unoccupied)		AV		×	COV	×
Fan Status (Fan powered boxes only)	BI			×		×
AI – Analog Input; AO – Analog output; BI – Binary Input; BO – Binary output; AV – Analog Value; BV – Binary Value						

2. Air Handler Units (serving multiple zones)

Point Description	AHU Tag	Hardware Points	Software Points	Network Point	Cx Trend	Continuous Trend	Show On Graphic
Return Air Temperature	All	AI			×	10 min.	×
Supply Air Temperature Setpoint (Science AHUs)	Science AHUs		AV		×	10 min.	×
Supply Air Temperature (Science AHUs)	Science AHUs	AI			×	10 min.	×
Cold Deck Supply Air Temperature	(Wray AHU-2, AHU-4, AHU-5) and Business AC-1B and AC-2B)	AI			×	10 min.	×
Hot Deck Supply Air Temperature	(Wray AHU-2, AHU-4, AHU-5) and Business AC-1B and AC-2B)	AI			×	10 min.	×
Cold Deck Supply Air Temperature Setpoint (Wray AHU-2, AHU-4, AHU-5) and Business AC-1B and AC-2B)	(Wray AHU-2, AHU-4, AHU-5) and Business AC-1B and AC-2B)		AV		×	10 min.	×
Hot Deck Supply Air Temperature Setpoint (Wray AHU-2, AHU-4, AHU-5) and Business AC-1B and AC-2B)	(Wray AHU-2, AHU-4, AHU-5) and Business AC-1B and AC-2B)		AV		×	10 min.	×
Mixed Air Temperature	All	AI			×	10 min.	×
DP across Filters	All	AI			×	10 min.	×
Outside Air Damper Position	(Wray AHU-2, AHU-4, AHU-5) and Business AC-1B and AC-2B)	AO			×	10 min.	×
Return Air Damper Position	All	AO			×	10 min.	×
Chilled Water Valve Command	All	AO			×	10 min.	×
Heating Water Valve Command	(Science AHU-1 Wray AHU-2, AHU-4, AHU-5) and Business AC-1B and AC-2B)	AO			×	10 min.	×
Duct Static Pressure Setpoint	All Science AHUs		AV		×	10 min.	×
Duct Static Pressure	All Science AHUs	AI			×	10 min.	×
Cold Deck Duct Static Pressure Setpoint	Business AC-1B and AC-2B		AV		×	10 min.	×
Cold Deck Duct Static Pressure	Business AC-1B and AC-2B	AI			×	10 min.	×
Hot Deck Duct Static Pressure Setpoint	Business AC-1B and AC-2B		AV		×	10 min.	×
Hot Deck Duct Static Pressure	Business AC-1B and AC-2B	AI			×	10 min.	×

Building Pressure	Science AHUs, Business AC-1B and AC-2B	AI			x	10 min.	x
Building Pressure Setpoint	Science AHUs, Business AC-1B and AC-2B		AV				x
Supply Fan VFD Start/Stop	Science AHUs, Business AC-1B and AC-2B	BO			×	COV	×
Supply Fan VFD Speed	Science AHUs, Business AC-1B and AC-2B	AO			×	10 min.	×
Supply Fan Status	Science AHUs, Business AC-1B and AC-2B	BI			×	COV	×
Return Fan VFD Start/Stop	Science AHUs,	BO			×	COV	×
Return Fan VFD Speed	Science AHUs,	AO			×	10 min.	×
Return Fan Status	All AHUs with RFs	BI			×	COV	×
Number of Pressure Requests	Science AHUs, Business AC-1B and AC-2B		AV		x	10 min.	x
Number of Cooling Requests	Science AHUs, Business AC-1B and AC-2B		AV		x	10 min.	x
Total VAV Airflow (sum)	Science AHUs		AV		x	10 min.	x
	AI – Analog Input; AO – Analog output; BI – Binary Input; BO – Binary output; AV – Analog Value; BV – Binary Value						

3. Air Handler Units (serving single zone)

Description	**Type**	**Device**
Supply Fan Start/Stop	DO	Connect to VFD Run
Outdoor/Return Air Damper	AO	Modulating actuator (dampers are linked and complementary)
Outdoor Air Temperature	AI	Temperature sensor at outdoor air intake
Mixed Air Temperature	AI	Averaging temperature sensor
Return Air Temperature	AI	Duct temperature sensor
Cooling Signal	AO	Modulating CHW valve ***OR*** Variable-capacity compressor
Heating Signal	AO	Modulating HW valve ***OR*** Modulating electric heating coil
Zone Temperature	AI	Room temperature sensor
Local Override (if applicable)	DI	Zone thermostat override switch
Occupancy Sensor (if applicable)	DI	Occupancy sensor
Window Switch (if applicable)	DI	Window switch
Zone Temperature Setpoint Adjustment (if applicable)	AI	Zone thermostat adjustment

Zone CO_2 Level (if applicable)	AI	Room CO_2 sensor
For units with actuated relief dampers but no relief fan, include the following points		
Relief Damper	AO	Modulating actuator
For units with a relief fan, include the following points		
Relief Fan Start/Stop	DO	
Relief Damper Open/Close	DO	Two position actuator
For units with a return fan, include the following points		
Return Fan Start/Stop	DO	
Return Fan Status	DI	Current switch
Return Fan High Static Alarm Reset	DO	Dry contact to 120V or 24V control circuit
Exhaust Air Damper (if applicable – damper may be barometric)	DO	Two position actuator

4. Exhaust Fans

Point Description	Hardware Points	Software Points	Network Point	Cx Trend	Continuous Trend	Show On Graphic
EF-SS1 Exhaust Start/Stop	BO			×	COV	×
EF-SS1 Exhaust Status	BI			×	COV	×

:

5. Power Meter

Point Description	Hardware Points	Software Points	Network Point	Cx Trend	Continuous Trend	Show On Graphic
Power (kW)	AI			×	10 min.	×

6. Chilled Water BTU Meter

Point Description	Hardware Points	Software Points	Network Point	Cx Trend	Continuous Trend	Show On Graphic
Flow (gpm)	AI			×	10 min.	×
Building Supply Temperature	AI			×	10 min.	×
Building Return Temperature	AI			×	10 min.	×
Btu/h	AI			×	10 min.	×

7. Hot Water BTU Meter

Point Description	Hardware Points	Software Points	Network Point	Cx Trend	Continuous Trend	Show On Graphic
Flow (gpm)	AI			×	10 min.	×
Building Supply Temperature	AI			×	10 min.	×
Building Return Temperature	AI			×	10 min.	×
Btu/h	AI			×	10 min.	×

3.5 SOFTWARE INTEGRATION - GRAPHICS

1. General
   a. Each graphic is to include all control points, devices and user adjustable setpoints/parameters associated with the system. Provide links that allow a user to logically negotiate all graphics in a hierarchical manner.
   b. Decimal precision. Unless indicated otherwise, point values shall use the following decimal precision.
      i. Temperatures and temperature setpoints: 1 decimal place.
      ii. Differential Pressure and differential pressure setpoints: 1 decimal place
      iii. Airflow (CFM) and airflow setpoints: no decimal places.
      iv. Water flow (GPM) and water flow setpoints: no decimal place.
      v. Valve and Damper positions: no decimal place.
      vi. Duct static pressure (Inches Water Column) and duct static pressure setpoints: 2 decimal places.
      vii. Building static pressure (Inches Water Column) and building static pressure setpoints: 3 decimal places.
   c. All valve and damper output positions should be denoted as %OPEN
   d. Provide consistency in measurement units.
   e. We recommend using graphic templates to minimize the number of files generated. Identical mechanical systems should utilize a common template that can be adjusted in a single place.
   f. All points, as specified in points list table, shall be displayed and adjustable (as applicable) in graphics.
   g. User adjustable points, displayed on any graphic page, shall be identifiable by highlighting upon mouse over.
   h. There shall be only one graphic header file that shall be used on all graphics required for the project.
   i. Graphics pages shall have numeric values large enough so that they are legible when a screen capture is scaled to 50%. (This prevents text sized that are too small and allows for readable pages on various monitors, when viewed remotely, and when screenshots are included in documents.
   j. Graphics pages should have a look and feel that matches the existing campus BAS graphics.
   k. Graphic Pages Required.
      i. At a minimum, all the example graphics depicted below, and all additional graphics described below (including where an example is not provided) shall be included as part of the project.
2. Chilled Water Plant Graphics
   a. New graphics pages
      i. Chilled water valve summary

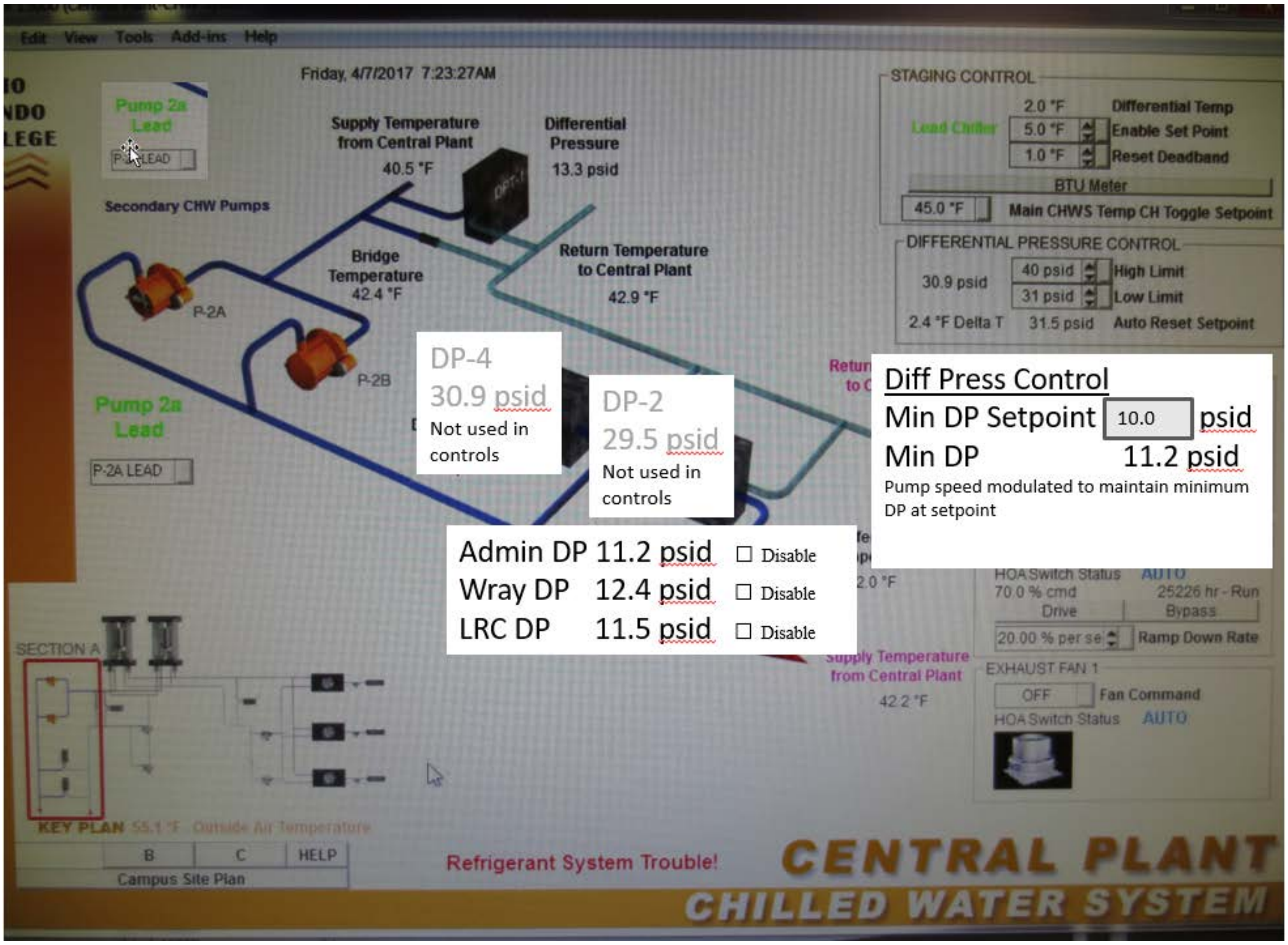
a) Graphic shall list Bldg, AHU, Valve position, Status, SATsp, and SAT in table format for all units.

b) Sample

b. Revised graphics pages

i. Condenser water page

a) Sample



c. Sample chiller page, with modifications shown.

d.

3. Hot Water Plant Graphics

a. New graphics pages

b.

4. Air Handler Pages (VAV with Reheat, Science Building)

a. The air handler graphics pages shall include all the points indicated in trend points (listed above).

b. Provide a link to the other air handler unit.

c. Provide a link to the respective floor plans.

d. Include total summed airflow from associated VAV terminal units.

e. Include Trim and Respond parameters – See Sequences of Operation for more details

i. Pressure Requests

a) Max Setpoint

b) Min Setpoint

c) Number of Requests, R (active sum)
d) Number of Ignore Requests, I (setpoint)
e) Other Trim and Respond Setpoints. Need to be accessible, but could be on a separate graphic
   1 Initial Setpoint
   2 Time Delay
   3 Time Step
   4 Trim Amount
   5 Respond Amount
   6 Max Respond Amount

ii. Cooling Requests
a) Max Setpoint
b) Min Setpoint
c) Number of Requests, R (active sum)
d) Number of Ignore Requests, I (setpoint)
e) Other Trim and Respond Setpoints. Need to be accessible, but could be on a separate graphic
   1 Initial Setpoint
   2 Time Delay
   3 Time Step
   4 Trim Amount
   5 Respond Amount
   6 Max Respond Amount

5. VAV Summary
   a. VAV Summary graphics shall include all VAVs for each AHUs on a single (scrollable) page.
   b. Tabular data will be sorted by terminal unit number.
   c. VAV Summary data shall be exportable to CSV format. Overview graphic shall include an “Export to CSV” button.
      i. Unit labels will be in column headings only so that numeric data is recognized in spreadsheet programs as a number.
   d. VAV Summary graphics shall include the following columns:
      i. VAV number, with link to Terminal Box Graphic
      ii. Floor number
      iii. Room number, in which thermostat is located
      iv. Description, an editable field.
         a) Default description should be “SSB Building”
      v. Zone temperature, See color coding below
      vi. Mode (heating, cooling, deadband)
      vii. Heating Setpoint
      viii. Heating demand
      ix. HW valve command
      x. Cooling setpoint
      xi. Cooling demand
      xii. Cooling Request Multiplier
      xiii. Cooling Requests
      xiv. %Cooling Request Hours
      xv. Airflow

xvi. Airflow setpoint
xvii. Percent of flow, (airflow/airflow setpoint)
xviii. Damper position (%)
xix. Pressure Request Multiplier
xx. Pressure Request
xxi. Pressure Request %
xxii. Min flow setpoint
xxiii. Max (cooling) flow setpoint
xxiv. Max heating flow setpoint

e. Zone temperature and Mode shall be colored according as flows:
   i. Blue – cold zone in heating, more than 2°F (adj.) below heating setpoint
   ii. Cyan – cool zone in heating, less than or equal to 2°F (linked to variable for cold zones) below heating setpoint
   iii. No coloring – zone temperature between heating setpoint and cooling setpoint
   iv. Pink – warm zone in cooling, less than or equal to 2°F (linked to variable for hots zones) above cooling setpoint
   v. Red – hot zone in cooling, more than 2°F (adj.) above cooling setpoint

f. Cooling and Pressure Requests shall be highlighted in some manner.

g. Sample layout provided below.

AHU-SS1						Heating		Cooling				Airflow									
VAV	Floor	Room	Desc	Temp	Mode	Heat-SP (°F)	HWV	Cool-SP	Cool-Req	Cool-Mult	Cool-Req%hrs	Airflow (cfm)	Airflow-SP	Airflow %	Damper	Press-Req	Press-Mult	Press-Req%hrs	Max (heat) flow	Min Flow	Max (cool) Flow
1-01	1	103B	Faculty Lounge	67.5	Heating	70.0	40%	74.0	0	0	2%	540	500	108%	20%	0	1	5%			
1-02	1	104V	Health	68.2	Heating	70.0	10%	74.0	0	1	1%	1108	1100	101%	60%	0	1	1%			
1-03	1	110	Student Services	70.5	Deadband	70.0	0%	74.0	0	1	4%	505	500	101%	35%	0	1	5%			
1-04	1	145		75.2	Cooling	70.0	0%	73.0	1	1	35%	765	1600	48%	98%	1	1	20%			
1-05	1	156	Finances	77.0	Cooling	70.0	0%	74.0	2	2	35%	1240	1300	95%	30%	0	1	2%			
	1																				
	2																				
	2																				
	2																				
	2																				
	2																				
	2																				

6. Floor Plans Pages
   a. Pages should include links to all other floor plan pages
   b. All VAV terminal units labeled, link to associated terminal unit graphic
   c. Show zone temperature
   d. Zone temperature shall be colored according as flows:
      i. Blue – cold zone in heating, more than 2°F (adj.) below heating setpoint
      ii. Cyan – cool zone in heating, less than or equal to 2°F (linked to variable for cold zones) below heating setpoint
      iii. No coloring – zone temperature between heating setpoint and cooling setpoint
      iv. Pink – warm zone in cooling, less than or equal to 2°F (linked to variable for hots zones) above cooling setpoint
      v. Red – hot zone in cooling, more than 2°F (adj.) above cooling setpoint

7. Terminal VAV Boxes
   a. Each terminal box graphic shall include all points indicated in in trend points (listed above).
   b. Graphics shall include unit Mode
   c. Include Trim and Respond Multipliers
      i. Pressure Request Multiplier (default is 1)
      ii. Cooling Request Multiplier (default is 1)

d. Each terminal box graphics should be accessible from links in the VAV summary page and in the Floor Plans

3.6 COMMISSIONING, TESTING, AND ACCEPTANCE

A. General

1. The contractor shall incorporate all Commissioning and testing activities into the construction schedule.
2. Provide documentation of all On-Site Testing to the owner as part of the O&M package.
3. The Contractor shall provide the Owner's representative remote read/write access to the BAS prior to functional testing.
4. Functional performance testing procedures will be provided by the owner's designated representative. Procedures shall be reviewed by the Contractor for issues pertaining to safety, equipment protection and warranty, and appropriateness of the procedure. The owner's designated representative has the option to witness all tests.
5. Contractor shall set up and provide trends for review by Owner's representative.
6. Prior to the Owners representative performing a Sequence of Operations Verification, the Contractor shall provide the Owner's representative a copy of the programming logic.
7. Test to consist of the following:
    a. Point-to-Point Installation Verification of all DDC I/O
    b. Controller Startup and Verification
    c. Calibration of Analog Inputs

B. Functional Testing and Sequence of Operation Verification for Commissioning Procedures

1. Point-to-Point Installation Verification Procedure to consist of the following (at a minimum) for all hard-wired points:
    a. Documentation: an Excel spreadsheet listing all I/O in the system including point name, address, analog range or digital normal state, engineering units. Provide one signature block per page for Contractor's representative and Owner's representative to accept the test results.
    b. Digital inputs: jumper or open the wires at the device and verify change of state at controller. Record results on spreadsheet.
    c. Analog Inputs: lift wire at device to see change of state and record default value on spreadsheet.
    d. Digital/Analog Outputs: command the field device from the controller and verify corresponding change of state at the field device. Record results on spreadsheet.
2. Controller Startup Procedures to consist of the following (as a minimum):
    a. Documentation - An Excel spreadsheet listing all controllers in the system including System Name, Controller Address, Application Type, Application #. Provide one signature block per page for Contractor's representative and Owner's representative to accept test results.
3. Calibration of analog inputs:
    a. Confirm and document proper calibration of all newly installed sensors. Sensors must match Contractor's temperature readings within ±1 °F.
    b. Confirm and document proper calibration of all installed supply air temperature sensors. Sensors must match Contractor's temperature readings within ±0.5 °F.
    c. Use calibration tool with twice the accuracy of instrument being tested. Record calibration offset on spreadsheet.
    d. Provide documentation to show that calibration tool has been calibrated in the last year.
    e. It is absolutely not acceptable to use an infrared non-contact thermometer to calibrate temperature sensors.

C. Functional Performance Testing

1. Provide a qualified technician to complete the functional testing per the functional performance test procedures provided by the owner's representative. The functional performance test form is to include areas to check and record each facet of the sequence of operations including but not limited to the following:
   a. Start/Stop
   b. Interlocks
   c. Safeties
   d. Valve stroke
   e. PID loops
   f. Modes of operation
   g. Power failure/recovery
2. Trend review of certain functions may be completed in place of functional testing. The contractor shall provide the owners representative with trend data in CSV format.
3. Performance testing will be done on site and remotely from the wireless management system.
4. Any unit malfunctions or temperature readings that are out of calibration will be presented to the Contractor in the form of a Project Deficiencies and Resolutions Log (PDR Log).
5. The Contractor shall repair any deficiencies found during functional testing.
6. The Contractor shall be back charged for additional testing time required by the owner's representative as a result of equipment not passing the functional test the first time.
7. The Contractor shall repeat the functional performance testing until all functional tests are passed.

D. 72 Hour Trend Test Procedures. The Contractor shall complete the following (as a minimum):
   1. Place entire system in Automatic Operation.
   2. Generate Trends and Trend Logs of all I/O as directed by Owner's Representative. The contractor shall provide the owners representative with trend data in CSV format.
   3. Review Trend Logs with Owner's Representative to ensure system is controlling properly and that control loops do not exhibit excessive oscillation.
   4. Owner's Representative shall have the right to change set points and verify that system responds properly.
   5. Repair any deficiencies found during 72 Hour Test.
   6. Re-execute 72 Hour Test until no deficiencies are found.

3.7 TRAINING

A. The Contractor shall provide training to designated personnel in the operation and maintenance of the system installed. An agenda must be submitted prior to training. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal working hours.
   1. Training for Owner's designated operating personnel shall include the following on-site training:
      a. Explanation of drawings, operations and maintenance manuals.
      b. Walk-through of the job to locate control components.
      c. Controller operation/function.
      d. Operator control functions including graphic generation and field panel programming.
      e. Explanation of adjustment, calibration and replacement procedures for all equipment provided on this project.
      f. Explanation of procedures to restore any network controller or zone controller. Training manual shall include screen captures, including instructional annotation, of each step required to accomplish the task.
      g. Training binder with training modules.
   2. Training will be schedules on two different days with one week in between.

B. The Owner may require personnel to have more comprehensive understanding of the hardware and software; additional training must be available from the Contractor. If such training is required by Owner, it will be contracted at a later date.

3.8 WARRANTY

A. General Requirements: Provide all labor, materials and equipment necessary to warrant the entire DDC system for a period of <u>one year</u> after project acceptance by the Owner.

B. Personnel: Provide qualified personnel to accomplish all work promptly and satisfactorily. The Owner shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

C. The Owner will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the complete system. Furnish Owner with a telephone number and e-mail address where the service representative can be reached at all times. Service personnel shall be at the site within 24 hours after receiving a request for service.

D. Systems Modifications: Provide any recommendations for system modification in writing to the Owner. Do not make any system modifications, including operating parameters and control settings, without prior written approval of the Owner. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.

3.9 TEST, ADJUSTING, AND BALANCING (TAB)

A. EXAMINATION

1. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
   a. Systems are started and operating in a safe and normal condition.
   b. Temperature control systems are installed complete and operable.
   c. Proper thermal overload protection is in place for electrical equipment.
   d. Final filters are clean and in place. If required, install temporary media in addition to final filters.
   e. Duct systems are clean of debris.
   f. Fans are rotating correctly.
   g. Fire and volume dampers are in place and open.
   h. Air coil fins are cleaned and combed.
   i. Access doors are closed and duct end caps are in place.
   j. Air outlets are installed and connected.
   k. Duct system leakage is minimized.
   l. Hydronic systems are flushed, filled, and vented.
   m. Pumps are rotating correctly.
   n. Proper strainer baskets are clean and in place or in normal position.
   o. Service and balance valves are open.

2. Submit field reports. Report defects and deficiencies noted during performance of services, which prevent system balance.
3. SYSTEMS BALANCING
   a. General:
      i. The decision regarding who shall retain the Balancing Contractor will be made on a project-by-project basis by the University. The Balancing Contractor shall comply with the Provisions of this article whether the Balancing Contractor is retained by the University under an independent

contract, or is retained as a subcontractor, by the University, by the General, or by the Mechanical Contractor.

ii. The Balancing Contract Documents shall stipulate that within two (2) weeks of award of the Contract, the Balancing Contractor shall submit to the General Contractor a written statement detailing all special requirements and additional installation of dampers, valves, access panels, etc. necessary to accomplish the balancing work. The Balancing Contractor shall be responsible for providing all labor, materials, and equipment necessary to complete the balancing work after this two (2) week period.

b. Pre-Balancing:

i. All systems shall be completed and tested early enough to enable completion of balancing prior to Owner moving in. The Architect and Project Manager shall be advised in writing when all systems have been completed and tested and are ready for balancing.

ii. Complete testing of all systems.

iii. The Mechanical Subcontractor shall complete or perform the following work prior to commencement of the balancing procedure:

a) Prior to the start of balancing, complete all "Punch List" items that will affect balancing of the systems.

b) Install all dampers and other balancing devices indicated in the Construction Documents and check to be sure they are properly installed, indexed, and in good working order.

c) Place all systems in automatic operation.

d) Schedule the work of all other trades to eliminate system shutdown for any reason once balancing is started.

e) Schedule the work of other trades to assure uninterrupted access to mechanical equipment rooms and conditioned spaces.

f) Check all motor starters and be sure the heater size is correct, taking length of electrical feeder into consideration.

g) Provide labor and material necessary to perform any system revisions required to allow completion of balancing.

h) Align all drives.

i) Set sheaves to provide indicated capacities at specified static pressures.

j) Set all manual dampers to 100% open position.

k) Set all balancing cocks to 100% open position.

l) All adjustable pitch pulleys shall be removed from the motor shaft; the shaft and pulley threads shall be cleaned, lightly oiled, and the pulley remounted, aligned and properly adjusted.

m) Clean interior of all plenums, casings, and ducts, and install temporary and final filters before starting any systems.

n) Operate all systems simultaneously in normal operating mode for 72 consecutive hours without shutdown and with all equipment in perfect working order.

o) Notify Contractor prior to start of tests to enable balancing to be scheduled.

p) Drill 1/2 inch diameter test holes in ductwork in the following locations: immediately up-and-downstream of each filter, fan, coil, and motorized damper; 12 inch on center. for traverse readings in all main ducts or as directed by the Balancing Contractor. Install a replaceable rubber or plastic plug in each test hole. Plugs in fume exhaust ducts shall be corrosion proof.

iv. Performance and Capacity Measurements:

a) Reading shall be taken of pressures, flow rates, RPM, amps, and volts (as applicable) for the following equipment:

1 Pumps

2 Air handling equipment

3 Coils

4 VAV fans (take readings of amp draw over full, half, and minimum capacity operating ranges).

5 Verify set points for controls.

c. Data indicating how the above readings compare with the manufacturer's published data shall be provided. Readings that do not conform to the manufacturer's published ratings shall be turned over to the Mechanical Contractor, whereupon corrections necessary to enable the equipment perform in accordance with the manufacturer's published data shall be made at no additional cost to the University.

d. The above readings shall be taken by the Balancing Contractor, who will submit to the Architect and the University's Project Manager a certification stating that the equipment has been checked and is performing in accordance with the manufacturer's performance and design criteria.

e. Balancing of Air and Hydronic Systems:

i. General:

a) System balancing shall be performed by a firm regularly engaged and specializing in the field of air and water balancing.

b) The balancing firm must have experience in projects of similar type and scope, and shall submit to the Project Manager, prior to bidding, a list of names and qualifications of all personnel proposed to do this work, including the qualifications of the supervisor and engineering technician. Personnel shall have past experience of such a nature that qualifies them for balancing of these systems.

c) The final balance report shall be checked by the Consulting Engineer.

d) A detailed description of procedures shall be submitted. These are to reflect the specific system and components of the particular building to be balanced. A description of which instruments will be used for each type of measurement shall be included. Only procedures consistent with the provisions and standard format described in this Article will be accepted. Generalizations in lieu of specifics will be considered as non-compliant bids and as such will not be considered.

f. Scope of Work:

i. The test and balance service shall be performed upon completion of the air-handling and water systems and after completion of general operating tests.

ii. Immediately following approval of mechanical shop drawings, the Balancing Contractor shall:

a) Study the Contract specifications, and drawings, and prepare a schedule to inspect equipment for air and water systems.

b) Recommend adjustments, corrections, and additions to equipment and air and water systems necessary for proper balancing, and submit these recommendations to the Architect and the University's Project Manager in a written report.

iii. During installation of mechanical systems, the Balancing Contractor shall:

a) Make field inspections prior to closing in portions of systems to be balanced; verify that all work, fittings, dampers, balancing devices, etc. are properly fabricated and installed as specified or shown on drawings, and that proper balancing can be done.

b) Prepare test and balancing procedures schedule, test record forms and technical information about the air and water systems necessary for balance work, and submit these materials to the Architect and the University's Project Manager for approval.

iv. Prior to the start of balancing work, the Balancing Contractor shall produce a single-line flow diagram of each system showing a representation of all components of the systems in their actual operational sequence. The diagram shall have a point-by-point tabulation of the flow, pressure and applicable temperature to be found at each point location on the diagram with design and actual final readings shown in the following format:

(<u>design reading</u>) (actual reading)

v. Upon completion of installation of air and water systems, and after completion of general operating tests by the Mechanical Contractor, the following work shall be done:

vi. Balancing shall include as a minimum, but not be limited to the following design and test-balance information:

g. Adjust and measure fume hood performance as follows:

i. Each hood shall be visually inspected for deficiencies. Each hood shall have an airfoil at the front edge of the counter top.

ii. Set all fume hood sashes (on one fan system) at fifteen inch (15") height.

iii. Measure the face velocity at the center of evenly spaced areas (approx. one square foot) in the face opening of the hood with a hot wire anemometer. Report the average of these readings as the fume hood face velocity.

iv. After measuring the face velocity, each hood shall be tested by a smoke test following the ASHRAE 110 Standard, Sections 6.2.1 and 6.2.2.

v. Make allowance for air filter resistance at the time of the tests. The main air supplies shall be at design air quantities and at an air resistance across the filter bank midway between the design specifications for clean and dirty filters.

vi. Verify control sequence, setting and operation of automatically controlled dampers. Final position of manual dampers shall be plainly marked after balancing is complete.

vii. Assure that all modulating control valves provided full-throttling wide-open (design) flows to 100% shutoff. Verify control sequences, settings and operation of all automatic control valves.

viii. Final position of balance valves shall be plainly marked after balancing is complete. Read and record shut-off head and wide open head of each pump.

ix. Air terminal reading shall be performed in accordance with the recommendations of the air device manufacturer. Submit a report for all tests made and for all readings taken.

x. Sound readings shall be made as directed by the University's Project Manager for each specific project.

h. Balancing Performance Criteria:

i. Total supply, return, or exhaust air quantities for any floor or major zone: -0% to +10%

ii. Air flow through grills, diffusers and registers

a) Air flow greater than 200 CFM: + 5%

b) Air flow 200 CFM or less: + 10%

c) Air flow at fume hoods: +/- 10 LFM (Avg.). Average fume hood face velocity tolerance with sash height at fifteen inches (15") and no single measured velocity less than seventy feet (70') per minute. LFM is linear feet per minute.

iii. Waterflow through individual system components: +/- 5%

iv. Pressure Reading

a) Air systems: +/- 0.02 inch WG

b) Water systems: +/- 0.5 psig

v. Temperature drop across coils: + 0.5^{o}F

i. Notify the University's Project Manager and General Contractor immediately and discontinue all balancing work if it is found that any part of the system cannot be balanced to design specifications. Submit a written report to the University's Project Manager and General Contractor as necessary, describing the component, i.e., fan drive, damper, pump, valve, etc., that does not function properly to permit proper balancing to be performed.

j. Instruments shall have been calibrated within the last six months and checked for accuracy prior to starting the balancing procedure. Make velocity reading with an instrument that does not require a separate timer. Submit to the University's Project Manager for approval a list of all instruments, their proposed applications, and the date of latest calibration.

k. Test Conditions: Capacity checks of the heating systems shall be performed during the balancing period and again during a design day the following winter. Capacity checks for the cooling systems shall be performed during the balancing period and again during a design day the following summer. Building lights shall be off for the heating check and on for the cooling check at time of initial balancing. Two weeks notice shall be given to the General Contractor and the University's Project Manager prior to each of the design day capacity checks.

l. Field Markings: Field markings shall be applied as follows:

i. Final balancing position of manual air duct dampers shall be plainly marked.

ii. Final position of hydronic balancing valves shall be plainly marked in a manner that will allow the set position to be reestablished.

m. Field Quality Control: After the Balancing Contractor has submitted records of final Readings and measurements for all systems, the University's Project Manager's Representative will make spot checks of each system. If spot check measurements differ from those submitted, the University's Project Manager will direct that the systems concerned be completely re balanced in the presence of the University's Project Manager's Representative and that new data be submitted. After submission of new data, the University's Project Manager's Representative will conduct a new series of spot checks of each system.

B. PREPARATION

1. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect/Engineer to facilitate spot checks during testing.

C. ADJUSTING

1. Ensure recorded data represents actual measured or observed conditions.
2. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
3. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
4. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

5. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.
6. Check and adjust systems approximately six months after final acceptance and submit report.

D. AIR SYSTEM PROCEDURE

1. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities.
2. Make air quantity measurements in main ducts by Pitot tube traverse of entire cross-sectional area of duct.
3. Measure air quantities at air inlets and outlets.
4. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts.
5. Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
6. Vary total system air quantities by adjustment of fan speeds. Provide sheave drive changes as required to vary fan speed. Vary branch air quantities by damper regulation.
7. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
8. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
9. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
10. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
11. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum airflow rate, full cooling, and at minimum airflow rate, full heating.
12. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries and in clean rooms.
13. Check multi-zone units for motorized damper leakage. Adjust air quantities with mixing dampers set first for cooling, then heating, then modulating.
14. For variable air volume system powered units set volume controller to airflow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable-air-volume temperature control.
15. On fan powered VAV boxes, adjust airflow switches for proper operation.

E. WATER SYSTEM PROCEDURE

1. Adjust water systems, after air balancing, to provide design quantities.
2. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow-metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
3. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
4. Effect system balance with automatic control valves fully open or in normal position to heat transfer elements.
5. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
6. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

F. equipment requiring testing, adjusting, and balancing

a. Fire Pumps
b. Sprinkler Air Compressor
c. Electric Water Coolers
d. Plumbing Pumps
e. Steam Condensate Pumps
f. Boiler Feedwater Pumps
g. HVAC Pumps
h. Water Tube Boilers
i. Packaged Steel Water Tube Boilers
j. Packaged Steel Fire Tube Boilers
k. Forced Air Furnaces
l. Direct Fired Furnaces
m. Reciprocating Water Chillers
n. Air Cooled Water Chillers
o. Centrifugal Water Chillers
p. Absorption Water Chillers
q. Induced Draft Cooling Tower
r. Blow Through Cooling Tower
s. Air Cooled Refrigerant Condensers
t. Packaged Roof Top Heating/Cooling Units
u. Packaged Terminal Air Conditioning Units
v. Unit Air Conditioners
w. Computer Room Air Conditioning Units
x. Air Coils
y. Evaporative Humidifier
z. Sprayed Coil Dehumidifier
aa. Terminal Heat Transfer Units
bb. Induction Units
cc. Air Handling Units
dd. Fans
ee. Air Filters
ff. Air Terminal Units
gg. Air Inlets and Outlets
hh. Controls Compressor
ii. Heat Exchangers

2. Report Forms
   a. Title Page:
      i. Name of Testing, Adjusting, and Balancing Agency
      ii. Address of Testing, Adjusting, and Balancing Agency
      iii. Telephone and facsimile numbers of Testing, Adjusting, and Balancing Agency
      iv. Project name
      v. Project location
      vi. Project Architect
      vii. Project Engineer
      viii. Project Contractor

ix. Project altitude
x. Report date

b. Summary Comments:
   i. Design versus final performance
   ii. Notable characteristics of system
   iii. Description of systems operation sequence
   iv. Summary of outdoor and exhaust flows to indicate amount of building pressurization
   v. Nomenclature used throughout report
   vi. Test conditions
c. Instrument List:
   i. Instrument
   ii. Manufacturer
   iii. Model number
   iv. Serial number
   v. Range
   vi. Calibration date
d. Electric Motors:
   i. Manufacturer
   ii. Model/Frame
   iii. HP/BHP and kW
   iv. Phase, voltage, amperage; nameplate, actual, no load
   v. RPM
   vi. Service factor
   vii. Starter size, rating, heater elements
   viii. Sheave Make/Size/Bore
e. V-Belt Drive:
   i. Identification/location
   ii. Required driven RPM
   iii. Driven sheave, diameter and RPM
   iv. Belt, size and quantity
   v. Motor sheave diameter and RPM
   vi. Center to center distance, maximum, minimum, and actual
f. Pump Data:
   i. Identification/number
   ii. anufacturer
   iii. Size/model
   iv. Impeller
   v. Service
   vi. Design flow rate, pressure drop, BHP and kW
   vii. Actual flow rate, pressure drop, BHP and kW
   viii. Discharge pressure
   ix. Suction pressure
   x. Total operating head pressure
   xi. Shut off, discharge and suction pressures
   xii. Shut off, total head pressure
g. Combustion Test:

i. Manufacturer
ii. Model number
iii. Serial number
iv. Firing rate
v. Overfire draft
vi. Gas meter timing dial size
vii. Gas meter time per revolution
viii. Gas pressure at meter outlet
ix. Gas flow rate
x. Heat input
xi. Burner manifold gas pressure
xii. Percent carbon monoxide (CO)
xiii. Percent carbon dioxide (CO2)
xiv. Percent oxygen (O2)
xv. Percent excess air
xvi. Flue gas temperature at outlet
xvii. Ambient temperature
xviii. Net stack temperature
xix. Percent stack loss
xx. Percent combustion efficiency
xxi. Heat output

h. Air Cooled Condenser:
i. Identification/number
ii. Location
iii. Manufacturer
iv. Model number
v. Serial number
vi. Entering DB air temperature, design and actual
vii. Leaving DB air temperature, design and actual
viii. Number of compressors

i. Chillers:
i. Identification/number
ii. Manufacturer
iii. Capacity
iv. Model number
v. Serial number
vi. Evaporator entering water temperature, design and actual
vii. Evaporator leaving water temperature, design and actual
viii. Evaporator pressure drop, design and actual
ix. Evaporator water flow rate, design and actual
x. Condenser entering water temperature, design and actual
xi. Condenser pressure drop, design and actual
xii. Condenser water flow rate, design and actual

j. Cooling Tower:
i. Tower identification/number
ii. Manufacturer
iii. Model number

iv. Serial number
v. Rated capacity
vi. Entering air WB temperature, specified and actual
vii. Leaving air WB temperature, specified and actual
viii. Ambient air DB temperature
ix. Condenser water entering temperature
x. Condenser water leaving temperature
xi. Condenser water flow rate
xii. Fan RPM

k. Exchanger:
i. Identification/number
ii. Location
iii. Service
iv. Manufacturer
v. Model Number
vi. Serial Number
vii. Steam pressure, design and actual
viii. Primary water entering temperature, design and actual
ix. Primary water leaving temperature, design and actual
x. Primary water flow, design and actual
xi. Primary water pressure drop, design and actual
xii. Secondary water leaving temperature, design and actual
xiii. Secondary water leaving temperature, design and actual
xiv. Secondary water flow, design and actual
xv. Secondary water pressure drop, design and actual

l. Cooling Coil Data:
i. Identification/number
ii. Location
iii. Service
iv. Manufacturer
v. Air flow, design and actual
vi. Entering air DB temperature, design and actual
vii. Entering air WB temperature, design and actual
viii. Leaving air DB temperature, design and actual
ix. Leaving air WB temperature, design and actual
x. Water flow, design and actual
xi. Water pressure drop, design and actual
xii. Entering water temperature, design and actual
xiii. Leaving water temperature, design and actual
xiv. Saturated suction temperature, design and actual
xv. Air pressure drop, design and actual

m. Heating Coil Data:
i. Identification/number
ii. Location
iii. Service
iv. Manufacturer
v. Air flow, design and actual

vi. Water flow, design and actual
vii. Water pressure drop, design and actual
viii. Entering water temperature, design and actual
ix. Leaving water temperature, design and actual
x. Entering air temperature, design and actual
xi. Leaving air temperature, design and actual
xii. Air pressure drop, design and actual

n. Electric Duct Heater:
i. Manufacturer
ii. Identification/number
iii. Location
iv. Model number
v. Design kW
vi. Number of stages
vii. Phase, voltage, amperage
viii. Test voltage (each phase)
ix. Test amperage (each phase)
x. Air flow, specified and actual
xi. Temperature rise, specified and actual

o. Induction Unit Data:
i. Manufacturer
ii. Identification/number
iii. Location
iv. Model number
v. Size
vi. Design air flow
vii. Design nozzle pressure drop
viii. Final nozzle pressure drop
ix. Final air flow

p. Air Moving Equipment:
i. Location
ii. Manufacturer
iii. Model number
iv. Serial number
v. Arrangement/Class/Discharge
vi. Air flow, specified and actual
vii. Return air flow, specified and actual
viii. Outside air flow, specified and actual
ix. Total static pressure (total external), specified and actual
x. Inlet pressure
xi. Discharge pressure
xii. Sheave Make/Size/Bore
xiii. Number of Belts/Make/Size
xiv. Fan RPM

q. Return Air/Outside Air Data:
i. Identification/location
ii. Design air flow

iii. Actual air flow
iv. Design return air flow
v. Actual return air flow
vi. Design outside air flow
vii. Actual outside air flow
viii. Return air temperature
ix. Outside air temperature
x. Required mixed air temperature
xi. Actual mixed air temperature
xii. Design outside/return air ratio
xiii. Actual outside/return air ratio

r. Exhaust Fan Data:
i. Location
ii. Manufacturer
iii. Model number
iv. Serial number
v. Air flow, specified and actual
vi. Total static pressure (total external), specified and actual
vii. Inlet pressure
viii. Discharge pressure
ix. Sheave Make/Size/Bore
x. Number of Belts/Make/Size
xi. Fan RPM

s. Duct Traverse:
i. System zone/branch
ii. Duct size
iii. Area
iv. Design velocity
v. Design air flow
vi. Test velocity
vii. Test air flow
viii. Duct static pressure
ix. Air temperature
x. Air correction factor

t. Duct Leak Test:
i. Description of ductwork under test
ii. Duct design operating pressure
iii. Duct design test static pressure
iv. Duct capacity, air flow
v. Maximum allowable leakage duct capacity times leak factor
vi. Test apparatus
a) Blower
b) Orifice, tube size
c) Orifice size
d) Calibrated
vii. Test static pressure
viii. Test orifice differential pressure

ix. Leakage

u. Air Monitoring Station Data:
  i. Identification/location
  ii. System
  iii. Size
  iv. Area
  v. Design velocity
  vi. Design air flow
  vii. Test velocity
  viii. Test air flow

v. Flow Measuring Station:
  i. Identification/number
  ii. Location
  iii. Size
  iv. Manufacturer
  v. Model number
  vi. Serial number
  vii. Design Flow rate
  viii. Design pressure drop
  ix. Actual/final pressure drop
  x. Actual/final flow rate
  xi. Station calibrated setting

w. Terminal Unit Data:
  i. Manufacturer
  ii. Type, constant, variable, single, dual duct
  iii. Identification/number
  iv. Location
  v. Model number
  vi. Size
  vii. Minimum static pressure
  viii. Minimum design air flow
  ix. Maximum design air flow
  x. Maximum actual air flow
  xi. Inlet static pressure

x. Air Distribution Test Sheet:
  i. Air terminal number
  ii. Room number/location
  iii. Terminal type
  iv. Terminal size
  v. Area factor
  vi. Design velocity
  vii. Design air flow
  viii. Test (final) velocity
  ix. Test (final) air flow
  x. Percent of design air flow

y. Sound Level Report:
  i. Location

ii. Octave bands - equipment off
iii. Octave bands - equipment on
iv. RC level – equipment on

z. Vibration Test:

i. Location of points:
a) Fan bearing, drive end
b) Fan bearing, opposite end
c) Motor bearing, center (if applicable)
d) Motor bearing, drive end
e) Motor bearing, opposite end
f) Casing (bottom or top)
g) Casing (side)
h) Duct after flexible connection (discharge)
i) Duct after flexible connection (suction)
j) Test readings:
k) Horizontal, velocity and displacement
l) Vertical, velocity and displacement
m) Axial, velocity and displacement

ii. Normally acceptable readings, velocity and acceleration
iii. Unusual conditions at time of test
iv. Vibration source (if non-complying)

PART 4 - SEQUENCES OF OPERATION

4.1 MISCELLANEOUS

A. Contractor shall review sequences prior to programming and suggest modifications where required to achieve the design intent. Contractor may also suggest modifications to improve performance and stability or to simplify or reorganize logic in a manner that provides equal or better performance. Proposed changes in sequences shall be included as a part of the Submittal Package.

B. Include costs for minor program modifications if required to provide proper performance of the system.

C. VFD speed percentages shall be scaled corresponding to 0-60Hz such that 0 Hz is equal to 0% and 100% is equal to 60 Hz. (This prevents the annoying practice where 0% is a non-zero minimum speed. See also VFD minimum setpoints below.)

D. The sections below are directly adapted from ASHRAE Guideline 36.

1. https://buildingenergy.cx-associates.com/2015/07/ashrae-guideline-36-the-next-generation-control-system/
2. Additional comments/context and project specifics are added with brackets [e.g. example comment].

4.2 GENERAL (Including Trim and Respond)

A. All [This subsection included such that numbers/letters correspond to ASHRAE Guideline 36].

1. Unless otherwise indicated in SOOs, control loops shall be enabled and disabled based on the status of the system being controlled to prevent wind-up.

2. When a control loop is enabled or re-enabled, it and all its constituents (such as the proportional and integral terms) shall be set initially to a Neutral value.
3. A control loop in Neutral shall correspond to a condition which applies the minimum control effect, i.e., valves/dampers closed, VFDs at minimum speed, etc.
4. When SOOs use outdoor air temperature present value and there are multiple outdoor air sensors, the physically closest sensor reading shall be used. [Not expected since each AHU will have an outdoor air temperature sensor.]
5. The term “proven” (i.e., “proven on”/ “proven off”) shall mean that the equipment’s DI status point matches the state set by the equipment’s DO command point.
6. The term “PID loop” or “control loop” is used generically for all control loops and shall not be interpreted as requiring proportional plus integral plus derivative gains on all loops. Unless specifically indicated otherwise, the following guidelines shall be followed:
    a. Use proportional only (P-only) loops for limiting loops (such as zone CO2 limiting loops, etc.) to ensure there is no integral windup.
    b. Do not use the derivative term on any loops unless field tuning is not possible without it.
7. To avoid abrupt changes in equipment operation, the output of every control loop shall be limited to a maximum rate of change of 25% per minute unless otherwise noted.
8. All setpoints, timers, and deadbands listed in sequences shall be capable of being adjusted by the operator without having to access programming whether indicated as adjustable in sequences or not. Software (virtual) points shall be used for these setpoints. Fixed scalar numbers shall not be imbedded in programs unless the value will never need to be adjusted (i.e. conversion factors).
9. Values for all points, including real (hardware) points used in control sequences shall be capable of being overridden by the user (e.g. for testing and commissioning). If hardware design prevents this for hardware points, they shall be equated to a software point and the software point shall be used in all sequences.
10. VFD minimum speed setpoints
    a. Tests shall be done for piece of equipment, except that for multiple pieces of identical equipment used for identical applications, only one piece of equipment need be tested with results applied to all.
    b. This work shall be done only after fan/pump system is fully installed and operational.
    c. Minimum speed setpoints for all VFD-driven equipment shall be determined as follows
        i. Start the fan or pump.
        ii. Manually set speed to 6 Hz (10%) unless otherwise indicated in control sequences. For cooling towers with gear boxes, use 20% or whatever minimum speed is recommended by tower manufacturer.
        iii. Observe fan/pump in field to ensure it is visibly rotating.
            a) If not, gradually increase speed until it is.
        iv. The speed at this point shall be the minimum speed setpoint for this piece of equipment.
        v. Record minimum speeds in log and store in software point
    d. Minimum speed for each piece of equipment shall be stored in a single software point that shall be used in programming (such as PID loop output range) and its value shall be assigned to the minimum speed setpoint stored in the VFD via the drive network interface. In this way there is only one minimum setpoint, rather than setpoints both in the drive and in software which could differ.
11. Trim & Respond (T&R) Resets
    a. Trim & Respond resets and zone/system reset requests where referenced in sequences shall be implemented as described below.
    b. “Requests” are pressure, cooling, or heating setpoint reset requests generated by zones or air handling systems.
        i. For each system with a Trim & Respond reset, provide the following software points:

a) Importance Multiplier (default = 1). This point is used to scale the number of requests the zone/system is generating. A value of zero causes the zone/system's requests to be ignored. A value greater than zero can be used to effectively increase the number of requests from the zone/system based on the critical nature of the spaces served, or to increase the requests beyond the number of ignored requests (defined by each system) in the Trim & Respond reset block.

b) Request-hours

1 This point accumulates the integral of requests (prior to adjustment of Importance Multiplier) to help identify zones/systems that are driving the reset logic. Every x minutes (adjustable, default 5 minutes), add x/60 times the current number of requests to this request-hours accumulator point.

2 The **request-hours** point is reset to zero upon a global command from the system/plant serving the zone/system – this global point simultaneously resets the request-hours point for all zones/systems served by this system/plant.

3 Cumulative **%-request-hours** is the zone request-hours divided by the zone run-hours (the hours in any Mode other than Unoccupied Mode) since the last reset, expressed as a percentage.

4 An alarm is generated if the zone Importance Multiplier is greater than zero, the zone %-request-hours exceeds 70%, and the total number of zone run-hours exceeds 40.

ii. See zone and air handling system control sequences for logic to generate Requests.

iii. Multiply the number of Requests determined from zone/system logic times the Importance Multiplier and send to the system/plant that serves the zone/system. See system/plant logic [Subsequent sections of Part 4] to see how Requests are used in Trim & Respond logic.

c. For each upstream system or plant setpoint being controlled by a T&R loop, define the following variables. All variables below shall be adjustable from a reset graphic accessible from a hyperlink on the associated system/plant graphic. Initial values are defined in system/plant sequences below. Values for trim, respond, time step, etc., shall be tuned to provide stable control.

Variable	**Definition**
SP_0	Initial setpoint
SP_{min}	Minimum setpoint
SP_{max}	Maximum setpoint
T_d	Delay timer
T	Time step
I	Number of ignored Requests
R	Number of Requests from zones/systems
SP_{trim}	Trim amount
SP_{res}	Respond amount (must be opposite in sign to SP_{trim})
$SP_{res-max}$	Maximum response per time interval (must be same sign as SP_{res})

d. Trim & Respond logic shall reset setpoint within the range SPmin to SPmax. When the associated device (e.g., fan, pump) is off, the setpoint shall be SP0. The reset logic shall be active while the associated device is proven on, starting Td after initial device start command. When active, every time step T, trim the setpoint by SPtrim. If there are more than I Requests, respond by changing the setpoint by SPres * (R-I), (i.e., the number of Requests minus the number of Ignored Requests), but no more than SPres-max. In other words, every time step T:

i. Change setpoint by SPtrim
ii. If R>I, also change setpoint by (R-I)*SPres but no larger than SPres-max

4.3 CHILLED WATER PLANT

A. Enable the chilled water plant based on CHW valve positions.
   1. When all CHW valves are 0% open (i.e. all AHUs are scheduled off) for 15 minutes (adjustable), Disable the chilled water plant.
   2. When any three (adjustable) valves are open more than 50% (adj.) for 15 minutes (adjustable), enable the chilled water plant.
   3. Use existing control sequences to energize/de-energize and stage central plant equipment when system is enabled/disabled.

B. Implement original controls sequences for primary chilled water pump speed control.
   1. Modulate the primary chilled water pumps speeds to maintain the effective differential pressure setpoint.
   2. The effective differential pressure setpoint is the product of the nominal differential pressure setpoint (17 psid, adj.) multiplied by one plus the % ramp up signal.
   3. The ramp up signal (%) is increased above 0% when the chiller water bridge temperature exceeds the chiller water supply temp by 0.5 °F.
      a. Show the Reverse Flow Status as in alarm when above 0.5 F.

C. Revise the secondary pump speed control to include new building differential pressure sensors.
   1. Modulate the secondary water pump speed to maintain the minimum DP at the DP setpoint.
      a. Minimum of three remote DP sensors.
      b. Allow operator to disable any of the three sensors through the graphics.

D. Implement chilled water reset control strategy.
   1. Modulate the chilled water temperature setpoint between a low (42 F, adj.) and high (48 F, adj.) range to maintain the maximum chilled water valve position at 85% (adj.).

E. Implement condenser water reset control strategy.
   1. Calculate wetbulb temperature using relative humidity sensor and main outdoor air temperature sensor.
   2. Reset condenser water supply temperature setpoint based on a linear outside air wetbulb reset schedule.
      a. At 55 F (adj.) outside air wet bulb, the CWST setpoint is 63 F (adj.)
      b. At 65 F (adj.) outside air wet bulb, the CWST setpoint is 73 F (adj.)

F. Verify cooling tower VFD speed staging controls.
   1. Fan VFD speeds modulated to maintain CWST setpoint.
   2. Pump VFD speeds modulated to maintain differential pressure setpoint (18 psid, adj.)
   3. Contractor to suggest improved sequences if appropriate.

G. Cross Reference Scope of Work: 1.2 C.4

4.4 HOT WATER PLANT

A. Enable the hot water plant based on HHW valve positions.

1. When all HHW valves are 0% open (i.e. all AHUs are scheduled off) for 15 minutes, turn OFF the hot water plant.
   a. This applies to all air handler HHW valve positions, not reheat valves.
2. When any three (adjustable) valve is open more than 50% (adj.) for 15 minutes, turn ON the hot water plant.
3. Hot water plant is locked out when outside air temperature is above 80 F (adj.).

B. Revise the secondary hot water pump speed control to include new building differential pressure sensors.
1. Modulate the secondary water pump speed to maintain the minimum DP at the DP setpoint.
   a. Minimum of three remote DP sensors.
   b. Allow operator to disable any of the three sensors through the graphics.

C. Implement heating hot water temperature reset control strategy.
1. Reset the heating hot water supply temperature setpoint based on a linear outside air temperature reset schedule.
   a. At 45 F (adj.) outside air temperature, the HHWST setpoint is 180 F (adj.)
   b. At 65 F (adj.) outside air temperature, the HHWST setpoint is 160 F (adj.)

D. Cross Reference Scope of Work: 1.2D

4.5 GENERIC THERMAL ZONES

A. All
1. This section applies to all sub zones of air handling systems, such as VAV boxes and fan-powered boxes, etc.
2. Minimum Outdoor Air
   a. Contractor shall verify that the minimum ventilation setpoints match the provided mechanical schedule and adjust as necessary to match.
3. Setpoints
   a. Each zone shall have separate occupied and unoccupied heating and cooling setpoints.
   b. The active setpoints shall be determined by the operating Mode of the Zone Group [see Zone Groups below].
      i. The setpoints shall be the occupied setpoint during Occupied Mode, Warm-up Mode, and Cool-down Mode.
      ii. The setpoints shall be unoccupied setpoints during Unoccupied Mode, Setback Mode, and Setup Mode.
   c. Default setpoints shall be based on zone type:

Zone Type	**Occupied**		**Unoccupied**	
	Heating	**Cooling**	**Heating**	**Cooling**
VAV - Perimeter	70°F	74°F	60°F	90°F
VAV - Interior	70°F (or N/A)	73°F	60°F (or	90°F
Mech/Elec Rooms	65°F	85°F	65°F	85°F
Networking/Comput	65°F	75°F	65°F	75°F

   d. The software shall prevent
      i. The heating setpoint from exceeding the cooling setpoint minus 1°F (i.e., the minimum difference between heating and cooling setpoints shall be 1°F)
      ii. The unoccupied heating setpoint from exceeding the occupied heating setpoint; and
      iii. The unoccupied cooling setpoint from being less than the occupied cooling setpoint.

e. Where the zone has a local setpoint adjustment knob/button. [Thermostat setpoint dial will be used as a setpoint adjustment.]
    i. The adjustment shall be capable of being limited in software.
        a) As a default, the adjustment shall be limited to ±2 degrees (adj) from the occupied cooling and heating setpoints.
    ii. The adjustment shall only be effective in Occupied Mode and shall be zero in all other modes.

f. Occupancy sensors. For zones that have an occupancy switch. [Not expected]
    i. When the switch indicates the space has been unpopulated for one minute continuously during the Occupied Mode, the active heating setpoint shall be decreased by 2°F and the cooling setpoint shall be increased by 2°F.
    ii. When the switch indicates that the space has been populated for one minute continuously, the active heating and cooling setpoints shall be restored to their previous values.

g. Hierarchy of Setpoint Adjustments: The following adjustment restrictions shall prevail in order from highest to lowest priority:
    i. Setpoint overlap restriction.
    ii. Absolute limits on local setpoint adjustment.
    iii. Local setpoint adjustment: Any changes to setpoint by local adjustment are frozen at the onset of the demand limiting event and remain fixed for the duration of the event. Additional local adjustments are ignored for the duration of the demand limiting event.
    iv. Scheduled setpoints based on Zone Group mode

4. Local override: When thermostat override buttons are depressed, the call for Occupied Mode operation shall be sent up to the Zone Group control for 60 minutes.
5. Control Loops
    a. Two separate control loops shall operate to maintain space temperature at setpoint, the Cooling Loop and the Heating Loop.
        i. The Heating Loop shall be enabled whenever the space temperature is below the current zone temperature heating setpoint and disabled otherwise.
        ii. The Cooling Loop shall be enabled whenever the space temperature is above the current zone temperature cooling setpoint and disabled otherwise.
    b. The Cooling Loop shall maintain the space temperature at the active cooling setpoint. The output of the loop shall be a virtual point ranging from 0% (no cooling) to 100% (full cooling).
    c. The Heating Loop shall maintain the space temperature at the active heating setpoint. The output of the loop shall be a virtual point ranging from 0% (no heating) to 100% (full heating).
    d. Loops shall be use proportional + integral logic. Proportional- only control is not acceptable, although the integral gain shall be small relative to the proportional gain. P and I gains shall be adjustable by the operator (Programmer level only may adjust this).
    e. See other sections for how the outputs from these loops are used.
6. Zone State
    a. Heating: when the space temperature is below the current zone heating setpoint.
    b. Cooling: when the space temperature is above the current zone cooling setpoint.
    c. Deadband: when not in either Heating or Cooling.
7. Zone Alarms
    a. Zone temperature alarms
        i. If the zone is 3°F above cooling or below heating setpoint for 10 minutes, generate Level 3 alarm.
        ii. If the zone is 5°F above cooling or below heating setpoint for 10 minutes, generate Level 2 alarm.

iii. Suppress zone temperature alarms as follows:

a) After zone setpoint is changed for a period of 10 minutes per degree of difference between the zone temperature at the time of the change and the new setpoint. This suppression period applies any time that the zone setpoint is changed.

b) While Zone Group is in Warm-up or Cool-down Modes.

c) For zones with an Importance multiplier of zero for its static pressure reset, SAT reset, or HWST reset Trim & Response loops.

b. For zones with CO_2 sensors:

i. CO_2 sensors: If the CO_2 concentration is less than 300 ppm, or the zone is in Unoccupied Mode for more than 2 hours and zone CO_2 concentration exceeds 600 ppm, generate a Level 3 alarm. The alarm text shall identify the sensor and indicate that it may be out of calibration.

ii. If the CO_2 concentration exceeds setpoint plus 10% for more than 10 minutes, generate a Level 3 alarm.

4.6 ZONE GROUPS

A. All

1. Each system shall be broken into separate Zone Groups composed of a collection of one or more zones served by a single air handler.
2. Zones shall be assigned to Zone Groups as follows:
   a. Each zone served by a fan-coil or single-zone air handler shall be its own Zone Group.
   b. For air handlers serving multiple zones, zones shall be assigned to Zone Groups as specified by the Owner or Owner's Representative or as follows:
      i. All computer rooms, networking closets, mechanical and electrical rooms served by the air handler shall be a single Zone Group.
      ii. A Zone Group shall not span floors.
      iii. A Zone Group shall not exceed 25,000 square feet.
      iv. If future occupancy patterns are known, a single Zone Group shall not include spaces belonging to more than one tenant/department.
   c. Assignment of zones to Zone Groups can be changed at the operator's workstation.
3. Each Zone Group shall have separate occupancy schedules and operating modes from other Zone Groups.

> *Note that, from the user's point of view, schedules can be set for individual zones, or they can be set for an entire Zone Group, depending on how the user interface is implemented. From the point of view of the EMCS, individual zone schedules are superimposed to create a Zone Group schedule, which then drives system behavior.*

4. All zones in each Zone Group shall be in the same operating mode at all times. If one zone in a Zone Group is placed in any mode other than Unoccupied Mode (due to override, sequence logic, or scheduled occupancy), all zones in that Zone Group shall enter that mode.
5. A Zone Group may be in only one mode at any given time.
6. Zone Group Operating Modes: Each Zone Group shall have the following modes:
   a. Occupied Mode: A Zone Group is in the Occupied Mode when any of the following is true:
      i. The time of day is between the Zone Group's scheduled occupied start and stop times.
      ii. The schedules have been overridden by the Occupant Override Button.

Warm-Up and Cool-Down Modes are used to bring the Zone Groups up to temperature based on their scheduled occupancy period. The algorithms used in these modes (often referred to as "Optimal Start") predict the shortest time to achieve occupied setpoint to reduce the central system energy use based on past performance.

We recommend using a global outdoor air temperature, not associated with any AHU, to determine Warm-up start time. This is because unit-mounted OA sensors, which are usually placed in the outdoor air intake stream, are often inaccurate (reading high) when the unit is off due to air leakage from the space through the OA damper.

b. Warm-Up Mode: For each zone, the EMCS shall calculate the required warm-up time based on the zone's occupied heating setpoint, the current zone temperature, the outdoor air temperature (imported campus point), and a mass/capacity factor for each zone. The mass factor shall be manually adjusted or self-tuned by the EMCS. If automatic, the tuning process shall be turned on or off by a software switch, to allow tuning to be stopped after the system has been trained. Warm-up Mode shall start based on the zone with the longest calculated warm-up time requirement, but no earlier than 2 hours before the start of the scheduled occupied period, and shall end at the scheduled Occupied start hour.
   i. Contractor shall use Campus BAS outdoor air temperature to determine warmup and cool-down mode start time. [Because AHU temp sensors are in the units, they are not representative of outdoor air temperature when units are off.

c. Cool-Down Mode: For each zone, the EMCS shall calculate the required cool-down time based on the zone's occupied cooling setpoint, the current zone temperature, the outdoor air temperature, and a mass/capacity factor for each zone. The mass factor shall be manually adjusted or self-tuned by the EMCS. If automatic, the tuning process shall be turned on or off by a software switch, to allow tuning to be stopped after the system has been trained. Cool-down Mode shall start based on the zone with the longest calculated cool-down time requirement, but no earlier than 2 hours before the start of the scheduled occupied period, and shall end at the scheduled Occupied start hour.
   i. Contractor shall use Campus BAS outdoor air temperature to determine warmup and cool-down mode start time. [Because AHU temp sensors are in the units, they are not representative of outdoor air temperature when units are off.

d. Setback Mode: During Unoccupied Mode, if any 5 zones (or all zones, if fewer than 5) in the Zone Group fall below their unoccupied heating setpoints, the Zone Group shall enter Setback Mode until all spaces in the Zone Group are 2°F above their unoccupied setpoints.

e. Freeze Protection Setback Mode: During Unoccupied Mode, if any single zone falls below 38°F, the Zone Group shall enter Setback Mode until all zones are above 42°F, and a Level 3 alarm shall be set.

f. Setup Mode: During Unoccupied Mode, if any 5 zones (or all zones, if fewer than 5) in the Zone rise above their unoccupied cooling setpoints, the Zone Group shall enter Setup Mode until all spaces in the Zone Group are 2°F below their unoccupied setpoints. Zones where the window switch indicates that a window is open shall be ignored.

g. Unoccupied Mode: When the Zone Group is not in any other mode.

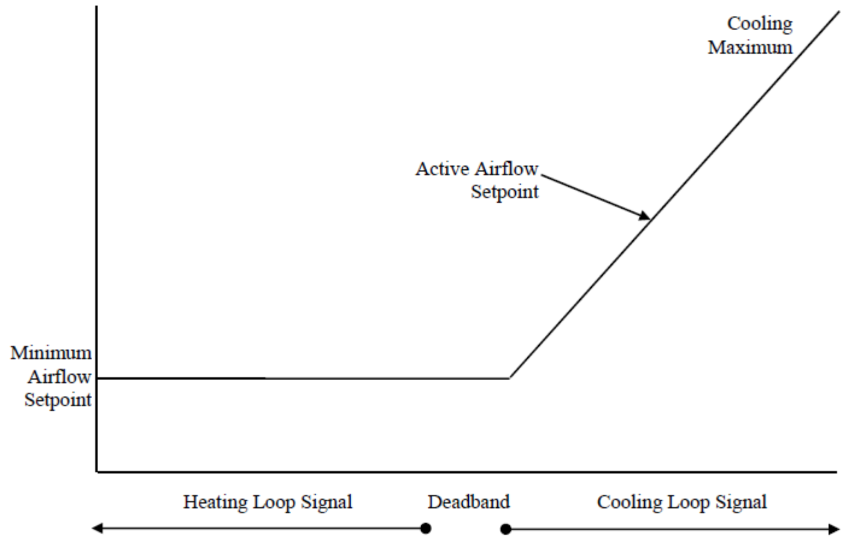
4.7 VAV COOLING-ONLY TERMINAL UNITS

A. All

1. See Generic Thermal Zones for setpoints, loops, control modes, alarms, etc.
2. Design airflow rates shall be as scheduled on plans:
   a. Zone maximum cooling airflow setpoint (Vcool-max)
   b. Zone minimum airflow setpoint (Vmin)
3. Active maximum and minimum setpoints shall vary depending on the Mode of the Zone Group the zone is a part of:

Setpoint	Occupied	Cool-down	Setup	Warm-up	Setback	Unoccupied
Cooling maximum	Vcool-max	Vcool-max	Vcool-max	0	0	0
Minimum	Vmin*	0	0	0	0	0
Heating maximum	Vmin*	0	0	0	0	0

4. Control logic is depicted schematically in the figure below and described in the following sections. Relative levels of various setpoints are depicted for Occupied Mode operation.



   a. When the zone is in Cooling, the Cooling Loop output shall be mapped to the active airflow setpoint from the minimum to the cooling maximum airflow setpoints.
      i. If supply air temperature from air handler is greater than room temperature, Cooling shall be locked out.
   b. When the zone is in Deadband or Heating, the active airflow setpoint shall be the minimum airflow setpoint.
5. The VAV damper shall be modulated by a control loop to maintain the measured airflow at the active setpoint.
6. Alarms
   a. Low airflow
      i. If the measured airflow is less than 70% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 3 alarm.
      ii. If the measured airflow is less than 50% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 2 alarm.
      iii. If a zone has an Importance multiplier of 0 for its static pressure reset Trim & Respond control loop, low airflow alarms shall be suppressed for that zone.
   b. Airflow sensor calibration. If the fan serving the zone has been off for 10 minutes and airflow sensor reading is above 20 CFM, generate a Level 3 alarm.
7. System Requests
   a. Cooling SAT Reset Requests
      i. If the zone temperature exceeds the zone's cooling setpoint by 5°F for 2 minutes, send 3 Requests,
      ii. Else if the zone temperature exceeds the zone's cooling setpoint by 3°F for 2 minutes, send 2 Requests,

iii. Else if the Cooling Loop is greater than 95%, send 1 Request until the Cooling Loop is less than 85%,

iv. Else if the Cooling Loop is less than 95%, send 0 Requests.

b. Static Pressure Reset Requests

i. If the measured airflow is less than 50% of setpoint while setpoint is greater than zero for 1 minute, send 3 Requests,

ii. Else if the measured airflow is less than 70% of setpoint while setpoint is greater than zero for 1 minute, send 2 Requests,

iii. Else if the Damper Loop is greater than 95%, send 1 Request until the Damper Loop is less than 85%,

iv. Else if the Damper Loop is less than 95%, send 0 Requests

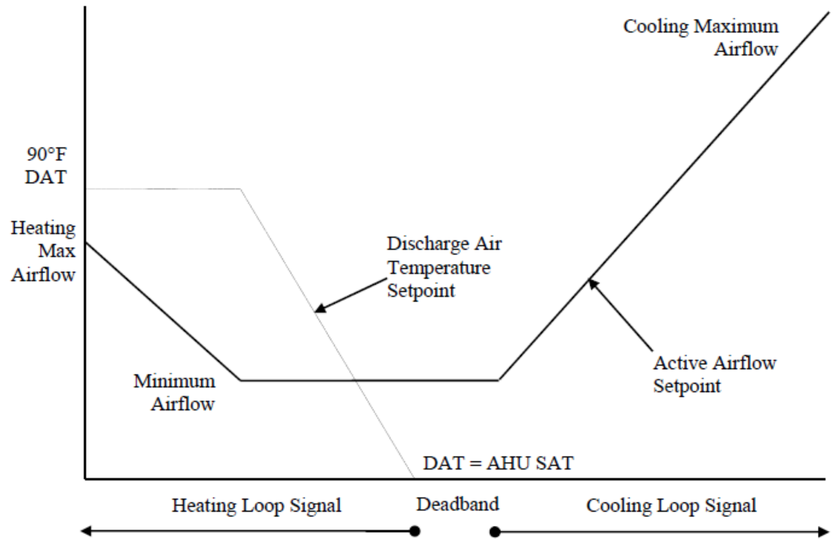
4.8 VAV REHEAT TERMINAL UNIT

A. All (This subsection included such that numbers/letters correspond to ASHRAE Guideline 36).

1. See Generic Thermal Zones for setpoints, loops, control modes, alarms, etc.
2. Design airflow rates shall be as scheduled on plans:
    a. Zone maximum cooling airflow setpoint (Vcool-max)
    b. Zone minimum airflow setpoint (Vmin)
    c. Zone maximum heating airflow setpoint (Vheat-max). [if Zone Max heating airflow is not on the VAV Schedule; please set Vheat-max equal to twice the Vmin but not more than Vcool-max.]
3. Active maximum and minimum setpoints shall vary depending on the Mode ofthe Zone Group the zone is a part of:

Setpoint	Occupied	Cool-down	Setup	Warm-up	Setback	Unoccupied
Cooling maximum	Vcool-max	Vcool-max	Vcool-max	0	0	0
Minimum	Vmin*	0	0	0	0	0
Heating maximum	Vheat- max	Vheat-max	0	Vcool-max	Vcool-max	0

4. Control logic is depicted schematically in the figure below and described in the following sections. Relative levels of various setpoints are depicted for Occupied Mode operation.



a. When the zone is in Cooling, the Cooling Loop output shall be mapped to the airflow setpoint from the minimum to the cooling maximum airflow setpoints. Hot water valve is closed unless the supply air temperature is below the minimum setpoint.
   i. If supply air temperature from air handler is greater than room temperature, Cooling loop signal shall be set to 0%.
b. When the zone is in Deadband, the active airflow setpoint shall be the minimum airflow setpoint. Hot water valve is closed unless the supply air temperature is below the *minimum setpoint*.
c. When the zone is in Heating, the Heating Loop shall maintain space temperature at the heating setpoint as follows:

> *The purpose of the following heating sequence is to minimize the reheat energy consumption by first increasing the SAT while maintaining minimum flow, and only increasing the total airflow if needed to satisfy the zone.*
>
> *The design engineer should set Vheat-max such that the design heating load is met by Vheat-max CFM at 90°F.*

   i. From 0-50%, the Heating Loop output shall linearly reset the discharge temperature from the current AHU SAT setpoint to the lesser of 90°F or 20°F above space temperature.
   ii. From 51%-100%, if the supply air temperature is greater than room temperature plus 5°F, the Heating Loop output shall reset the active airflow setpoint from the minimum airflow setpoint to the maximum heating airflow setpoint.
d. The hot water valve shall be modulated to maintain the discharge air temperature at setpoint. (Directly controlling heating valve position from the zone temperature control loop is not acceptable.)
e. In any Mode except Unoccupied, the hot water valve shall be modulated to maintain a supply air temperature no lower than 50°F.
f. The VAV damper shall be modulated by a control loop to maintain the measured airflow at the active setpoint.

5. Alarms
   a. Low airflow
      i. If the measured airflow is less than 70% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 3 alarm.
      ii. If the measured airflow is less than 50% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 2 alarm.
      iii. If a zone has an Importance multiplier of 0 [see General section above] for its static pressure reset Trim & Respond control loop, low airflow alarms shall be suppressed for that zone.
   b. Airflow sensor calibration. If the fan serving the zone has been off for 10 minutes and airflow sensor reading is above 20 CFM, generate a Level 3 alarm.
6. System Requests
   a. Cooling SAT Reset Requests
      i. If the zone temperature exceeds the zone's cooling setpoint by 5°F for 2 minutes, send 3 Requests,
      ii. Else if the zone temperature exceeds the zone's cooling setpoint by 3°F for 2 minutes, send 2 Requests,
      iii. Else if the Cooling Loop is greater than 95%, send 1 Request until the Cooling Loop is less than 85%,
      iv. Else if the Cooling Loop is less than 95%, send 0 Requests.
   b. Static Pressure Reset Requests
      i. If the measured airflow is less than 50% (adj) of setpoint while setpoint is greater than zero for 1 minute, send 3 Requests,

ii. Else if the measured airflow is less than 70% of setpoint while setpoint is greater than zero for 1 minute, send 2 Requests,

iii. Else if the Damper Loop is greater than 95%, send 1 Request until the Damper Loop is less than 85%,

iv. Else if the Damper Loop is less than 95%, send 0 Requests

4.9 AIR HANDLING UNIT SYSTEM MODES

A. All (This subsection included such that numbers/letters correspond to ASHRAE Guideline 36).

1. AHU system Modes are the same as the Mode of the Zone Group served by the system. When Zone Group served by an air handling system are in different modes, the following hierarchy applies (highest one sets AHU mode).
   a. Occupied Mode
   b. Cool-down Mode
   c. Setup Mode
   d. Warm-up Mode
   e. Setback Mode
   f. Freeze Protection Setback Mode
   g. Unoccupied Mode

4.10 MULTIPLE ZONE VAV AIR HANDLING UNIT

A. All

1. Supply Fan Control
   a. Supply Fan Start/Stop
      i. Supply fan shall run when system is in the Cool-down Mode, Setup Mode, or Occupied Mode.
      ii. If there are any VAV-reheat boxes on perimeter zones, supply fan shall also run when system is in Setback Mode or Warmup Mode (i.e., all Modes except Unoccupied).
      iii. Totalize current airflow rate from VAV boxes and display on AHU graphic at discharge duct.
   b. Static Pressure Setpoint Reset
      i. Static pressure setpoint: Setpoint shall be reset using Trim & Respond logic. The following parameters are suggested as a starting place, but they will require adjustment during the commissioning/tuning phase:

Variable	**Value**
SP_0	0.5 inches
SP_{min}	0.1 inches
SP_{max}	1.3 inches
T_d	10 minutes
T	2 minutes
I (ignored)	2
R	Zone Static Pressure Reset Requests
SP_{trim}	-0.05 inches
SP_{res}	+0.06 inches
$SP_{res-max}$	+0.13 inches

   c. Static Pressure Control

High pressure trips may occur if all VAV boxes are closed (as in Unoccupied Mode) or if fire/smoke dampers are closed (in some FSD designs, the dampers are interlocked to the fan status rather than being controlled by smoke detectors).

i. Supply fan speed is controlled to maintain duct static pressure at setpoint when the fan is proven on. Where the Zone Groups served by the system are small, provide multiple sets of gains that are used in the control loop as a function of a load indicator (such as supply fan airflow rate, the area of the Zone Groups that are occupied, etc.).

2. Supply Air Temperature Control

a. Control loop is enabled when the supply air fan is proven on, and disabled and output set to FAN-OFF (no heating, minimum economizer) otherwise.

b. Supply Air Temperature Setpoint

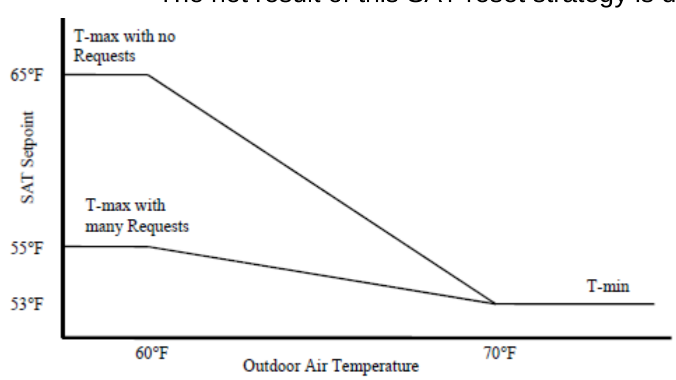
i. During Occupied Mode: Setpoint shall be reset from T-min when the outdoor air temperature is 70°F and above, proportionally up to T-max when the outdoor air temperature is 60°F and below.

a) T-min shall be the design cooling coil leaving air temperature per coil schedule.

b) T-max shall be reset using Trim & Respond logic between SP_{min} (the design supply air temperature per the AHU schedule) and SP_{max}. The following parameters are suggested as a starting place, but they will require adjustment during the commissioning/tuning phase:

Variable	Value
SP_0	SP_{max}
SP_{min}	Design SAT (55ºF typ)
SP_{max}	65ºF
T_d	10 minutes
T	2 minutes
I (ignore)	2
R	Zone Cooling SAT Requests
SP_{trim}	+0.2ºF
SP_{res}	-0.3ºF
$SP_{res-max}$	-1.0ºF

The net result of this SAT reset strategy is depicted in the chart below:



ii. During Setup or Cool-Down Modes: Setpoint shall be T-min.

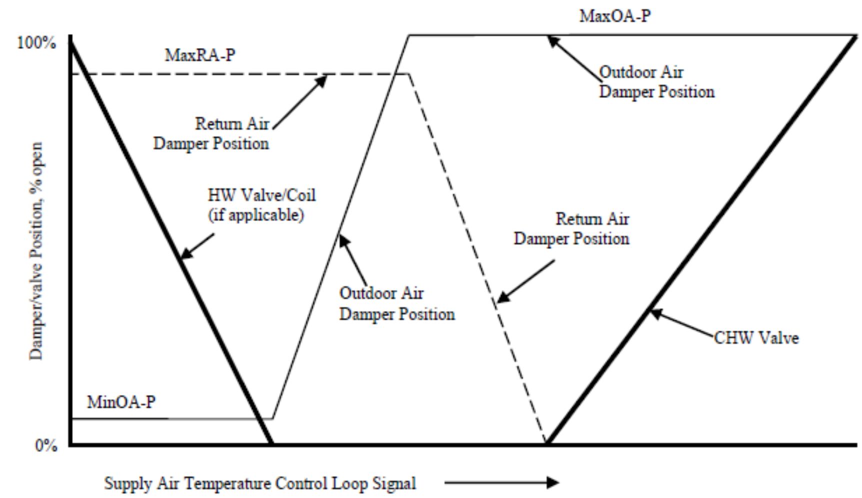
iii. During Warm-Up and Setback Modes: Setpoint shall be 95°F.

a) Note that a high temperature can be used since cooling-only terminal units will have 0 flow during these modes.

Outdoor air and return air dampers are sequenced rather than complementary (as per most standard sequences) to reduce fan power at part loads.

c. For units with a combined minimum outdoor air and economizer damper: Supply air temperature shall be controlled to setpoint using a control loop whose output is mapped to sequence the hot water valve, outdoor air damper, return air damper, and chilled water valve as shown in the diagram below. Outdoor air and return air dampers are sequenced rather than complementary (as per most standard sequences) to reduce fan power at part loads. Outdoor air damper minimum (MinOA-P) and maximum (MaxOA-P) positions and return air damper maximum position (MaxRA-P) are limited for economizer lockout and to maintain minimum outdoor airflow.

i. The points of transition along the x-axis shown and described below are representative. Separate gains shall be used for each section of the control map (hot water, economizer, chilled water), which are determined by the Contractor to provide stable control. If this is not possible, Contractor shall adjust the precise value of the x-axis thresholds shown in the figure to provide stable control.



3. Minimum Outdoor Air Control with a single common damper for minimum outdoor air and economizer functions and airflow measurement
   a. The outdoor air damper minimum position shall be set in accordance with Title 24.
4. Economizer Lockout
   a. The normal sequencing of the economizer dampers shall be disabled whenever the outdoor air temperature exceeds the economizer lockout temperature as specified in the following table, which varies by climate zone and economizer control device type:

Device Type	ASHRAE Climate Zones	Economizer Lockout Temperature
Differential Dry Bulb	1B, 2B, 3B, **3C**, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	$T_{OA} > T_{RA}$

   b. Once the economizer is disabled, it shall not be re-enabled within 10 minutes, and vice versa.

5. Return Fans
   a. Return fan operates whenever associated supply fan is proven on.
   b. Return fan speed shall be controlled to maintain building static pressure at setpoint of 0.05" (adj.).
   c. Building static pressure shall be time averaged with a sliding 5-minute window (to dampen fluctuations). The averaged value shall be that displayed and used for control.

6. Relief Fans
   a. A relief fan shall be enabled when its associated supply fan is enabled and shall be disabled otherwise.
   b. Building static pressure shall be time averaged with a sliding 5-minute window (to dampen fluctuations). The averaged value shall be that displayed and used for control.
   c. A P-only control loop maintains the building pressure at a setpoint of 0.05 inches (adj.) with an output ranging from 0 to 100%. The loop is disabled and output set to zero when relief system is disabled.
      i. Powered relief: When control loop is above 10% for 1 minute, relief fans shall start. Fan speed signal to relief fan shall be equal to the control loop signal but no less than the minimum fan speed. When control loop signal drops to minimum speed for 1 minute, fans shall stop but relief dampers shall remain open.
   d. Outdoor air damper and relief air damper position will be set to 100% (fully open) when unit is enabled and shall be closed when unit is off.
      i. Note: Functional test to determine if dampers fully open before fan speeds reach full speed. Safety time delay may be needed.
   e. For fans in a Level 2 alarm, discharge damper shall be closed.
7. Freeze Protection

The first stage of freeze protection locks out the economizer. Most likely this has already occurred by this time, but this logic provides insurance.

   a. If the supply air temperature drops below 40°F for 5 minutes, override the outside air damper to the minimum position, and modulate the heating coil to maintain a supply air temperature of at least 42°F. Disable this function when supply air temperature rises above 45°F for 5 minutes.

A timer is used (rather than an OAT threshold) to exit the second stage of freeze protection because a bad OAT sensor could lock out ventilation indefinitely, while a timer should just work and thus avoid problems with the unit getting "stuck" in this mode with no ventilation.

Upon timer expiration, the unit will re-enter the previous stage of freeze protection (minOA ventilation, with heating to maintain SAT of 42°F), after which one of three possibilities will occur:

1) If it is warm enough that the SAT rises above 45°F with minimum ventilation, the unit will remain in Stage "a" freeze protection for five minutes, then resume normal operation.

2) If it is cold enough that SAT remains between 38°F and 45°F with heating and minimum ventilation, the unit will remain in Stage "a" freeze protection indefinitely, until outdoor conditions warm up.

3) If it is so cold that SAT is less than 38°F with minimum ventilation, despite heating, then the unit will revert to Stage "b" freeze protection, where it will remain for one hour. This process will then repeat.

b. If the supply air temperature drops below 38°F for 5 minutes, fully close both the economizer damper and the minimum outdoor air damper for one hour, and set a Level 3 alarm noting that minimum ventilation was interrupted. After one hour, the unit shall resume minimum outdoor air ventilation and enter the previous stage of freeze protection.

Stage three can be triggered by either of two conditions. The second condition is meant to respond to an extreme and sudden cold snap.

Protecting the cooling coil in this situation will require water movement through the coil, which means that the CHW pumps need to be energized.

Heating coil is controlled to an air temperature setpoint. The sensors will not read accurately with the fan off, but they will be influenced by proximity to the heating coil. A temperature of 80°F at either of these sensors indicates that the interior of the unit is sufficiently warm. This avoids the situation where a fixed valve position leads to very high (and potentially damaging) temperatures inside the unit.

c. Upon signal from the freezestat (if installed) or if supply air temperature drops below 38°F for 15 minutes or below 34°F for 5 minutes, shut down supply and return/relief fan(s), close outdoor air damper, and make the minimum cooling coil valve position 20%, modulate the heating coil to maintain the higher of the supply air temperature or the mixed air temperature at 80°F, and set a Level 2 alarm indicating the unit is shut down by freeze protection.

   i. If a freeze protection shutdown is triggered by a low air temperature sensor reading, it shall remain in effect until it is reset by a software switch from the operator's workstation. (If a freeze stat with a physical reset switch is used instead, there shall be no software reset switch.)

8. Alarms

   a. Maintenance interval alarm when fan has operated for more than 1500 hours: Level 5. Reset interval counter when alarm is acknowledged.

   b. Fan alarm is indicated by the status being different from the command for a period of 15 seconds.

      i. Commanded on, status off: Level 2

      ii. Commanded off, status on: Level 4

   c. Filter pressure drop exceeds alarm limit: Level 5. The alarm limit (DP_x) shall vary with fan speed (x) as follows:

$$DP_x = DP_{100}(x)^{1.4}$$

where DP100 is the high limit pressure drop at design airflow (determine limit from filter manufacturer) and DP_x is the high limit at airflow speed signal (expressed as a fraction). For instance, the setpoint at 50% of VFD speed would be $(.5)^{1.4}$ or 38% of the design high limit pressure drop.

d. High building pressure (more than 0.10"): Level 3

e. Low building pressure (less than 0.0"): Level 4

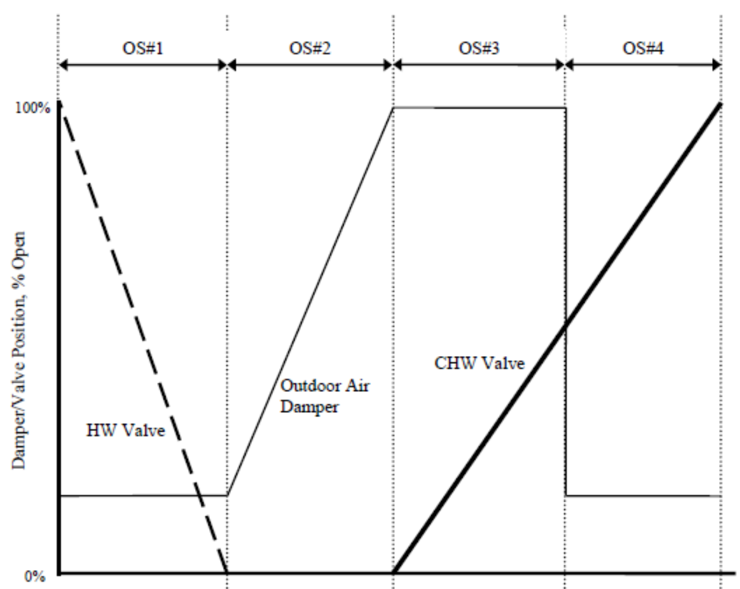
9. Automatic Fault Detection and Diagnostics

a. AFDD conditions are evaluated continuously and separately for each operating air handling unit.

b. The Operating State (OS) of each AHU shall be defined by the commanded positions of the heating coil control valve, cooling coil control valve, and economizer damper in accordance with the following table and corresponding graphic.

> *The Operating State is distinct from and should not be confused with the Zone Status (Cooling, Heating, Deadband) or Zone Group Mode (Occupied, Warm-up, etc).*
>
> *OS#1 – OS#4 represent normal operation during which a fault may nevertheless occur, if so determined by the fault condition tests in section e below. By contrast,*
>
> *OS#5 typically represents an abnormal or incorrect condition (such as simultaneous heating and cooling) arising from a controller failure or programming error, but it may also occur normally, e.g., when dehumidification is active.*

Operating State	Heating Valve Position	Cooling Valve Position	Outdoor Air Damper Position
#1: Heating	> 0	= 0	= MIN
#2: Free Cooling, Modulating OA	= 0	= 0	MIN < X < 100%
#3: Mechanical + Economizer Cooling	= 0	> 0	= 100%
#4: Mechanical Cooling, Min OA	= 0	> 0	= MIN



c. The following points must be available to the AFDD routines for each AHU:

i. Supply air temperature

ii. Mixed air temperature

iii. Return air temperature
iv. Outdoor air temperature
v. Duct static pressure
vi. SATSP = supply air temperature setpoint (downstream of cooling coil)
vii. DSPSP = duct static pressure setpoint
viii. HC = heating coil valve position command; 0% ≤ HC ≤ 100%
ix. CC = cooling coil valve position command; 0% ≤ CC ≤ 100%
x. FS = fan speed command; 0% ≤ FS ≤ 100%

d. The following values must be continuously calculated by the AFDD routines for each AHU:

i. Five minute (default) rolling averages of the following point values; operator shall have the ability to adjust the averaging window for each point independently

a) SAT_{AVG} = rolling average of supply air temperature
b) MAT_{AVG} = rolling average of mixed air temperature
c) RAT_{AVG} = rolling average of return air temperature
d) OAT_{AVG} = rolling average of outdoor air temperature
e) DSP_{AVG} = rolling average of duct static pressure

ii. %OA = actual outdoor air fraction as a percentage $= \frac{MAT - RAT}{OAT - RAT}$, or per airflow measurement station if available.

iii. $\%OA_{MIN}$ = Active minimum OA setpoint (MinOAsp) divided by actual total airflow (from sum of VAV box flows, or by airflow measurement station) as a percentage.

iv. ΔOS = number of changes in Operating State during the previous 60 minutes (moving window)

e. The following internal variables shall be defined for each AHU. All parameters are adjustable by the operator, with initial values as given below:

Default values are derived from NISTIR 7365 (Jeffery Schein, October 2006) and have been validated in field trials. They are expected to be appropriate for most circumstances, but individual installations may benefit from tuning to improve sensitivity and reduce false alarms.

The default values have been intentionally biased towards minimizing false alarms, if necessary at the expense of missing real alarms. This avoids excessive false alarms that will erode user confidence and responsiveness. However, if the goal is to achieve the best possible energy performance and system operation, these values should be adjusted based on field measurement and operational experience.

Values for physical factors such as fan heat, duct heat gain, and sensor error can be measured in the field or derived from trendlogs. Likewise the occupancy delay and switch delays can be refined by observing in trend data the time required to achieve quasi steady state operation.

Other factors can be tuned by observing false positives and false negatives (i.e., unreported faults). If transient conditions or noise cause false errors, increase the alarm delay. Likewise, failure to report real faults can be addressed by adjusting the heating coil, cooling coil, temperature, or flow thresholds.

Variable Name	Description	Default Value
ΔT_{SF}	Temperature rise across supply fan	2° F
ΔT_{MIN}	Minimum difference between OAT and RAT to evaluate economizer error conditions (FC#6)	10° F
□ SAT	Temperature error threshold for SAT sensor	2° F

□ RAT	Temperature error threshold for RAT sensor	2° F
□ MAT	Temperature error threshold for MAT sensor	2° F
□ OAT	Temperature error threshold for OAT sensor	2° F if local sensor @ unit.
□ F	Airflow error threshold (note used)	30%
□ VFDSPD	VFD speed error threshold	5%
□ DSP	Duct static pressure error threshold	0.1”
ΔOS_{MAX}	Maximum number of changes in Operating State	7
ModeDelay	Time in minutes to suspend Fault Condition evaluation after a change in Mode	90
AlarmDelay	Time in minutes that a Fault Condition must persist before triggering an alarm	60

f. There are 13 potential Fault Conditions that can be evaluated by the AFDD routines. If the equation statement is true, then the specified fault condition exists. The Fault Conditions to be evaluated at any given time will depend on the Operating State of the AHU.

These equations assume that the SAT sensor is located downstream of the supply fan, and the RAT sensor is located downstream of the return fan. If actual sensor locations differ from these assumptions, it may be necessary to add or delete fan heat correction factors.

FC #1	**Equation**	$DSP < DSPSP - \square_{DSP}$ <u>and</u> $VFDSPD \geq 99\% - \square_{VFDSPD}$	**Applies to OS #1 – #5**
	Description	Duct static pressure is too low with fan at full speed	
	Possible Diagnosis	Problem with VFD Mechanical problem with fan Fan undersized SAT Setpoint too high (too much zone demand)	
FC #2	**Equation**	$MAT_{AVG} + \square_{MAT} < \min[(RAT_{AVG} - \square_{RAT}), (OAT_{AVG} - \square_{OAT})]$	**Applies to OS #1 – #5**
	Description	MAT too low; should be between OAT and RAT	
	Possible Diagnosis	RAT sensor error MAT sensor error OAT sensor error	
FC #3	**Equation**	$MAT_{AVG} - \square_{MAT} > \max[(RAT_{AVG} + \square_{RAT}), (OAT_{AVG} + \square_{OAT})]$	**Applies to OS #1 – #5**
	Description	MAT too high; should be between OAT and RAT	
	Possible Diagnosis	RAT sensor error MAT sensor error OAT sensor error	
FC #4	**Equation**	$\Delta OS > \Delta OS_{MAX}$	**Applies to OS #1 – #5**
	Description	Too many changes in Operating State	
	Possible Diagnosis	Unstable control due to poorly tuned loop or mechanical problem	
FC #5	**Equation**	$SAT_{AVG} + \square_{SAT} \leq MAT_{AVG} - \square_{MAT} + \Delta T_{SF}$	**Applies to OS #1**
	Description	SAT too low; should be higher than MAT	
	Possible Diagnosis	SAT sensor error MAT sensor error Cooling coil valve leaking or stuck open Heating coil valve stuck closed or actuator failure Fouled or undersized heating coil HW temperature too low or HW unavailable	

FC #6	**Equation**	$\lvert RAT_{AVG} - OAT_{AVG} \rvert \geq \Delta T_{MIN}$ and $\lvert \%OA - \%OA_{MIN} \rvert >$ □$_F$	**Applies to OS #1, #4**
	Description	OA fraction is too low or too high; should equal $\%OA_{MIN}$	
	Possible Diagnosis	RAT sensor error MAT sensor error OAT sensor error Leaking or stuck economizer damper or actuator	
FC #7	**Equation**	$SAT_{AVG} < SATSP -$ □$_{SAT}$ and $HC \geq 99\%$	**Applies to OS #1**
	Description	SAT too low in full heating (coil is saturated)	
	Possible Diagnosis	SAT sensor error Cooling coil valve leaking or stuck open Heating coil valve stuck closed or actuator failure Fouled or undersized heating coil HW temperature too low or HW unavailable	
FC #8	**Equation**	$\lvert SAT_{AVG} - \Delta T_{SF} - MAT_{AVG} \rvert > \sqrt{\frac{SAT^2 + MAT^2}{2}}$	**Applies to OS #2**
	Description	SAT too high or too low; should equal MAT	
	Possible Diagnosis	SAT sensor error MAT sensor error Cooling coil valve leaking or stuck open Heating coil valve leaking or stuck open	
FC #9	**Equation**	$OAT_{AVG} -$ □$_{OAT} > SATSP - \Delta T_{SF} +$ □$_{SAT}$	**Applies to OS #2**
	Description	OAT is too high for free cooling without additional mechanical cooling	
	Possible Diagnosis	SAT sensor error OAT sensor error Cooling coil valve leaking or stuck open	

FC #10	**Equation**	$\lvert MAT_{AVG} - OAT_{AVG} \rvert > \sqrt{\frac{MAT^2 + OAT^2}{2}}$	**Applies to OS #3**
	Description	MAT is too high or too low; should equal OAT	
	Possible Diagnosis	MAT sensor error OAT sensor error Leaking or stuck economizer damper or actuator	
FC #11	**Equation**	$OAT_{AVG} + \square_{OAT} < SATSP - \Delta T_{SF} - \square_{SAT}$	**Applies to OS #3**
	Description	OAT is too low for 100% OA cooling	
	Possible Diagnosis	SAT sensor error OAT sensor error Heating coil valve leaking or stuck open Leaking or stuck economizer damper or actuator	

FC #12	**Equation**	$SAT_{AVG} - \square_{SAT} - \Delta T_{SF} \geq MAT_{AVG} + \square_{MAT}$	**Applies to OS #3, #4**
	Description	SAT too high; should be less than MAT	
	Possible Diagnosis	SAT sensor error MAT sensor error Cooling coil valve stuck closed or actuator failure Fouled or undersized cooling coil CHW temperature too high or CHW unavailable Heating coil valve leaking or stuck open	
FC #13	**Equation**	$SAT_{AVG} > SATSP + \square_{SAT}$ and $CC \geq 99\%$	**Applies to OS #3, #4**
	Description	SAT too high in full cooling (coil is saturated)	
	Possible Diagnosis	SAT sensor error Cooling coil valve stuck closed or actuator failure Fouled or undersized cooling coil CHW temperature too low or CHW unavailable Heating coil valve leaking or stuck open	

g. A subset of all potential fault conditions is evaluated by the AFDD routines. The set of applicable fault conditions depends on the Operating State of the AHU:

i. In OS #1 (Heating), the following Fault Conditions shall be evaluated:

a) FC#1: Duct static pressure is too low with fan at full speed
b) FC#2: MAT too low; should be between RAT and OAT
c) FC#3: MAT too high; should be between RAT and OAT
d) FC#4: Too many changes in Operating State
e) FC#5: SAT too low; should be higher than MAT
f) FC#6: OA fraction is too low or too high; should equal %OAMIN
g) FC#7: SAT too low in full heating (coil is saturated).

ii. In OS#2 (Modulating Economizer), the following Fault Conditions shall be evaluated:
   a) FC#1: Duct static pressure is too low with fan at full speed
   b) FC#2: MAT too low; should be between RAT and OAT
   c) FC#3: MAT too high; should be between RAT and OAT
   d) FC#4: Too many changes in Operating State
   e) FC#8: SAT too high or too low; should equal MAT
   f) FC#9: OAT is too high for free cooling without mechanical cooling.

iii. In OS#3 (Mechanical + 100% Economizer Cooling), the following Fault Conditions shall be evaluated:
   a) FC#1: Duct static pressure is too low with fan at full speed
   b) FC#2: MAT too low; should be between RAT and OAT
   c) FC#3: MAT too high; should be between RAT and OAT
   d) FC#4: Too many changes in Operating State
   e) FC#10: MAT is too high or too low; should equal OAT
   f) FC#11: OAT too low for 100% OA
   g) FC#12: SAT too high; should be less than MAT
   h) FC#13: SAT too high in full cooling (coil is saturated).

iv. In OS#4 (Mechanical Cooling, Min OA), the following Fault Conditions shall be evaluated:
   a) FC#1: Duct static pressure is too low with fan at full speed
   b) FC#2: MAT too low; should be between RAT and OAT
   c) FC#3: MAT too high; should be between RAT and OAT
   d) FC#4: Too many changes in Operating State
   e) FC#6: OA fraction is too low or too high; should equal %OAMIN
   f) FC#12: SAT too high; should be less than MAT
   g) FC#13: SAT too high in full cooling (coil is saturated).

h. For each air handler, the operator shall be able to suppress the alarm for any Fault Condition.

i. Evaluation of Fault Conditions shall be suspended under the following conditions:
   i. When AHU is not operating.
   ii. For a period of ModeDelay minutes following a change in Mode (e.g., from Warm-up to Occupied) of any Zone Group served by the AHU.

j. Fault Conditions which are not applicable to the current Operating State shall not be evaluated.

k. A Fault Condition that evaluates as true must do so continuously for AlarmDelay minutes before it is reported to the operator.

l. When a Fault Condition is reported to the operator, it shall be a Level 3 alarm and shall include the description of the fault and the list of possible diagnoses from the table above.

4.11 DUAL-DUCT AIR HANDLING UNIT (BUSINESS)

A. Deck Temperature Reset

1. Reset the hot deck temperature setpoint based on a linear outside air temperature reset schedule.
   a. At 45°F (adj.) outside air temperature, the Hot Deck setpoint is 90°F (adj.)
   b. At 80°F (adj.) outside air temperature, the Hot Deck setpoint is 70°F (adj.)
2. Reset the cold deck temperature setpoint based on a linear outside air temperature reset schedule.

a. At 45°F (adj.) outside air temperature, the Cold Deck setpoint is 65°F (adj.)
b. At 80°F (adj.) outside air temperature, the Cold Deck setpoint is 52°F (adj.)

B. Mixed Air Temperature and Economizer
1. Mixed air temperature setpoint shall be 1°F below the Cold Deck temperature setpoint.
2. Modulate outside air and return air damper to maintain mixed air temperature at the mixed air temperature setpoint.
3. When unit is operating, the outside air damper position shall not go below the minimum economizer position (adj.).
4. Economizer shall lockout to minimum position when the outside air temperature is above the return air temperature.

C. Fan Speed Control
1. Modulate Fan VFD speed to maintain a constant duct static setpoint of 1.0 iwc (adj.).
a. The control loop shall control to the maximum duct static pressure sensor reading (of the two deck pressure sensors).

4.12 MULTIZONE AIR HANDLING UNIT (WRAY)

A. Deck Temperature Reset
1. Reset the hot deck temperature setpoint based on a linear outside air temperature reset schedule.
a. At 45°F (adj.) outside air temperature, the Hot Deck setpoint is 90°F (adj.)
b. At 80°F (adj.) outside air temperature, the Hot Deck setpoint is 70°F (adj.)
2. Reset the cold deck temperature setpoint based on a linear outside air temperature reset schedule.
a. At 45°F (adj.) outside air temperature, the Cold Deck setpoint is 65°F (adj.)
b. At 80°F (adj.) outside air temperature, the Cold Deck setpoint is 52°F (adj.)

B. Mixed Air Temperature and Economizer
1. Mixed air temperature setpoint shall be 1°F below the Cold Deck temperature setpoint.
2. Modulate outside air and return air damper to maintain mixed air temperature at the mixed air temperature setpoint.
3. When unit is operating, the outside air damper position shall not go below the minimum economizer position (adj.).
4. Economizer shall lockout to minimum position when the outside air temperature is above the return air temperature.

4.13 INDEPENDENT EXHAUST FANS

A. All
1. Schedule
a. The exhaust fan shall start according to the earliest occupied time for all HVAC zones for each day of the week. The exhaust fan shall stop when the last HVAC occupancy schedule ends for each day of the week.
2. Alarms
a. Fan Fail: Alarm when fan is commanded on and fan status is off.
b. Fan in Hand: Alarm if fan is commanded off but the fan status is on.

Quick Reference Table for All Projects and Costs

Red/italic is in progress

Highlighted section to be filled in by bidding contractor

	SOW section	Task	System	Building	Subtask	Proposed Sub-contractor name and contact if Applicable (N/A) if not	Unit Price	Quantity	UOM	Total Price	P39	Comfort	Note (for Rio Hondo)	SOW Items	Estimated Cost	Notes
	A	Replace DDC Controlled 3-way CHW water valves with 2-way	CHW Valves	Various	DDC controlled 3-way to DDC controlled 2-way ChW valve and actuator replacements. Includes all labor, piping modifications, wiring and disposal. Use exsisting controller for integration into Campus BAS			5	AHU		Core	Yes	Core Requirement to achieve Prop39 savings goals and improve comfort at Science			
	B	Controls Modifications and New/Replaced Sensors	CHW Plant	Central Plant	Includes modifications to exsisting code, addition of specified graphics and sensor replacements and installation as noted in SOW			1			Core		Core Requirement to achieve Prop39 savings goals			
	C	Controls Modifications and New/Replaced Sensors	HW Plant	Central Plant	Includes modifications to exsisting code, addition of specified graphics and sensor replacements and installation as noted in SOW			1			Core		Core Requirement to achieve Prop39 savings goals			
	D	Motor, Pully and Belt Replacements.	AHUs	Science	Replace motor, pully and belts on AHU-1 SF (40hp), AHU-3 SF (25hp), AHU-4 SF (40hp), AHU-6 SF (7.5hp)			1	group		Core	Yes	Core Requirement to improve comfort at Science			
	E	AHU Economizer Damper Actuotor Repairs and Control Modifications	AHUs	Science	Repair damper actuators so they respond to contol signal and revise control stratagy.			1	group		Core	Yes	Core Requirement to improve comfort at Science			
	F	AHU Repair and Maintenance	AHUs	Science	Replace pully and belts on AHU-5 SF (40hp), clean coils, repair VFD communications and other miscellaneous items.			1	group		Core	Yes	Core Requirement to improve comfort at Science			
	G	Replace DDC AHU and VAV Box Controllers, Reheat Valves, and Thermostats	AHUs and VAV Boxes	Science	Upgrade all existing DDC AHU and VAV box controllers and reheat valves with new controllers and valves. Replace existing thermostats. Total of 108 VAV zones. 16 cooling only, the rest with re-heat.			108	zones		Core	Yes	Core Requirement to improve comfort at Science			Counted on BAS, see: K:\Jobs\Rio Hondo Community College\Scope of Work\Science Terminal Units 2018.02.07
	H	Pneumatic to DDC Retrofit	AHUs	Wray	Three (3) CV multi-zone air handlers, one (1) single zones air handler, and twelve (12) Exhaust fans			1			Core	Yes	Core Requirement to achieve Prop39 savings goals and improve comfort at Wray building			
	I	Pneumatic to DDC Retrofit	AHUs	Bus/Art	Two (2) variable volume dual duct air handlers (AC-1B and AC-2B), One (1) Single zone air handler (Photo Lab), three (3) exhaust fans.			1	group		Core	Yes	Core Requirement to achieve comfort at Business building.			
	J	Test and Balance	CHW Distribution	Various	Test and Balance - CHW Distribution - Various			57	coils				57 chilled water coils connected to CP			
	K	Test and Balance	HW Distribution	Various	Test and Balance - HW Distribution - Various			57	coils				Does not include zone level coils			
	L	Test and Balance	HW Distribution	Science	Test and Balance - HW Distribution - Science			92	zones				92 VAV Reheat boxes			Counted on BAS, see: K:\Jobs\Rio Hondo Community College\Scope of Work\Science Terminal Units 2018.02.07
	M	Test and Balance	Air Distribution	Science	Test and Balance - Air Distribution - Science			108	zones				6 air handlers, 108 VAV boxes			Counted on BAS, see: K:\Jobs\Rio Hondo Community College\Scope of Work\Science Terminal Units 2018.02.07
	N	Test and Balance	Air Distribution	Wray	Test and Balance - Air Distribution - Wray			108	zones				6 air handlers, 108 VAV boxes			Counted on BAS, see: K:\Jobs\Rio Hondo Community College\Scope of Work\Science Terminal Units 2018.02.07
Alt-1	O	Staging Isolation Valves and Controls	Cooling Tower	Central Plant	Cooling tower isolation valves , 11-inch Cost to include all labor, hardware and software for integration into existing BAS			6	valves				Add alternate			
Alt-2	P	Test and Balance	Cooling Tower	Central Plant	Balance condenser flow to cooling tower using six existing balancing valves to ensure that condenser water is evenly distributed to all nozzles under design conditions.			6	valves				Add alternate			
Alt-3	Q	DDC VAV Box Controllers, Reheat Valves, and Thermostats	Zone Level	Bus/Art	Retrofit existing pneumatically controlled DD mixing boxes with DDC controls and install thermostats.			31	zones				Add alternate			
Alt-4	R	DDC Bldg Isolation Valves	CHW Distribution	Various	Install isolation valves on building chilled water supply and return lines			18	valves				Add alternate			For: Admin, Business, LRC, Science, Student Services, Student Union, Tech, and Wray
Alt-5	S	DDC Bldg Isolation Valves	HW Distribution	Various	Install isolation valves on building hot water supply and return lines			16	valves				Add alternate			For: Admin, Business, LRC, Science, Student Services, Student Union, and Tech (Wray has dedicated HHW)

AHU Maintenance - Science Building

		Cnt	AHU-1 1 S	AHU-2 2 N	AHU-3 2 S	AHU-4 3 N	AHU-5 3 S	AHU-6 1 N
Maintenance	Vacuum unit and condensate pans.	6	y	y	y	y	y	y
	Clean coils.	6	y	y	y	y	y	y
	Grease fan bearings and check tubing.	5	No	y	y	y	y	No
Supply Fan	Replace Supply Fan motor	4	40-hp (bad bea	No	25-hp	40-hp	No	7.5hp
	Replace Supply Fan Motor Pulley	5	2 1/8 x 9 inch 4 groove B	No	1 7/8 x 7.5. 2 groove B	2 1/8 x 8 inch 5 groove B	1 7/8 x 9 inch 2 groove B	1 3/8 x 5.5 2 groove B
	Replace Supply Fan Motor Belts	5	4-B140	No	2 B128	5-B140	2-B140	2-BX38
	Replace Canvas for Supply Fan	5	y	y	y	y	No	No
	Replace Supply Fan Door Handles	4	No	y	y	y	No	No
Return Fan	Replace return fan motor	2	5-hp	No	No	No	No	No
	Replace return fan pulley	2	1 1/8 x 4.75 1 groove B	No	No	No	No	No
	Replace return fan belt	3	1-B74	No	No	No	1-B77	No
Dampers	Replace OSA Damper Actuator	5	y	y	y	y	No	y
	Replace Return Air Damper Actuator	4	No	y	No	y	y	No
	Replace Return Air Damper *Linkage*	3	No	No	No	Mount opposit	Mount opposit	No
	Replace Relief Air Damper Actuator	3	No	y	No	y	No	No
	Replace Relief Air Damper *Linkage*	2	No	No	Correct	No	No	No
	Replace Status Contactors (Normally Closed)	3	RF In, RF Out	No	RF In, RF Out (s	No	No	SF In, SF Out
Boards	Replace AIM1 board for OSA and RA actuators	3	No	No	y	y	No	No
	Replace AIM1 board for CHWV	2	No	No	No	No	y	y
	Replace AIM1 board for HWV	2	y	No	No	No	No	No

Rio Hondo - Valves for Units Served By Central Plant

			Chilled Water				Heating Hot Water				Controls	
			Valve		Design		Valve		Design			
Building	Tag	Notes	Existing	Proposed	Flow (GP	Pipe dia (in)	Existing	Proposed	Flow (GPM	Pipe dia (in)	Existing	Proposed
Business	AHU-1B		**2-way**	**2-way**	138	3	**3-way**	**2-way**	22.1	1.5	Pneu	DDC
Business	AHU-2B		**3-way**	**2-way**	38	2	**2-way**	**2-way**	5.7	1	Pneu	DDC
Business	AHU-Photo		**3-way**	**3-way**	38	2	**3-way**	**3-way**	5.7	1	Pneu	DDC
Science	AHU-1		**NO VALVE**	**2-way**	162	3	**3-way**	**3-way**	24	1.5	DDC	DDC
Science	AHU-2		**3-way**	**2-way**	168	3	NA	NA	NA	NA	DDC	DDC
Science	AHU-3		**3-way**	**2-way**	154	3	NA	NA	NA	NA	DDC	DDC
Science	AHU-4		**3-way**	**2-way**	191	3	NA	NA	NA	NA	DDC	DDC
Science	AHU-5		**3-way**	**3-way**	168	3	NA	NA	NA	NA	DDC	DDC
Wray	AHU-2		**2-way**	**2-way**	145	4	2-way	NA	45.7	NA	Pneu	DDC
Wray	AHU-3		**3-way**	**3-way**	34	2	NA	NA	12.5	NA	Pneu	DDC
Wray	AHU-4		**2-way**	**2-way**	73	2.5	NA	NA	22.4	NA	Pneu	DDC
Wray	AHU-5		**2-way**	**2-way**	74	2.5	NA	NA	22.8	NA	Pneu	DDC

Rio Hondo - Valves for Units Served By Central Plant

			Chilled Water				Heating Hot Water				Controls		Notes	SOURCES			
			Valve		Design		Valve		Design					CHW	HHW	CHW	HHW
Building	Tag	Notes	Existing	Proposed	Flow (GPM)	Pipe dia (in)	Existing	Proposed	Flow (GPM)	Pipe dia (in)	Existing	Proposed		2-way/3-way existing	2-way/3-way existing	Valve flow/size	Valve flow/size
Admin	AHU-1		2-way	2-way	96	3	2-way	2-way	12.5	1.25	DDC	DDC		"Arik Notes" tab	"Arik Notes" tab	"Valve Schedule" & "Admin Valves" tabs	"Valve Schedule" & "Admin Valves" tabs
Admin	AHU-2		2-way	2-way	172	3	2-way	2-way	27.5	2	DDC	DDC		"Arik Notes" tab	"Arik Notes" tab	"Valve Schedule" & "Admin Valves" tabs	"Valve Schedule" & "Admin Valves" tabs
Business	AHU-1B		2-way	**2-way**	138	3	**3-way**	3-way	22.1	1.5	Pneu	DDC		"Arik Notes" tab	"Arik Notes" tab	"Valve Schedule" & "Business Valves" tabs	"Valve Schedule" & "Business Valves" tabs
Business	AHU-2B		3-way	**2-way**	38	2	2-way	2-way	5.7	1	Pneu	DDC		"Arik Notes" tab	"Arik Notes" tab	"Valve Schedule" & "Business Valves" tabs	"Valve Schedule" & "Business Valves" tabs
Business	AHU-Photo		3-way	**3-way**	38	2	3-way	3-way	5.7	1	Pneu	DDC	No mech schedules	"Arik Notes" tab	"Arik Notes" tab		
LRC	AHU-1		3-way	3-way	149.5	4	NA	NA	NA	NA	DDC	DDC	Cooling only	"LRC Schedule" tab	NA	NA	NA
LRC	AHU-2		2-way	2-way	130	4	NA	NA	NA	NA	DDC	DDC	Cooling only	"LRC Schedule" tab	NA	NA	NA
LRC	FC-1		2-way	2-way	2.3	0.75	2-way	2-way	0.9	0.75	DDC	DDC		"LRC Schedule" tab	"LRC Schedule" tab	"LRC Schedule" tab	"LRC Schedule" tab
LRC	FC-2		2-way	2-way	1.7	0.75	2-way	2-way	0.5	0.75	DDC	DDC		"LRC Schedule" tab	"LRC Schedule" tab	"LRC Schedule" tab	"LRC Schedule" tab
LRC	FC-3		2-way	2-way	6.3	1.25	2-way	2-way	2.4	0.75	DDC	DDC		"LRC Schedule" tab	"LRC Schedule" tab	"LRC Schedule" tab	"LRC Schedule" tab
LRC	FC-4		2-way	2-way	5.1	1	2-way	2-way	0.9	0.75	DDC	DDC		"LRC Schedule" tab	"LRC Schedule" tab	"LRC Schedule" tab	"LRC Schedule" tab
LRC	FC-5		2-way	2-way	5.1	1	2-way	2-way	0.9	0.75	DDC	DDC		"LRC Schedule" tab	"LRC Schedule" tab	"LRC Schedule" tab	"LRC Schedule" tab
LRC	FC-6		**2-way**	2-way	3	0.75	2-way	2-way	0.1	0.75	DDC	DDC	One FC / "end of the line" is 3-way, assuming FC-6	"LRC Schedule" tab	"LRC Schedule" tab	"LRC Schedule" tab	"LRC Schedule" tab
Science	AHU-1		NO VALVE	2-way	162	3	3-way	3-way	24	1.5	DDC	DDC		"Arik Notes" tab	"Valve Schedule" tab	"Science Schedule" tab	"Valve Schedule" tab
Science	AHU-2		3-way	**2-way**	168	3	NA	NA	NA	NA	DDC	DDC	Cooling only	"Science Schedule" tab	NA	"Science Schedule" tab	NA
Science	AHU-3		3-way	**2-way**	154	3	NA	NA	NA	NA	DDC	DDC	Cooling only	"Science Schedule" tab	NA	"Science Schedule" tab	NA
Science	AHU-4		3-way	**2-way**	191	3	NA	NA	NA	NA	DDC	DDC	Cooling only	"Science Schedule" tab	NA	"Science Schedule" tab	NA
Science	AHU-5		3-way	3-way	168	3	NA	NA	NA	NA	DDC	DDC	Cooling only	"Science Schedule" tab	NA	"Science Schedule" tab	NA
Science	AHU-6		3-way	**2-way**	38	1.5	NA	NA	NA	NA	DDC	DDC	Cooling only	"Science Schedule" tab	NA	"Science Schedule" tab	NA
Student Services	AHU-1		2-way	2-way	132.1	3	2-way	2-way	72.2	2.5	DDC	DDC		"Arik Notes" tab	"Arik Notes" tab	"Student Services Schedule" tab	"Student Services Schedule" tab
Student Union	AHU-1		2-way	2-way	91.2	3	2-way	2-way	32.1	2	DDC	DDC		"Arik Notes" tab	"Arik Notes" tab	"Student Union Schedule" tab	"Student Union Schedule" tab
Student Union	FC-1		2-way	2-way	3	0.75	NA	NA	NA	NA	DDC	DDC	Cooling only	"Arik Notes" tab	NA	"Student Union Schedule" tab	NA
Student Union	FC-2		2-way	2-way	3	0.75	NA	NA	NA	NA	DDC	DDC	Cooling only	"Arik Notes" tab	NA	"Student Union Schedule" tab	NA
Student Union	FC-3		2-way	2-way	3	0.75	NA	NA	NA	NA	DDC	DDC	Cooling only	Assumed save as FC-2	NA	"Student Union Schedule" tab	NA
Student Union	MAH-1		2-way	2-way	28	2	2-way	2-way	12	1.25	DDC	DDC		"Arik Notes" tab	"Arik Notes" tab	"Student Union Schedule" tab	"Student Union Schedule" tab
Tech	AHU-1A		2-way	2-way	8.4	1	2-way	2-way	4.3	0.75	DDC	DDC		"Tech Valves" tab	"Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab
Tech	AHU-2A		2-way	2-way	4.7	1	2-way	2-way	2.3	0.75	DDC	DDC		"Tech Valves" tab	"Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab
Tech	AHU-3A		2-way	2-way	7.4	1	2-way	2-way	3.9	0.75	DDC	DDC		"Tech Valves" tab	"Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab
Tech	AHU-4A		2-way	2-way	6.5	1	2-way	2-way	2.9	0.75	DDC	DDC		"Tech Valves" tab	"Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab
Tech	AHU-5A		2-way	2-way	8.9	1	2-way	2-way	4.5	0.75	DDC	DDC		"Tech Valves" tab	"Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab
Tech	AHU-6A		2-way	2-way	7.4	**1**	2-way	2-way	3.9	**0.75**	DDC	DDC	Pipe sizes not in drawings, assumed	"Tech Valves" tab	"Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab
Tech	AHU-7A		2-way	2-way	7	1	2-way	2-way	4	0.75	DDC	DDC	No mech schedules	"Arik Notes" tab	"Arik Notes" tab		
Tech	FC-1A		NA	2-way	NA	NA	NA	2-way	NA	NA	DDC	DDC	DX units, not on central plant	NA	NA	NA	NA
Tech	FC-2A		NA	2-way	NA	NA	NA	2-way	NA	NA	DDC	DDC	DX units, not on central plant	NA	NA	NA	NA
Tech	AC-1B		2-way	2-way	7	1	2-way	2-way	3	0.75	DDC	DDC	No mech schedules				
Tech	AC-2B		2-way	2-way	7	1	2-way	2-way	3	0.75	DDC	DDC	No mech schedules				
Tech	AHU-1B		2-way	2-way	12.1	1.25	2-way	2-way	5.7	1	DDC	DDC		"Tech Valves" tab	"Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab
Tech	AHU-3B		2-way	2-way	3.2	1	2-way	2-way	1.6	0.75	DDC	DDC		"Tech Valves" tab	"Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab
Tech	AHU-4B		2-way	2-way	6.5	1.5	2-way	2-way	2.9	1.25	DDC	DDC		"Tech Valves" tab	"Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab
Tech	AHU-5B		2-way	2-way	6.8	1	2-way	2-way	3.7	0.75	DDC	DDC		"Tech Valves" tab	"Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab
Tech	AHU-1C		2-way	2-way	7.4	1	2-way	2-way	3.9	0.75	DDC	DDC		"Tech Valves" tab	"Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab
Tech	AHU-2C		3-way	3-way	7	1	3-way	3-way	3	0.75	DDC	DDC	"3-way Valve @ furthest AH", assuming AHU-2C	"Tech Valves" tab	"Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab	"Tech Schedule" & "Tech Valves" tab
Tech	FC-1C		2-way	2-way	NA	NA	2-way	2-way	NA	NA	DDC	DDC	No mech schedules				
Wray	AHU-2		2-way	**2-way**	145	4	NA	NA	45.7	NA	Pneu	DDC	Not heated by central plant	"Wray Schedule" tabs	"Wray Schedule" tabs	"Wray Schedule" & "Wray Valves" tabs	"Wray Schedule" & "Wray Valves" tabs
Wray	AHU-3		3-way	**3-way**	34	2	NA	NA	12.5	NA	Pneu	DDC	Not heated by central plant	"Wray Schedule" tabs	"Wray Schedule" tabs	"Wray Schedule" & "Wray Valves" tabs	"Wray Schedule" & "Wray Valves" tabs
Wray	AHU-4		2-way	**2-way**	73	2.5	NA	NA	22.4	NA	Pneu	DDC	Not heated by central plant	"Wray Schedule" tabs	"Wray Schedule" tabs	"Wray Schedule" & "Wray Valves" tabs	"Wray Schedule" & "Wray Valves" tabs
Wray	AHU-5		2-way	**2-way**	74	2.5	NA	NA	22.8	NA	Pneu	DDC	Not heated by central plant	"Wray Schedule" tabs	"Wray Schedule" tabs	"Wray Schedule" & "Wray Valves" tabs	"Wray Schedule" & "Wray Valves" tabs

2-way	Pneu	4	42	2-way	27	29
3-way	**Pneu**	**3**		**3-way**	4	
unknown	**Pneu**	0		**unknown**	0	
No valve	Pneu	0		NA	16	
TOTAL		7		TOTAL	31	
2-way	DDC	30				
3-way	**DDC**	**7**				
unknown	**DDC**	**0**				
No valve	DDC	1				
TOTAL		38				

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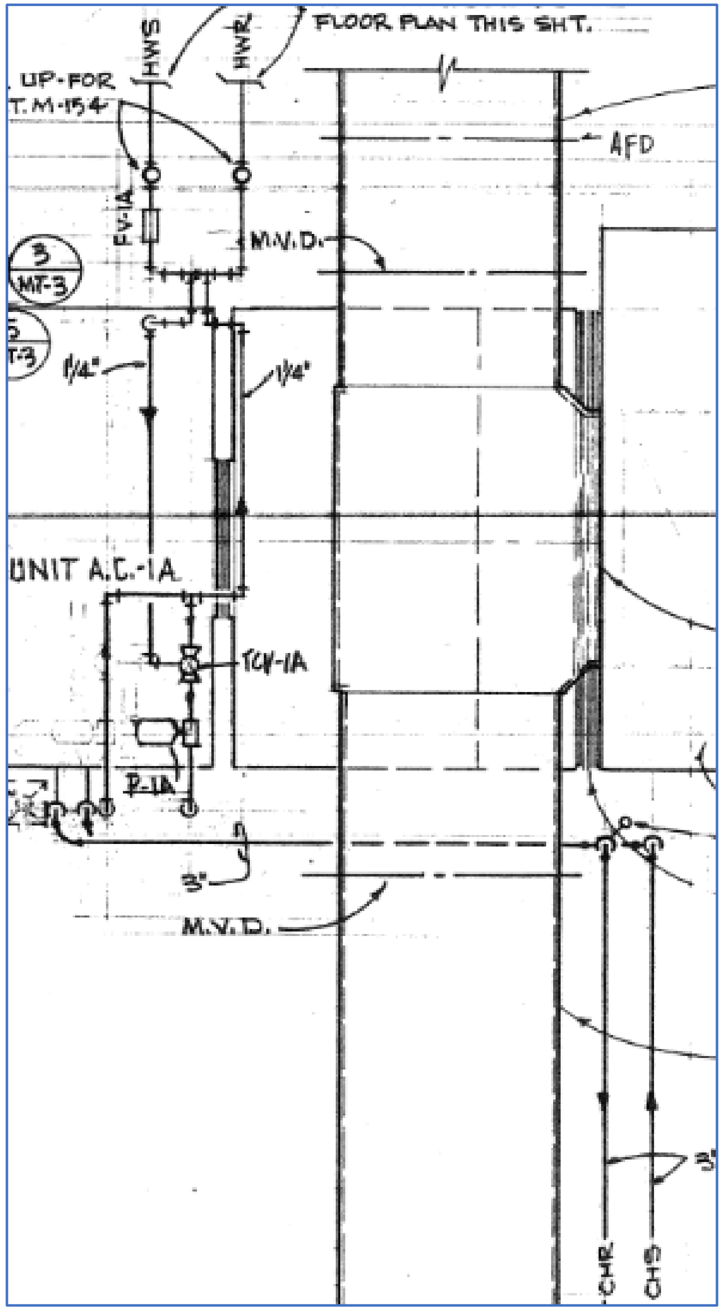
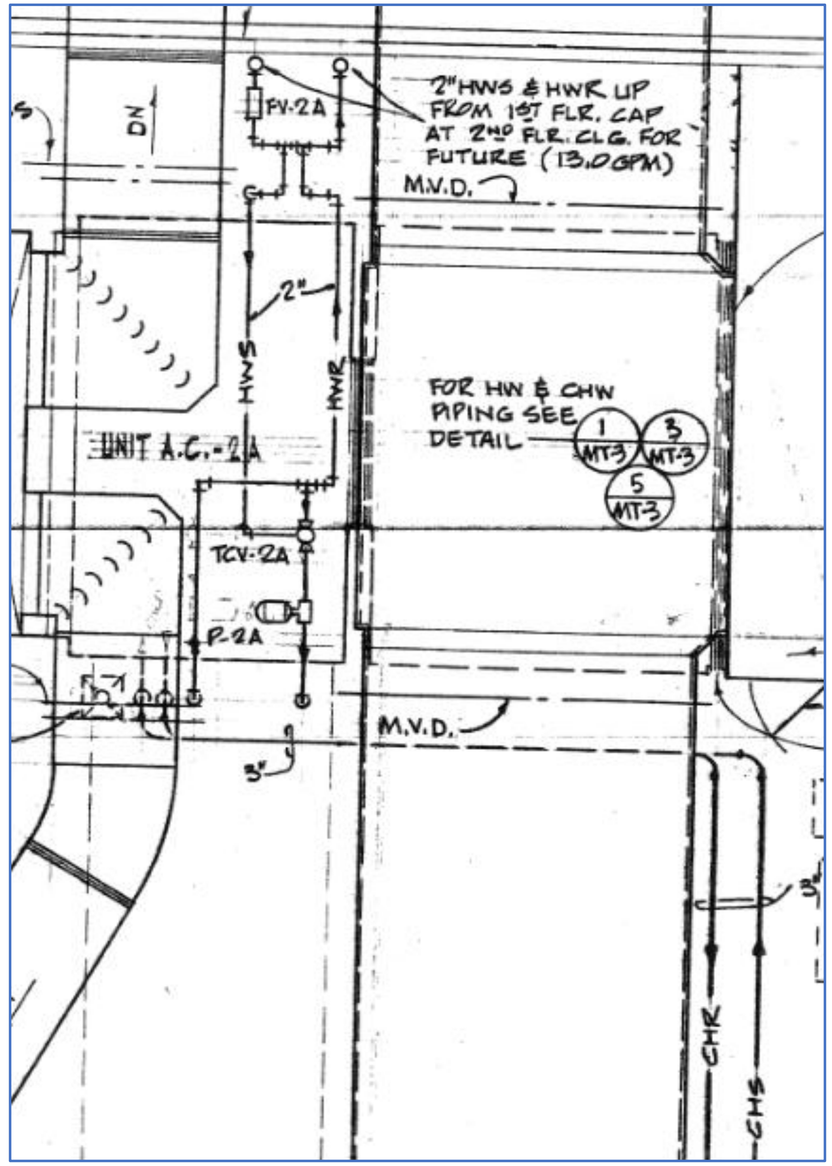
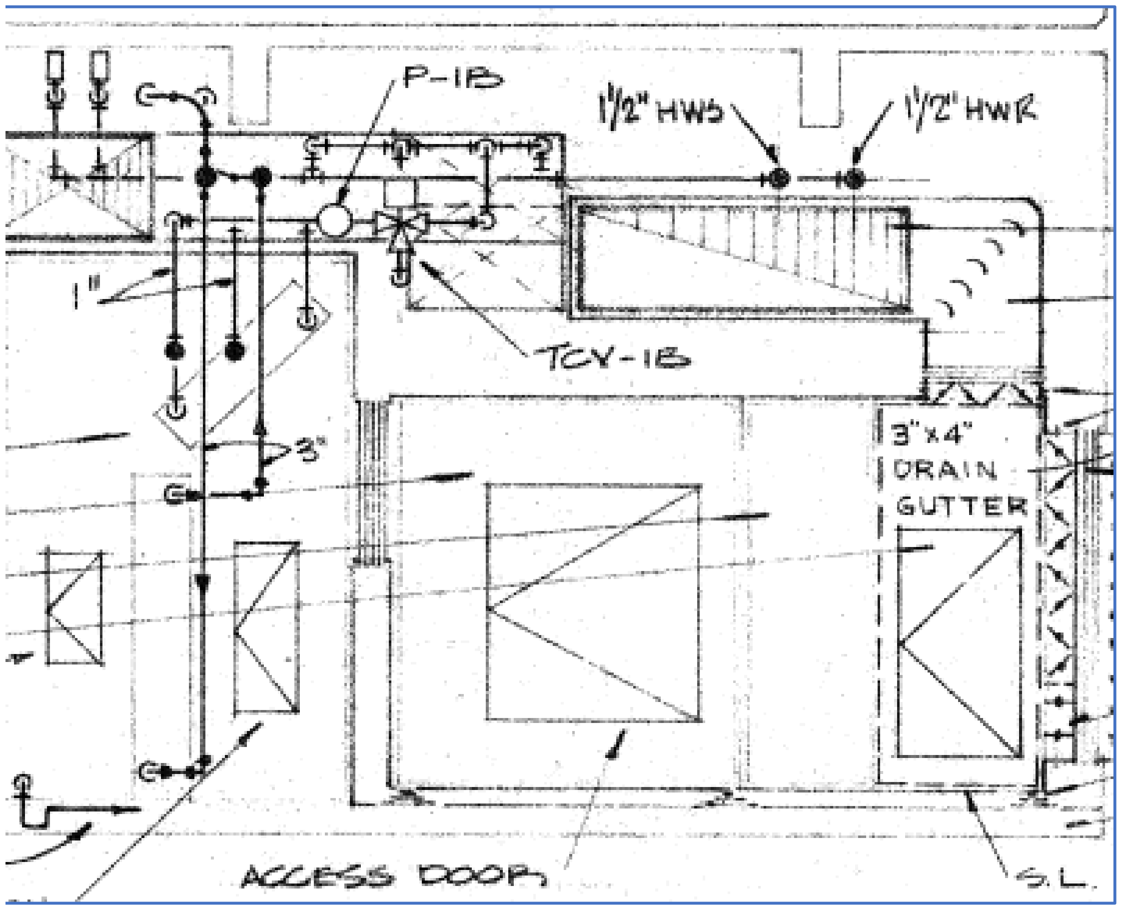


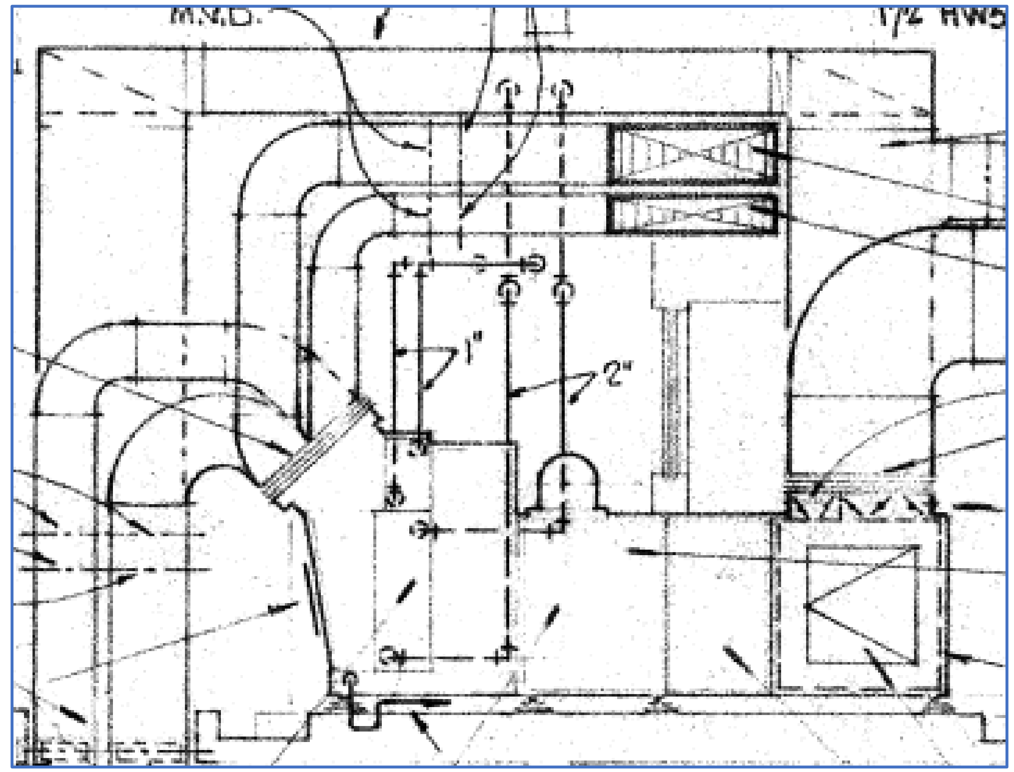


Source: K:\Jobs\Rio Hondo Community College\Site Information\Business\Mechanical Plans\Mechanical\AC-1B&2B Duct Diagram

AC-1B



AC-2B



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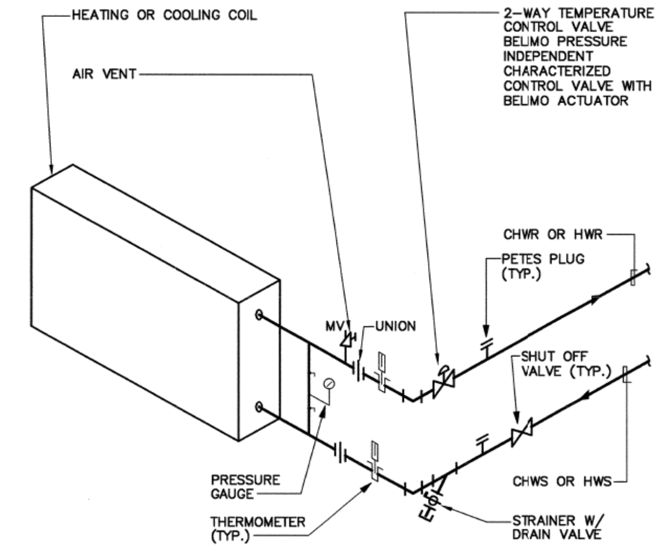
FAN COIL UNIT

UNIT NO.	MANUFACTURER & MODEL NO.	SERVICE	SUPPLY FAN C.F.M.	SUPPLY FAN E.S.P.	O.S.A CFM	COOLING CAPACITY(MBH) SENS.	COOLING CAPACITY(MBH) TOTAL	ENT. AIR °F. D.B.	ENT. AIR °F. W.B.	LVG. AIR °F. D.B.	LVG. AIR °F. W.B.	COIL AIR P.D.	COIL ROWS	COIL FINS/IN.	CHILLED WATER G.P.M.	CHILLED WATER P.D.	CHILLED WATER ENT. °F.	CHILLED WATER LVG. °F	HEATING CAP.(MBH) TOTAL	ENT. AIR °F. D.B.	LVG. AIR °F. D.B.	COIL AIR P.D.	COIL ROWS	COIL FINS/IN.	HOT WATER G.P.M.	HOT WATER P.D.	HOT WATER ENT. °F.	HOT WATER LVG. °F
FC 1	TEMTROL FC-181	ADMIN. ASSIST	435	0.35	120	12.2	16.0	78.5	63.7	52.8	50.9	0.42	5	8	2.3	1.0	41	61	26.2	65.0	120.6	0.11	5	8	0.9	0.29	200	140
FC 2	TEMTROL FC-181	DEAN'S OFFICE	370	0.35	75	9.1	11.6	76.1	62.7	52.8	51.6	0.22	5	8	1.7	2.55	41	61	1.8	65.0	97.5	0.07	5	8	0.5	0.04	200	140
FC 3	TEMTROL FC-183	EXTENDED HOURS STUDY	960	0.5	400	45.9	62.6	81.6	66.0	51.4	51.1	0.84	6	12	6.3	3.75	41	61	69.2	65.0	110.6	0.10	2	7	2.4	3.43	200	140
FC 4	TEMTROL FC-182	TELECONF. LOUNGE	990	0.35	740	35.8	50.5	84.7	67.8	51.4	51.1	0.87	8	10	5.1	1.26	41	61	24.6	65.0	87.9	0.05	1	8	0.9	0.19	200	140
FC 5	TEMTROL FC-182	TELECONF. LOUNGE	990	0.35	740	35.8	50.5	84.7	67.8	51.4	51.1	0.87	8	10	5.1	1.26	41	61	24.6	65.0	87.9	0.05	1	8	0.9	0.19	200	140
FC 6	TEMTROL FC-182	LIBRARY MEETING ROOM	700	0.35	300	20.1	29.8	80.3	65.0	52.8	50.0	0.30	6	8	3.0	2.13	41	61	1.9	65.0	97.5	0.04	1	10	0.1	0.18	200	140

AIR HANDLING UNIT

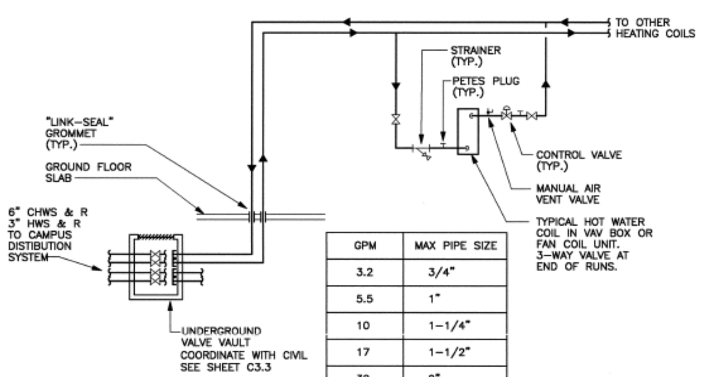
UNIT NO.	MANUFACTURER & MODEL NO.	SERVICE	SUPPLY FAN C.F.M.	SUPPLY FAN T.S.P.	RETURN FAN C.F.M.	RETURN FAN T.S.P.	O.S.A. CFM	COOLING CAPACITY(MBH) SENS.	COOLING CAPACITY(MBH) TOTAL	ENT. AIR °F. D.B.	ENT. AIR °F. W.B.	LVG. AIR °F. D.B.	LVG. AIR °F. W.B.	COIL AREA (FT²)	COIL AIR P.D.	COIL FACE VEL. (FPM)	COIL ROWS	COIL FINS/IN.	CHILLED WATER G.P.M.	CHILLED WATER P.D.	CHILLED WATER ENT. °F.	CHILLED WATER LVG. °F
AH 1	TEMTROL WF-RD79	FIRST FLOOR	39,700	5.1	37,500	2.2	12,800	1.1843	1.4951	79.2	64.1	51.7	51.3	86.7	0.73							
AH 2	TEMTROL WF-RD70	SECOND FLOOR	35,100	5.1	33,000	2.2	9,400	1.0156	1.3011	78.6	64.1	51.9	51.5	75.8	0.75							



NOTE:

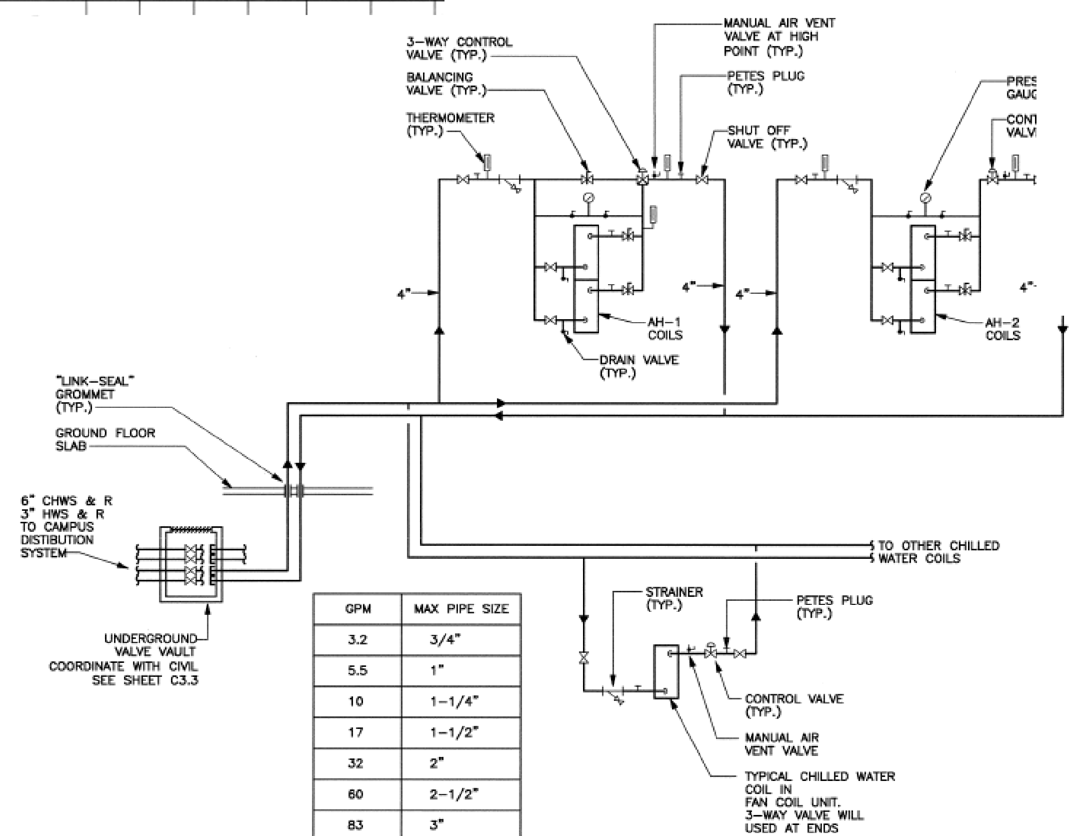
1. BRANCH PIPING SHALL BE FULL SIZE, VENT HIGH POINTS AS REQUIRED.
2. WATER SHALL BE PIPED COUNTER FLOW TO AIRFLOW, SUPPLY AT BOTTOM.
3. LOCATE PIPING TO CLEAR ACCESS DOORS.
4. FOR PIPE SIZES & CONTINUATION SEE DRAWINGS.
5. INSULATE PIPING PER SPECIFICATIONS.

4 FAN COIL UNIT COIL CONNECTIONS
SCALE: NONE



GPM	MAX PIPE SIZE
3.2	3/4"
5.5	1"
10	1-1/4"
17	1-1/2"
32	2"
60	2-1/2"
83	3"

6 HEATING HOT WATER SCHEMATIC PIPING DIAGRAM
SCALE: NONE



GPM	MAX PIPE SIZE
3.2	3/4"
5.5	1"
10	1-1/4"
17	1-1/2"
32	2"
60	2-1/2"
83	3"
240	4"
720	6"

7 CHILLED WATER SCHEMATIC PIPING DIAGRAM
SCALE: NONE

Source: K:\Jobs\Rio Hondo Community College\Site Information\Science\Mechanical Drawings\M Sheets

AIR HANDLING UNIT AND RETURN FAN SCHEDULE

UNIT NO.	MANUFACTURER MODEL NO.	SERVICE	FAN MOTOR						CHILLED WATER COIL DATA															
			CFM	RPM	E.S.P.	T.S.P.	HP.	VOLTAGE	BTU/HR	ENT. AIR		LVG. AIR		GPM	A.F. INCH	P.D. FEET H2O	COIL SIZE (INCHES)	ROWS	COIL F.A.	FPI	3-W VALVE		CH. WATER	
										DB°F	WB°F	DB°F	WB°F								SIZE	P.D.	IN°F	OUT°F
AH 1	MCQUAY MODEL CAH-050F	SEE FLOOR PLAN	29,500	948	2.5"	4.4"	40	460V, 3ø	1,090,100	84.0	65.0	53.5	52.5	162	0.83	8.0	(2) 39 x 107	6	58.0	8	3"	4 psi	44	56
AH 2	MCQUAY MODEL CAH-050F	SEE FLOOR PLAN	28,700	924	2.5"	4.2"	40	460V, 3ø	1,071,840	80.4	65.6	53.7	53.1	168	0.83	8.6	(2) 39 x 107	6	58.0	8	3"	4 psi	44	56
AH 3	MCQUAY MODEL CAH-050F	SEE FLOOR PLAN	23,100	852	2.5"	4.0"	30	460V, 3ø	976,350	83.4	67.0	53.7	53.1	154	0.77	9.2	(2) 33 x 107	6	49.0	8	3"	4 psi	44	56
AH 4	MCQUAY MODEL CAH-050F	SEE FLOOR PLAN	32,700	835	2.5"	4.4"	40	460V, 3ø	1,130,000	80.4	65.6	54.9	54.2	191	0.99	5.4	(2) 39 x 107	6	58.0	8	3"	4 psi	44	56
AH 5	MCQUAY MODEL CAH-050F	SEE FLOOR PLAN	26,400	886	2.5"	4.0"	40	460V, 3ø	1,080,700	82.6	66.5	53.5	53.0	168	0.72	8.6	(2) 39 x 107	6	58.0	8	3"	4 psi	44	56
AH 6	MCQUAY MODEL CAH-010	SEE FLOOR PLAN	6,000	1078	2.0"	3.5"	7.5	460V, 3ø	229,100	82.0	66.5	54.6	54.0	38	0.83	3.3	(1) 33 x 53	6	12.0	8	1-1/2"	4 psi	44	56
RF																								

Source: K:\Jobs\Rio Hondo Community College\Mechanical Plans\Student Services\3Student Services Bid Set-Drawings

AIR HANDLING UNIT SCHEDULE

EQUIP. NO.	MANUFACTURER AND MODEL NO.	LOCATION AND SHT REF	AREA SERVED	SUPPLY FAN								RETURN/EXHAUST FAN							
				CFM	ESP. (IN. W.C.)	TOTAL S.P. (IN. W.C.)	WHEEL DIA. TYPE	RPM	MOTOR VOLT/PH/HZ	MOTOR BHP	MOTOR HP	CFM	ESP. (IN. W.C.)	TOTAL S.P. (IN. W.C.)	WHEEL DIA. TYPE	RPM	MOTOR VOLT/PH/HZ	MOTOR BHP	MOTOR HP
AH 1	MCQUAY OAH069GDAM	LEVEL 3 M1.23	ENTIRE BUILDING	33,000	3.00	4.79	40.25	1264	460/60/3	40.45	50	30,000	1.00	1.18	36.50	1263	460/60/3	20.18	25

EQUIP. NO.	COOLING COILS											REHEAT COILS									
	CAPACITY TOTAL (MBH)	CAPACITY SENSIBLE (MBH)	AIR ENT.(°F) DB/WB	AIR LVG.(°F) DB/WB	AIR P.D. (IN. W.C.)	QTY./ROWS/FPI	FACE AREA (SQ. FT.)	WATER GPM	WATER ENT. (°F)	WATER LVG. (°F)	WATER P.D. (FT. W.C.)	TOTAL (MBH)	AIR ENT.(°F) DB/WB	AIR LVG.(°F) DB/WB	AIR P.D. (IN. W.C.)	QTY./ROWS/FPI	FACE AREA (SQ. FT.)	WATER GPM	WATER ENT. (°F)	WATER LVG. (°F)	WATER P.D. (FT. W.C.)
AH 1	1,330	920	80.0/67.0	54.5/53.9	0.61	2/6/10	72.75	132.1	41.0	61.1	19.10	33,000	40.0	90.4	0.28	3/2/13	58.75	72.2	200.0	149.6	1.30

(1) PROVIDE PRE-FABRICATED, EXTERNAL VIBRATION ISOLATION ROOF CURB WITH INTEGRAL SEISMIC RESTRAINTS. PROVIDE PITCHED CURB MATCHING ROOF PITCH. COORDINATE WITH GENERAL CONTRACTOR. PROVIDE FACTORY DISCONNECT.

(2) PROVIDE MINIMUM MERV-7 PRE-FILTER(S) & MINIMUM MERV-13 FINAL FILTER(S).

(3) PROVIDE 100% OUTSIDE AIR DRY BULB ECONOMIZER.

(4) PROVIDE A VARIABLE FREQUENCY DRIVE (VFD) FOR EACH SUPPLY AND RETURN FAN, WITH NEMA 3R ENCLOSURE, BYPASS, 5% LINE REACTOR, RFI/EMI FILTER.

(5) PROVIDE PRE-FABRICATED SOUND TRAPS BUILT IN THE UNIT, SEE

(6) FOR EQUIPMENT ANCHORAGE REFER TO SHEET M0.06 DETAIL 13.

PIPE SIZE SCHEDULE

SYSTEM	TYPE	PIPE SIZE	MAXIMUM GPM
CHILLED AND HOT WATER	BLACK STEEL	5"	500
	BLACK STEEL	4"	280
	BLACK STEEL	3"	140.0
	COPPER TYPE L		130.0
	BLACK STEEL	2-1/2"	80.0
	COPPER TYPE L		82.0
	BLACK STEEL	2"	50.0
	COPPER TYPE L		46.0
	BLACK STEEL	1-1/2"	25.0
	COPPER TYPE L		21.5
	BLACK STEEL	1-1/4"	17.0
	COPPER TYPE L		13.2
	BLACK STEEL	1"	8.0
	COPPER TYPE L		7.6
	BLACK STEEL	3/4"	4.2
	COPPER TYPE L		3.6
	BLACK STEEL	1/2"	1.9
	COPPER TYPE L		1.3

FAN COIL UNIT SCHEDULE (COOLING ONLY)

EQUIP. NO.	MANUFACTURER AND MODEL NO.	LOCATION AND SHT REF	AREA SERVED	TYPE	SUPPLY FAN: CFM (MEDIUM)	SUPPLY FAN: ESP (IN. W.C.)	SUPPLY FAN: MOTOR VOLT/PH/HZ	SUPPLY FAN: MOTOR QUANTITY	SUPPLY FAN: MOTOR HP	SUPPLY FAN: DRIVE	COOLING COILS: CAPACITY (MBH) SENSIBLE	COOLING COILS: AIR ENT. (°F) DB	COOLING COILS: AIR LVG. (°F) DB	COOLING COILS: AIR P.D. (IN. W.C.)	COOLING COILS: WATER GPM	COOLING COILS: WATER ENT. (°F)	COOLING COILS: WATER LVG. (°F)	COOLING COILS: WATER P.D. (FT. W.C.)
FC 1	JOHNSON CONTROLS FNP12	MECH. CLOSET 001 M2.01	ELEV. MACH RM. 002	PLENUM RETURN	1,400	0.25	208/1/60	2	1/6	DIRECT	30,240	80	60	–	3	41	61	3
FC 2	JOHNSON CONTROLS FNP12	ELECT. RM. 004 M2.01	TELECOM RM. 003	PLENUM RETURN	1,400	0.25	208/1/60	2	1/6	DIRECT	30,240	80	60	–	3	41	61	3
FC 3	JOHNSON CONTROLS FNX12	ELECT. RM. 004 M2.01	ELECT. RM. 004	EXPOSED	1,400	0.25	208/1/60	2	1/6	DIRECT	30,240	80	60	–	3	41	61	3

NOTES: (1) PROVIDE AIR FILTERS AS PER AIR FILTER SCHEDULE (2) FOR EQUIPMENT ANCHORAGE REFER TO SHEET M0.06 DETAIL 2.

PIPE SIZE SCHEDULE

SYSTEM	TYPE	PIPE SIZE	MAXIMUM GPM
CHILLED AND HOT WATER	BLACK STEEL	4"	280
	BLACK STEEL	3"	140.0
	COPPER TYPE L		130.0
	BLACK STEEL	2-1/2"	80.0
	COPPER TYPE L		82.0
	BLACK STEEL	2"	50.0
	COPPER TYPE L		46.0
	BLACK STEEL	1-1/2"	25.0
	COPPER TYPE L		21.5
	BLACK STEEL	1-1/4"	17.0
	COPPER TYPE L		13.2
	BLACK STEEL	1"	8.0
	COPPER TYPE L		7.6
	BLACK STEEL	3/4"	4.2
	COPPER TYPE L		3.6

AIR HANDLING UNIT SCHEDUL

EQUIPMENT NO.			AH 1	MAH 1
MANUFACTURER AND MODEL NO.			MAQUAY OAH045GDDC	MAQUAY OAH012GDDC
LOCATION AND SHEET REF.			MECHANICAL WELL M2.02	MECHANICAL WELL M2.02
AREA SERVED			ALL LEVELS	KITCHEN 102
SUPPLY FAN		CFM	21,000	5,500
		ESP. (IN. W.C.)	2.25	2.00
		TOTAL S.P. (IN. W.C.)	4.37	3.81
		WHEEL DIA. TYPE	33	16.50
		RPM	1,456	2,977
		DRIVE TYPE	BELT	BELT
		VSD (Y OR N)	Y	Y
	MOTOR	VOLT/PH/HZ	460/3/60	460/3/60
		BHP	23.81	8.65
		HP	25	10
RETURN FAN		CFM	9,100	–
		ESP. (IN. W.C.)	1.25	–
		TOTAL S.P. (IN. W.C.)	1.37	–
		WHEEL DIA. TYPE	20	–
		RPM	2,379	–
		DRIVE TYPE	BELT	–
		VSD (Y OR N)	Y	–
	MOTOR	VOLT/PH/HZ	460/3/60	–
		BHP	6.97	–
		HP	7.5	–
COOLING COILS		CFM	21,000	5,500
	CAPACITY (MBH)	TOTAL	1,029	283
		SENSIBLE	782	215
	AIR	ENT. (°F) DB/WB	86.2 / 68.0	90.0 / 70.0
		LVG. (°F) DB/WB	52.1 / 51.9	54.1 / 53.7
		P.D. (IN. W.C.)	1.18	0.91
		QTY./ROWS/FPI	2/6/12	1/6/10
		TOTAL FACE AREA (SQ. FT.)	42.62	12.15
	WATER	GPM	91.20	28.00
		ENT. (°F)	41	41
		LVG. (°F)	63.6	61.3
		P.D. (FT. W.C.)	24.10	7.10
HEATING COILS		TOTAL (MBH)	21,000	5,500
	AIR	ENT. (°F) DB/WB	55.0	40
		LVG. (°F) DB/WB	88.8	90.7
		P.D. (IN. W.C.)	0.15	0.19
		QTY./ROWS/FPI	2/1/8	1/1/13
		TOTAL FACE AREA (SQ. FT.)	41.25	11.46
	WATER	GPM	32.10	12.00
		ENT. (°F)	200	200
		LVG. (°F)	151.8	149.3
		P.D. (FT. W.C.)	3.60	1.60
VIBRATION ISOLATION		FRAME	2" INTERNAL SPRING ISOLATORS AT EACH FAN	2" INTERNAL SPRING ISOLATORS AT EACH FAN
		ISOL. TYPE		
		DEFL. (IN.)		
MIN. OA (CFM)			13,400	5,500

Source: K:\Jobs\Rio Hondo Community College\Site Information\Technology\Mechanical Drawings\M0.2

AIR HANDLING UNIT SCHEDULE

SYSTEM				FAN DATA											CHILLED WATER COOLING COIL									HOT WATER HEATING COIL								
								MOTOR DATA							AIRSIDE					WATERSIDE						AIRSIDE			WATERSIDE			
MARK	AREA SERVED	LOCATION	MANUFACTURER MODEL	CFM	T.S.P.	RPM	BHP	HP	RPM	V–ø	CFM	CAPACITY TOT./SENS. (MBH)	ROWS	FPI	EDB	EWB	LDB	LWB	ΔP IN	EWT	LWT	GPM	ΔP FT	HEATING CAPACITY (MBH)	ROWS	EDB	LDB	ΔP IN	EWT	LWT	GPM	ΔP FT
AH–1A	BLDG "A" COMP. LAB. 101	CEILING	CARRIER 42BHC30	2800	3.10"	–	–	5.0	–	460v, 3ø	2800	84.4 / 68.1	6	10	79	66	56.8	56.2	0.44	41.0	61.0	8.4	1.36	108.2	1	65	100.3	0.03	200	150	4.3	7.59
AH–2A	BLDG "A" COMP. LAB. 102	CEILING	CARRIER 42BHC16	1600	4.0"	–	–	2.0	–	460v, 3ø	2400	46.9 / 38.3	6	10	79	66	57.1	56.5	0.51	41.0	61.0	4.7	1.41	56.9	1	65	97.5	0.04	200	150	2.3	1.10
AH–3A	BLDG "A" COMP. LAB. 103	CEILING	CARRIER 42BHC30	2400	2.25"	–	–	1.5	–	460v, 3ø	2400	73.8 / 59.2	6	10	79	66	56.5	56.0	0.33	41.0	61.0	7.4	1.06	98.3	1	65	102.5	0.03	200	150	3.9	6.26
AH–4A	BLDG "A" – AV RM. 106	CEILING	CARRIER 42BHC20	2100	2.55"	–	–	1.5	–	460v, 3ø	2100	64.8 / 51.3	6	10	79	66	56.7	56.0	0.61	41.0	61.0	6.5	3.20	72.1	1	65	96.4	0.05	200	150	2.9	2.12
AH–5A	BLDG. "A"–M/W TOILET, JAN. CLASSROOMS 114/115	CEILING	CARRIER 42BHC30	3000	3.50"	–	–	3.0	–	460v, 3ø	3000	89.1 / 72.3	6	10	79	66	57.0	56.4	0.51	41.0	61.0	8.9	1.55	112.2	1	65	99.2	0.04	200	150	4.5	8.16
AH–6A	BLDG. "A" ASSMBLY 118/OFF.119	CEILING	CARRIER 42BHC30	2400	2.25"	–	–	1.5	–	460v, 3ø	2400	73.8 / 59.2	6	10	79	66	56.5	56.0	0.33	41.0	61.0	7.4	1.06	98.3	1	65	102.5	0.03	200	150	3.9	6.26
AH–1B	BLDG. "B" BOSCH CLASSROOM (121)	CEILING	CARRIER 42BHC40	3500	2.45"	–	–	3.0	–	460v, 3ø	3500	120.6 / 91.3	6	10	79	66	55.2	54.7	0.38	41.0	61.0	12.1	3.63	141.8	1	65	102.0	0.03	200	150	5.7	16.73
AH–2B	NOT USED																															
AH–3B	BLDG. "B" HONDA LAB (141)	CEILING	CARRIER 42BHC10	1000	1.60"	–	–	0.75	–	460v, 3ø	1000	32.5 / 25.3	6	10	79	66	56.4	56.0	0.36	41.0	61.0	3.2	1.82	39.7	1	65	101.3	0.03	200	150	1.6	3.46
AH–4B	BLDG. "B" MULTI MEDIA/CONT.EDU	CEILING	CARRIER 42BHC20	2100	2.55"	–	–	1.5	–	460v, 3ø	2100	64.8 / 51.3	6	10	79	66	56.7	56.0	0.61	41.0	61.0	6.5	3.20	72.1	1	65	96.4	0.05	200	150	2.9	2.12
AH–5B	BLDG. "B" RECEPTION/LOBBY & OFFICES	CEILING	CARRIER 42BHC30	2200	1.85"	–	–	1.5	–	460v, 3ø	2200	67.9 / 54.4	6	10	79	66	56.4	56.0	0.33	41.0	61.0	6.8	0.90	92.2	1	65	103.3	0.03	200	150	3.7	5.15
AH–1C	BLDG. "C" – TOLLRM (148) CLASSRM S/S (146), CLASSRM (144)	CEILING	CARRIER 42BHC30	2400	2.25"	–	–	1.5	–	460v, 3ø	2400	73.9 / 59.2	6	10	79	66	56.5	56.0	0.33	41.0	61.0	7.4	1.06	98.3	1	65	102.5	0.03	200	150	3.9	6.26
AH–2C	BLDG. "C" –	CEILING	CARRIER 42BHC30	2400	3.20"	–	–	3.0	–	460v, 3ø	2400	70.3 / 56.6	6	10	79	66	57.4	56.5	0.33	41.0	61.0	7.0	3.78	75.5	1	65	93.7	0.03	200	150	3.0	2.32
AH–1D	BODY SHOP BUILDING	CEILING	CARRIER 42BHC20	2100	2.10"	–	–	1.5	–	460v, 3ø	1900	60.5 / 47.3	6	10	79	66	56.2	55.6	0.61	41.0	61.0	6.0	2.79	69.0	1	65	98.2	0.05	200	150	2.8	1.94

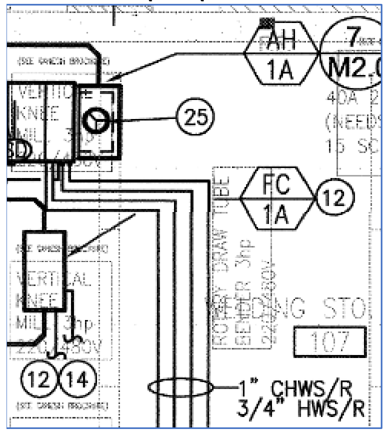
REMARKS: ① PROVIDE DUCT SMOKE DETECTOR ② WITH ECONOMIZER

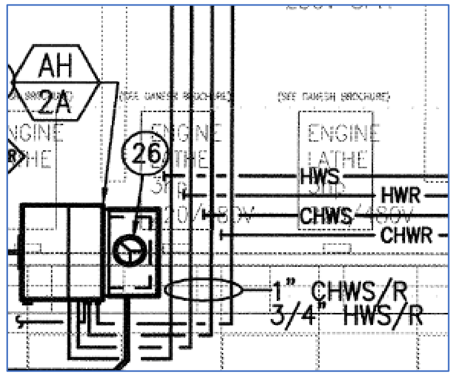
AIR CONDITIONING UNIT SCHEDULE

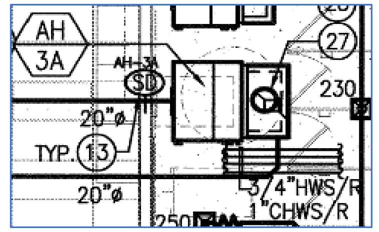
MARK NO.	AREA SERVED	LOCATION	CAPACITY				MOTOR DATA								WEIGHT (LBS)	CONDENSING UNIT			ELECTRICAL			UNITS WEIGHT (LBS)	REMARKS
			TOTAL (MBH)	NOMINAL TONS	CFM	ESP (IN)	BHP	HP	V	PH	HZ	FLA	MCA	MOCP		FLA	MCA	MOCP	V	PH	HZ		
FC–1A, CU–1A FC–2A, CU–2A	SEE PLANS	CEILING	18	1.5	600	.33	–	1/5	208	1	60	1.5	1.9	15	100	8.7	10.7	15	208	3	60	165	CARRIER INDOOR UNIT FB4B018 WITH MATCHING OUTDOOR CONDENSING UNIT 38HDC018 ①②③④

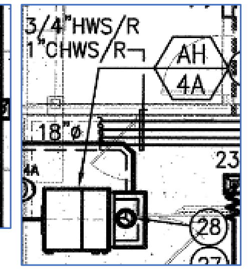
REMARKS: ① WIRING AND PIPING SHALL BE PER MANUFACTURER'S RECOMMENDATIONS. ② PROVIDE VIBRATION ISOLATION (1" MIN. DEFLECTION) AND SEISMIC RESTRAINT. ③ PROVIDE WITH OIL SEPARATOR AND SUCTION ACCUMULATOR. ④ PROVIDE CONDENSATE PUMP @ FCU'S.

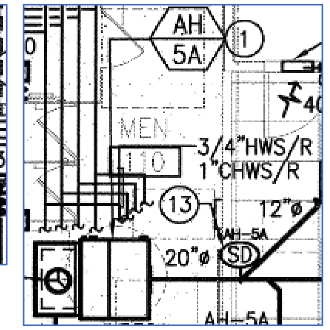
Source: K:\Jobs\Rio Hondo Community College\Site Information\Technology\Mechanical Drawings\M1.1
K:\Jobs\Rio Hondo Community College\Site Information\Technology\Mechanical Drawings\M1.2
K:\Jobs\Rio Hondo Community College\Site Information\Technology\Mechanical Drawings\M2.0

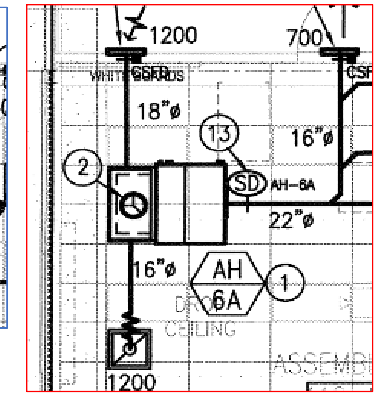


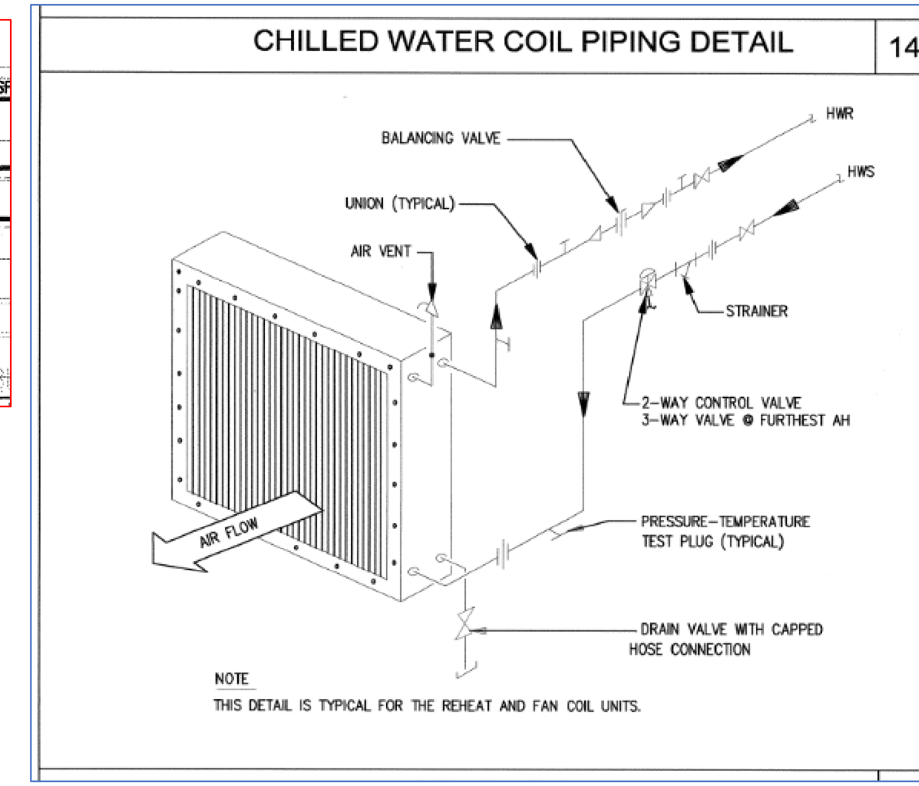


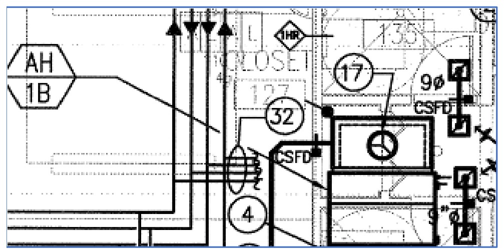


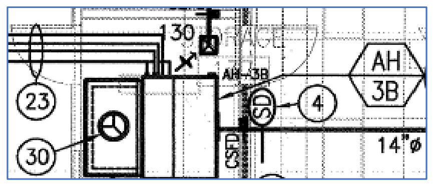


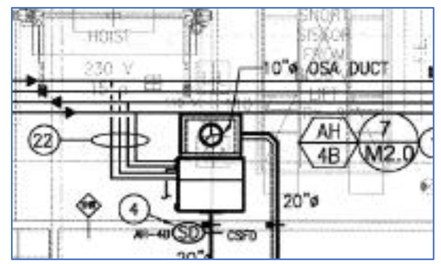


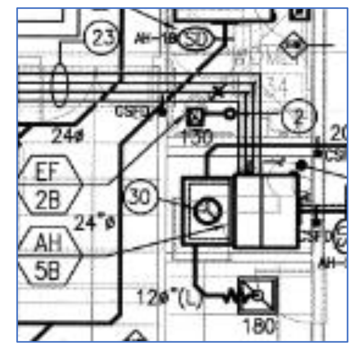


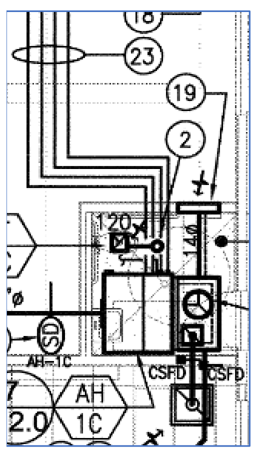


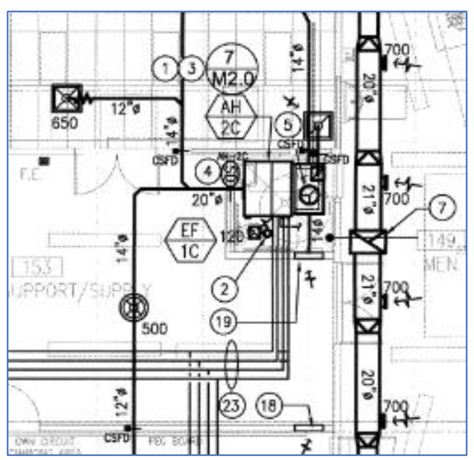












(22) 1 1/2"CHWS/R, 1-1/4"HWS/R

(23) 1"CHWS/R, 3/4"HWS/R

(24) 1-1/4"CHWS/R, 3/4"HWS/R

(25) 3"CHWS/R, 2"HWS/R

(26) 21"x21" OPENING FOR GRAVITY RELIEF VENT AT ROOF

(27) 13"x13" OPENING FOR GRAVITY RELIEF VENT AT ROOF

(28) 15"x15" OPENING FOR GRAVITY RELIEF VENT AT ROOF

(29) 17"x17" OPENING FOR GRAVITY RELIEF VENT AT ROOF

(30) 8"ø OSA DUCT UTR WITH ROOF JACK

(31) CARMON EXHAUST SYSTEM BY RIO HONDO COLLEGE

(32) 1-1/4"CHWS/R, 1"HWS/R

Source: **K:\Jobs\Rio Hondo Community College\Site Information\Wray\Mechanical Drawings**
K:\Jobs\Rio Hondo Community College\Site Information\Wray\Mechanical Drawings\File0032 WRAY THEATER & CAMPUS INN

NG AND VENTILATING. UNIT SCHEDULE

TYPE W COOLING COIL 8 FINS/INCH

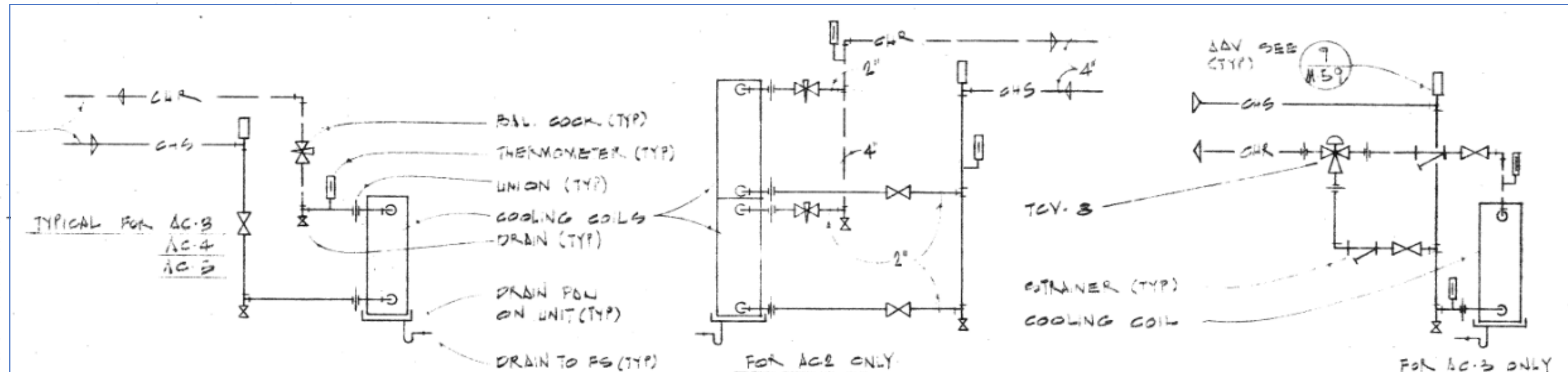
SYMBOL	MAKE & MODEL	LOCATION	CFM	SIZE T×L	FACE AREA □	AIR FRIC H_2O	ROWS	ENT. AIR DB	ENT. AIR WB	LVG AIR DB	LVG AIR WB	GPM	ENT. H_2O °F	LVG. H_2O °F	PD. FEET
AC-1															
AC-2	ABC 63 AB	BASEMENT	23,300	2-27×120	62.4	0.31	6	82	66.5	58	56.2	145	44	54	11.7
AC-3	ABC 1A 18	BASEMENT	5,320	22×51	10.8	0.48	6	82	66.5	58	56.2	34	44	54	2.9
AC-4	ABC 2AB 20	FAN RM	11,300	26×111	27.9	0.35	6	82	66.5	58	56.2	73	44	54	11.5
AC-5	ABC 2AB20	MECH. EQUIP RM.	11,500	26×111	27.9	0.38	6	82	66.5	58	56.2	74	44	54	11.8
H&V-1	FARR 14000	KITCHEN ROOF	ROTARY TYPE EVAP COOLER W/2 ELECTRIC MOTOR 100 W. BA												
H&V-2	ABC 1V12	WORK SHOP													

TYPE W HEATING COIL 8 FINS/I

SYMBOL	CFM	SIZE T×L	FACE AREA □	AIR FRIC H_2O	ROWS	ENT AIR °F	LVG AIR °F	GPM
AC-1								
AC-2	19,400	2-27×120	31.2	0.15	2	62.7	95	45.7
AC-3	5,320	12×51	10.2	0.11	2	62.7	95	12.6
AC-4	9,400	13×111	13.9	0.18	2	62.7	95	22.4
AC-5	9,550	13×111	13.9	0.19	2	62.7	95	22.8
H&V-1	14,000	24×96	22.3	0.2	2	62.7	95	40.4
H&V-2	3,000	14×36	4.9	0.14	2	62.7	95	8.65

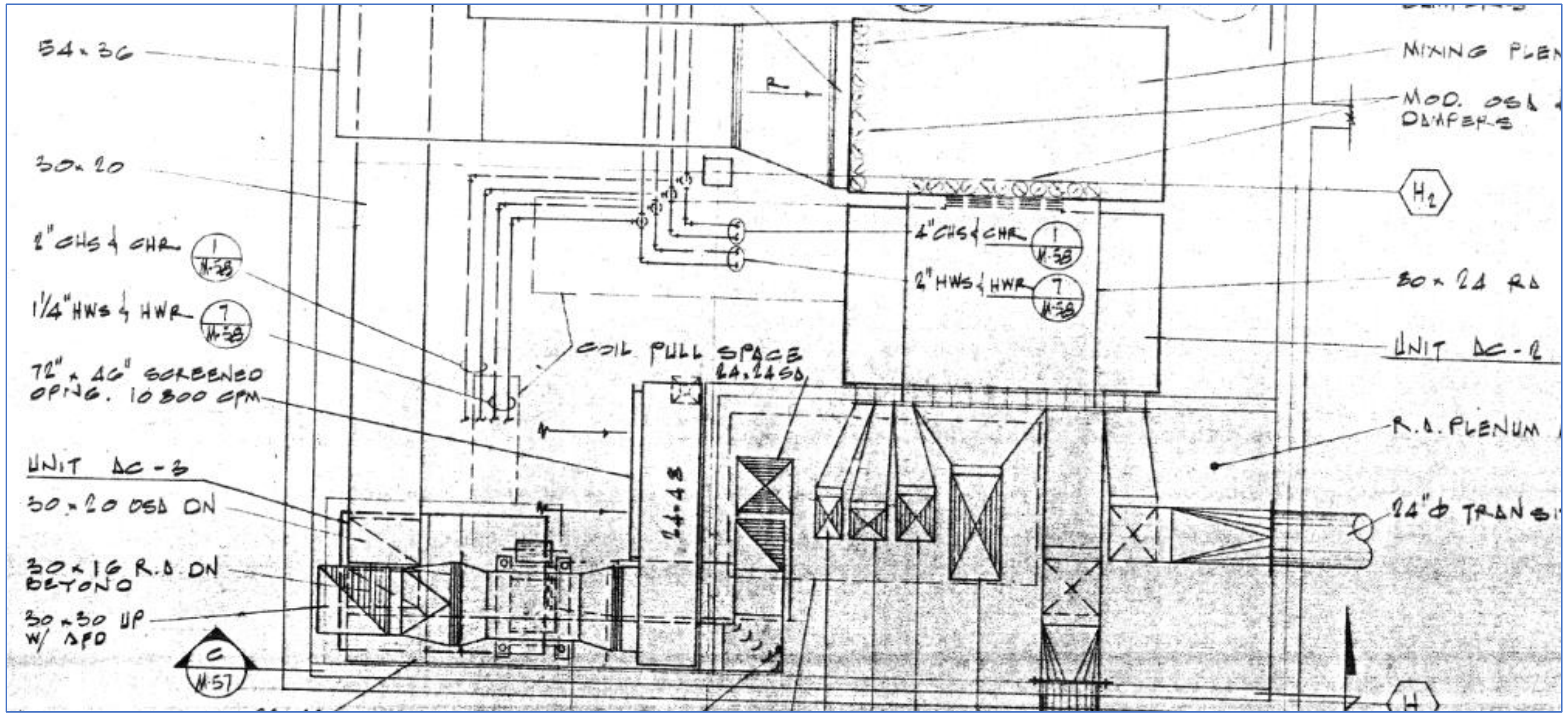
TEMPERATURE CONTROL VALVE SCHEDULE

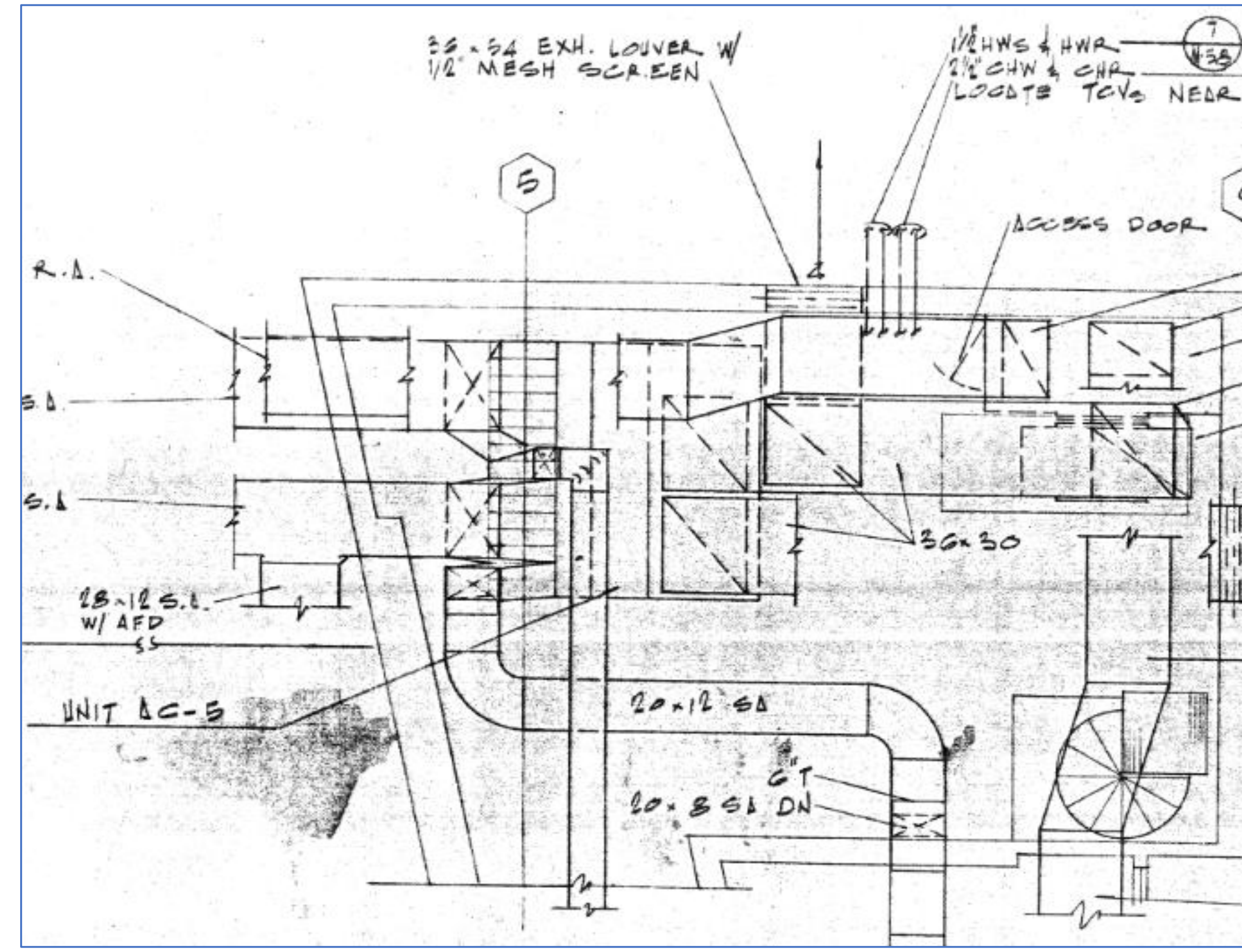
DESCRIPTION	EQUIPMENT SERVED	SERVICE	PD. PSI	CAPACITY GPM	STEAM #/HOUR	REMARKS
TCV-1 TO 3						SEE S.C. SCHED.
TCV-4	MAIN SYSTEM	HOT WATER	4	153	—	
TCV-5	H&V-1	HOT WATER	2	40.4	—	
TCV-6	H&V-2	HOT WATER	2	8.5	—	
TCV-7	AC-2	HOT WATER	3	45.7	—	
TCV-8	AC-3	CHILLED WATER	4	34	—	
TCV-9	AC-3	HOT WATER	2	2.5	—	
TCV-10	AC-4	HOT WATER	3	22.4	—	
TCV-11	AC-5	HOT WATER	3	22.8	—	
TCV-12	DOM HW TANK	STEAM	6	—	800 #/HR	

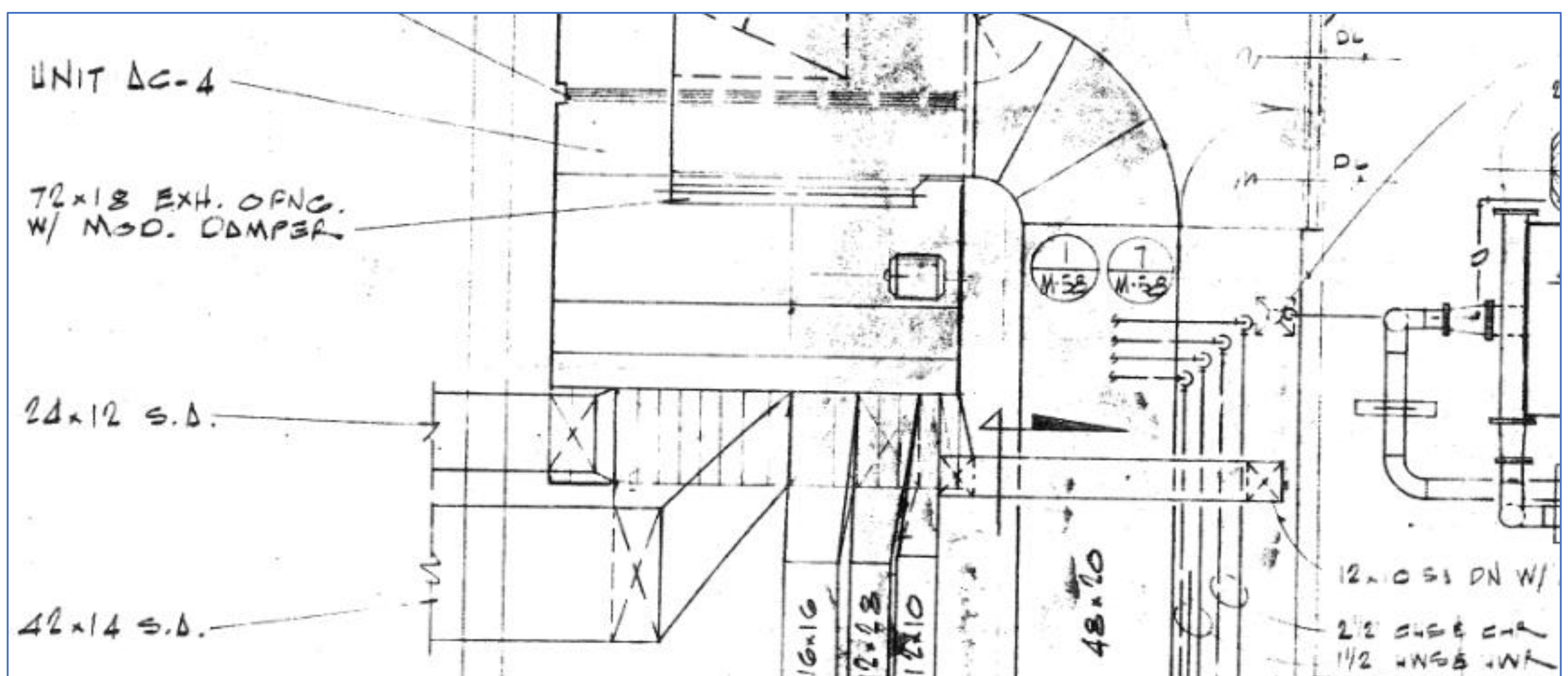


COOLING COIL PIPING DIAGRAM 1 M-58
NO SCALE

Source: K:\Jobs\Rio Hondo Community College\Site Information\Wray\Mechanical Drawings\File0031 WRAY THEATER & CAMPUS INN
K:\Jobs\Rio Hondo Community College\Site Information\Wray\Mechanical Drawings\File0030 WRAY THEATER & CAMPUS INN







Source: K:\Jobs\Rio Hondo Community College\Mechanical Plans\Mech Details\019

TEMP. CONTROL VALVE SCHEDULE

MARK	EQUIP. SERVICE	PRESS. DROP P.S.I.	CAP.	REMARKS	MARK	EQUIP. SERVICE	PRESS. DROP P.S.I.	CAP.	REMARKS
TCV-1	MAIN HTG.	5	3300#/HR	MOD. STEAM	TCV-1A	AC-1A	3	12.5 GPM	MOD. 3 WAY
TCV-2	MAIN HTG.		6700#/HR		TCV-2A	AC-2A		27.5 GPM	
					TCV-1L	AC-1L		31.5 GPM	
TCV-13G	GYM HTG.		1050#/HR		TCV-1B	P-1B		27.8 GPM	
TCV-14G	GYM HTG.		2100#/HR		TCV-2B	AC-2B		5.7 GPM	MOD. 2 WAY
TCV-15G	GYM DOMEST.		2350#/HR		TCV-1G	AC-1G		20.4 GPM	MOD. 3 WAY
TCV-16G	POOL		3500#/HR		TCV-2G	AC-2G		11 GPM	
TCV-17G	RAD. FLR.	5	125#/HR	MOD. STEAM	TCV-3G	AC-3G		25.6 GPM	
TCV-3	CT-1	7	925 GPM	MOD. 3 WAY	TCV-4G	AC-4G		5.8 GPM	
TCV-1T	AC-1T	3	3.0 GPM		TCV-5G	AC-5G		5.8 GPM	
TCV-2T	AC-2T		18.8 GPM		TCV-6G	AC-6G		5.8 GPM	
TCV-3T	AC-3T		14.6 GPM		TCV-7G	AC-7G		5.8 GPM	
TCV-4T	AC-4T		6.3 GPM		TCV-8G	AC-8G		2.9 GPM	
TCV-5T	AC-5T		22 GPM		TCV-9G	AC-9G		2.4 GPM	
TCV-6T	P-1T		43.8 GPM		TCV-10G	AC-10G		2.9 GPM	
TCV-7T	P-2T		20.9 GPM		TCV-11G	P-3G		6 GPM	
TCV-1S	AC-1S		24 GPM		TCV-12G	P-4G	3	8.5 GPM	MOD. 3 WAY
TCV-2S	AC-2S		18.2 GPM						
TCV-3S	AC-3S		9.1 GPM						
TCV-4S	AC-4S		14.1 GPM						
TCV-5S	AC-5S	3	23 GPM	MOD. 3 WAY					

FLOW VENTURI SCHEDULE

MARK	LOCATION	SIZE	G.P.M. CH.W.	G.P.M. H.W.	MARK	LOCATION	SIZE	G.P.M. CH.W.	G.P.M. H.W.
FV-1	BOILER PLANT	2½"		64.7	FV-1A	ADMIN. BLDG.	1¼"		12.5
FV-2	SCIENCE BLDG.	3"		99.3	FV-2A	ADMIN. BLDG.	2"		27.5
FV-3	SCIENCE BLDG.	3"		56.1	FV-1L	LIBRARY	2"		31.5
FV-4	BUS. ED. CHILLER PLANT	6"	464.0		FV-1B	BUS. EDUCATION	2"		27.8
FV-5	LIBRARY	4"	278.0		FV-1G	WOMEN'S GYM	1¼"		11.0
FV-6	BOILER PLANT	1½"	19.0		FV-2G	MEN'S GYM	1½"		23.2
FV-7	SCIENCE BLDG.	6"	282.8		FV-3G	MEN'S GYM	1½"		25.6
FV-1T	VOCAT. TECH.	2½"		43.8					
FV-2T	VOCAT. TECH.	2"		20.9					
FV-1S	SCIENCE BLDG.	1½"		24.0					
FV-2S	SCIENCE BLDG.	1¼"		18.2					
FV-3S	SCIENCE BLDG.	1¼"		9.1					
FV-4S	SCIENCE BLDG.	1¼"		14.1					
FV-5S	SCIENCE BLDG.	1½"		23.0					

AIR CONDITIONING UNIT SCHEDULE

MARK	AREA SERVED	MAKE & MODEL	¢ STD. AIR	S.P. IN. W.G.	FAN RPM	O.V. FPM	MOTOR HP	MOTOR V Φ	COOLING COIL ¢ STD. AIR	TONS	ENT. AIR DB	ENT. AIR WB	LVG. AIR DB	LVG. AIR %SAT.	SIZE Φ	FACE VEL. FPM	AIR FRIC. WET	WATER GPM	WATER PD. FT.	WATER ENT. TEMP.	WATER LVG. TEMP.	MIN. ROWS	SERIES	HEATING COIL ¢ STD. AIR (MAX)	BTU	AIR TEMP. ENT.	AIR TEMP. LVG.	SIZE Φ	FACE VEL. F.P.M. (MAX)	AIR FRIC. IN.W.G.	WATER GPM	WATER PD. FT.	WATER ENT. TEMP.	WATER LVG. TEMP.	MIN. ROWS	SERIES	FILTERS	REMARKS
AC-1T	TECH. OFFICE	AMER. STD. № 115	4100	1½	850	1740	2	480/3	3600	9.5	82.40	67.50°	58°	90	7.8	460	.45"	19.0	6.0	43°	55°	6	W	3360	85800	63°	86.5°	4.8	700	.20	3.0	2.5	210°	150°	2	W	6-16"x20"x2"	MULTI-ZONE
AC-2T	WELDING	№ 35	18420	1½	1180	2026	7½								NONE									12100	563400	54°	97°	17.3		.20	18.8				2		20-16"x25"x2"	MULTI-ZONE W/S.P. PLATE ①
AC-3T	METAL TECH.	№ 35	14540	1¼	940	1600	5								NONE									12100	438100	55°	88.5°	17.3		.20	14.6				2		20-16"x25"x2"	" " "
AC-4T	AUTO TECH.	№ 118	5620	1	567	1643	2								NONE									4130	168040	54°	91.5°	5.9		.20	6.3				2		9-16"x20"x2"	" " "
AC-5T	WELD HOOD	№ 42	24000	¾	1056	2140	10								NONE									24000	650000	35°	60°	34.6		.06	22.0				1		22-20"x25"x2"	
AC-1S	1ST FLR. SOUTH	№ 42	20790	2½	1100	1870	15		18000	523	90.4°	69.9°	58°	90	41.6	430	.40"	104.6	7.0	43°	55°	6	W	14600	714400	46°	91.3°	20.8		.20	24.0				2		22-20"x25"x2"	DOUBLE DUCT
AC-2S	2ND FLR. NORTH	№ 42	20690	2¼	1100	1870	15		18000	40.9	83.8°	67.2°	58°	90	41.6	430	.40"	81.8	7.0	43°	55°	6	W	14600	548000	63°	98°	20.8	700	.20	18.2				2		22-20"x25"x2"	
AC-3S	2ND FLR. SOUTH	№ 42	17680	2	960	1600	10		15300	38.7	85°	67.4°	58°	90	41.6	370	.32"	77.4	5.2	43°	55°	6	W	12600	272600	63°	83°	20.8	600	.20	9.1				2		22-20"x25"x2"	
AC-4S	3RD FLR. NORTH	№ 52	21400	2	872	1575	15		18200	56.2	86.7°	67.8°	58°	90	51.9	350	.30	112.4	7.0	43°	55°	6	W	15700	422715	63°	88°	27.7	570	.20	14.1				2		24-20"x25"x2"	
AC-5S	3RD FLR. SOUTH	AMER. STD. № 52	22070	2	885	1630	15	480/3	19000	50.4	90°	69.4°	58°	90	51.9	370	.30	100.8	7.0	43°	55°	6	W	15700	687800	50°	93.7°	27.7	570	.20	23.0	2.5	210°	150°	2	W	24-20"x25"x2"	DOUBLE DUCT
AC-6S	ANIMAL RM.	McQUAY № SH-52	300	.18 EXT.	1050	–	2A.	120/1	300	1.0	94°	71°	63°	90	1.5	200	–	R-12 @ 40° F. SUCTION				3	–					NONE									1-8"x46"x1"	DX FAN COIL UNIT
AC-1A	ADMIN. BLDG.	AMER. STD. № 52	21955	2	885	1615	15	480/3	18600	48.0	84.3°	67.4°	58°	90	51.9	360	.30	96.0	7.0	43°	55°	6	W	15400	575820	63°	85.5°	27.7	560	.20	12.5	2.5	210°	150°	2	W	24-20"x25"x2"	DOUBLE DUCT
AC-2A	LIB. ARTS	№ 52	32930	2¼	905	1995	25		28000	86.0	86.3°	68°	58°	90	62.4	450	.41	172.0	8.0	43°	55°	6	W	22000	827200		98°	31.2	700	.20	27.5						30-	
AC-1L	LIBRARY	№ 63 ④	37620	2¼	1000	2285	25		32000	98.0	84°	67.4°	58°	90	62.4	510	.48	196.0	8.0	43°	55°	6	W	22000	944460		103°	31.2	700	.20	31.5						30-	
AC-1B	BUS. ED.	№ 52	25565	2½	1010	1885	15		22000	69.0	86°	68°	58°	90	51.9	425	.38	138.0	7.0	43°	55°	6	W	18000	663300		97.3°	27.7	650	.20	22.1						24-20"x25"x2"	
AC-2B	ARTS & CRAFTS	№ 215	7850	2¼	1060	1700	7½		6600	19.0	84°	67.3°	58°	90	15.9	420	.31	38.0	7.0	43°	55°	6		5500	170040		94°	8.7	630	.20	5.7						12-16"x20"x2"	DOUBLE DUCT ②
AC-1G	WOM'S. S & L	№ 218	11450	1	570	1670	5								NONE									8000	610130		106°	10.9	700	.20	20.4						18-16"x20"x2"	MULTI-ZONE W/ S.P. PLATE
AC-2G	WOM'S GYM	№ 42	21000	1½	1005	1870	10								NONE									14600	329200		84°	20.8	700	.20	11.0						22-20"x25"x2"	
AC-3G	MENS S & L	AMER. STD. № 35	15555	1¼	1041	1760	7½								NONE									12000	764445		94°	17.3	700	.20	25.6						20-16"x25"x2"	MULTI-ZONE W/ S.P. PLATE
AC-4,5,6,7G	MEN'S GYM	AAF № LY.S-12500	13450	1½	685	1970	7½								NONE									13450	174600		75°	22.5	600	.15	5.8						10-20"x25"x2"	AUDIVENT UNIT ③
AC-8G & 10G	COED. & EXCER.	AAF № LY.S-4500	5130	¾	599	1140	1½								NONE									5130	86350		78.5°	15.0	340	.10	2.9						8-16"x20"x2"	AUDIVENT UNIT
AC-9G	GYMNASTICS	AAF № LY.S-3500	4350	1	1000	1600	1	480/3							NONE									4350	73120	63°	78.5°	8.25	530	.10	2.4	2.5	210°	150°	2	W	6-16"x25"x2"	AUDIVENT UNIT

Building	2-Way (No Change)	3-Way (Upgrade to 2-Way)	DDC (No Change)	Pneumatic (Upgrade to DDC)	Notes
Admin	AHU-1, AHU-2		AHU-1, AHU-2		
Business	AHU-2B	AHU-1B, AHU-3B		AHU-1B, AHU-2B, AHU-3B	
LRC	AHU-2	AHU-3, FC-1,2,3,4,5,6	AHU-2, AHU-3, FC-1,2,3,4,5,6		Did not visually verify that FC-1,2,3,4,5,6…may be 2-way
Science		AHU-2,3,4,5,6	AHU-1,2,3,4,5,6		AHU-1: Missing CHW Valve Completely
Student Services	AHU-1,2,3		AHU-1,2,3		
Student Union	AHU-1, FC-1, FC-2, FC-3, MAH-1		AHU-1, FC-1, FC-2, FC-3, MAH-1		FC-2 assumed to be 2-way, not visually verified
Tech	14 single zone air handlers and associated EFs, 3 fan coil units		14 single zone air handlers and associated EFs, 3 fan coil units		Only AHU-7A was visually verified, we assumed the other AHUs also have 2-way CHWVs
Wray	AHU-Dining, AHU-Music, AHU-Theater	AHU-TV Studio		AHU-Dining, AHU-Music, AHU-Theater, AHU-TV Studio	

Building	2-Way (No Change)	3-Way (Upgrade to 2-Way)	DDC (No Change)	Pneumatic (Upgrade to DDC)	Notes
Admin	AHU-1, AHU-2		AHU-1, AHU-2		
Business	AHU-2B	AHU-1B, AHU-3B		AHU-1B, AHU-2B, AHU-3B	
LRC	AHU-2	AHU-3, FC-1,2,3,4,5,6	AHU-2, AHU-3, FC-1,2,3,4,5,6		Did not visually verify that FC-
Science		AHU-2,3,4,5,6	AHU-1,2,3,4,5,6		AHU-1: Missing CHW Valve Completely
Student Services	AHU-1,2,3		AHU-1,2,3		
Student Union	AHU-1, FC-1, FC-2, FC-3, MAH-1		AHU-1, FC-1, FC-2, FC-3, MAH-1		FC-2 assumed to be 2-way, not visually verified
Tech	14 single zone air handlers and associated EFs, 3 fan coil units		14 single zone air handlers and associated EFs, 3 fan coil units		Only AHU-7A was visually verified, we assumed the other AHUs also have 2-way CHWVs
Wray	AHU-Dining, AHU-Music, AHU-Theater	AHU-TV Studio		AHU-Dining, AHU-Music, AHU-Theater, AHU-TV Studio	

Table 5.3: Building AHUs 2-Way or 3-Way HHWV with DDC or Pneumatic Controls (In Orange)

Building	2-Way (No Change)	3-Way (Upgrade to 2-Way)	DDC (No Change)	Pneumatic (Upgrade to DDC)	Notes
Admin	AHU-1, AHU-2		AHU-1, AHU-2		
Business	AHU-2B	AHU-1B, AHU-3B		AHU-1B, AHU-2B, AHU-3B	
LRC		FC-1,2,3,4,5,6	FC-1,2,3,4,5,6		AHUs don't have pre-heat. Did not visually verify FC-1,2,3,4,5,6… may be 2-way
Science		AHU-1	AHU-1		AHU-1 is the only AHU with pre-heat.
Student Services	AHU-1		AHU-1		
Student Union	AHU-1, MAH-1		AHU-1, MAH-1		
Tech	14 single zone air handlers and associated EFs, 3 fan coil units		14 single zone air handlers and associated EFs, 3 fan coil units		Only AHU-7A was visually verified, we assumed the other AHUs also have 2-way HHWVs
Wray		AHU-Dining, AHU-Dining, AHU-Music, AHU-Theater		AHU-Dining, AHU-Music, AHU-Theater, AHU-TV Studio	

Building	2-Way (No Change)	3-Way (Upgrade to 2-Way)	DDC (No Change)	Pneumatic (Upgrade to DDC)	Notes
Admin	AHU-1, AHU-2		AHU-1, AHU-2		
Business	AHU-2B	AHU-1B, AHU-3B		AHU-1B, AHU-2B, AHU-3B	
LRC		FC-1,2,3,4,5,6	FC-1,2,3,4,5,6		AHUs don't have pre-heat. Did not visually verify FC-1,2,3,4,5,6… may be 2-way
Science		AHU-1	AHU-1		AHU-1 is the only AHU with pre-heat.
Student Services	AHU-1		AHU-1		
Student Union	AHU-1, MAH-1		AHU-1, MAH-1		
Tech	14 single zone air handlers and associated EFs, 3 fan coil units		14 single zone air handlers and associated EFs, 3 fan coil units		Only AHU-7A was visually verified, we assumed the other AHUs also have 2-way HHWVs
Wray		AHU-Dining, AHU-Dining, AHU-Music, AHU-Theater		AHU-Dining, AHU-Music, AHU-Theater, AHU-TV Studio	

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LRC
AHU-1
3-way valve, digital

AHU-2
2-way valve, digital

WRAY
not heated by central plant
future gn
Music AHU
pneumatic, could be two way

Theatre
2-way, pneumatic

Work shop
heating only

Dining Room AC 2
2-way pneumatic
3 full
8AM-5P

Theatre (marketing) AC3
3-way valve pneumatic
Ruby probably
Returns

Student Union
MAU 2 way valve
AHU 2 way valve > DDC
FC-1 2 way valve
FC-2 2 way valve
Serves, super small data center

Student Services
AHU-1 on roof
2-way - DDC
chilled water

AHU-2 2-way
Heating hot water

Tech
AHU 7a - 2 way valves on
(fan coil) chilled water
2 way valves on
hot water

AHUS
3 way chilled water valve

AHU 4
3 way valves

AHU 3
3 way valve

AHU 2
tripped & r
3-way valve

Engineering AHU
2nd Floor - two pn
way valve
1st Floor AHU (70 open) - 3 way valve

AHU 3 photo lab
3-way valve pneumatic

Admin
1st floor AHU
2-way valve

2nd Floor AHU
crazy
but 2-way

L Tower
MAIN AHU (top floors)
serves all

Added 5 package unit to 5th floor

Won't be occupied for 3 years

Science AHU-1 - one bowl
→ no chilled water valve
→ Removed 4 or 5 years ago
→ 100% flow through coil at all time

Science AHU-3
3-way valve - 1) throttle
48°F in
46 F out