Jefferson County School District, R-1

Support Services

TECHNICAL GUIDELINES

DIVISION 23 – HEATING VENTILATING AND AIR CONDITIONING

AUGUST 2022

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DIVISION 23 – HEATING, VENTILATING AND AIR-CONDITIONING (HVAC)

23 00 01 General – August 2021

- Only the Construction Project Manager is authorized to accept delivery of equipment or spare parts specified to be delivered to the owner.
    1. The specifications shall define time of delivery as a milestone early in the project and relative to some identifiable event.
- Warranties
    1. Reference “General Conditions” for warranty periods and conditions except for special conditions and warranties, which shall be identified and listed within the appropriate individual Sections.
- Roofing details relating to the installation of mechanical equipment shall be shown on Architectural or Roofing drawings not on Mechanical.
- Do not attach or route any mechanical components directly to the roof in any manner that could interfere with future roof maintenance or replacement. Maintain a minimum of 24” between top of roof and bottom of equipment overhangs, duct work etc. Duct or piping supports shall be placed with no more than 10’ spacing. Gas piping shall be supported from pre-manufactured supports and not permanently attached to the roof.
- Do not install piping in under slab chases where clearances will be less than 4 feet bottom of pipe to top of slab.
- Tracer Wire:
    1. Reference Division 33 for type and size of tracer wire for underground pipe runs and utilities.
    2. Install warning caution tape above underground pipe runs and utility lines.
    3. Install at all underground pipe runs and utility lines, to run with each underground pipe and utility listed in this Division 23.
- Relief air fans designed with capacity to relieve AHUs while in 100% economizer mode and maintain a building *maximum* positive pressure of 0.02 inches.
- Design Documents shall include a list of all parts and equipment deliverable to the owner (meters, gages, valve handles, etc. etc.).
- Design Documents involving the modification or replacement of existing systems or equipment shall include a specific list of work items and shall give clear direction on phases of work if applicable.
    1. Statements of a global nature to rehabilitate, i.e.; "as required" or “as necessary" are not acceptable.
    2. Include model and serial numbers for all existing equipment to be renovated and update Construction Drawings with current equipment Identification Numbers when available.

- Design Documents for modification or demolition of existing systems shall include drawings of equipment and materials to be removed.
  1. Statements of a global nature such as "Remove all pipe in this area" are not acceptable.
  2. Include model and serial numbers for all rehabilitated equipment and equipment removed.
  3. For equipment being removed, obtain direction from District Project Manager on what is to be returned to Jeffco and what can be otherwise disposed of.
- Completely coordinate between Fire Alarm, Electrical, Temperature Control and Mechanical disciplines for the installation of Combination Smoke and Fire Dampers.
  1. Fire and Smoke dampers shall be included in the Coordination Schedule/Matrix.
  2. Coordination Schedule/Matrix will be included in Division 01. The architect will coordinate all disciplines to review and coordinate prior to inclusion in the specifications.
  3. A sequence of operation entitled "Smoke Control" shall be included in design documents whenever modifications impacting the operation of the smoke control systems are made or a new Air Handling Unit is installed.
- The Architectural, Structural, and Mechanical design shall accommodate the largest and heaviest equipment listed as "acceptable" in the specifications.
  1. This includes structural loading capabilities and coordination with mechanical spaces including location of duct penetrations.
- Xcel Rebate Program
  1. Consultant to collect and submit the following data:
     a. <u>Manufacturer, Model #, and Quantity are needed for every rebate.</u> If multiple models are used, each must be included, quantities must be very clear. Provide summary sheet tagging all equipment under consideration for rebate.
        (1) Cooling Efficiency Rebates require Cut sheets that detail Tons/Unit as well as efficiency information – EER, FLV, IPLV, NPLV, SEER. Must qualify per efficiency ratings. After 9/1/2015, RTU's, PTAC, and air cooled chillers will be discounted at point of purchase.
        (2) Drive Rebates require Drive HP, Motor HP, Motor RPM, Open (OLV) or Closed Drive and cut sheets. Rebates are for new and replacement VFDs.
        (3) Motor Rebates require the following for the new <u>and the replaced</u> motors. Motor Type (Open or Closed), RPM, Nominal Efficiency at full load, HP, the end use (fan, pump, etc.), manufacturer and model # of new and old motors.
        (4) Heating Efficiency (for Xcel Gas Customers only) MBH of Boiler, Average fluid temp, R-value of piping insulation, linear feet of piping for every pipe size.

(5) Lighting rebates will be handled by CLEAResult, requirements can vary. Jeffco will contact CLEAResult at the beginning of each project to ensure that the needed information is gathered.

b. Include invoices for labor and materials in addition to manufacturer cut sheets. (Has to be an invoice rather than PO or other forms.)

c. Consultant to check on status of rebates with contractor when the pay-app for 50% completion is submitted. Rebates received at time of purchase shall be given to Jeffco at this point (if not already).

END SECTION 23 00 01

23 00 02 HVAC Criteria – August 2017

The Educational Specifications and Facilities Planning Standards contain criteria for HVAC (Mechanical) systems and shall be considered a part of these Guidelines. It is essential that District energy guidelines be observed for the operation of the heating, ventilating, air condition (HVAC).

- To maintain an environment conducive to the educational mission of the district, the classroom temperature, when occupied, should be no higher than 70 degrees during the heating season and no lower than 76 degrees during the cooling season. Heating, ventilation, and air conditioning systems may be fully operational only when the buildings are fully occupied.
- Heating and cooling equipment will be activated no earlier than necessary each morning to allow temperatures to reach adequate levels by the time students arrive.
- Exhaust fans will be turned off when a building is not occupied.
- Accessibility
    1. Install all HVAC equipment and control devices in "Readily Accessible" locations as defined by Chapter 1, Article 100, of the most recent issue of the National Electrical Code and International Mechanical Code.
- Include access doors or hatches in hard ceiling or walls where needed to reach mechanical devices such as valves, strainers, dampers, controllers, etc. or where in the judgment of the designer maintenance access will be necessary. Access to be no less than 24” x 24” clear opening. Contractors may be asked to demonstrate “reasonable accessibility” to the District Project Manager or a member of the design team during construction, whether installed access is sufficient shall be up to the discretion of the District Project Manager. A minimum of 24” shall be provided in front of controllers for air terminals or other above ceiling HVAC equipment, no piping, conduits, or any other equipment shall be placed below the clearance zone.

- When reusing or connecting to existing piping, clarify to what extent the contractor is to clean and test the existing system. Design Engineer shall recommend to District Project Manager if preliminary Test and Balance data is needed prior to the commencement of work.
  1. Connections to existing pipe shall be made with new isolation valves.
  2. Documents shall define extent of cleaning, testing and replacement of existing insulation.
  3. System shutdowns shall be coordinated with and approved by the District Project Manager.
- Applicable codes: Refer to Division 1, IBC, AGA, UL, ASME, NEC, ADA), IFGC, IMC, IPC, ASHRAE 90.1, ASHRAE 55, ASHRAE Thermal Guidelines for Data Processing Environments and others as may be designated by Authorities Having Jurisdiction.
- Evaluate discharge plenums vs. horizontal discharge ductwork on Roof Mounted Air Handling Units for the effect on cost, noise and unit efficiency.
- Equipment Room Recommendations
  1. Comply with ASHRAE Standards 15-1992 with special emphasis on:
     a. Oxygen Deprivation Sensor for A1 Refrigerants or a Refrigerant Sensor for B1 and all other refrigerants
     b. Equipment Room Alarm
     c. Mechanical Ventilation.
     d. Emergency power off switches (EPOs).
  2. Comply with local and state boiler code for requirements of EPOs, room fire rating, egress, etc.
- Comply with most recent ASHRAE Standard - *Ventilation for Acceptable indoor air Quality, Minimum Ventilation Rates in Breathing Zone* - OR – most recent IMC *Minimum Ventilation Rates*; whichever is greater.
- Schools at elevations below 7,000 feet shall be air-conditioned.
- Schools above 7,000 feet elevation shall not be air-conditioned.
- Design for major remodels of existing buildings that do not have air-conditioning shall include the addition of air-conditioning, if below 7,000 feet in elevation.
- HVAC Design Conditions:
  1. Temperature:
     a. Outside:
        (1) Cooling – 90°F DB, 62°F WB
        (2) Heating – (-10°F) at elevations below 6,500 feet and (-20ºF) at elevations above 6,500 feet.

b. Inside: (Per The Board of Education Guideline ECF - District Regulation ECF-R)

(1) Occupied Spaces:

(i) Cooling – No lower than 76.0 Deg F. in Cooling Season.

(ii) Heating – No higher than 70.0 Deg F. in Heating Season.

(b) Occupancy and Ventilation (occupancy to be verified) per Design Based Demand Ventilation, Demand Control Ventilation based on CO2 Content and Education Specifications:

c. Unoccupied Spaces:

(a) No cooling.

(b) Heating - 55 to 60 degrees during the heating months.

d. Classrooms: 30 occupants.

e. Gymnasiums:

Air Handling Units serving spaces with a capacity of over 300 occupants shall be installed with a means of heat recovery from the relief/exhaust airstream.

(1) Elementary Schools

(a) Occupied Cycle 30 occupants.

(b) Events Cycle 500.

(2) Middle Schools

(a) Occupied Cycle 60 occupants.

(b) Events Cycle 600.

(3) High Schools

(a) Occupied Cycle 90 occupants.

(b) Events Cycle 2,500 occupants.

f. Cafeterias:

Air Handling Units serving spaces with a capacity of over 300 occupants shall be installed with a means of heat recovery from the relief/exhaust airstream.

(1) Elementary Schools – Cafeteria

(a) Class Cycle 30 occupants.

(b) Lunch Cycle 160 occupants.

(2) Middle Schools – Auditoria

(a) Class Cycle 60 occupants.

(b) Lunch Cycle 300 occupants.

(c) Events Cycle 600 occupants.

(3) High Schools - Commons

(a) Class Cycle 100 occupants.

(b) Lunch Cycle 650 occupants.

g. Auditoriums – High Schools only

(1) Stage:

(a) Occupied Cycle 60 occupants.

(2) House Seating:

(a) Events Cycle 575 occupants.

h. Music Rooms – Minimum air circulation 1.5 CFM/Sq./Ft.

i. Work Rooms – Calculate exhaust requirements for copiers, laminating equipment etc. Control to create a negative pressure relationship compared to surrounding areas.

j. Kiln Areas/Rooms - Calculate exhaust requirements. Control to create a negative pressure relationship compared to surrounding areas.

k. Nurses' Station – Clinic Area: Calculate exhaust requirements. Control to create a negative pressure relationship compared to surrounding areas.

l. Wood Shop Areas – Exhaust a minimum of 0.5 CFM per Sq.Ft. per Table 403.3.3.1.1 IMC.

m. Art Room - Exhaust a minimum of 0.7 CFM per Sq.Ft. per Table 403.3.3.1.1 IMC.

n. Science Rooms - Exhaust a minimum of 1.0 CFM per Sq.Ft. per Table 403.3.3.1.1 IMC.

- Noise Criteria:
  1. Classroom < or = an NC Level of 30 decibels.
  2. Corridors < or = an NC level of 40 decibels.
  3. Wood Shop < or = an NC level of 40 decibels.
  4. Music Rooms < or = an NC level of 25 decibels.
     a. Do not place mechanical equipment above the ceiling or on the roof above a music room.
  5. High School Auditorium and Stage < or = an NC level of 25 decibels.
- Heating and Cooling Calculations
  1. When sizing heat transfer media quantities, heat transfer equipment, pumps, boilers and chillers base calculations on the use of a 30% Propylene glycol solution heat transfer media based on density at altitude.
- Roof mounted equipment and piping

1. Refer to Division 7 of these guidelines for thermal and moisture barrier criteria.

END SECTION 23 00 02

23 00 03 HVAC System – August 2021

- System Configurations:
  1. The details in these descriptions and all sequences of operation are intended to serve as a guide to mechanical systems design and control.
  2. It remains the responsibility of the Design Engineer to verify applicability of these systems and to refine them and/or offer alternative solutions to best meet the needs of each project.
  3. See also Section 23 75 00 Custom Packaged Outdoor HVAC Equipment
  4. Inhibited propylene glycol shall be used in all hydronic systems at 30% concentration.
- Central Heating Plant
  1. Gas fired hot water, boilers, two @ 65+/- % or three @35 to 45 % of design heating load, with Boiler Circulating Pump (BCP) on each boiler.
  2. Condensing Boilers with differential pressure control and Variable Frequency Drive HWP Control. Condensate traps to be installed per manufacture's written installation instructions.
  3. Two "Heating Water Pumps" (HWP), one stand-by. Each having the capacity to provide design flow pumps and shall be controlled through Variable Frequency Drives. Operation shall alternate on a cycle no longer than 30 days.
     a. Provide analysis to District Project Manager and District Energy Manager comparing energy consumption of this pumping configuration to primary/secondary pumping configuration.
  4. Install three-way valves at end of heating water loops and pressure independent control valves on AHU coils.
  5. Minimum water flow through three-way valves in the building heating water system shall be 20% of design total. Coil velocity under any operating condition shall be between 2 fps and 6 fps.
  6. Boiler room / boiler piping arrangement to be reverse or direct return with full pipe size bypass of boilers.
  7. If required, BCP capacity to match boiler output at design ΔT.
  8. Each HWP shall be sized to handle the peak campus flow. Include cold start factor in load calculations.
- Central Cooling Plant

1. Cooling water generating plant.
    a. For new buildings, buildings receiving a major replacement of mechanical equipment or others authorized for mechanical cooling, use:
        (1) Electric water chiller with single primary chilled water pump.
        (2) Chiller types:

            Chillers shall meet performance requirements of most recent ASHRAE 90.1 and must exceed performance minimums to qualify for most recent Xcel rebates.

        (a) Elementary and Middle Schools - Air Cooled or Direct Expansion
        (i) AHUs serving areas with low occupancy may be permitted to use Direct Expansion cooling. Obtain written approval of District Project Manager to use Direct Expansion cooling systems on areas with "low" ventilation requirements (areas such as small classrooms, administration areas, etc.).
        (b) High Schools – Air or Water Cooled as determined by engineering and cost evaluation.
            1. Install pressure independent control valves at air-handling unit coils.
            2. The chilled water system shall be a modular type design that is capable of operating at 30% system load on one circuit.
            3. PP-R pipe for cooling towers.

- Thermal Storage
    1. The use of thermal storage is to be reviewed by Jeffco Schools Executive Director of Facilities & Construction Management, Director of Building Maintenance, Director of Construction Management, Director of Facilities Planning and Property, District Energy Manager, and District Commissioning Engineer.
- Central Plant Piping
    1. Four pipe heating/cooling system.
    2. New construction two pipe heating/cooling change-over systems are prohibited
- Special Use Areas
    1. General Compliance
        a. All equipment supplied and installed in the following areas shall be UL certified or, if approved by Authorities Having Jurisdiction, may be field certified.
    2. Administration Area
        a. Constant volume unit with heating and DX cooling hot gas by-pass) and VAV Terminal Units with HW heating coils.
            (1) Size for low entering air temperature as defined elsewhere in this document.

(2) Shall be designed to operate independently from the rest of campus as DX during summer months. For operation during shoulder months, unit shall also be equipped with heating and cooling coils connected to the central heating and cooling plants. Each space shall have independent zone VAV heating/cooling control and sensor.

3. Nurses' Station (Clinic)
   a. Shall have a 150 CFM negative offset from adjacent areas.
4. Auditorium
   a. Minimum of two air-handling units. One for Stage and one for House Seating.
   b. Units shall be:
      (1) Inside easily accessible mechanical rooms or roof mounted air handling units
      (2) Constant volume with hot water heating, chilled water cooling, air side economizer, demand CO2 control and return fan.
      (3) Circulating pumps on coils with approval of District Project Manager only.
      (4) All rotating equipment, coils and controls shall be mounted on the roof in NEMA 4 enclosure.
      (5) Do not mount equipment requiring maintenance at ceiling of Auditorium.
5. Gymnasium
   a. Units shall be:
      (1) Inside easily accessible mechanical rooms or roof mounted air handling units
      (2) Variable volume with hot water heating, chilled water cooling (sized for classroom occupancy - not event occupancy), air side economizer, demand CO2 control and return fan.
      (3) Circulating pumps on coils with approval of District Project Manager only.
   b. Heating and ventilation shall be sized for "Events" cycle heating load.
   c. Ventilation shall be sized for occupant load.
   d. All rotating equipment coils and controls shall be readily accessible mechanical spaces within the building.
   e. Do not mount equipment requiring maintenance at ceiling of Gym.
6. Kitchen/Cafeteria
   a. One air handling unit with complete HVAC sized for area. Air handler shall not provide make-up air for kitchen hood exhaust fan.
   b. System shall be VAV.

c. Roof mounted exhaust fan over kitchen for dishwasher.

d. If Commons are in a heavy glazed area, designer may seek written approval from District Project Manager to make provisions to use separate AHUs for commons and kitchen.

e. Minimum of one roof mounted air handling unit with complete HVAC.

f. Roof mounted exhaust fan over kitchen for dishwasher. Operation of exhaust fan shall be interlocked with operation of dishwasher.

7. Kitchen Make-up-air

   a. Kitchen heating only gas fired unit controlled to 60 – 70 Deg. F DA-T for tempered make-up air to match required exhaust for Grease hood.

   b. Make up air units shall not be utilized for space heating and cooling needs.

8. Computer Classroom

   a. The room shall be served by two separate systems controlled by a single controller.

      (1) Primary system will be an individual temperature control zone served from the area AHU with VAV air quantity and heating coil sized as a normal classroom of thirty students.

      (2) Secondary system shall either be a separate ducted fan coil unit or a mini-split system with wall or ceiling mounted cassettes. In existing schools only.

         (a) DX system shall include low ambient (-10 °F) package.

         (b) Locate condenser on the roof and fan evaporator coil where the noise impact will not exceed District Acoustic Standards of NC 30.

9. Makerspace and S.T.E.M. Classrooms

   a. VAV Terminal Unit with heating coil controlled by wall mounted temperature sensor. Each classroom shall be equipped with a CO2 sensor; room air terminal shall go to VAV max when CO2 levels are too high. If this does not satisfy room sensor, Outside Air Damper on AHU to modulate to satisfy critical zone. Refer to Section 23 09 93 for sequence of operation.

   b. Other special systems and exhaust that may be required specific to the use of the space and program.

10. MDF/Communication Room:

    a. Install a properly sized split system DX Cooling Unit with remote condenser.

    b. Electrical: 240 or 208 v, 1 ph.

    c. Condenser shall be located on the roof and include a low ambient (-10 °F) package and hail guards.

(1) Provide a 2-inch high sheet metal drain pan around condensing unit with 1-inch threaded nipple through side of pan.

(2) Hail guard approved by district PM

d. Accurately calculate cooling load space shall be cooled to 85 deg F

e. Acceptable Manufacturers: Fujitsu, Carrier, Trane, York (JCI), Mitsubishi, Sanyo, Daikin, and LG.

11. Vestibule/Entry:

a. Provide heating.

b. Provide non-heated air curtain or make vestibule 200 CFM Positive per 2.5 ft of door.

12. Corridors and toilets do not require a separate control zone.

a. Provide ventilation air from adjacent zones.

b. Each space shall be designed to be a minimum of 50 CFM positive to the corridor with the exceptions of toilets, equipment rooms, IDF/MDF rooms, and the nurse station.

c. Exhaust requirements for toilets shall conform to IMC. Provide supply air to toilets only if total exhaust flow is greater than 200 CFM. If so, maintain 200 CFM offset to adjacent areas. Supply inlet to be placed near the entrance.

13. Kilns:

a. Gas fired:

(1) Meet all requirements for fuel fired boiler

b. Electric:

(1) Include accommodation for unit mounted “Enviro- vent” with wall switch.

(2) Above Kiln: Provide exhaust fan with cooling thermostat in parallel with wall switch for waste heat and fumes.

14. Wood Shop in Middle and High School

a. Wood shop area shall be 100% exhaust and make up air when Dust Collector is energized.

b. Exhaust equipment installed within the shop area shall carry a UL Certification either by manufacturer or field verified by a UL inspector.

c. Size local R/A grilles and add filter (meeting district standard) to accommodate static pressure increase for the additional filteration.

15. Family and Consumer Sciences

a. All cooking range vent hoods and over-range microwaves shall vent to the building exterior.

b. Recirculating units are prohibited.

16. Science Classroom and Preparation Room

a. Classroom

(1) Classroom to have ducted exhaust up to exhaust fan with motorized damper for ability to exhaust 100% of the air supplied to the space.

(2) Provide motorized damper(s) on return air from room such that when the exhaust damper is energized, return air damper(s) from the classroom is closed.

(3) Provide a one-hour crank timer and control interlocks to control exhaust fan and return air damper(s). Consideration should be given to control of VAV terminal unit minimum position.

(4) Fume Hoods: Exhaust directly to the building exterior.

b. Preparation Room

(1) Install roof-mounted, plume-type, lab exhaust fan sized for canopy hood. Control of fan to be associated with sash position. Obtain manufacture's installation documents for canopy hood to coordinate control and required CFM.

- General Classrooms/offices Air Handling Unit and Terminal Units.

1. Temperature Control Zoning:

a. Each room shall be individually zoned.

2. Roof mounted or indoor air handling units (AHU).

a. Units equipped with:

(1) Supply fan controlled by variable frequency drive.

(2) Return/exhaust fan controlled by variable frequency drive. Do not use units with RA and EA chamber upstream of the fan; - this creates an exhaust only fan.

(3) All fans shall comply with the fan power limitation defined in the current IECC.

(4) Hot water heating coil with coil pump when required and chilled water cooling coil pressure independent control valve.

(5) Full air-side economizer with outside air, return air and exhaust air dampers. CO2 control shall be provided to control minimum outside air position.

(a) Economizer enable temperature computed by the average of sensor in airstream and on the North side of the building.

(6) On roof mounted units do not use Vertical Discharge units.

(7) Duct connections shall be centered on unit ends.

(8) AHUs shall be designed to have a coil velocity of not more than 400 FPM, unless approved by Jeffco Project Manager.

3. Individual Classrooms:

   a. VAV Terminal Unit with heating coil controlled by wall mounted temperature sensor. Each classroom shall be equipped with a CO2 sensor; room air terminal shall go to VAV max when CO2 levels are too high. If this does not satisfy room sensor, Outside Air Damper on AHU to modulate to satisfy critical zone. Refer to Section 23 09 93 for sequence of operation.

   b. Consideration given to supplemental heating:

      (1) Baseboard radiation with self-contained control valves.

      (2) Radiant floor systems.

         (a) Engineer to provide cost based analysis to District Project Manager and receive written approval of the use of a radiant floor system.

- Cabinet Unit Heaters and Unit Heaters.
  1. Ceiling mounted hot water cabinet unit heaters in vestibules.
  2. Hot water unit heaters in Boiler Rooms and Water Service Entry Rooms.
- Design Considerations
  1. Do not install air handling equipment above ceilings or in spaces between structural members within the building.
     a. Mount on roof, on dunnage, or install in mechanical rooms.
  2. Provide shut-off valves and unions to isolate each item of equipment, branch circuit or section of piping.
  3. Provide three-way valves in heating and cooling lines serving equipment as required to avoid dead end runs.
  4. Provide strainers at temperature control valves.
  5. Do not use solder containing lead.
  6. Install pipe accessories and valves in easily accessible locations for service.
  7. Do not locate pipe in exterior walls. If it is impossible to avoid provide heat trace and exceed ASHRAE 90.1 insulation requirements by a minimum of ½" of thickness.
  8. Provide isolation and drain valves on pressure gauges.
  9. Pumps, fans, coils, unions and valves shall not be located in ceiling spaces above classrooms, gymnasiums or auditoriums without written consent from the District Project Manager.
     a. 30" minimum clearance required in front of terminal box controllers and terminal box valve package.

10. Test water pipe at 120 psig for two hours with no sign of leaks or pressure loss.
11. Test all operating devices.
    a. Keep written records of all tests, at minimum: the date of the test, system or subsystem tested; test medium and pressure used; duration of test; test results; name and signature of individual performing test.
    b. Engineer of Record to approve all documentation of equipment tests and submit written documentation to District Project Manager for final acceptance.
12. Use hot water cabinet unit heaters in vestibules and entries or areas where ventilation requirements are minimal.
    a. The use of unit heaters is not allowed in return air ceiling plenums.
    b. Equipment or duct mounted devices, which may require maintenance or replacement in locations where maintenance activities will have minimal disruption to the function of the school.
13. Pipe Material and Manufacturers Markings:
    a. When reviewing submittals and on site observations include a careful check for pipe origin, manufacture and markings.
14. All motors 1 hp or greater shall be equipped with a VFD. All roof mounted exhaust fans to have VFD installed on a wall no higher than 8’ AFF unless approved by Jeffco Project Manager.
15. Install factory control direct drive exhaust fans for fans with a HP rating of less than ½ HP

- The following Systems or Equipment are prohibited without prior approval of the District Project Manager and the District Mechanical Engineer:
  1. Unit Ventilators.
  2. Radiant Panels.
  3. Ice Storage.
  4. Fan-powered VAV terminal units.
  5. Radiators or other heating units on walls of student restrooms.
  6. Gas-fired heating units except for restricted applications e.g. Kitchen make-up air units.
  7. The re-use of existing under floor radiant heating systems.
  8. Heat pumps except in small single application services. Heat pumps are permitted for use in IDF/MDF rooms and as a secondary source of cooling in computer labs.
  9. Plastic, fiberglass, or composition material sheaves or gear drives are prohibited.
  10. Mechanical joints piping systems.

a. Do not use Victaulic (or other manufacturer) couplings in heating or cooling piping systems.

b. Pro Press or equivalent mechanical fittings over 2" in diameter will be given consideration as approved by the District Project Manager and the District Mechanical Engineer. .

END SECTION 23 00 03

23 00 04 HVAC Restoration & Retrofit – October 2017

- When reusing existing ductwork specify cleaning and pressure testing of the existing duct system.
  1. Pressure testing criteria may be limited to eliminating audible sound caused by leaks.
- When reusing or connecting to existing piping, clarify to what extent the contractor is to clean and test the existing system.
  1. Connections to existing pipe shall be made with new isolation valves between the new and existing and a full size valved bypass on the new piping side of the system. Include valved flushing tees where needed to clean the system.
     a. Drawings to include location of air bleed at high point(s) of system.
- When reusing existing duct zone coils, specify cleaning of coils as part of the work. Confirm this scope with the District Project Manager.

END SECTION 23 00 04

23 05 13 Common Motor Requirements for HVAC Equipment – August 2021

- Work in this section is restricted to specific manufacturers that have been previously approved by Jefferson County School District, R-1.
  1. Allen Bradley
  2. Cutler-Hammer
  3. S & S
  4. Square-D
  5. Yasikawa VFD
  6. ABB VFD
  7. General Electric
  8. Danfoss VFD
- Motor starters and disconnects shall be provided by the Manufacturer as an integral feature of motorized equipment.

1. Standard magnetic contactor-type with HAND-OFF-AUTO switch, overload heaters, 120 volt control transformer, single phase protection, under voltage protection and spare N.O. and N.C. contacts for control by Divisions 23.
    a. NEMA enclosure appropriate for the service or 3R for wet areas.
2. Use combination disconnect/motor starters whenever possible.
    a. Ensure redundant disconnects and starters are not specified or installed, especially with boilers.
3. Specify electronic (adjustable) overload protection.
4. Specify phase protection down-stream of over-current and over-load protection devices. Install independent 3 phase protection between fuse block and motor starter/overload protection.
5. Specify liquid tight conduit on motor connections.
6. Specify bonding bushings on conduits serving HVAC equipment motors.
7. Starters are to be specified for motors 3/4 HP and larger.
8. Provide 1 starter/VFD control for each pump. Do not use 1 VFD to control multiple pumps.

- All new motors for use with variable frequency drives shall be inverter rated and shall be shaft grounded, unless protected with insulated or ceramic bearings.
- VFD will have the ability to provide "ALARM" and "MOTOR" (Fan or Pump) status. (preferred)
- All existing motors that are to have variable frequency drives added to them shall be inverter rated and shall have shaft grounding kits added if grounding kits are not already in place, unless motors are already protected with insulated or ceramic bearings.
- Electric motor drives
    1. Motors 3/4 HP and larger: 480 Volt, Three-Phase, 60 Hertz, 1,800 and/or 1,200 rpm, ODP enclosure, 40 C ambient, continuous duty, service factor of 1.15, copper windings, Class B or F insulation, standard mounting. Lower voltage motors are acceptable for buildings without 480 volt power but 3 phase is required.
    2. Bearings: Double shielded ball in accordance with ANSI B3.16-1972.
    3. Motor wiring: Terminate in a NEMA terminal box mounted on the motor case and of the manufacturer's standard size. The terminal box shall have a bolt type copper ground connector.
    4. Motors 1/2 HP or less may be split capacitor single phase with sleeve bearings, standard frame size and RPM, available from more than one manufacturer.
    5. Minimum Motor Efficiencies shall conform to most recent ASHRAE Standard *Minimum Nominal Efficiency for General Purpose Design A and Design B Motors*.

6. Provide 1 starter/VFD control for each pump. Do not use 1 VFD to control multiple pumps.

END SECTION 23 05 13

23 05 23 General Duty Valves for HVAC Piping – August 2022

- Work in this section is open to any product or material meeting the requirements of this Technical Guideline.
- Comply with MSS-92-1980, *Valve User's Manual*
- Ball valves shall be full port. Apollo 70-240 series 316 ball and stem (solder ends). Apollo 77-140 series 316 SS ball and stem (NPT threaded ends). Apollo 77WLF-140-A SS ball and stem (lead free, press ends) or approved equal. Do not use Apollo international.
- Submit names of proposed valve manufacturers.
- Natural gas service: iron body lubricated plug type with square nut actuator and matching nut wrench.
- UL list solenoid valves intended for fuel gas shut off.
- Butterfly: full flanged or lug - no wafer configuration. Keystone 362 HP high performance series, Milwaukee HP series high performance, or BRAY McCannalok HP high performance series. Carbon steel body (ASTM A216-WCB) lugged style with lever handle or approved equal.
- Drain valves shall be ball valves with GHT male end and chained cap.

END SECTION 23 05 23

23 05 45 Noise & Vibration Control – August 2015

- Work in this section is open to any product or material meeting the requirements of this Technical Guideline.
- Mechanical noise in classrooms is of particular concern because of the adverse effect on student performance
    1. Provide sufficient installation details to eliminate or limit excessive noise.
    2. Therefore, in addition to proper equipment selection and coordination with other disciplines, system design must include adequate detail to eliminate contractor design in critical areas.
    3. Noise Criteria:
        a. Classroom < or = an NC Level of 30 decibels.

b. Corridors < or = an NC level of 40 decibels.

c. Wood Shop < or = an NC level of 40 decibels.

d. Music Rooms < or = an NC level of 25 decibels.

e. Stage Area < or = an NC level of 25 decibels.

f. Auditorium < or = an NC level of 25 decibels.

- Sound attenuators shall be used only in consultation with District Project Manager and District Mechanical Engineer before including them in the design.
- Hydronic isolators, flex connectors or expansion joints:
  1. Do not use devices with exterior metal braiding.

END SECTION 23 05 45

23 05 53 Identification for HVAC Piping & Equipment – August 2017

- Work in this section is open to any product or material meeting the requirements of this Technical Guideline.
- Provide markers, labels and schedules for HVAC pipes, equipment, control panels, switches, magnetic starters, relays etc.
- A list of the wording, symbols, letter size, and color coding used for pipe and equipment identification shall be included in maintenance manuals.
- Written acceptance of markers and labels to be provided by District Project Manager prior to installation of ceiling tiles.
- Reference Standards:
  1. Comply with ANSI A13.1 - Identification of Piping Systems.
- Valve Tags are not required.
- Equipment labels:
  1. Equipment symbols or name abbreviations used on design documents shall be in the form: AAANNN.
     a. AAA is a two or three letter abbreviation for the type of equipment.
     b. NNN represents any number in the sequence 1 to 999.
  2. When numbering equipment, begin in the northwest corner of the building and end in the southeast corner.
     a. The same number (NNN) may be reused if it has a unique prefix.
- Small Equipment Tags

1. Stamp tags with the unique identification used on the drawings to indicate the system and type of equipment followed by a number. (Example: CWP-1, CWVenturi-2, HWRP-1, etc.).

- Marker Materials & Methods:
  1. Pipe Markers (above grade):
     a. Pressure sensitive markers: Brady type B-350 flexible film identification markers and tape, with legend size and color coding per ANSI A13.1 - 1981.
     b. Plastic wrap around labels taped in place.
  2. Pipe Markers (below grade):
     a. Bright colored continuously printed plastic ribbon tape
     b. Minimum 6 inches wide by 4 mil thick
     c. Manufactured for direct burial with #12 trace wire located in 2x4 junction boxes at each end of piping three feet above finished grade.
  3. Ductwork Markers:
     a. Not required.
  4. Equipment Labels:
     a. White (black) plastic laminate with black (white) engraving, or standard brass bars.
     b. Provide labels to uniform size commensurate with the size of the equipment to which attached.
     c. Minimum 1-inch high letters.
     d. Pressure-sensitive embossed labels are prohibited.
  5. Equipment Location Labels above T-Bar Type Ceiling Panels
     a. Locate in corner of T-bar closest to equipment using ½ inch wide plastic laminate engraved label – black lettering on white background.
     b. Label each concealed device or equipment location for any device or equipment that will require maintenance to include, but not limited to, HVAC equipment, contactors, power packs, disconnects, controllers, etc.
  6. Type B Vents: Embossed or riveted name plates.
- Installation:
  1. Install Equipment Labels with corrosive-resistant mechanical fasteners or adhesive.
     a. Degrease and clean surfaces to receive adhesive.
     b. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
  2. Install tags with corrosion resistant chain or cable

3. Provide ceiling labels to locate valves or dampers above T-bar type panel ceilings. Locate in corner of T-bar closest to equipment using ½ inch wide clear label with black lettering.
4. Do not paint or insulate over nameplates.

- Piping
  1. Identify service and direction of flow of piping in crawlspaces, above ceilings, etc., as well as exposed to view.
     a. Provide identification markings at valves, equipment, terminal points, both sides of piping passing through walls and floors and at approximately every fifteen feet.
  2. Pressure Sensitive Markers:
     a. Apply in accordance with manufacturer's recommendations
     b. Marker adhesion will be tested for permanence.
     c. Replace any markers showing loose corners, bubbles, or other failings.
  3. Use an arrow with each pipe identification marker.
     a. The arrow shall always point away from the marker and in the direction of the flow.
     b. Color and height of arrow to be same as the marker.
     c. If flow can be both directions, use a double-headed arrow.
  4. Apply markers near valves to show proper identification of pipe contents and direction of flow.
  5. Apply markers so lettering is in the most legible position.
     a. For overhead piping, apply on the lower half of the pipe where view is unobstructed so it can be read from floor level.
  6. Install preformed and lettered plastic markers completely around pipe in accordance with manufacturer's instructions.
  7. Domestic hot water to be labeled "DHWS" or "DHWR" and heating hot water to be labeled "HWS" or "HWR".
     a. Do not use simply "HW".
  8. Install underground plastic pipe markers 6 to 8 inches below finished grade directly above buried pipe.

END SECTION 23 05 53

23 05 93 Testing, Adjusting & Balancing for HVAC – August 2021

- Test and Balance services shall be bid to the Mechanical Contractor

- The Engineer shall include in their review comments on the balance report an identification of any values that deviate from the allowed tolerances and an explanation of why the values cannot be met. Consider the following in the evaluation:
    1. Incorrect balance report.
    2. Incorrect installation.
    3. Incorrect design.
- Use procedural standards for TAB of environmental systems as outlined in the latest versions of AABC, NEBB, and/or SMACNA procedural manuals.
    1. Once a procedural standard is selected, that same standard shall be applied to all equipment of that class for TAB work on this project.
- TAB field work shall be performed under the direct supervision of an AABC, TABB or NEBB certified TAB supervisor or a Professional Engineer.
    1. This individual shall perform the work or be on-site at least 33% of the total time TAB work is in progress.
- Contract payment retainage may be withheld against the General Contractor until the final completion of this section of work has been demonstrated by the submission of the TAB report and an evaluation of its contents has been made by the coordinating Engineer, Commissioning Authority or their representative.
- The contractor shall submit a list of balance devices (dampers & valves), that they perceive as necessary for proper balance of the systems, but are not indicated in the construction documents.
    1. Submit the list to the Architect and Project Manager within twenty working days of contract award.
    2. If the Engineer and District Project Manager agree that any of the devices on the list are necessary, a change order will be issued to cover the cost of installation.
    3. If such devices are not identified but required for balancing, they shall be installed at the expense of the contractor.
- Coordinate scheduling of work with the General Contractor, appropriate subcontractors, the District Commissioning Engineer and the District Project Manager.
- Provide written notification to District Project Manager five (5) working days prior to commencing TAB and a schedule for completing the work. This also applies to pre-TAB activities on renovation projects.
- Provide written notification to the General Contractor, Mechanical Contractor, the District Project Manager and the District Commissioning Engineer, within 24 hours, of an equipment failure preventing TAB work from proceeding.
- Air and hydronic TAB work shall not begin until the applicable system is cleaned, flushed, is in full working order and has been accepted by the Jefferson County Public School District Commissioning Engineer.

- Cleaning chemicals to be used in hydronic systems must be permitted by water district. MSDS sheets must be part of submittal.
- Hydronic systems requiring glycol shall have the designated percentage installed prior to balancing.
- Requirements of Work:
    1. Adjust air handling systems to the following tolerances
        a. Supply systems within +/- 5% of design value.
        b. Economizer damper systems shall be verified in the minimum and maximum positions.
    2. Adjust hydronic systems to the following tolerances:
        a. Heating water systems within +/10% of design value.
        b. Chilled water systems within +/- 5% of design value.
- Permanently mark the final balance position of all balancing valves and dampers.
- Unit ventilators shall be tested for supply air and outside air quantities at maximum and minimum outside air damper positions. Adjust dampers to meet scheduled values.
- Tab Report
    1. Provide a preliminary report to the Mechanical Engineer and District Commissioning Engineer within 5 days of finishing preliminary balancing.
    2. Provide documentation showing that equipment to be used during TAB has been calibrated within the last 12 months.
    3. Provide a draft TAB report to the Engineer.
        a. This shall be reviewed within 5 days and approved for use by Mechanical Engineer and the District Commissioning Engineer.
        b. The Mechanical Engineer and Commissioning Engineer shall use the draft report for the purpose of verifying data within the draft TAB report.
        c. Upon completion, the draft TAB report and notes will be returned to the MC.
    4. The draft TAB report shall be in the same format and contain information as will be included in the final TAB report.
    5. Provide TAB report as required by IECC.
- Verification
    1. Upon completion of the TAB work the balancing firm shall demonstrate fluid flow quantities indicated in a preliminary TAB report
        a. The TAB representative shall be a member of the same team used during the original testing.

b. Equipment used during the random testing shall be the same equipment used during the original testing.

c. The system or equipment being verified shall be in the same operating mode as during the original TAB test.

d. Up to 10% of the air readings shall be re-tested and shall be designated by the Design Engineer and Commissioning Engineer.

e. Up to 10% of the balanced heating hydronic component readings shall be re-tested.

f. Up to 20% of the balanced chilled water component readings shall be re-tested.

g. Whenever system verifications do not meet specifications the entire system shall be re-balanced and rechecked

2. When required by the Engineer, the TAB contractor shall perform unique tests to verify proper operation of special systems.

END SECTION 23 05 93

23 07 00 HVAC Insulation – August 2021

- Work in this section is open to specific manufacturers that have been previously approved by Jefferson County School District, R-1 Facilities Services Department.
  1. Certainteed
  2. Knauf
  3. Manville
  4. Owens-Corning
- Provide materials with flame spread index of 25 or less and smoke development index of 50 or less as tested in accordance with ASME E84 (NFPA 225)
  1. Use fiberglass insulation products only. Polyethylene foam is prohibited
- Pipe Insulation:
  1. Insulation on pipe joints exposed in occupied spaces shall be jacketed with Zeston 2000 PVC or approved alternate, factory cut and curled to size
  2. Only packaged exterior mounted refrigerant line sets may use closed cell foam rubber, or other similar material approved by the Engineer.
     a. Seal cell foam, joints and seams.
  3. All other cold line exterior piping shall be insulated with fiber glass insulation with integral vapor barrier stapled and finished with heavy coat of brushed on vapor barrier.
     a. Fit insulation with a sealed all-weather jacket of aluminum cladding.

4. Cold line interior piping shall be insulated with fiber glass insulation with integral vapor barrier stapled and finished with heavy coat of brushed on vapor barrier.
5. Horizontal portions of roof drains and roof drain bowls shall be insulated with fiber glass insulation with integral vapor barrier stapled and finished with heavy coat of brushed on vapor barrier
6. Insulation on all systems shall at a minimum conform to ASHRAE Standard 90.1-2013.

- Equipment and Tank Insulation:
  1. Either flexible fiberglass blanket meeting ASTM C-553 Type 1 or rigid fiberglass board meeting ASTM C-612 Class 2 with all-service jacket
  2. Do not insulate heating water pumps or heating system and cooling system expansion tanks.
  3. Insulate chilled water pumps.
  4. Insulate all heating and cooling water and refrigerant piping inside cabinets of Unit Ventilators, Air Handling Units, Unitary Air Conditioning Equipment and terminal heating and cooling units.
- Duct Insulation:
  1. Thermal insulation is not required on return or exhaust air ductwork not exposed to outdoor temperatures.
  2. Ductwork exposed to the weather shall be water tight.
  3. Supply duct systems shall be insulated.
- Install per manufacturers recommendation.
- Self-sealing laps on pipe insulation cover to be stabled a 6 inches OC and then painted with vapor proof sealant.

END SECTION 23 07 00

23 09 13 Instrumentation and Control Devices – August 2021

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and the Supplementary Conditions and Division 01 and Division 23 Specification Sections, apply to this Section.

B. Reference Divisions 26 and 28.

1.2 SUMMARY

A. This Section includes the following:

1. Low voltage control wiring and conduit.
2. Preassembled control panels.
3. Construction supervision.
4. Demonstration and training.
5. Warranty.

B. System shall be Direct Digital Control (DDC).

1.3 DEFFINITIONS

A. "Central Control Station" – District Building Automation Group Office, 809 Quail Street, Building #4, Lakewood, Colorado 80215.

B. "Central DDC Panel" - Central Control Panel, one location in each school.

C. "Unit Control" - Control module located at a piece of operating equipment.

D. "Remote PC" - Temporary connection via laptop or portable personal computer.

E. "Security Office" - Building #1; 24-hour security office/Central DDC Panel or Ethernet.

F. "District Building Automation Group" – 809 Quail Street, Building #4, Lakewood, Colorado 80215.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer specializing in control system installations.

B. Technicians working on the project shall have completed the following training courses: Curriculum for Operators, BACnet/MS/TP Custom Programming for the installed devices and Systems Extended Architecture Engineering and Setup.

C. Manufacturer Qualifications: Engage a firm experienced in manufacturing control systems similar to those indicated for this Project and that have a record of successful in-service performance with a minimum of 7 years' experience backed up with K-12 portfolio references.

D. Startup Personnel Qualifications: Engage specially trained personnel in direct employ of manufacturer of primary temperature control system.

1.5 SUBMITTALS

A. General: Submit each item in this article according to the conditions of the Contract and Division 01 Specification Sections.

B. The submittal package shall include:

1. Warranty letter including start date of warranty.
2. Shop drawings.
    a. Index sheet of the drawings.

b. Legend including all symbols used on the control drawings.

c. Plan view of the facility indicating major corridors and room locations including:

1) Point to point wiring (abbreviated versions of the final as-built drawings specified above).

2) Location of temperature control panels.

3) Location of outdoor air temperature sensors located by the Mechanical Engineer. One to be in outdoor air stream and another to be located on the North side of the building.

4) Location of relay enclosures containing three or more relays.

5) Location of controllers installed above ceilings.

d. Control panels including layout of panel internal components and door components.

e. System sequence of operation printed on the associated drawings. Use uppercase and lowercase fonts rather than all uppercase.

f. Sources of electrical power for controllers and control panel. Include the power panel number and circuit breaker.

g. Place a border around details, such as exhaust fans, cabinet heaters, and motor starters, located on the control drawings.

3. Manufacturer's data:

a. All submittals must be clearly legible on manufacturers' data sheets.

b. Submittal sheets containing multiple model numbers shall have the specific models clearly identified.

4. Two hardcopies of as-built Control Drawings maximum size 11" x 17" and files of those drawings in electronic form in AutoCAD® format of the following:

a. Point to point connection diagrams for wiring.

b. The detailed sequence of operation.

c. The bill of materials used on the project.

d. Valve Schedules

e. Flow Diagrams

5. Installation and calibration instructions.

a. Software programs and sequences written in the program language and in English.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Johnson Controls, IncMilwaukee, WI

1. Metasys.

B. ATS Controls, Cambridge ON, Canada

1. Alerton

C. Manufacturer Pre-Approved Prior to Bid

2.2 ACCEPTABLE INSTALLERS

A. Johnson Controls Inc.

B. ATS Automation

C. Approved Alternate prequalified by Jeffco Public Schools to install Johnson Controls FX product line.

2.3 SYSTEM REQUIREMENTS

A. Unless specified otherwise, provide fully proportional components.

B. Provide necessary relays and signal boosters to make system complete and operable as required by sequence of operation.

2.4 MISCELLANEOUS DEVICES

A. Plastic laminate labels:

1. All control panels, junction boxes larger than 4-11/16” x 4-11/16” containing components, controller enclosures, and duct mounted sensors require screwed or riveted plastic laminate labels, no adhesives. Control valves and damper actuators do not require laminate labels.

2. Control panels shall have labels attached to the panel face and control components within the panel.

3. Do not attach labels to replaceable devices or sensors.

4. Junction boxes smaller than 4-11/16” x 4-11/16” and not containing relays or control devices do not require plastic laminate labels. These need to be identified using a permanent black ink marker with a “TC” on the cover.

B. 24V Control Power Transformer with low voltage over-load protection.

C. Control Relay Load Control.

D. Shielded cable: Used on critical communication and sensor lines as recommended by the manufacturer or advised by the consulting engineer.

PART 3 - EXECUTION

3.1 GENERAL

A. The controls contractor shall be responsible for preassembly and installing panels and all hardware with their own employees.

B. The controls contractor shall be responsible for providing the system and training of School District personnel in its proper function and maintenance.

C. Wiring, conduit placement, and the installing of actuators and related linkage may be subcontracted to a School District approved installer but controls contractor shall label and connect all wiring terminations and be responsible for the subcontractor's work.

3.2 DEMONSTRATION AND TRAINING

A. Instruct Owner's operating personnel in operation and maintenance of control system. Furnish three instruction manuals covering function, operation, maintenance of control components. Furnish control system record drawings and sequence of operation to Owner and Mechanical Engineer for inclusion in O&M Manuals.

B. Prior to the Start of Training:

1. All equipment will be operational and Accepted by Mechanical Engineer.

2. O&M Manuals will be Complete

C. Eight hours total of training shall be given to Jeffco maintenance staff, facility managers, BAS Technicians and others connected to operation of facility/project area as determined by the District Project Manager.

1. Minimum 7 working days' notice to District Project Manager to include date and time of training.

3.3 WIRING

A. Plenum rated wire inside of plenums. Wiring suspended neatly from the overhead structure with bridle rings. Do not lay on top of ceiling tiles. Minimum wire size, 18 AWG stranded.

B. Reference District Technical Details drawing for wire support details.

C. Color code wiring terminals and provide a cross reference to the drawings to ease later check-out and diagnosis. Color coding is as follows:

Input/Output Point Type or Wire Type	Cable or Jacket Color
AI	Yellow
AO	Tan
DI	Orange
DO	Violet

N2 Bus/BACnet	Blue, Yellow, Violet Wires
24vac	Orange and Brown

D. Place exposed control wiring in conduit.

E. Coordinate location of thermostats and other exposed control sensors with plans and room details before installation. Locate thermostats 60 inches above floor. Thermostats shall not be placed in direct sunlight or near any powered device as identified on architectural floor plans. Ideally a thermostat is located beneath a return or an exhaust grille.

F. Unless otherwise shown on electrical drawings, provide line voltage wiring for all new control panels and accessory equipment.

G. Installation of low voltage control wiring is the responsibility of the Temperature Controls Contractor. The 120V powering of control devices shall be the responsibility of the Electrical Contractor.

H. Interlock alarms with starter switching to bypass alarm when equipment is manually disconnected.

I. Where controllers are relocated, wire nuts or splices shall not be utilized. New control wiring shall be provided to extend the controller to the new location.

J. Inactive and unused cables shall be removed from the plenum.

3.4 POST INSTALLATION INSPECTION AND REPORT

A. Upon completion of the temperature control installation, check system, including equipment, and certify to Engineer that system is performing as specified. System check should include a point to point verification of all control devices.

END OF SECTION 23 09 13

23 09 23 Integrated Automation Local Control Units – August 2021

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and the Supplementary Conditions and Division 01 and Division 23 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Electronic analog or direct digital automatic temperature controllers for individual HVAC equipment.

PART 2 - PRODUCTS

2.1 GENERAL

A. Mount controllers, relays, switches, etc., for equipment in enclosed 12 gauge control panels with baked enamel finish, hinged locking doors. Mount control devices and indicators for equipment located in exposed areas subject to outside weather conditions inside weatherproof enclosures. Panel location shall be convenient for service. Provide nameplates beneath each panel-mounted control device describing function of device.

B. Prewire electrical devices within panel to terminal strips with inter-device wiring within panel completed prior to installation of system.

2.2 ALL INDIVIDUAL EQUIPMENT (APPLICATION SPECIFIC) CONTROLLERS

A. Function independently on loss of communications with the central DDC controller.

B. Capable of program changes or displaying data while in communication with:

1. A portable computer plugged into the central DDC controller.

2. A remote computer via Ethernet through the central DDC controller.

C. Locally adjustable address, setpoints, and sensor scaling.

D. Control by proportional, integral, derivative, or combinations.

E. Proportional heating and cooling with adjustable deadband.

F. Either 0 or 10 VDC or 4 to 20 mA proportional output.

G. Internal switches (or software) for each output to change from direct to reverse acting.

2.3 MAJOR EQUIPMENT CONTROLLERS

A. Local and central control of each air handling unit, chiller and boiler, by a controller mounted on or near that piece of equipment.

B. Each electronic controller shall have the below listed data (as applicable) readable and commandable at the individual equipment controller with a plug-in computer, at the central DDC controller or from a remote computer via Ethernet, as applicable. Design a communications bus capable of reading and writing control points per the lists below: (* = read only).

1. Each air handling unit:

a. Fan start/stop.

b. Command mixed air damper % open to outside air.

c. Command Exhaust air damper percent open.

d. Command Heating coil valve percent open.

e. Evaporative Cooler pump start/stop.

f. Command Evaporative Cooler valve fill/drain.

g. Return air temperature.

h. Discharge air temperature.

i. Mixed air temperature.

j. Smoke detector alarm

k. Freeze stat alarm

l. Supply fan status.

m. Return fan status.

2. Average items a and b for logic sharing (Chiller enable, Economizer function, etc.):

   a. North outside air temperature sensor (OAT-N) using the sensor which resets heating water temperature. Analog sensor for OAT-N is to terminate in the Heating Plant Controller.

   b. Outside Air Temperature Roof (OA-T – TR) – Analog Input for outside air temperature roof. Locate in outdoor air side of Roof Top Unit.

3. Heating Water system:

   a. Each boiler enable/disable.

   b. Each boiler status on/off*.

   c. Boiler circ pumps start/stop.

   d. Boiler circ pumps status on/off*.

   e. Heating water pumps start/stop.

   f. Heating water pumps status on/off*.

   g. Heating water supply temperature.

   h. Heating water return temperature*.

   i. Heating water flow as measured downstream of pump discharge,

   j. Alarm status*.

4. Chilled Water system:

   a. Chiller enable/disable.

   b. Chiller status on/off.*

   c. Cooling Tower enable/disable.

   d. Cooling Tower fan status on/off.*

   e. Chilled water pump start/stop.

   f. Chilled water pump status on/off*

g. Chilled water supply temperature.

h. Chilled water return temperature*.

i. Chilled water flow measured downstream of pump discharge.

j. Condenser water pump start/stop.

k. Condenser water pump status on/off*

l. Condenser water supply temperature.

m. Condenser water return temperature*.

n. Condenser water flow measured downstream of the pump discharge.

o. Alarm status*.

5. Mode:

a. Occupied.

b. Unoccupied.

c. Warm-up*.

2.4 VAV TERMINAL CONTROLLERS

A. Modulate the heating control valve (two-position valves are not permitted).

B. Modulate the VAV terminal damper position.

C. Each control valve locally and centrally controlled by a single controller mounted accessible and near to heating/chilled water coil or by one controller serving a local group of coils and mounted in the area served.

D. Readable and adjustable at each controller or space sensor, the central DDC controller or from a remote computer via Ethernet:

1. Room heating setpoint temperature, occupied/unoccupied.

2. Room cooling setpoint temperature, occupied/unoccupied.

3. Actual room temperature (read only).

4. Control valve commanded percent open.

5. VAV terminal commanded percent open.

6. Discharge air temperature downstream of VAV heating coil

7. Supply air flow and setpoint

2.5 HEATING PLANT CONTROLLER

A. Use a major equipment controller reporting to the central DDC control panel to sequence the existing boilers and reset heating water temperature. Boiler manufacturer's control panels are not permitted.

B. Use the North outside air temperature sensor (OA-TN, in Heating/Chilled Water Plant Controller) to reset heating water temperature. The location of this sensor shall be identified on the as-built temperature control and construction drawings.

C. Follow the guidelines above for major equipment controllers.

2.6 COOLING PLANT CONTROLLER

A. The existing chiller is supplied with a manufacturer's central controller factory designed to smoothly integrate the operation of the chiller and chilled water pumps. All interlocks and sensors must be integrated to provide seamless operation of the chiller and ancillary equipment. The DDC system is limited to enabling the cooling plant, reading water temperatures and resetting temperatures.

2.7 INDIVIDUAL EQUIPMENT CONTROLLER SOFTWARE

A. Routinely report to the central DDC controller.

B. Continuously poll data for changes at minimum intervals of 100 milliseconds.

C. Continuously accumulate data pulses up to two per second.

D. Digital outputs in four forms: pulsed, sustained, pulse width modulated and binary staged closures.

1. Pulsed closures: 200 milliseconds.
2. Keep sustained closures in the commanded state until receipt of a contrary command.
3. Vary pulse width modulation form 100 milliseconds to 255 seconds.
4. Permit up to eight levels of staging.

PART 3 - EXECUTION

3.1 GENERAL

A. Locate each individual equipment controller near the equipment served and label its function.

B. Rooftop air handling unit local controllers shall be installed in an accessible location inside of the rooftop unit (preferably within the weather proof valve/VFD cabinet). Control panels shall be installed in a section where there is a marine light.

C. Follow the accessibility requirements of 230913 "Instrumentation and Control Devices for HVAC".

END OF SECTION 23 09 23

23 09 24 Integrated Automation Central DDC Panel & Software - August 2021

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and the Supplementary Conditions and Division 01 and Division 23 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

B. Central DDC Controller Panel: The term Central DDC Controller Panel in this document refers to the main DDC controller in the controlled building that acts as the hub for communication with individual equipment controllers, holds most or all of the control software, connects directly via Ethernet, communicates with field devices via BACnet/MS/TP protocol, and resides in the Telecommunications Room.

C. Software for the above.

1.3 DELIVERABLES

A. Provide a copy of software to Jefferson County Public School Project Manager and also to the Jefferson County Public School Mechanical Commissioning Engineer for review by the third party commissioning agent prior to sending to job-site and prior to installing in network controller.

B. Provide a copy of the approved temperature control shop drawings to the Jefferson County Public School Mechanical Commissioning Engineer upon approval by the Engineer.

C. A database of the site specific graphic files for each site shall be provided to the Jefferson County Public School Mechanical Commissioning Engineer.

PART 2 - PRODUCTS

2.1 CENTRAL DDC CONTROLLER PANEL

A. The Network Automation series controllers sized as required to accommodate the number of existing points at the site location.

B. Stand-alone multi-tasking: Disconnecting of remote off site computer shall not affect control system operation.

C. Industrial single board computer with nonvolatile solid-state flash memory to store all programs.

D. Standard Universal Serial Bus (USB) connections.

E. Battery backup to save data from Dynamic Random Access Memory into flash memory when power to the Central DDC Controller is interrupted.

F. Real time clock with battery backup.

G. Light-emitting diodes (LEDs) to indicate power, communications, and faults.

H. Removable screw terminals for 24 VAC power and filed network bus connections. Standard 9-pin sub-D connectors for RS-232-C serial ports. RJ-11

telephone line connector for internal modem. RJ-45 connector for Ethernet connection.

I. Optional internal modem.

J. NEMA 1 cabinet(s) assembled: Furnished and installed by controls contractor. House the microprocessor, communication interface, all controllers (except those required for individual equipment), relays, indicators, clocks, switches, pilot lights, override timers, etc., to allow quick access for adjustment and troubleshooting.

K. Provide Uninterruptable Power Supplies for the new Central DDC Controller panels as indicated in the scope of work and drawings.

2.2 CENTRAL DDC CONTROLLER SOFTWARE

A. The software shall be current release. Or one that will be fully compatible with Manufacturers current release.

B. Site Management Portal User Interface provides data and graphic screens to supported Web browsers. Authorized users simply log on to the DDC from the Web browser to access the Site Management Portal. This embedded user interface is ideal for smaller networks and remote locations where a dedicated computer platform to support a user interface is not required.

C. System Security enables a Central DDC Controller to recognize legitimate users with valid user IDs and passwords at the Site Management Portal user interface. User access data is encrypted in the transmission and in the Central DDC Controller database. The system administrator manages user profiles, authorization levels, user ID, password, and specific Central DDC Controller data access privileges in each user account.

D. Standard Access allows access to a subset of the standard Site Management Portal capabilities based on their assigned permissions.

E. Monitoring and Control all the mechanical and electrical systems in a typical building by collecting data from the field devices and then coordinating and sending the required commands to the controlled equipment at the required priority.

F. Global Search allows you to search the building automation system and manage lists of objects, which can be used by other features for commanding, trending, reporting, and object selection.

G. Global Command allows you to send a single command to multiple objects, and view a log of the command results.

H. Transaction Recording audits and logs all user actions performed through the Central DDC Controller.

I. Alarm and Event Processing enables Central DDC Controllers to send alarm and event messages to Web browsers, pagers, e-mail servers, Network Management

Systems, and serial printers, as well as store and view alarm and event logs on the Central DDC Controller and transfer it to an ADS/ADX.

J. Historical Trend Data can be collected by Central DDC Controllers for any monitored value at user-defined intervals, or trending can be based on Change-of-Value. You can use trend logs to analyze building system performance and locate system problems. Central DDC Controller trend logs can be transferred to the ADS/ADX at defined intervals or when the Central DDC Controller logs are full.

K. Totalization Data allows you to monitor energy (and other consumables) use and generate cost reports to support utility cost reductions, and also provides data for service, maintenance, and early identification of building system problems.

L. Trend Studies allows you to view multiple trend extensions in a single view to facilitate monitoring and troubleshooting the Building Automation System site.

M. Scheduling allows you to define occupancy periods and start and stop times for mechanical or electrical equipment. Operating parameters can be set according to time of day, day/days of the week, holiday, or for calendar dates.

N. Network-Wide System Interlocking enables Central DDC Controllers to collect field controller data, make logical comparisons, and issue relevant commands to other field controllers anywhere on the network.

O. Optimal Start automatically determines the best time to start heating and cooling systems to ensure that the facility is ready for occupants. It adjusts to seasonal variations and reduces energy use.

P. Database Configuration Management allows you to define the building automation system configuration and database offline for download to the Central DDC Controller. All the required database configuration software resides on the Central DDC Controller or SCT. You do not need a copy of the database on your local client computer to make authorized changes.

Q. To simplify error checking and reprogramming, write software in logical groups or subroutines, each serving one piece of equipment or an intuitive collection. Add non-functional remarks where required in the software to explain the function of each group and identify the equipment controlled. As much as possible, reuse standard routines that have been proven effective by experience and duplicate them for identical equipment.

R. Software adjustments and modifications can be made by District Building Automation Group once the facility has been placed into warranty with the approval of the Jefferson County Public School Project Manager and the Temperature Control Contractor.

S. Software adjustments and modifications can be made by District Building Automation Group once the facility has been placed into warranty without approval of Jefferson County Public School Project Manager and the Temperature Control Contractor if the facility is in imminent danger of being damaged.

PART 3 - EXECUTION

3.1 GENERAL

A. At the District's discretion, the District may secure a third party commissioning agent to verify the programming of the system before and after installation. This contractor shall include all work necessary to provide the commissioning agent with the documentation and information necessary to verify the work.

B. Install and check out proprietary software on the remote computer(s).

C. Existing temperature control as-built drawings can be provided at request by the Jefferson County Public Schools Project Manager.

D. Prior to the start of work, the contractor shall verify the communication of all of the existing controllers at the site and provide a documented list of the communicating controllers and points to the Jefferson County Public Schools Project Manager. Any non-communicating controllers shall be documented in writing to the Jefferson County Public Schools Project Manager prior to the start of work.

1. Controls contractor to notify District Project Manager when controllers have been repaired. Controls contractor to receive written acceptance of previously non-communicating controllers from District Project Manager before project close-out.

E. The communication of all of the existing controllers and points shall be documented in writing after the installation indicating that all of the existing controllers are communicating and that work is complete. The documentation shall be provided separately for each site.

F. The contractor shall obtain the existing site specific software from the District Project Manager prior to the start of work. The District has site adapted programs for each site due to nuances with each site. The software conversion shall utilize the site adapted programs and assure operability after the installation.

G. All category 1 alarms shall be verified for operability after the installation is completed.

H. Provide a printed copy of the final sequence of operations, a point assignment list and an expository manual devoted to the proprietary software.

I. Provide a minimum of 36 hours of training on the temperature controls systems equipment and software. Schedule all training with the Jefferson County Public Schools Project Manager. No training will start until O&M Manuals have been provided and the system has been accepted by Jefferson County Public Schools Project Manager. Jefferson County Public Schools does not recognize substantial completion.

J. All removed control panels shall be turned over to the Jefferson County Public Schools Project Manager in good condition.

K. Any training required to maintain School District technician competency of the system because of mandatory software, firmware or hardware upgrades during the

warranty period shall be provided at no additional cost to the School District. This type of training is in addition to the formal training listed above.

L. Locate the central DDC panel within the Telecommunication Room, near the Building Interface Panel so that there is a single point of control for the entire building.

3.2 CONTROLS ZONE HEIRARCHY STRUCTURE

Note: This section is presented in its entirety. It is suggested that the engineer cut and paste from this section to create a project specific specification section.

A. The school district shall be zoned into the following hierarchy structure in the software programming. The zone designation of any new school will be provided by the District Project Manager.

1. Zone 1
    a. Adams Elementary
    b. Coal Creek Elementary
    c. Lukas Elementary
    d. Meiklejohn Elementary
    e. Ryan Elementary
    f. Sheridan Green Elementary
    g. Witt Elementary
    h. Parr Elementary
    i. Thomson Elementary
    j. Weber Elementary
    k. Zerger Elementary
    l. Three Creeks K-8 School
    m. Wayne Carl Middle School
    n. Mandalay Middle School
    o. Moore Middle School
    p. Standley Lake Senior High School
    q. Pomona Senior High School
    r. Ralston Valley Senior High School
2. Zone 2
    a. Fitzmorris Elementary

b. Hackberry Hill Elementary
c. Lawrence Elementary
d. Peck Elementary
e. Russell Elementary
f. Swanson Elementary
g. Allendale Elementary
h. Campbell Elementary
i. Fairmount Elementary
j. Fremont Elementary
k. Sierra Elementary
l. Stott Elementary
m. Van Arsdale Elementary
n. Vanderhoof Elementary
o. Arvada Middle School
p. Drake Middle School
q. Oberon Middle School
r. Arvada Senior High School
s. Arvada West Senior High School
t. North Transportation

3. Zone 3
   a. Kyffin Elementary
   b. Mitchell Elementary
   c. Pleasant View Elementary
   d. Shelton Elementary
   e. Welchester Elementary
   f. Kullerstrand Elementary
   g. Maple Grove Elementary
   h. Pennington Elementary
   i. Prospect Valley Elementary
   j. Vivian Elementary
   k. Wilmore-Davis Elementary
   l. Anderson Daycare

m. Applewood Cottages
n. Manning Junior/Senior High School
o. Bell Middle School
p. Golden Senior High School
q. Wheat Ridge Senior High School
r. Earl Johnson School
s. Litz Preschool
t. 809 Quail Complex – Less Building 4

4. Zone 4
   a. Edgewater Elementary
   b. Lumberg Elementary
   c. Martensen Elementary
   d. Molholm Elementary
   e. Stevens Elementary
   f. Belmar Elementary
   g. Eiber Elementary
   h. Glennon Heights Elementary
   i. Slater Elementary
   j. Wheat Ridge Middle School
   k. Creighton Middle School
   l. Jefferson Senior High School
   m. Lakewood Senior High School
   n. Dennison
   o. Jeffco Open School
   p. Miller Special
   q. 20th & Hoyt Campus
   r. Planetarium
   s. 6th & Kipling Stadium/Driver Training
   t. Trailblazer Stadium
   u. 809 Quail Street-Building 4 Only
5. Zone 5
   a. Deane Elementary

b. Irwin Elementary
c. Kendrick Lakes Elementary
d. Lasley Elementary
e. Patterson Elementary
f. Stein Elementary
g. Devinny Elementary
h. Foothills Elementary
i. Green Mountain Elementary
j. Hutchinson Elementary
k. Rooney Ranch Elementary
l. O'Connell Middle School
m. Dunstan Middle School
n. Alameda Senior High School
o. Green Mountain Senior High School
p. Education Center
q. Landscape Services
r. Long View High School
s. McClain High School
t. Warren Tech

6. Zone 6
   a. Bear Creek Elementary
   b. Green Gables Elementary
   c. Kendallvue Elementary
   d. Peiffer Elementary
   e. Red Rocks Elementary
   f. Westgate Elementary
   g. Blue Heron Elementary
   h. Colorow Elementary
   i. Mt. Carbon Elementary
   j. Powderhorn Elementary
   k. Westridge Elementary
   l. Carmody Middle School

m. Summit Ridge Middle School
n. Bear Creek Senior High School
o. Dakota Ridge Senior High School
p. Brady Exploration
q. South Transportation
r. D'Evelyn Middle/Senior High School
s. Fehringer Ranch

7. Zone 7
   a. Bradford Primary
   b. Coronado Elementary
   c. Mortensen Elementary
   d. Shaffer Elementary
   e. Stony Creek Elementary
   f. Ute Meadows Elementary
   g. Columbine Hills Elementary
   h. Dutch Creek Elementary
   i. Governor's Ranch Elementary
   j. Leawood Elementary
   k. Normandy Elementary
   l. Bradford Intermediate
   m. Deer Creek Middle School
   n. Falcon Bluffs Middle School
   o. Ken Caryl Middle School
   p. Chatfield Senior High School
   q. Columbine Senior High School
8. Zone 8
   a. Elk Creek Elementary
   b. Marshdale Elementary
   c. West Jefferson Elementary
   d. West Jefferson Preschool
   e. Bergen Meadows Elementary
   f. Parmalee Elementary

g. Ralston Elementary
h. Wilmont Elementary
i. West Jefferson Middle School
j. Evergreen Middle School
k. Evergreen Senior High School
l. Waste Water Treatment Plant
m. Water Treatment Plant
n. Windy Peaks OELS
o. Mount Evans OELS
p. West Transportation

3.3 MAPPED POINT DESIGNATIONS

Note: This section is presented in its entirety. It is suggested that the engineer cut and paste from this section to create a project specific specification section.

A. The following designations shall be used for all mapped points with the associated units and/or states with the associated definitions:

ADMINISTRATION ONLY	DESIGNATION	UNITS OR OFF STATE	UNITS OR ON STATE	DEFINITIONS
ADMIN ONLY	ACTCLGSP	DEG F		Analog Data Actual Cooling Setpoint
ADMIN ONLY	ACTHTGSP	DEG F		Actual Heating Setpoint
	AHU-OCCD	OFF	ON	Analog Data Any Air Handling Unit Enabled
	ALRMHORN	OFF	ON	Binary Output Alarm Horn (On Both Pumps Fail)
	ALRMLITE	OFF	ON	Binary Output Alarm Light (On One Pump Fail)
	ALRMREST	OFF	ON	Binary Input Alarm Reset Button
ADMIN ONLY	ALTCLGDB	DEG F		Analog Data Alternate Cooling Dead Band
	ANY_OVR	OFF	ON	Binary Data Any Override Is Active

	AVG-TMP	DEG F		Analog Data Average Zone Temperature
	BLRn-C	OFF	ON	Binary Output Boiler Control (Enable) n = Boiler #
	BnHI-C	OFF	ON	Binary Output Boiler High Fire Control n = Boiler #
	BnLO-C	OFF	ON	Binary Output Boiler Low Fire Control n = Boiler #
	BHOUTPUT	%CMD		Analog Output Box Heating Output
ADMIN ONLY	BHPIDIT	SEC		Analog Data Box Heating Control Integration Rated
ADMIN ONLY	BHPIDPB	DEG F		Analog Data Box Heating Control Proportional Band
ADMIN ONLY	BHPIDPV	% CMD		Analog Data Box Heating Control Process Variable
	BLDPMP-R	OFF	ON	Binary Data Building Pump Required for Heating/Cooling
	BLD-REST	DEG F		Analog Data Building Water Reset Temperature
	BLDG-PSI	In. Wg		Analog Input Building Static Pressure Input
	BLRn-ALM	NORMAL		ALARM Binary Input Boiler Alarm n = Boiler #
	BLR-CMD	% CMD	Analog Output	Percent of Boiler Command from PID
	BLRS-T	DEG F		Analog Input Boiler Water Supply Temperature
	BOXHTG	%CMD		Analog Output Box Heating Command
	BXFAN-C	OFF	ON	Binary Output Box Heating Fan Output Control
	BXFAN-S	OFF	ON	Binary Input Box Heating Fan Status
	CADn-S	OFF	ON	Binary Input Combustion Air Damper Status n =Damper #
	CCP-C	OFF	ON	Binary Output Coil Circulation Pump Control
	CCP-S	OFF	ON	Binary Input Coil Circulation Pump Status
	CHn-ALM	OFF	ON	Binary Input Chiller Alarm n = Chiller #

	CHLRn-C	OFF	ON	Binary Output Chiller Enable n = Chiller #
	CHLRn-S	OFF	ON	Binary Input Chiller Status n = Chiller #
ADMIN ONLY	CHWS-SP	DEG F		Analog Data Chilled Water Set Point
	CHWR-T	DEG F		Analog Input Chilled Water Return Temperature
	CHWS-T	DEG F		Analog Input Chilled Water Supply Temperature
ADMIN ONLY	CLGBIAS	DEG F		Analog Data Cooling Bias
	CLG-CMD	% CMD		Analog Output Percent Cooling Command
	CLG-LOCK	OFF	ON	Binary Data Cooling Lockout Data Point
ADMIN ONLY	CLG-SP	DEG F		Analog Data Cooling Setpoint
	CLG-VLV	% CMD		Analog Output Cooling Valve Control Output
ADMIN ONLY	CLOADF	DEG F		Analog Data Cooling Enable Outside Air Temp Differential
ADMIN ONLY	CLOASP	DEG F		Analog Data Cooling Enable Outside Air Temp Setpoint
	CMAXFLO	CFM		Analog Data/Setpoint Maximum VAV Box Air Flow in CFM
ADMIN ONLY	COMMSP	DEG F		Analog Data Common Zone Setpoint
ADMIN ONLY	CPIDIT	SECOND		Analog Data Cooling Control Integration Rate
ADMIN ONLY	CPIDPB	DEG F		Analog Data Cooling Control Proportional Band
ADMIN ONLY	CPIDPV	% CMD		Analog Data Cooling Control Process Variable
	CVn-CTL	OFF	ON	Binary Output Control Valve 2 Control n = Valve #
	D/F-C	DRAIN	FILL	Binary Output Fill And Drain Output Control
	D/N-C	NIGHT	DAY	Binary Output Day Night Output Control
	DA-T	DEG F		Analog Input Discharge Air Temperature
ADMIN ONLY	DBSWOV	DEG F		Analog Data Economizer Switchover Dead Band
	DEMAND-L	% CMD		Analog Data Percent Cooing Demand

ADMIN ONLY	DHIT	MINUTE		Analog Data Discharge Heating Integration Rate
ADMIN ONLY	DHPB	DEG F		Analog Data Discharge Heating Proportional Band
ADMIN ONLY	DHRB	DEG F		Analog Data Discharge Heating Reset Band
	DHSPCALC	DEG F		Analog Data Discharge Air Temperature Calculation
	DHWP-C	OFF	ON	Binary Output Domestic Water Pump Control (Enable)
	DHWP-S	OFF	ON	Binary Input Domestic Water Pump Status
	DMP-C	% OPEN		Analog Output Damper Output Control
	DMPRPOS	% OPEN		Analog Data VAV Box Damper Position
	DOD-PMP	OFF	ON	Binary Output Domestic Water Pump Control (Enable)
	DPR-C	% OPEN		Analog Output Outside/Mixed/Return Damper Output Command
	DUCT-PSI	In Wg		Analog Input Discharge Duct Static Pressure
	DXn-C	OFF	ON	Binary Output Direct Expansion (n = DX #) Output Control
ADMIN ONLY	ECONDIF	DEG F		Analog Data Economizer Differential
	EFx-C	OFF	ON	Binary Output Exhaust Fan Control Output x = Exhaust Fan #
	ENnn-CS			CS-Object For Multiple Duct Coils nn = Enclosure Address
	EVAPn-C	OFF	ON	Binary Output Evaporative Cooling Pump Output Control n = Pump #
	FILL-C	OFF	ON	Binary Output Evaporative Cooling Sump Fill Output Control
ADMIN ONLY	FLOERR	CFM		Analog Data Air Flow Error in Cubic Feet Per Minute
ADMIN ONLY	FLOWAREA	SQ FT		Analog Data Area of Discharge Air Opening
ADMIN ONLY	FLOWCOEF			Analog Data Scaliar Variable
	FRZ-ALM	NORMAL	ALARM	Binary Data Possible Freeze Condition Exists
	GLY-ALM	NORMAL	ALARM	Binary Data Low Glycol Alarm

	HCP-C	OFF	ON	Binary Output Heating Water Coil Circulation Pump Output Control
	HCWR-T	DEG F		Analog Input Heating/Cooling Water Return Temperature
	HCWS-T	DEG F		Analog Input Heating/Cooling Water Supply Temperature
	HI-RM	DEG F		Analog Data Calculated The Room Highest Temp Not Calling For H/C
ADMIN ONLY	HLL	DEG F		Analog Data Discharge Heating Low Limit
	HT-CL-M	HTG	CLG	Binary Data Heating/Cooling Mode Switch
ADMIN ONLY	HTG-ENA	DEG F		Analog Data Heating Enable Setpoint
ADMIN ONLY	HTGBIAS	DEG F		Analog Data Heating Setpoint Bias
ADMIN ONLY	HTG-SP	DEG F		Analog Data Zone Heating Setpoint
	HTG-VLV	% OPEN		Analog Output Heating Valve Output Control
	HTG-LOCK	OFF	ON	Analog Data Heating Lockout is Active
ADMIN ONLY	HTOADF	DEG F		Analog Data Heating Enable Outside Air Temp Differential
ADMIN ONLY	HTOASP	DEG F		Analog Data Heating Enable Outside Air Temp Setpoint
	HTRn-C	OFF	ON	Binary Output Bus Heater Outlet Control Output n = Control Relay #
	HWPn-C	OFF	ON	Binary Output Hot Water Pump Control (Enable) n = Pump #
	HWPn-S	OFF	ON	Binary Input Hot Water Pump Status n = Pump #
	HWR-CMD	% CMD		Analog Data Hot Water Return Percent of Heating Command
	HWR-REST	DEG F		Analog Data Heating Water Reset Calculation
	HWR-T	DEG F		Analog Input Hot Water Return Temperature
	HWS-CMD	% CMD		Analog Output Hot Water Supply Percent of Heating Command
	HWS-T	DEG F		Analog Input Hot Water Supply Temperature
	HWV-C	% CMD		Analog Output Hot Water Valve Command
	ISOVLV-C	OFF	ON	Binary Output Isolation Valve Control
	LEAD/LAG	Pn	Pn	Binary Data Lead/Lag Calculation n = Pump #
	LOGLYCOL	NORMAL	ALARM	Binary Input Low Glycol Alarm
	LOW-RM	DEG F		Analog Data Calculated The Lowest Room Temp Not Calling For H/C

	LT-ALM	NORMAL	ALARM	Binary Input Low Temperature Alarm
ADMIN ONLY	MALL	DEG F		Analog Data Mixed Air Low Limit Temperature
ADMIN ONLY	MALLDB	DEG F		Analog Data Mixed Air Low Limit Dead Band
ADMIN ONLY	MALLIT			Analog Data Mixed Air Low Limit Integration Rate
ADMIN ONLY	MALLPB	DEG F		Analog Data Mixed Air Low Limit Proportional Band
	MA-T	DEG F		Analog Input Mixed Air Temperature
ADMIN ONLY	MINPOSSP	%		Analog Setpoint Minimum Position Limit
	MODE	UNOCC	AUTO	Binary Input Unoccupied Mode Switch Input
	OA-TN	DEG F		Analog Input Outside Air Temperature North
	OA-TR	DEG F		Analog Input Outside Air Temperature Roof
	OCC-C	UNOCC	OCCPD	Binary Data Building Occupancy Status
ADMIN ONLY	OCCCMIN	CFM		Analog Data Occupied Minimum Air Flow in CFM
ADMIN ONLY	OCCHBIAS	DEG F		Analog Data Occupied Heating Bias
ADMIN ONLY	OCCHTGFL	CFM		Analog Data Occupied Heating Flow
	OCCSTS	UNOCC	OCCPD	Binary Data Occupied Status
ADMIN ONLY	OSH-SP	DEG F		Analog Data Optimal Start Heating Set Point
	OVERRIDE	OFF	ON	Binary Input Override Enable Input
	Pn-C	OFF	ON	Binary Output Pump Control n = Pump #
	Pn-S	OFF	ON	Binary Input Pump Status n = Pump #
	PKUPGAIN			
	PMP-HRS	HOURS		Analog Data Totalized Runtime on Main Heating Pumps
	RA-T	DEG F		Analog Input Return Air Temperature
	RELIEF-C	% OPEN		Analog Output Building Pressure Relief Damper Output Command
	RF-C	OFF	ON	Binary Output Relief Fan Output Control
	RF-S	OFF	ON	Binary Input Relief Fan Status
	RSTRTDLY	MINUTE		Analog Output Return Fan Start Delay

	SDMODE	OFF	ON	Shut Down Binary Data Mode Switch
	SETPT-CS			CS-Object For Individual System
	SF-C	OFF	ON	Binary Output Supply Fan Control
	SF-S	OFF	ON	Binary Input Supply Fan Status
	SF-VFD	% CMD		Analog Output Supply Variable Freq. Drive Output Control
	SMK-ALM	NORMAL	ALARM	Binary Input Smoke Duct Detector Status
ADMIN ONLY	SP-DB	In. Wg		Analog Data Duct Static Pressure Dead Band
ADMIN ONLY	SP-IT	MINUTE		Analog Data Duct Static Integration Rate
ADMIN ONLY	SP-PB	In. Wg		Analog Data Duct Static Proportional Band
ADMIN ONLY	SPRAMPST	%/sec		Analog Data Supply Fan VFD Ramp-up Time
ADMIN ONLY	SP-SET	In. Wg		Analog Data/Setpoint Duct Static Setpoint
	S-VP	In. WC		Analog Input Supply Air Velocity Pressure
	SUM-WIN	Summer	Winter	Binary Data .Summer Winter Mode
ADMIN ONLY	SUPFLOSP	CFM		Analog Data Supply Air Flow Setpoint in CFM
	SUPFLOW	CFM		Analog Data Supply Air Flow in CFM
	SWLL-TS	NORMAL	ALARM	Binary Data Software Low Limit
ADMIN ONLY	SWOVDIF	DEG F		Analog Data Economizer Switchover Temperature
	SYSTEM-C	OFF	ON	Binary Data System Control
	SYS-ENA	OFF	ON	Binary Data Systems Enable Data Point
	SYSTEM AIR HANDLING UNIT			"nnnnAHx Where nnnn=School Number, Air Handling, x=Unit Number"
	SYSTEM CHILLED WATER			"nnnnCHWS Where nnnn=School Number, Chilled Water System"
	SYSTEM DUCT COILS			"nnnnDCx Where nnnn=School Number, Duct Coil, x=Unit Number"
	SYSTEM FAN COIL UNITS			"nnnnFCU Where nnnn=School Number, Fan Coil Units"
	SYSTEM HARDWARE			"NCxxN2 Where NC, xx= Network Controller Node, N2"
	SYSTEM HEATING COOLING			"nnnnHCS Where nnnn=School Number, Heating/Cooling System"

	SYSTEM HEATING WATER			"nnnnHWS Where nnnn=School Number, Hot Water System"
	SYSTEM EXTERIOR LIGHTING			"nnnnLTG Where nnnn=School Number, Exterior Lighting Systems"
	SYSTEM MAKE AIR UNIT			"nnnnMUAx Where nnnn=School Number, Make-up Air Unit, x=Unit Number"
	SYSTEM MULTI ZONE UNIT			"nnnnMZx Where nnnn=School Number, Multi-Zone Unit, x=Unit Number"
	SYSTEM MISC			"nnnnMISC Where nnnn=School Number, Miscellaneous"
	SYSTEM ROOF TOP UNIT			"nnnnRTx Where nnnn=School Number, Roof Top Unit, x=Unit Number"
	TIMER	OFF	ON	Binary Data Software Override Timer
ADMIN ONLY	UCNCDF	DEG F		Analog Data Unoccupied Cooling Differential
ADMIN ONLY	UCNCSP	DEG F		Analog Data Unoccupied Cooling Setpoint
ADMIN ONLY	UCNHDF	DEG F		Analog Data Unoccupied Heating Differential
ADMIN ONLY	UCNHSP	DEG F		Analog Data Unoccupied Heating Setpoint
ADMIN ONLY	UNCCMIN	CFM		Analog Data Unoccupied Air Flow in CFM
ADMIN ONLY	UNOCEPB	DEG F		Analog Data Unoccupied Economizer Proportional Band
	VAIN-C	% CMD		Analog Output Supply Fan Inlet Vain Output Command
	VLV-CL	OFF	ON	Binary Output 3-Point Floating Valve Closed
	VLV-CMD	%		Analog Output Heating Command
	VLV-OP	OFF	ON	Binary Output 3-Point Floating Valve Open
	W-C-ADJ	DEG F		Analog Input Warm/Cool Thermostat Adjust Setpoint
ADMIN ONLY	ZCDB	DEG F		Analog Data Zone Cooling Dead Band
ADMIN ONLY	ZCIT	MINUTE		Analog Data Zone Cooling Integration Rate

ADMIN ONLY	ZCPB	DEG F	Analog Data Zone Cooling Proportional Band
ADMIN ONLY	ZEPB	DEG F	Analog Data Zone Cooling Economizer Proportional Band
ADMIN ONLY	ZHDB	DEG F	Analog Data Zone Heating Dead Band
ADMIN ONLY	ZHIT	MINUTE	Analog Data Zone Heating Integration Rate
ADMIN ONLY	ZHPB	DEG F	Analog Data Zone Heating Proportion Band
	ZN-T	DEG F	Analog Input Zone Temperature
ADMIN ONLY	ZSP	DEG F	Analog Data/Setpoint Zone Temperature Setpoint

Any point/definition not listed above will require written approval from the Jefferson County Public Schools Project Manager prior to implementation.

END OF SECTION 23 09 24

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Where control devices are specified to be part of a manufactured piece of equipment, provided any additional devices, piping, and wiring required to achieve the specified sequence of operation.

1.3 DEFINITIONS

A. "Central Control Station" – District Building Automation Group.

B. "Central DDC Panel - Central Control Panel, one located in each School.

C. "Unit Control" – Control module located at a piece of operating equipment.

D. "Remote PC" – Temporary connection via laptop or portable personal computer.

E. "Security Office" – 809 Quail Street, Building # 1, Lakewood, Colorado, 80226 24 hour security office/Central DDC Panel or Ethernet.

F. "District Building Automation Group" – 809 Quail Street, Building #4, Lakewood, Colorado 80226.

PART 2 - EXECUTION

2.1 SEQUENCE OF OPERATION

A. Heating Water Plant

1. Components

a. Boilers B-1 and B-2.

b. Boiler circulating pumps BCP-1 and BCP-2.

c. Heating Water pumps HWP-1 and HWP-2.

d. Combustion air dampers 1 and 2.

e. Differential pressure sensors DP-1 and DP-2.

f. Stand-alone Direct Digital Controller with local display override and control board for all heating water plant points.

g. Alarm silence push button for each Heating Water Pump.

h. Start sequencers on boilers and pumps.

i. Current sensors on all pumps to detect operation, prove flow and define status. Where VFD is utilized use VFD provided status.

j. Readings from flow meters.

k. Limit arms on all combustion air dampers to prove damper fully opened.

2. General

a. Cycle times, remote temperature setpoints and time delay periods for pump operation shall be controlled from the Heating Water Plant Direct Digital Controller and be adjustable from the Central Control Station or Remote PC.

b. When any supply fan command is ON, on any AHU which has either a heating water coil or serves any duct heating coil, the heating water enable set point will be changed to the occupied heating water enable temperature.

3. Heating mode Sequence of Operation

a. Temperature setpoints shall be adjustable through building automation system (not from Boiler Controller).

b. Heating Lockout:

1) A software point shall be included to lockout the heating plant. That point will be manually activated by Building Automation. When active the heating lock will write to the heating water system enable set point adjusting it to 40 Deg. F.

c. Occupied Cycle:

1) At average reading of North outside temperature sensors (OA-TN) ≤60ºF start lead Heating Water Pump through respective VFD, lead Boiler Circulating Pump and open combustion air damper 1. Once combustion air damper is proven open by limit arm and proof of flow is established at both pumps enable lead boiler. ("Enable" allows the controls and safeties at the boiler control panel to function).

2) Temperature control sequence shall sequence boilers to maintain heating water return temperature (HWR-T) according to the manufacturer's recommendation.

3) When temperature control sequence above requires heat from the next boiler; start the lag boiler circulating pump and open combustion air damper 2. Once water flow and damper position fully opened is proven, enable lag boiler. Provide a time delay, set at 10 minutes, between start of lead boiler circulating pump and start of lag boiler circulating pump.

4) Ramp heating water pump VFD in response to differential heating water loop pressure as sensed by DP-1 to be set to a psi determined upon final balance of the heating water system (software adjustable). Obtain final pressure from the balancing contractor and include this information in the As-Built Control drawings.

5) If the lead heating water pump fails or the combustion air damper fails; start the next heating water pump and/or open the next combustion air damper. Do not disable controls. Lead/lag sequence shall have automatic reset.

6) Heating Water Pump Lead/Lag priority shall be switched after 168 hours of operation. Lead Boiler and Lead Boiler Circulating pump Lead/Lag priority shall be automatically switched after 168 hours of operation.

d. Unoccupied Cycle:

1) At North outside air temperature (OA-TN) >45°F and all supply fan commands in the OFF state, the heating plant is disabled.

2) At North outside air temperature (OA-TN) ≤45°F start Lead Heating Water Pump, Lead Boiler Circulating Pump and open combustion air damper 1. Once combustion air damper is proven open by limit arm and proof of flow is established at both pumps, enable lead boiler. ("Enable"

allows the controls and safeties at the boiler control panel to function.)

3) Temperature control sequence shall sequence boilers to maintain heating water return temperature (HWR-T) per the manufacture's recommendations.

4) Ramp heating water pump VFD in response to differential heating water loop pressure as sensed by DP-2 to be set to a system operating pressure determined upon final balance of the heating water system (software adjustable). Obtain final pressure from the balancing contractor and include this information in the As-Built Control drawings.

e. Supply and return water temperature sensors and a PI mode controller shall stage the boilers and their associated circulating pumps and combustion air dampers with first on being first off. Change the lead sequence after 30 days of runtime so as to age boilers and boiler pumps evenly.

f. Boiler circulating pumps shall continue to run for 5 minutes after shut down of associated boiler.

g. Change the lead sequence of boilers, boiler circulating pumps and heating water pumps so as to age evenly.

h. Alarms: Refer to Alarms Paragraph.

i. Adjust current sensors to detect no load condition.

B. Chilled Water Plant

1. Components:

a. Chiller CH-1.

b. Chilled Water Pump CHWP-1 with VFD.

c. Cooling Tower CT-1 with VFD.

d. Condenser Water Pump CWP-1.

e. Current sensors on pumps to detect operation prove flow and define status. Where VFD is utilized use VFD provided status.

2. General

a. Cycle timed, remote temperature setpoints and time delay periods for pump operation shall be controlled from the Chiller Plant Controller and adjustable from the Central Control Station or Remote PC.

b. The chiller has its own panel mounted controls, safeties and controls to respond to remote chilled water temperature setpoint and demand limiting inputs.

c. Activation of the timer on any Air Handling Unit which has chilled water cooling from Unoccupied Cycle to Occupied Cycle will put the chilled water plant in Occupied Cycle.

d. Events Cycle initiation for the gymnasium will not activate the chiller.

3. Chilled Water Mode Sequence of Operation

a. Temperature setpoints shall be adjustable through building automation system (not through chiller control panel).

b. Occupied Cycle:

1) When average of North outside temperature sensors (OA-TN) ≥69°F chilled water pump and condenser water pump shall run. Once proof of flow is established, enable the chiller and start the cooling tower through the VFD.

2) "Enable" allows the controls and safeties provided in the manufacturers' chiller control panel to function.

3) When average of North outside air temperature sensors (OA-TN) <66°F disable the chiller and stop chilled water pump and condenser water pump.

4) After the chiller has started maintain the condenser water temperature in the manufacturer's recommended range by varying the speed of the cooling tower fan motor through the VFD. Stop the fan whenever the chiller stops. Actual condenser water temperature and the setpoint range shall be readable and adjustable points from Central Control Station or Remote PC.

5) When the North outside air temperature (OA-TN) drops to 35°F, a solenoid valve on the make-up water line shall close and all drain valves shall open. Reverse the sequence when the chiller is enabled.

6) Parameters for operation of waterside economizer shall be provided in Construction Documents.

c. Unoccupied Cycle:

1) Chiller, chilled water pump, tower and condenser water pump shall remain off. Unless required by equipment manufacturer.

C. Air Handling Units:

1. Components:

a. Supply Fan with VFD.

b. Return/Relief Fan with VFD.

c. Outside Air and Return Air dampers.

d. Exhaust Air Damper.

e. Heating Water Coil Pump where needed.

f. Heating Water Temperature Control Valve (TCV).

g. Chilled Water Temperature Control Valve (TCV).

h. Outside Air Temperature Sensor (OA-TR, for only one of the air handling units, mounted within outside air intake stream, mounted in shade of bird screening.)

2. Cycle times, temperature setpoints and delay periods shall be controlled from air handling unit controller and adjustable from Central Control Station or remote PC via Ethernet.

a. Overrides:

1) Safety.

i) Smoke detection. Upon detection of smoke, detector in supply air stream shall:

a. Stop supply and return fans.

b. Close outside air and exhaust air dampers and open return air damper by direct interlocks.

c. Reset shall be through the fire alarm panel not through DDC System.

d. Division 26 Contractor shall alarm Fire Alarm Control Panel.

ii) Temperature, low limit temperature switch (LLTS) shall:

a. Stop supply and return fans.

b. Open temperature control valves to full flow through coil.

c. Close outside air and exhaust air dampers and open return air dampers.

d. Hard wire LLTS to required devices. Use DDC software low limit as approved by Jeffco BAS personnel.

e. Hard wire and DDC reset shall be manually activated..

f. Alarm as specified in Alarms paragraph of this specification. This is a category 2 alarm.

2) Mixed air low limit: Refer to occupied cycle sequence.

3) Override Panel: Override panel located in MDF Room shall have located on the panel face, a 1-inch high be 3-inch wide identifier for each air handling unit tagged per Drawing XXX with a green LED and OFF/AUTO/ON toggle directly below it. Function of this combination shall be as follows:

i) Normal Mode: Toggle is in the "AUTO" position. Unit is controlled through the building automation system to the District schedule. LED is energized whenever the supply fan status has proof of operation and de-energized whenever the supply fan status indicates the fan is off.

ii) Override Mode – ON: Toggle is switched to the "ON" position. If unit is off due to the District schedule, unit will start for a single, scheduled override period of 4 hours (software adjustable). LED is energized whenever the supply fan status has proof of operation and de-energized whenever the supply fan status indicated the fan is off. At the end of the scheduled override period the unit shall be controlled through the building automation system to the District schedule.

iii) Override Mode – OFF: Toggle is switched to the "OFF" position. When toggle is switched to "OFF", the unit will revert to the unoccupied cycle as defined below. LED is energized whenever the supply fan status has proof of operation and de-energized whenever the supply fan status indicates the fan is off.

3. Sequence of Operation:

a. Occupied Cycle:

1) Supply and Return fans shall run continuously.

2) Building Automation System (BAS) shall poll all VAV terminal damper positions and modulate supply fan speed through VFD to maintain static pressure as sensed at

remote duct sensor to ensure that at least one VAV terminal damper is 95% open (adjustable) and all terminal units are satisfied.

3) On initial fan start, outside air and exhaust dampers shall remain closed and return air damper open long enough to stabilize unit temperature and avoid tripping the LLTS.

4) When supply fan stops, outside air and exhaust dampers shall close and return air damper shall open. When fan re-starts unit shall go to occupied cycle control.

5) Return air, outside air and exhaust air dampers shall be mechanically linked or controlled from a common control signal.

6) Revise to Heating water coil pump(s) shall run anytime the air handling unit is commanded Occupied. Heating Mode:

   i) Outside air damper minimum position shall be determined by CO2 sensing as outlined in current IECC.

   ii) If any one VAV terminal is at its fully open position and the respective carbon dioxide sensor still exceeds its setpoint then modulate the outside air damper to provide more outside air. When carbon dioxide levels in all spaces are within setpoint, revert back to minimum outside air damper position.

   iii) When mixed air temperature ≤ 55ºF a mixed air control low limit shall override the temperature control setting and allow the outside air damper to close.

7) Cooling Mode:

   i) Modulate economizer dampers and cooling coil TCV as per current IECC.

   ii) When average of North/Rooftop (OA-TN (Plant Sensor) and OA-TR) outside air temperature exceeds the return air temperature, the outside air damper shall remain only open to its minimum position provided that Carbon Dioxide levels in all spaces are within the acceptable range.

   iii) If any one VAV terminal is at its fully open position and the respective carbon dioxide sensor still exceeds its setpoint then modulate the outside air damper to provide more outside air. When carbon

dioxide levels in all spaces are within setpoint, revert back to normal economizer mode.

b. Unoccupied Cycle:

1) Supply and return fan shall remain off.

2) Heating coil TCV shall remain under control to keep the unit from overheating or freezing.

3) Outside air and exhaust air dampers shall remain closed. Return damper shall remain open.

4) Unoccupied Setback: When the coldest zone temperature drops below 58°F (adjustable), the supply and return fan shall cycle on, the outside air and exhaust air dampers shall be closed, the return damper shall be open and the heating coil TCV shall be modulated to maintain unoccupied setback temperature. VAV terminal units associated with the air handling unit shall revert to heating mode. Upon a rise above 63°F in the coldest zone then the unit shall resume unoccupied cycle mode.

c. Morning Warm-up:

1) Utilize optimal start routines to meet conditioning requirements by start time.

2) Outside air and exhaust air dampers shall remain closed and return damper shall remain open. The dampers shall remain in this position until the scheduled start time is exceeded.

3) Modulate the heating coil TCV to maintain the programmed discharge air temperature.

4) Keep history of start times to create optimum start time for morning warm-up.

d. Morning Cool-down (to be used during the school year only):

1) Use the Optimum Start Time for morning cool-down (as determined by historical data)

2) Outside air and exhaust air dampers shall be opened and return damper shall be closed. The dampers shall remain in this position until the scheduled start time is exceeded.

3) Keep history of start times to create optimum start time for morning cool-down.

e. Cooling Lockout:

1) A software point shall be included to lockout cooling. That point will be manually activated by Jeffco Schools Facility Management Building Automation.

D. Exhaust Fans:

1. Exhaust Fans which are Interlocked.

a. Interlock exhaust fans to run with associated air handlers.

2. Exhaust Fans thermostatically controlled (EF-X, EF-Y and EF-Z).

a. IDF and Utility Rooms Fan shall operate and motorized damper shall open when room temperature is above 85°F (adjustable) as sensed by line-voltage thermostat and shut down when temperature drops below 80°F (adjustable).

3. Exhaust Fans interlocked with light switches (EF-X, EF-Y and EF-Z).

a. Fan shall be interlocked with noted light switch such that fan is energized whenever light is turned on and shall remain off when light switch is off.

4. Dishwasher Exhaust Fan EF-1:

a. Control by local on/off switch provided with dishwasher hood (Division 26).

E. Kitchen Make-up Air Unit (MAU-1), Grease Hood Exhaust Fan (EF-1) and Fire Suppression Interface Panel (FSIP):

1. General:

a. Wiring from the FSIP to mechanical equipment and remote relays on electrical circuits affected by activation of the suppression system are the responsibility of Division 23. Relays outside the FSIP are provided by Divisions 23 and 26.

b. Gas Solenoid valve is furnished by the Fire Suppression System supplier and installed under Division 23.

c. Activation of the Fire Suppression System (through (FSIP) shall:

1) Activate EF-1.

2) Stop MAU-1.

3) Deactivate power to the lights under the grease hood.

4) Deactivate power to the normally closed solenoid valve in the gas supply to any equipment under the grease hood.

5) Stop the air handling unit serving the kitchen.

6) Stop the dishwasher exhaust fan.

2. Sequence of Operation for MAU-1 and EF-1:

a. EF-1 is controlled by a switch as specified by IMC and provided under Division 23/26.

b. EF-1 and MAU-1 shall be interlocked such that whenever EF-1 is turned on by switch, MAU-1 energizes and maintains a 60°F (adjustable) discharge air sensor by local control panel provided in Division 23. Whenever EF-1 is turned off by switch, MAU-1 shall be de-energized.

c. Upon Activation of the FSIP, EF-1 shall run and MAU-1 shall remain off.

F. Split system DX cooling unit for the Computer Classroom (FCU-X/CU-X):

1. Sequence of operation:

a. Cycle times, temperature set points and delay time periods shall be controlled from the building BAS.

b. Unit shall cycle to satisfy room cooling set point.

G. Split system DX cooling unit for the MDF Room (FCU-Y/CU-Y):

1. Sequence of operation:

a. Unit shall cycle to satisfy packaged thermostat provided with unit and installed by Division 23.

b. Do not integrate packaged DX controls into BAS.

c. A separate BAS temperature sensor shall be provided in the room and shall generate a Category 2 alarm when the room temperature rises above 90°F (adjustable).

H. VAV Terminal Units:

1. Components:

a. Damper Actuator.

b. Heating Water Temperature Control Valve (TCV).

c. Room Temperature Sensor.

d. Room CO2 Sensor.

e. Discharge Air Sensor

2. Occupied Cycle:

a. Modulate the VAV terminal damper to vary the supply air volume to the space to maintain space temperature to within ±2°F of the room sensor cooling setpoint of 76°F (adjustable). When the space temperature is below 2°F of the room sensor cooling setpoint then the VAV terminal damper shall adjust to minimum position. Upon further fall in temperature to 70°F the hot water TCV shall be modulated opened to maintain space temperature to within ±2°f of

the room sensor heating setpoint of 70°F (adjustable). Once the TCV is 100% open and the space temperature is more than 2°F below the room sensor heating setpoint then VAV terminal damper shall modulate open to satisfy heating CFM setpoint.

b. When carbon dioxide (CO2) sensor senses CO2 levels greater than 800 ppm (adjustable), modulate VAV terminal damper open to provide more air to the space.

3. Unoccupied Cycle:

a. VAV terminal damper shall be fully open.

I. Exterior Lighting:

1. Time schedule and runtime shall be controlled from exterior lighting zone controller and adjustable from Central Control Station or remote PC via Ethernet.

2. Exterior Lighting (three circuits) shall be turned on and off according to software adjustable time clock function as scheduled by Owner.

3. Override Switch: Override switches located on Temperature Control Override Panel shall have located below each toggle switch, a 1" high by 3" wide identifier tag labeled "Parking Lot" below switch. Function of the toggle switch is that when toggled "on", the lights on that circuit will come on for a single, scheduled override period of 1 hour (software adjustable). This override can only occur between the hours of 5pm and midnight, seven days a week. Toggling the switch at any time other than between 5pm and midnight will not affect the normal operation of the parking lot lights.

J. Domestic water recirculating pump PCP-1:

1. Domestic water recirculating pump PCP-1 shall be energized and de-energized according to software adjustable time clock function as scheduled by Owner.

K. Sewage ejector pump SE-1:

1. Provide current sensor to detect runtime and no load condition when pump is energized from local control panel. Generate a Category 2 alarm should the pump fail

L. Crawl space temperature and humidity:

1. Provide temperature sensors to sense crawl space temperature and humidity. Generate a Category 2 alarm when the room temperature rises below 55ºF (software adjustable) and/or the room humidity rises above 65% (software adjustable).

M. Cabinet Unit Heaters and Unit Heaters (Vestibules, Boiler Rooms and Equipment Rooms, and some corridors):

1. Integral thermostat shall cycle fan to maintain an adjustable 65°F (+/- 2°F) space temperature. Interlock the fan with a strap-on aquastat on the heating water supply pipe so that the fan operates only when water temperature is above 100ºF.

N. Alarms:

1. Definitions:

   a. Category 1 Alarm: Immediate attention, notify Jefferson County Public Schools Security Building 1 through central reporting and Central Control Station.

   b. Category 2 Alarm: Attention required by the next business day, notify Central Control Station.

   c. Category 3 Alarm: Local alarm only. RED light indication. This is not a DDC function.

2. Imminent Freeze Alarm: Category 1 Alarm:

   a. The heating water system controller shall monitor the North outside air temperature sensors (OA-TN), the heating water supply temperature, the heating water flow status and set an alarm if any one of these conditions is met:

      1) Outside air temperature <35ºF and no heating water flow – or

      2) Outside air temperature <35ºF and HWS temperature is < 120ºF.

3. Phase failure / Power failure Alarm: Category 1 Alarm:

   a. Central Control Station shall monitor panel provided by Division 26. Alarm shall be set upon signal from panel that a phase failure and/or power failure was sensed.

4. Category 2 Alarms:

   a. Smoke detector or fan failure in air handling unit.

   b. Heating water pumps: Lead pump failure.

   c. Flame failure is alarmed at any one boiler.

   d. Chilled water pump - no flow.

   e. Each low limit temperature switch.

   f. MDF Room – too hot (above 90ºF software adjustable).

   g. Crawl Space – too cold (below 55ºF software adjustable).

h. Crawl Space – too humid (above 65% software adjustable).

i. Sewage ejector pump failure.

j. Sewage ejector pump run time greater than 30 seconds (software adjustable).

5. If the Central Control Station is connected to the Central DDC Panel, when an alarm occurs in the latter an alarm notification shall interrupt as a pop up window or border message onto any display in progress on the Central Control Station.

O. Control Point Trending:

1. Trending can be initiated once the General Contractor in writing states the HVAC System is fully operational and that status has been certified by the Mechanical Engineer.

2. Temperature control contractor is responsible for all trending activity. This includes generating, starting, stopping and directing trends to the correct report group.

3. All active binary and analog inputsand outputs shall be trended. Analog and Binary data points shall be included.

4. Each analog point shall be sampled every 15 minutes for a total duration of 168 hours, continuous.

5. Binary points shall be sampled upon change of state.

6. Engineer and Jeffco Coordinating Engineer will review trended data and either issue acceptance of the HVAC System operational readiness or provide a list to the General Contractor of what is required to achieve that readiness.

END OF SECTION 23 09 93

23 11 26 Facility Natural Gas Piping – August 2015

- See Division 22 – Plumbing.

END OF SECTION 23 11 26

23 21 13 Hydronic Piping – August 2022

- Work in this section is restricted to specific manufacturers that have been previously approved by Jefferson County School District, R-1.
- Included:
  1. Pipe – Heating water, Cooling (Chilled) water, Condenser water (cooling tower), Condensate, and Refrigerant

2. Piping Specialties
    a. Flow measuring devices – Venturi Type
3. Refrigeration Specialties
4. Water Treatment Equipment & Materials - Glycol makeup units, Filter Feeder, – Heating and Cooling water systems Chemical feed system - Condenser water
5. System cleaning, heating and cooling hydronic system start-up documentation.

- Qualifications:
    1. Any Journeyman Pipefitter, HVAC installer or Steamfitter working on the jobsite shall be licensed by "City and County of Denver."
    2. Acceptable contractor licenses are as follows:
        a. Heating and ventilating journeyman
        b. Refrigeration journeyman
        c. Steamfitter journeyman
        d. Any mechanical supervisor's certificate
    3. An equal license or certificate may be presented and must be approved by the District Project Manager.
    4. The license must be on their person at all times while on the jobsite and be available for inspection by Jeffco staff at any time during the work.
- Allowable Journeyman/Apprentice Ratios:
    1. The installer (contractor) must use apprentices on the jobsite. At no time shall the ratio of two apprentices to one journeyman be exceeded on the jobsite.
- Size pipe at 6'/100' max. head loss
- Steel Pipe
    1. Heating, Cooling and Condenser water pipe allowed for all sizes.
        a. ASTM-A53, Grade B, Schedule 40
        b. ASTM A106 Schedule 40 (for high temperature)
        c. ASTM A120: Not permitted in any service
    2. Welded pipe installer qualifications.
        a. Pipe welds must be performed by a certified welder. Welder must be certified in SMAW-E6010, E7018, which falls under section IX of the ASME code, Boiler and Pressure Vessel (welding and brazing), ASME B31 and Appendix B31.1 2007, Power Piping Welding Procedures. Welder certifications shall be verified before installation starts.
        b. Jefferson County Public Schools also requires welded pipe installers to be ASME certified when welding on systems less than 30 psig.

- Copper Pipe and Tubing
  1. Heating and Cooling piping allowed on sizes 2 inches and smaller only: ASTM B88 Type L hard drawn
  2. Drains and Condensate piping: - Type DWV per ASTM-B306 or Type L hard ASTM B88
  3. Refrigeration piping: - Type ACR per ASTM-B280
  4. PP-R pipe for cooling towers.
- Fittings
  1. Steel pipe: flanged or butt weld for larger sizes, ASTM B31. Use schedule 40 seamless, butt welded steel conforming to ASTM A234 standards for welded fittings.
  2. Copper water or drain: wrought copper or cast bronze. Lead free solder.
  3. Press type fitting are acceptable up to 2 inches. Press type fittings 2-1/2 inch and above requires approval from the District Project Manager.
     a. Viega or approved equivalent.
  4. Make all connections between ferrous and non-ferrous material through brass fittings. Install isolation valve on ferrous side of brass fitting. Dielectric fittings are prohibited.
  5. Install flexible hose connectors on the suction and discharge of hydronic pumps. Rubber EPDM flex connectors are prohibited.
     a. Provide flexible hose connector(s) as indicated on the contract drawings or as required to accommodate any thermal expansion, contraction or seismic movement of the piping system.
     b. Flexible hose connectors shall be capable of compensating for lateral movement and vibration.
     c. Flexible hose connectors shall be manufactured complete with section of corrugated metal house, compatible braid, with inlet and outlet connections as required.
     d. For flammable liquid or gas service up to 4-inches, flexible hose connector shall be CSA/AGA certified.
     e. Corrugated Hose:
        (1) Stainless Steel
        (2) Type 304
        (3) Type 321
        (4) Type 316
     f. Braid:
        (1) 304 stainless steel braid shall be used for any series 300 stainless steel hose.

(2) Bronze braid shall be used for any bronze hose.

g. Fittings, materials of construction, and end fitting type shall be consistent with pipe material and equipment/pipe connection fittings. Copper fittings shall not be attached to stainless steel hose.

h. Acceptable Manufacturers:

(1) Metraflex

(2) Flexicraft

(3) Hosecraft USA

(4) Approved equivalent

- Connections at Reheat Coils:

1. Connections to all reheat coils shall be hard piped, the use of metal braided or other flex connectors for this purpose is prohibited.

- Anti-seize.

1. Use on all bolts and cap screws.

- Refrigerant:

a. Brazed joint or flared

b. Brazed joints: long radius wrought-copper or forged-brass sweat fittings. Do not use cast sweat-type fittings. Cadmium free filler metal.

c. Flare joints: standard SAE forged brass short-shank.

d. On line sizes > 1” OD – Install brazed isolation valves at condensing unit and evaporative coil.

- Pressure Gauges: Work in this section is open to specific manufacturers that have been previously approved by Jefferson County School District.

1. Four and One-half inch minimum face diameter, ¼ inch NPT brass bottom mount, steel case, adjustable steel pointer, accuracy 1% of full scale or better.
2. Stainless steel case, phosphorous bronze Bourdon tube and corrosion resistant movement.
3. Maximum range: approximately double the expected working pressure of the service, must have resolution to the 1/2" inch if not less.
4. Install with an isolation valve and a drain valve between the gauge and the isolation valve. Needle valves or pet cocks are not allowed; use ball valves only
5. White face with black lettering.
6. Calibration adjustment by screwdriver.
7. Acceptable manufacturers:

a. Ashcroft

b. Duro
c. Dwyer
d. Foxboro
e. Honeywell
f. Johnson
g. Marsh
h. Meriam
i. Mueller Brass
j. Trerice
k. U.S. Gauge

8. Manometers and gauges calibrated in pressures less than 50 inches of water shall be by Dwyer or Meriam.

- Thermometers in this section are open to specific manufacturers that have been previously approved by Jefferson County School District.
  1. Battery powered electronic.
  2. Bottom or back pipe thread connection.
  3. Use thermal wells with heat transfer enhancement compound in piping services.
  4. Range(s):
     a. Heating Water: 50°F to 300°F with 2° F scale divisions
     b. Cooling Water: 20°F to 100°F with 2° F scale divisions
  5. Accuracy: 1% of full scale or better.
  6. Acceptable manufacturers:
     a. Cooper
     b. Davis
     c. Duro
     d. Foxboro
     e. Marsh
     f. Taylor
     g. Trerice
- Piping specialties Work in this section is open to specific manufacturers that have been previously approved by Jefferson County School District.
  1. MPT pressure temperature taps, ¼ inch or ½ inch. Stainless steel for condensate services, brass or bronze for water and air services, extended stem.

2. Acceptable manufacturers:
   a. Universal Lancaster
   b. Sisco
   c. Peterson Equipment Co.
3. Backflow Prevention:
   a. See Division 22.
4. Automatic Air Vents:
   a. High capacity float-type with brass or semi-steel body, copper float and removable top for cleaning.
   b. Install on air purge with isolation valve and other points as required.
5. Expansion Tanks:
   a. Closed hydro-pneumatic diaphragm or bladder type, welded steel, rated for 125 psig, cleaned, prime coated, steel support saddles.
   b. Acceptable expansion tank manufacturers:
      (1) Amtrol
      (2) Armstrong
      (3) Bell & Gossett
      (4) Taco
      (5) Thrush
6. Air/Dirt Separators:
   a. High-efficiency coalescing type; fabricated, tested and stamped in accordance with the ASME code, manual blow down valve and removable head for cleaning, 125 psig working pressure. Units shall be sized to maintain required maximum entering water velocity and pressure drop as per manufacturer's recommendation.
   b. Acceptable manufacturers:
      (1) Spirotherm/Spirovent
      (2) Armstrong
      (3) Bell & Gossett/Xylem
      (4) Taco
      (5) Thrush

6. Relief Valves:
   a. Bronze or iron body, bronze trim, bronze lifting gear, ASME rated direct spring loaded type, lever operated, non-adjustable factory set discharge pressure.
   b. Acceptable Manufacturers:

(1) Bell & Gossett/Xylem

(2) A.W. Cash

(3) Armstrong

(4) Farris

(5) Kunkle

(6) Watts

7. Combination Check and Shut-off Valves:

   a. Cast iron body, contoured disc, calibrated balancing adjustment, back seating valve stem. Install on discharge side of pump with stem up, suitable for 175 psig working pressure and 300º operating temperature.

   b. When installing wafer check valves between flanges, use stud bolts to install. "All-thread" is not acceptable as a bolt.

   c. Pressure Reducing Valve: all bronze, adjustable spring and diaphragm; integral strainer, female thread connections.

   d. Acceptable manufacturers:

      (1) A. W. Cash

      (2) Armstrong

      (3) Bell & Gossett/Xylem

      (4) Fisher

      (5) Taco

8. Refrigeration specialties.

   a. Filter-dryers:

      (1) Conform to ARI Standard 710

      (2) Full flow replaceable core in sizes 1/2" and larger

      (3) Sealed type in sizes smaller than 1/2"

      (4) Use desiccant cores that will not plug, cake, channel, or break down, but remove water, acid, and foreign material from the refrigerant.

      (5) Construct so that no desiccant can pass into the refrigerant lines.

      (6) Minimum bursting pressure, 1,500 psi

      (7) Provide in liquid line to each evaporator

   b. Strainers:

      (1) Brass or cast iron body

      (1) Not less than 60-mesh non-corrodible screen of a free area not less than ten times the pipe diameter

c. Sight Glass in the liquid line preceding each expansion valve

d. Discharge-line oil separator:

(1) Rated capacity equal to or greater than that of the compressor

(2) Provide with an oil-float valve assembly or needle valve and orifice assembly, drain-line shutoff valve, and sight glass.

(3) Connect oil-return line to the compressor

e. Charging valves: General purpose type with brass bodies, flared or soldered ends, removable valve core and quick coupling connection at valve inlet.

9. Flow Measuring Devices:

a. Flow measuring devices 2 inches and smaller may be a combination measuring device and balancing/shut off valve assembly or a separate venturi with a remote balancing valve.

(1) Non-ferrous pressure die-cast construction with sweat or threaded ends, 300 psi WSP at 250°F

(2) Venturi/ball valve with integral flow measuring tops, adjustable memory set, and full size locking indicating handle.

(3) Orifice-type balancing devices are not acceptable.

(4) Minimum accuracy +/-3%,

(5) Preferred Manufacturer:

(a) IMI Flow Design or approved equal

(6) Turbine flow meters are acceptable

(i) Onicon or approved equal

b. Flow measuring devices 2 ½" and larger shall consist of a venturi unit and separate balancing valve.

(1) Cast steel with weld ends or machined steel for butt welding, 150 psi WSP at 250°F

(2) Venturi unit shall include manual shut-off valves and quick-disconnect fittings at meter taps and shall be furnished with tags marked with Venturi size, station designations, GPM, and meter reading for GPM.

(3) Orifice-type balancing devices are not acceptable.

(4) Venturi bore sizes shall be selected so that meter read-out at specified flow rate is between 7 inches and 27 inches w.g.

(5) Minimum accuracy +/-3%,

(6) Meter in High Impact case to match venturi output values.

(7) Acceptable manufacturers:

(a) Barco

(b) Gerand

(c) Preso

- Water Treatment Equipment

1. Work in this section is open to specific manufacturers that have been previously approved by Jefferson County School District, R-1 Facilities Services Department.
2. Glycol Feeder Unit shall be a packaged unit manufactured by a company with a minimum of 5 years of manufacturing experience.
   a. Field assembled or built up systems by the Contractor are not acceptable.
   b. Unit shall include but not be limited to:
      (1) Reservoir tank - 30 gallon minimum, polyethylene with removable cover and hose bib drain mounted on steel stand with four legs with foot pads.
      (2) Positive displacement rotary gear pump 115/60/1
         (a) Acceptable Manufacturers:
            1. Axiom, model SF100 Packaged Hydronic System Feeder (preferred)
            2. J.L. Wingert
            3. Bell
            4. Gossett
      (3) NEMA type 1, control enclosure.
      (4) Control panel shall be UL listed as a unit.
      (5) Momentary spring loaded push button switch for testing the operation of the pump.
      (6) Relief valve adjustable between 10 and 20 psi.
      (7) Dual point float switch to protect pump from low level and dry contacts to connect alarm to Section 23 09 93.
      (8) Pressure switch for pump(s) control shall be (3-35psi differential). Locate pressure switch in loop main.
      (9) Pressure buffer tank ahead of pressure switch to prevent pump cycling due to system piping pressure fluctuations during operation.
      (10) All rigid piping shall be type L copper.
      (11) Manual fill only with an air gap connection from the potable water supply down-stream of the building Back Flow Preventer. Make NO hard connections to the water supply.

(12) Glycol Feeder shall not be put in service until Hydronic System has been accepted by the Mechanical Engineer and District Mechanical Commissioning Engineer.

c. Acceptable Manufacturers:

(1) Aquachem

(2) Calcium Control

(3) Morr

(4) Neptune

(5) RM Aquatech

(6) Wessel

d. Deliver system to the owner with a full reservoir tank of 30% glycol solution.

e. MC is responsible to monitor and maintain system pressure for a minimum of 6 months after Hydronic System acceptance.

3. Filter Feeder:

a. By pass type Two gallon capacity steel tank, with 3 ½" feed opening and integral metal basket & 5 micron cloth media filter.

(1) No funnel.

(2) Contractor to furnish 2 additional 5 micron filters for owner stock.

b. Approved Manufacturers

(1) Neptune Chemical Pump Company

(2) Ca Control

(3) Approved equivalent.

4. Chemical Feed System for Cooling Towers:

a. Water treatment Subcontractor shall have been in business and providing water treatment services in the geographical area for a minimum of 5 years.

b. System shall be a Total-Dissolved-Solids Bleed and Pulse Feed Treatment System for automatic injection of Biocides and Inhibitors determined by the subcontractor or equivalent.

c. System shall include but not be limited to:

(1) Makeup water meter,

(2) Dual Biocide feed with timer control and two positive displacements pumps

(3) Bleed solenoid valve

(4) Conductivity controller (bleed or blowdown control by Beta Hydac, Pulsa Feeder or alternate acceptable to Jefferson County Public School District Project Manager.

(5) Automatic Blowdown valve.

d. Chemicals shall include but not be limited to:

(1) Inhibitor – 360 PPM organophosphate and Biocide

(2) Level determined by subcontractor

e. Clean and flush towers and all piping.

f. System subcontractor/supplier shall provide complete service including chemicals for one full cooling season.

g. Subcontractor/supplier shall provide one hour of training to the owner.

h. Contractor to furnish for inclusion the O&M manual:

(1) Water test data on chemical concentrations

(2) MSDS sheets and manufacturer and supplier of all chemicals used.

i. Acceptable subcontractors:

(1) Dearborn,

(2) Garret-Calahan

(3) HOH

(4) Nalco

(5) Approved equivalent

- Automatic Air Vents shall be installed with ball type isolation valves upstream and unions on vent discharge pipe.
- Wye type strainers shall be installed upstream of all control valves.
- Coil valves and drains
  1. All heating and cooling coils shall have ball type isolation valves and drain valves with GHT, cap and chain.
- Install pressure-temperature taps on each side of all pumps and heat transfer devices (including heating coils and cooling coils). Taps must be readily accessible, installation must take into account insertion length of temperature probes and insulation.
- Install one hydronic balancing valve, as defined above, heat exchanger, and each section of fin tube radiation.
- Install pressure independent control valve at all air handling unit coils.
- Provide valves on lines before they enter and after they leave a relatively inaccessible area such as basement, crawl space or trench.
- Dielectric Fittings
  1. Are prohibited, use brass fittings between dissimilar metals.
- Provide filter feeders in the heating and cooling systems.

- Refrigerant pipe
  1. Pitch suction lines 1 inch in 15 feet toward the compressor and per manufacturer installation instructions.
  2. Install oil traps, consisting of short radius fittings, at the bases of vertical suction lines.
  3. Contractor to furnish shop drawings of refrigerant pipe sizing, layout and accessories.
- Expansion tanks, air separators and other devices heavier than 200 pounds may not be suspended from overhead without written permission from the Structural Engineer.
- Rotating equipment shall be pad mounted with the exception of recirculation pumps.
- Flow (paddle) Switches are not recommended.
  1. They may be used if required by equipment manufacturer.
  2. The Engineer shall carefully and fully detail flow switch installation if used.
- Provide pipe dope as recommended by the manufacturer for glycol systems with threaded piping.
- Gauges and Thermometers:
  1. Calibrate all gauges and thermometers in the presence of the District Engineer prior to installation.
- Test refrigerant pipe in accordance with ARI standards.
  1. Pressure test. Vacuum Test to a micron level of < 50 microns for 15 minutes.
- Cooling Tower (Condenser) Water System:
  1. Install flanged connection at outlet basin.
  2. Add meter for bleed and feed lines.
  3. Install solenoid valves in the drain and make-up water lines See Division 25.
  4. Design piping so any pipe subject to freezing will drain when drain line solenoid valve opens.
  5. Do not install strainer in the suction pipe between the tower and condenser water pump. Install suction strainer at pump volute.
  6. Shall be setup to run with a heat exchanger as a waterside economizer.
- Pre-operational flush and cleaning:
  1. Notify the Jefferson County School District, R-1 Project Manager five (5) work days in advance of starting the cleaning.
  2. Cleaning and flushing of all systems shall take place in the presence of the Jefferson County School District, R-1 Project Manager and District personnel.

3. "Certification of Work Certificate" documents the cleaning procedure and personnel involved.
4. The designated representative observing the cleaning shall sign the certification.
   a. School personnel or custodial staff are not authorized to certify the procedure.
5. Closed piping systems, heating water and chilled water, shall be cleaned using a cold alkaline cleaning solution at normal system pumping pressures.
   a. Contractor will furnish chemicals.
   b. Cleaning Solution:

Chemicals	Oz per 100 gal. of system volume
Trisodium phosphate (alkaline)	16 oz.
Sodium Hydroxide (alkaline)	1 oz.
Dawn dishwashing soap (surfactant)	1 oz.
Sodium Sulfite (oxygen scavenger)	1 oz.

6. The cleaning solution must begin with a minimum pH of 12.0.
7. Procedure to Clean an Entire Hydronic System:
   a. Isolate the expansion tank from all cleaning solutions.
   b. Follow designed parameters as defined by the engineer in specifications and in drawing details for how debris may be removed from the system without being forced through heat transfer equipment including reheat coils.
   c. Fill system with the alkaline cleaning solution.
      (1) Make sure that the cleaning solution circulates through all piping and heat transfer components in the hydronic system.
      (2) Open all two way valves to 100 % Coil flow. Open all three way valves to 50% flow to coil and 50 % return.
   d. Circulate the alkaline cleaning solution in any heating water or chilled water system for 48 hours at no more than 3 fps in main pipe.
      (1) Repair any leaks while circulating.
   e. Drain the alkaline cleaning solution and fill the system with domestic cold water.
      (1) Circulate and flush as necessary until the circulated rinse water reaches a pH of 8.5 maximum at all end points of the hydronic system.
   f. When the rinse water has reached 8.5 pH, remove and clean all piping strainers throughout the system.
      (1) Do not drain the rinse water from the piping system until the propylene glycol is ready to be installed.

(2) The District Project Manager or representative must verify and approve the cleanliness of the system.

(3) A minimum of three samples will be taken of each hydronic system.

(4) The Contractor and the Owner will each retain one sample and one sample will be sent for chemical analysis.

g. Drain and partially fill the hydronic system with clean domestic cold water.

(1) Install the inhibited propylene glycol to a concentration of 30%.

(2) The Owner will sample and install the water treatment chemicals after the glycol is charged into the system -- pH buffer, oxygen scavenger, and corrosion inhibiting surfactant.

h. Before using the glycol feeder, thoroughly clean the tank of dirt, oil, grease, and solids.

(1) Fill the tank completely full with domestic cold water and one gallon of chlorine bleach.

(2) Allow to stand overnight.

(3) Rinse the tank free of chlorine.

i. Fill the glycol feeder with a solution of water and propylene glycol (PG), 30% minimum or +9^{o}F or lower freeze point.

(1) Maintain a full glycol tank (30% minimum) until the system has been thoroughly vented of air and all of the leaks have been repaired for a minimum of six months from the project acceptance date.

(2) Leave a full tank of 30% PG upon project completion.

j. Submit the "Certification of Work" and the quantity of propylene glycol that was charged into the piping system.

(1) Transmit the information to the District Project Manager.

k. Include a copy of the "Certification of Work," the propylene glycol quantity, the MSDS sheets, and the name of the chemical supplier in the O&M Manuals.

l. Glycol feed system(s)

(1) Leave tanks filled with a 30% solution Inhibited Polypropylene Glycol.

m. Provide 1 hour of training on Condenser water chemical system.

n. Deliver venturi flow meter to Jefferson County School District, R-1 Project Manager prior to installation of venturis.

o. Mechanical contractor shall provide the District Project Manager a heating a cooling hydronic system start-up procedure check list prior to system fill.

p. Mechanical contractor shall provide the District Project Manager the verified check list post-system fill and start-up.

END SECTION 23 21 13

23 21 23 Hydronic Pumps – August 2022

- Work in this section is restricted to specific manufacturers that have been previously approved by Jefferson County School District, R-1.
- Specify and include in the Equipment Schedule two operating points for any pump that is designed to operate singly and in parallel with another pump.
- Pump seals: Confirm that the correct seals are installed. Coordinate and confirm the appropriate selection of seals with Jefferson County School District, R-1 Project Manager.
- Applicable codes, standards and regulations:
    1. HI - Hydraulic Institute - *Standard for Centrifugal Pumps*
    2. ASTM - American Society for Testing and Materials
    3. NEC - National Electrical Code
    4. NEMA - National Electrical Manufacturer's Association
- Service
    1. Vibration shall be such that the value of self-excited vibration velocity is less than 0.10 inch/second when measured with a vibration meter on the frame or bearings of the pump assembly in any of the three axes.
        a. The pump and motor assemblies shall be both statically and dynamically balanced so as not to exceed the vibration limits specified.
    2. 70% minimum efficiency at the design point for pumps larger than 3 HP
    3. The nameplate horsepower rating without consideration of the service factor, shall not be exceeded at any point along the performance curve of any pump at its rated rpm.
- Construction Details for Pumps larger than ½ HP.
    1. Use horizontal centrifugal end suction or split case, cast iron bronze fitted. Close coupled units are not recommended.
    2. Constantly rising characteristic curve from design point to minimum flow.
    3. Bronze impeller.
    4. Re-greasable ball bearings
    5. Mechanical seals with carbon seal rings and ceramic seats.
    6. Non-ferrous metal nameplate with manufacturer's name, model number, GPM, head, impeller diameter and RPM.
- Acceptable manufacturers for water pumps larger than 1/2 HP:

1. Armstrong
2. Peerless
3. Taco
4. Bell & Gossett/Xylem
5. Worthington

- Bronze fitted in-line centrifugal or cartridge pumps of 1/2 HP or less may be used as circulators or boosters in heating closed loop water systems. In-line pumps larger than 1/2 HP are not recommended. If space limitations do not permit base mounted pumps, Discuss with the District.
- Acceptable manufacturers for water pumps 1 HP and less:
  1. Amtrol
  2. Armstrong
  3. Bell & Gossett/Xylem
  4. Grundfos
  5. Oberdorfer
  6. Taco
- Documentation – Submittal and Maintenance manuals shall include:
  1. Two copies of submittal for each pump service offered
  2. Certified dimensional drawings including locations, sizes and types of each piping connection, baseplate mounting details and electrical connections.
  3. Installation, maintenance, disassembly, operating and parts-list manuals.
  4. Recommended spare parts list.
  5. Characteristic design curve.
  6. Standard manufacturer's catalog data.
  7. Factory test certification of vibration testing.
- Installation
  1. Place unions or flanges between all pumps and the isolation valves on the suction and discharge lines so that the pump may be removed for service without cutting the piping, draining, or disabling the system.
  2. Place corrugated stainless-steel hose and braid, carbon steel plate flanges, and all welded construction pump flex connectors on the suction and discharge of pump. Rubber EPDM flex connectors are prohibited.
  3. Include pressure gauges and P/T taps in the suction and discharge lines in locations that will provide a reasonably accurate check of pump performance, and on both sides of the strainer or suction diffuser.

4. Where applicable, grout all pump bases with a HP > 30

END SECTION 23 21 23

23 31 00 HVAC Ducts & Casings – August 2017

- Work in this section is open to any product or material meeting the requirements of this Technical Guideline.
- Consultant shall specify pressure and show on drawings using SMACNA Standards.

DUCT CRITERIA		
	Air Velocity (Ft/Min)	Static Pressure Loss (in. w.c. /100')
Low Pressure	1200	0.1
Medium Pressure	1500	0.15
High Pressure*	2000	0.2

*Ductwork greater than 1600 Ft/Min is not permitted

- High pressure ductwork is not permitted in Jeffco Schools. The maximum allowable duct velocity is 1600 FPM.
- Duct systems shall be pressure tested per SMACNA Standards set in Appendix C. Ductwork downstream of terminal boxes need not be tested.
- The Engineer of Record to be present during testing and to direct the T&B contractor which sections to test. Testing shall be conducted on 100% of exterior ductwork. Testing shall be conducted on 25% of interior ductwork on each system. If a section fails it shall be repaired and then retested until it passes.
    1. Duct leakage testing of exterior ductwork must be conducted before external insulation is applied. Acceptance of District Project Manager is required before installing external insulation after testing.
- All supply ducts upstream of air terminals shall be constructed before testing. District Project Manager to provide approval before testing time is set with T&B contractor.
- Air terminals shall not be connected during testing. Blank off plates may be used over terminal unit takeoffs.
- Flex duct not shall not be tested.
- When the design includes the use of existing ductwork, that duct shall be cleaned and tested for leaks.
    1. Coordinate with the District Project Manager for sealing of excessive leaks and include as a line item in the bid.
- Ductwork shall not have an aspect ratio greater than 3:1.
- Do not use fiberglass ductwork.

- Use flexible ductwork only at low-pressure on individual runouts to diffusers, registers and grilles Length shall not exceed eight feet.
- Balancing dampers shall be provided at end of run before flex duct connection or at single branch takeoff.
- Duct Liner – Where indicated line duct work with 1 inch thick, 1.5lb/Ft^3, anti-microbial impregnated fiberglass. Install in compliance with current edition of SMACNA and manufacturers recommendations.
- Comply with current edition of SMACNA "Round Industrial Duct Construction" manual for ducts carrying particulate or corrosive fumes.
- Make from galvanized steel conforming to ASTM A525 and A527.
- Exterior ductwork: Use SMACNA T-24 flanged transverse joint reinforcement by Ductmate or manufactured approved equivalent.
    1. Use butyl rubber sealant at exterior galvanized metal ductwork and flashing
    2. Silicone is prohibited
    3. Exterior ductwork shall have be 22 gauge minimum or thicker.
    4. A maximum spacing of 60 inches is permitted in between joints and 30 inches of spacing in between external reinforcement.
    5. Spiral round duct is accepted for exterior use. With internal insulation only, no external insulation.
    6. For exterior ducts equal to or greater than 4’ in height, Engineer of Record shall advise Jeffco Project Manager whether structural bracing may be required.
    7. Where duct work is installed on roofs, all 90 degree elbows shall be long radius type.
    8. Gasketed flanged duct and Pittsburg seam lock shall be used at duct work on roofs.
        a. No ductwork shall be installed on roofs with “S”-type seams on the top and bottom and fastened with drive systems on the sides.
- Insulation thickness and R value shall comply with minimum requirements of ASHRAE 90.1 2013.
- Kitchen Ductwork
    1. Grease hood exhaust duct may be black iron construction.
    2. Dishwasher exhaust shall be stainless steel.
    3. Confirm requirements for fire rated enclosure.
    4. Conform to IMC, NFPA, and manufacturer installation instructions.
- Do not use dovetail connections.
- Do not use bull-headed tees.
- Pantleg fittings are only permitted in negative pressure systems.

- Make duct size changes and offsets with no greater than 15º transitions.
- Where possible, one or two 45º offsets are preferable to an elbow.
- Double wall turning vanes to be used in elbows larger than 12x12.
- Unequal ells shall be radius type without turning vanes.
    1. Use transitions and duct splits with equal ells.
- Use 45 standard branch at square and rectangular duct branch connections. Do not use "extractors" Extractors may be used at duct mounted side-wall diffusers.
- Duct connections at RTU/AHU shall be centered on the end of the unit. Five equivalent diameters of straight duct shall be provided before any transitions or fittings.
- Do not use splitter dampers.
- Include volume control devices required for air balancing on the contract drawings.
- Though pressure testing of duct systems designed for less than 3 inch static pressure is not required, the system must be free of undue noise caused by air leaks.
- Install and seal ductwork in accordance with Current edition of SMACNA *HVAC Duct Construction Standards.*
- Allow no sharp metal edges to extend into the air stream of ducts. Air inlet collars on mixing units shall conform to and be flush with the flexible tubing or other inlet connections.
- Install fire dampers and combination smoke & fire dampers with code-approved sleeves in accordance with the UL requirements. Use frame CR for all round ducts. Use frame B for rectangular and square ducts.
- Open access doors against air pressure.

END SECTION 23 31 00

23 33 00 Air Duct Accessories – August 2016

- Work in this section is restricted to specific manufacturers that have been previously approved by Jefferson County School District, R-1.
- Square and Rectangular Dampers:
    1. Design to withstand a wind pressure of 45 pounds per square foot (134 mph) with a maximum blade deflection measured at mid-span of 1/180 of blade span. No permanent set acceptable.
    2. Damper Blades shall be galvanized steel and side (jamb or blade end) seals shall be stainless steel.
        a. Prior to including any of the manufacturers listed below verify that they offer galvanized/stainless steel dampers.

3. Max pressure drop through a wide open damper with a free area ratio (total open area between blades divided by the nominal area) of 0.75 and at an approach velocity of 500 fpm (standard air): 0.015 inches WC
4. Frames:
    a. Heavy gauge galvanized sheet steel hat channel.
5. Blades:
    a. Brake-formed at the edges to provide stiffeners
    b. Galvanized steel shaft not less than ½ inch diameter
    c. Nylon, teflon or oil impregnated sintered bronze bushings
6. Operating motor outside the air stream
7. Jack shafts and rods solid round galvanized steel
8. Acceptable manufacturers:
    a. American Warming and Ventilating, Inc.
    b. Greenheck
    c. Honeywell, Inc.
    d. Johnson Service Co
    e. Louvers & Dampers, Inc.
    f. Nailor
    g. Pacific Air Products Co
    h. Penn Ventilator Co.
    i. Ruskin Manufacturing Co

- Round and Oval Dampers:
    1. May be made by the ductwork fabricator.
    2. Damper collars and blades:
        a. Fabricated of galvanized steel sheet in the following minimum thickness gauges:

Diameter	Collar	Blade
3 inches thru 14 inches	11	14
15 inches thru 26 inches	10	12
27 inches thru 36 inches	9	10

    3. Shaft: Solid steel rod, at least ¼ inch diameter galvanized, welded to the blade.
    4. Dampers shall have blade stops and be fitted with locking-type hand quadrant controls.

5. Sleeve shaft bearings: Sintered bronze, teflon, nylon.

- Fire Dampers
  1. Conform to NFPA Standard 90A, construct and test in accordance with UL Safety Standard 555 for a 1 ½ hour rating and carry a UL label.
  2. Damper frame and blades: Galvanized steel.
  3. Dampers: Curtain-type with the blades held out of the air stream by a fusible link rated at the temperature recommended by the design engineer.
  4. Equip for vertical or horizontal installation as required by the location shown on the applicable drawing. Spring loaded in horizontal installations.
  5. Secure fusible links with "S" hooks.
  6. Access doors on the upstream or downstream side of the duct at each damper, of sufficient size to enable a worker to reset the damper.
  7. Damper frames: At least 16 gauge for ducts not over 24 inches high and 36 inches wide. 14 gauge for larger sizes.
  8. Acceptable fire damper manufacturers:
     a. American Warming and Ventilating, Inc.
     b. Controlled Air Manufacturing Ltd.
     c. Greenheck
     d. Honeywell, Inc.,
     e. Johnson Service Co
     f. Louvers & Dampers Inc.
     g. Nailor
     h. Ruskin Manufacturing Co.
- Combination Smoke and Fire Dampers:
  1. Conform to NFPA Standard 90A, construct and test in accordance with UL Safety Standard 555 for a 1-1/2 hour rating and carry a UL label.
  2. Damper frame and blades: Galvanized steel.
  3. Factory sleeve in conformance with jurisdictional authority. Mount operator on exterior of sleeve and link to operating shaft.
  4. Operators shall be UL listed and labeled with 120 VAC electric motor operated with end switches for indication of closed damper position.
  5. Design Engineer shall carefully coordinate this item between FA, TC, Elec. and Mech.

6. Include on the construction documents a strong statement that the installation of dampers shall be in strict accordance with manufacturer recommendation. No portion of a damper motor may be imbedded in structure
7. Acceptable fire damper manufacturers:
    a. Air Balance
    b. Greenheck
    c. National Controlled Air
    d. Presco
    e. Ruskin Manufacturing Co
    f. Safe-Air

- Access Doors:
    1. At automatic and manual dampers, fire dampers, coils, in-duct thermostats, variable air volume boxes and other devices requiring service and/or inspection.
    2. Hand entry access door openings: 24 inches x 24 inches minimum if the duct permits. Personnel entry doors: 18 inches x 42 inches minimum.
    3. Provide doors with a stiffening frame minimum of 2 gauges thicker than the attached ductwork and construct so that they can be operated without distorting.
    4. Continuous reinforcing bar or angle against which the door will close.
    5. 1/8 inch neoprene gasket
    6. Galvanized hinges with bronze pins
    7. Brass sash-lock fasteners on hand entry doors and handles operable from either side on personnel entry doors.
    8. Insulate doors installed in insulated ducts.
    9. 14-gauge material of the same type as the duct construction.
- To minimize noise, locate manual air-flow control dampers for diffusers and registers as far from the device as possible but still in the room or adjacent corridor.

END SECTION 23 33 00

23 35 00 Special Exhaust Systems – August 2016

- Work in this section is open to any product or material meeting the requirements of this Technical Guideline.
- Table Canopy Hood:
    1. Acceptable Manufacturer
        a. "Lab Safety Supply" – Ph. 1.800.356.0783

- Lab (Fume) Hood:
  1. Hoods shall be bypass design for high plume and dilution.
  2. Exhaust fans shall be upblast with chemical resistant coating and shall exhaust directly to the building exterior.
  3. Safeaire, Cook, Greenheck or approved equivalent.
  4. Minimum sash velocity = 100 linear feet per minute
  5. Plumbing:
     a. No cup sink
     b. No water supply
     c. No drain

END SECTION 23 35 00

23 42 00 Ultra Violet Germicidal Irradiation (UVGI) System – August 2022

- Work in this section is restricted to specific manufacturers listed.
- General:
  1. System shall meet OSHA requirements for Ozone Emissions.
- Submittals:
  1. Product data
  2. Engineering data sheets and shop drawings
  3. Operation and Maintenance Data
- Acceptable Manufacturers:
  1. Puro Lighting (proprietary bulbs)
  2. Freshaire (propriety bulbs procured directly or through JCI)
  3. UV Resources bulbs (non-proprietary OSRAM Sylvania or Phillips products only)
  4. EvergreenUV (non-proprietary OSRAM Sylvania or Phillips products only)
  5. Others considered on a case by case basis
- Devices shall be designed to:
  1. Be installed within air handling units or nearby ductwork. Preferred installation is in the return air ductwork (to minimize airflow to be treated) or mixed air box (to prolong exposure).
  2. Disinfect airflow not HVAC coils or surfaces (no LED).
  3. Achieve a Log2 (99%) disinfection rate for Influenza.
  4. Maintain 80% effectiveness described above after two years of operation.
  5. Interlock lights with supply fan operation.

6. Interlock lights with a switch on the outside of the air handling unit.
7. Meet ASHRAE Handbook Chapters 17 & 62 requirements.
8. Provide external viewport to monitor operation.
9. Provide metal warning placards.
10. Provide doped bulbs that do not emit UVV or Vacuum UV light so that ozone is not created.
11. Provide bulbs with protective shielding or Teflon coating to prevent breakage and mercury exposure.
12. Emit no ultra violet light into occupied spaces.

- Commissioning shall include:
  1. During design: Calculated dosages and product specification data must be provided to Jeffco Coordinating Engineer for each air handling unit to verify desired kill rate. Specification data must contain UV wattage, bulb length, and life expectancy. The contractor must provide the airflow rate, height and width dimensions of the box/duct, and orientation of the equipment for each installation. Airflow rates and dimensions can be found in the JCPS Construction Management Archives room.
  2. After installation: Measurements with a calibrated UV meter to ensure operation and that there is no exposure in the occupied spaces. OSHA exposure limits are not acceptable, because the limits apply to adults and JCPS occupants remain stationary for long lengths of time.

END SECTION 23 42 00

23 37 00 Air Outlets & Inlets – August 2016

- Work in this section is restricted to specific manufacturers that have been previously approved by Jefferson County School District, R-1.
  a. Anemostat
  b. Barber-Coleman
  c. Carnes
  d. Kreuger
  e. Nailor
  f. Price
  g. Titus
  h. United McGill
- Grilles, Diffusers, Registers
  1. Painted steel or aluminum of a color approved by the Architect

2. Grilles intended for use in gyms, locker rooms, bathrooms or in accessible openings large enough for a child to crawl through shall be steel security type, securely fastened to the wall or floor with tamperproof fasteners.
3. Locate air volume adjustment points above suspended ceilings or in locations that discourage tampering.
4. Do not use perforated plates over diffusers.
    a. Use diffusers that do not need this feature.
5. Ceiling diffusers:
    a. Mount flush with ceiling
        (1) Select diffuser for maximum Coanda effect with minimal smudging.
        (2) Diffuser shall be non-adjustable and without integral damper. For volume control use duct mounted manual volume damper accessible through the ceiling.
        (3) Frame all diffusers etc. do not cut ceiling tile
6. Transfer grilles through walls, floors or doors shall be privacy-type.
7. Grilles placed in walls shall have louvers parallel to the floor.
8. Diffusers shall be designed for a maximum NC of 30.
9. Supply diffusers shall be louver type.
10. Linear diffusers to be used in supply ducts in heavy glazed areas shall be designed for proper throw. Lengths shall be either 6’ or 4’.
11. Perforated registers are not to be used.

END SECTION 23 37 00

23 52 00 Heating Boilers – August 2021

- Work in this section is restricted to specific manufacturers that have been previously approved by Jefferson County School District, R-1.
    1. Aerco Condensing Boiler – Benchmark Series
    2. Riello Condensing Boiler – Array Series
    3. Lochinvar Condensing Boilers – Crest Series
- If the site cannot physically accommodate the use of a high efficiency boiler or costs are anticipated to be unreasonably high, a like-for-like replacement may be considered provided that the replacement is compliant with International Existing Building Code (IEBC) requirements. Approval must be obtained from the District Project Manager and Energy Manager prior to selection of a non-condensing boiler for acceptance as the basis of design.

- Modular Boiler systems may be used only for replacement of like systems.
- Domestic water heaters/boilers shall be less than 200 MBH in size.
- Layout of equipment and routing of piping in boiler or HVAC Equipment rooms must consider the potential of freezing.
    1. Freeze avoidance shall not rely on:
        a. Unit heaters
        b. Dampers in combustion air ducts
        c. Heat tape on piping or equipment.
- Review design concepts with the Jefferson County School District, R-1.
- Combustion air openings for appliances with draft hoods shall be "Engineered" per IBC.
- Start-up proof of performance and flue gas testing and report by factory authorized personnel
    1. The Contractor shall not perform start-up services.
- Boilers:
    1. Thermal efficiency: As dictated by current IMC, IECC, and ASHRAE 90.1.
    2. Rated at 50 psi minimum working pressure.
    3. Baked enamel finish, R15 insulation or greater
- Exclude combination starter disconnects from boiler package.
- Boiler Controls shall include operating control, safety controls integral to the boilers, local status, local alarms, and contacts for an alarm signal to Direct Digital Controller on flame failure.
    1. These controls shall be contained in a boiler mounted cabinet and be capable of interface with a "Heating Plant Controller" specified elsewhere in this Division.
    2. The "Heating Plant Controller" shall enable the Boiler Controls. All status and local alarms in the boiler mounted cabinet shall have pilot lights.
- Boiler Control Panel
    1. Each boiler shall include a control panel with the following pilots:
        a. Power
        b. Call for heat
        c. Pilot
        d. Main
        e. Alarm
            (1) Fail only with two position silence toggle.

- Boiler Trim:
  1. Combination thermometer and pressure gage
  2. Water temperature control operator
  3. High Limit safety control
  4. Low water cutoff
  5. ASME safety relief valve(s) 40# minimum
  6. Electronic pilot safety control
  7. Auxiliary safety shutoff valve
  8. Electric gas valve operator
  9. Pilot and main gas pressure regulator
  10. Main manual gas shutoff valve
  11. Pilot cock
  12. 100% gas pilot safety shutoff
  13. Draft diverter or barometric draft control for atmospheric burners.
  14. Staged (preferred) or Modulating gas burner
  15. Spark ignition
- Cast Iron Boilers shall include at least two sections with inspection and cleanout tappings on each end.
- Aluminum heat exchangers in condensing boilers are prohibited without the approval of District Project Manager.
- Tube type boilers shall include full opening and removable access doors at each end.
- Install boilers on 4 inch raised reinforced concrete housekeeping pad(s).
- Design system with isolation valves on the makeup water, gas and heating water lines so that any one unit may be taken out of service without affecting other unit(s)
- System designed for peak design load to be met in the event of any single equipment failure (n+1 redundancy).
- Install unions on discharge of Pressure relief valves.

END SECTION 23 52 00

23 55 00 Fuel Fired Heaters - August 2016

- Work in this section is restricted to specific manufacturers that have been previously approved by Jefferson County School District, R-1.
  1. Reznor

2. Trane
3. Modin
4. Hastings
5. Greenheck

- Gas Fired Kitchen Make-up Air Unit
  1. Unit shall be single zone, constant volume, 55 Deg F. discharge air temperature indirect gas fired with:
     a. Supply Air Fan
     b. No cooling.
        (1) Cooling shall be provided from cafeteria unit.
     c. 100 % outdoor air.
     d. Sized and controlled to match Grease Hood exhaust fan capacity and operation.
     e. Package controls
        (1) Building Automation System will monitor supply fan status and discharge air temperature.
     f. Interlock with Kitchen Grease Hood exhaust fan provided by Division 26. Grease hood controlled per IMC and IFGC.
        (1) Coordinate with FSIP - Fire Suppression Interface Panel.
     g. Safeties:
  2. Discharge air temperature of 40°F or less for more than five minutes will stop the fan.

END SECTION 23 55 00

23 60 05 Refrigeration Equipment and Refrigerants – October 2010

- Work in this section is open to any product or material meeting the requirements of this Technical Guideline.
- Comply with applicable codes and standards regarding control, inventory control, tracking and disposition of refrigerants used.
  1. This shall include but not be limited to:
     a. Federal Register Part II EPAm 40CFR part 82.
     b. Colorado Department of Health, Regulation No. 15, Control of Emission of Ozone Depleting Compounds.
     c. The Code of Colorado Regulations 5 CLR 1001-19.
     d. ASHRAE Guideline 3-1990.

e. Refrigerant equipment must meet the efficiency performance requirements for the current Xcel rebate program. If equipment does not qualify, gain approval of District Energy Manager and District Project Manager.

f. EPA, Clean Air Act.

- Refrigerants R-11, R-12 and R-22 for new equipment are prohibited.
- Equipment containing refrigerant shall be tagged with an Identification Tag that identifies the type of refrigerant and the quantity held.
  1. Tags shall be engraved brass pop-riveted to the equipment.
- Test refrigerant systems using pressure not vacuum.
- Do not use the compressor for evacuating the system.
- Include a receiver to hold complete refrigerant charge for systems containing 50# or more of refrigerant.
  1. Include access valves on systems containing less than 50#
- Except for factory sealed units, furnish two complete charges of lubricating oil for each compressor crankcase.
  1. Use one charge during performance testing.
  2. Upon satisfactory completion of the tests, drain the oil and replace with the second charge.
- Shut down system if initial start-up and testing takes place in winter and machines will remain inoperative.
  1. Repeat start-up and testing operation at beginning of first cooling season.
- Provide factory start-up services for the chiller and cooling tower.

END SECTION 23 60 05

23 63 00 Refrigerant Condensers – August 2017

- Work in this section is restricted to specific manufacturers that have been previously approved by Jefferson County School District, R-1.
  1. Carrier
  2. Copeland
  3. McQuay
  4. Trane
  5. TSI
  6. York
- Air Cooled Condensing Unit

1. Self-contained, factory assembled, pre-wired, suitable for outdoor use with cabinet, compressors, condensing coil and fans with guards, integral sub-cooling coil, controls, liquid receiver, wind deflector, and louvered panels to adequately protect the condenser fins against hail.
2. Hermetically sealed, 1,750 rpm, positive lubrication, crankcase heater, cylinder unloaders, motor overload protection, service valves, and filter dryer.
3. Condenser:
    a. Vertical discharge, direct drive axial fans, resiliently mounted with guard and motor.
    b. Permanently lubricated ball bearing motors with built-in current and overload protection.
4. Controls:
    a. High and low pressure cutouts for compressor, oil pressure control, non-recycling pump-down, reset relay.
    b. Timer circuits to prevent rapid loading and unloading of compressor.
    c. Hot gas bypass with multi staged compressors.
5. Weatherproof cabinet:
    a. Galvanized steel with baked enamel finish
    b. Removable access doors or panels with quick fasteners.
    c. Corrosion resistant materials for parts exposed to the weather.
6. Provide a 2-inch high sheet metal drain pan around condensing unit with 1-inch threaded nipple through side of pan.
7. Manufacturer installation instructions regarding required clearances to provide airflow to the chiller shall be provided on Contract Documents at the DD Phase.

END SECTION 23 63 00

23 64 00 Packaged Chillers – August 2022

- Work in this section is restricted to specific manufacturers that have been previously approved by Jefferson County School District, R-1.
    1. Carrier
    2. Daikin Applied/McQuay
    3. Trane
    4. Smardt
- Applicable standards and regulations:

1. ANSI - American National Standards Institute (Safety Codes for Mechanical Refrigeration)
2. ARI - Air Conditioning and Refrigeration Institute - (All applicable equipment rating and construction standards)
3. ASME - American Society of Mechanical Engineers - (Boiler and Pressure Vessel Code, Section VIII, Division 1, latest edition)
4. NEC - National Electrical Code
5. NEMA - National Electrical Manufacturer's Association - (Motors for Hermetic Refrigeration Compressors)
6. ARI factory performance test required for chillers > 100 tons.
7. ASHRAE - Standard 15, *Safety Code for Mechanical Refrigeration*
8. Latest CFC regulations.
9. Eligible for current Xcel Energy rebates.
10. Manufacturer installation instructions regarding required clearances to provide airflow to the chiller shall be provided on Contract Documents on DD Phase.
11. If an alternate chiller is offered by Contractor prior to bid, the Contractor shall provide a letter from the Mechanical Engineer to the Architect outlining the manufacturer's required clearances in writing. If the Architect is satisfied that all of the manufacturer's installation requirements are met by the designed yard and adjacent structures, the Architect shall sign acceptance on the letter. If the architect is not satisfied that the chiller enclosure will meet installation requirements, then they must seek direction from the District Project Manager.

- Minimum efficiencies shall be per ASHRAE Standard 90.1.
- Design chilled water supply temperature 44°F.
- Design condenser water temperature 73°F.
- Cooling/Chilled Water will be 30 % Propylene Glycol.
    1. The condenser cooling liquid will be water containing biocides and anti-scaling compounds.
- Air cooled chillers are preferred in lieu of water-cooled.
- Open compressor motor chillers are prohibited.
- Chillers:
    1. Preferred Electrical characteristics - 460v, 3ph, 60hz
        a. No single phase equipment
    2. Single factory package with these minimum features:
        a. Refrigerant compressor(s)

b. Air or water cooled refrigerant condenser

c. Evaporator

d. Expansion valve

e. Electric drive motors for the compressor(s) and oil pump

f. Controls mounted in a common panel

g. Water cooled oil cooler and oil circulating pump

h. Electric oil pre-heater

3. Self-excited vibration velocity < 0.10 inch/second in any of the three axes.
4. Heat exchanger fouling factor: 0.0005.
5. Evaporator
   a. Shell-and-tube design with seamless copper tubes and designed, manufactured, tested and stamped in accordance with Section VIII, Division 1, latest edition of the ASME Boiler and Pressure Vessel Code and its addenda.
   b. Shell:
      (1) Carbon steel plate, incorporate rupture disc conforming to ANSI/ASHRAE Safety Code, and be furnished with a 150 psig cast-iron water box.
      (2) Factory-applied thermal insulation.
   c. Positive liquid and vapor seal between the refrigerant and water side of the shell
   d. Copper tube wall thickness: 0.035 inch.
   e. Position intermediate tube support sheets along the length of the shell to avoid contact and relative motion between adjacent tubes.
   f. Use multiple layers of metal mesh screen or some other device to form an eliminator to be installed over the tube bundle along the entire length of the evaporator to prevent liquid refrigerant carryover into the compressor.
6. Water Cooled Condenser
   a. Shell and tube design with seamless copper tubes, integral fins. Stamp in accordance with Section VIII, Division 1, latest edition of the ASME Boiler and Pressure Vessel Code.
   b. Position intermediate tube support sheets along the length of the shell to avoid contact and relative motion between adjacent tubes.
   c. Copper tube wall thickness: 0.035 inch.
7. Purge system to operate automatically for removing any non-condensables and water vapors which may be present in the refrigerant system.
   a. Automatic non-condensable discharge and refrigerant return.
   b. Remove water with a manual blow-off valve.

8. Controls and Safeties
    a. Completely pre-wired control panel mounted on the chiller assembly: -120V single phase/60 Hz with its own transformer-numbered terminal strip for field interlock wiring-individually numbered and color coded panel wires-number wires same as the manufacturer's circuit drawings.
    b. Provide surge/transient voltage suppression protection for 120V single phase 60Hz power source(s) to control panel.
    c. Automatic safety shutdown with a pilot light and a manual reset each for low evaporator refrigerant temperature, high condenser pressure, high motor temperature and low oil pressure.
    d. Capacity control mechanisms to limit maximum amperage drawn by the compressor.
        (1) Set point of the compressor demand limit adjustable to any value between 40 and 100% of full load
    e. Individual dial-type pressure gauges to indicate purge drum, condenser, evaporator and oil pressures.
    f. Anti-recycle timer to ensure safe intervals between successive compressor starts.
    g. Panel-mounted meters to indicate total number of compressor starts and elapsed running time.
        (1) A system pilot light to indicate control power "ON" to the panel.
    h. Pilot lights:
        (1) start-up in progress
        (2) anti-recycle timer active
        (3) condenser water pump on
        (4) chilled water pump on
        (5) oil pump on
        (6) chiller on
    i. Adjustable temperature controls:
        (1) deadband
        (2) Chilled water supply temperature set point between 45 °F and 55 °F
    j. Wire safety controls to the starter to stop the chiller if:
        (1) low evaporator temperature
        (2) high condenser pressure
        (3) high compressor motor temperature
        (4) low oil pressure

(5) loss of condenser water flow

(6) loss of chilled water flow

(7) imminent freezing of chilled water

k. Include demand limiting capability. Mechanical Engineer to provide sequence to limit chiller loading based on Outside Air Temperature.

l. Include a device to reset the chilled water supply temperature set point from the return water temperature.

(1) Incorporate a minimum of two field adjustable reset schedules into the controls to match any application with the reset schedule.

m. Permit automatic chiller unloading during periods when the load decreases below the normal operation.

(1) Automatically restart upon an increase in load.

n. Provide connections to automatically start and stop or demand limit the chiller from a future remote energy management device.

o. Provide the capacity to unload the chiller from a remote signal.

p. Compressor motor starter

(1) Factory mounted, wired and tested on the chiller.

(2) Free standing starters requiring field wiring are not acceptable unless mounted next to the chiller.

(3) Include an electronic motor protection system to monitor and protect against overload and phase unbalance.

q. Distribution fault protection to prevent reconnection of the compressor motor while it is out-of-phase with the line voltage.

(1) If a distribution fault is detected, the fault trip indicator shall be displayed and manual reset shall be required.

(2) Distribution faults of 1-1/2 electrical cycle durations shall be detected and the compressor motor shall be disconnected within six electrical cycles.

r. Manually reset high and low refrigerant pressure cutout switches.

s. Relief valve in compressor discharge circuit.

(1) No valves between the compressor discharge and the relief valve.

t. Interlocks that will permit field connections from these interrupt signals:

(1) The compressor motor power interrupted on loss of cooling or chilled water flow.

(2) The compressor motor cannot start until the chilled water pump and cooling water pump are operating.

u. Disconnect switch mounted on the frame near the starter.

v. Furnish with chilled and condenser water flow switches

w. An ammeter for each electrical power phase.

x. Display panes shall be under lockable panel doors and not exposed to sunlight.

9. Vibration Isolators
    a. Free-standing, laterally stable without any housing, and complete with acoustical friction pads between the base-plate and the support.
10. Warranty
    a. 5 year warranty on all reciprocating compressors
11. Options for Air cooled chillers
    a. Include:
        (1) Louvered Hail Guard Panels
        (2) Safety screens bolted to the unit frame and safety hasps on all doors
        (3) Access panels.

END SECTION 23 64 00

23 65 00 Cooling Towers – August 2016

- Work in this section is restricted to specific manufacturers that have been previously approved by Jefferson County School District, R-1.
    1. BAC
    2. Marley
- Include in the design a temperature activated dump/fill system for freeze protection.
- Roof mounted locations are prohibited.
- Cooling Tower Components:
    1. Housing Propeller fan and variable frequency drive fan motor with controls and guard.
    2. Add sump low water control. Prohibit condensing water pump start under low level condition.
    3. Sump with bottom outlet
    4. Drift eliminators
    5. Water distribution fill
    6. Make-up water float valve
    7. Use electric sump heaters where required.

8. Equalizer pipe if cells are to be used simultaneously.

- Comply with the CTI (Cooling Tower Institute) Standards
- Design with an approach of not more than 8 F and a range of not more than 15 F.
- Vibration shall be such that the value of self-excited vibration velocity is less than 0.10 inch/second when measured with a vibration meter on the frame or bearings of the tower in any of the three axes.
    1. The fan and motor assembly shall be statically and dynamically balanced so as not to exceed the vibration limits specified.
    2. Each fan shall be associated with a VFD.
- Hot dipped galvanized steel construction with a minimum coating of 2-1/2 ounces per square foot conforming to ASTM A-123.
    1. Fiber Glass, Plastic or other nonmetal materials are prohibited.
- If more than one cell, separate each cell from the adjacent cell by a full galvanized steel wall. Include a center divider in each cell that will prevent wind blowing through the louvers and carrying out water spray.
- Bolts, nuts and washers: Silicon bronze or galvanized steel.
- Design louvers to prevent ice formation from blocking entering air during subfreezing weather.
- Tower Fill:
    1. Pre-assembled PVC meeting NFPA requirements.
- Limit drift losses to 0.2% of tower capacity.
- Cold water basin:
    1. Outlet – bottom depressed sump. Do not use side outlet.
    2. Basin shall be 14 ga. Stainless steel.
    3. Include stainless steel suction screen and cast bronze float fill valve.
    4. Remote basins are not recommended.
        a. If considered review with District Project Manager.
- Drift eliminators:
    1. Two-pass non-corrosive
- Distribution.
    1. Individual upper distribution piping fed from main headers equipped with flow control valves so that any cell may be shut down for maintenance without interfering with the operation of any other cell
    2. Low pressure, splash-type distribution nozzles

3. Single ASA 125 lb. serrated flat face flanged connection for the hot water inlet

- Fans
  1. Propeller with cast aluminum blades
  2. Right-angle spiral bevel gear speed reduction
  3. Stainless steel drive shafts
  4. Drive and fan safety guards.
- Location
  1. To minimize student vandalism, do not use Squeegee or other rock material in the area of the cooling tower.
- Install condenser water filters or strainers at ground level when required.
- Design the pipe system so pipe subject to freezing will drain on automatic system drain down.
- Include automatic drain down and make-up water features in the condenser water system.
- Install flanged connection at the basin low water level in condenser water return line.
- Consider PVC pipe for any portion of the system that drains and dries out when the tower is not running.
- Locate in area with minimal occupancy.

END SECTION 23 65 00

23 73 00 Indoor Central-Station Air Handling Units – August 2021

- General Design Requirements:
  1. Work in this section is restricted to specific manufacturers that have been previously approved by Jefferson County School District, R-1.
  2. Engineer's design shall
     a. Avoid over pressurization.
     b. Ensure an adequate return air path.
     c. Include dampers necessary to balance the return air
  3. No prepackaged controls except where required by manufacturer for safe operation of gas burners and refrigerant cooling.
- Codes and Standards: AMCA, ASHRAE, NFPA, UL, NEMA, NEC, AGA, AHRI
- Acceptable Air Handler Manufacturers:
  1. AAON Units
  2. Carrier

3. Greenheck
4. Trane
5. JCI/York
6. Temtrol
7. Equipment recommended by project engineer and accepted by Jeffco Project Manager

- Cabinet Construction Requirements:
  1. Baked enamel finish
  2. Double wall construction, 18 gage steel walls, 20 gage steel doors
  3. Floor panels shall be capable of bearing a 200 lb. load placed on a one square foot with a deflection not to exceed 1 inch per 200 inches span
  4. R-12, NFPA 90A rated insulation in doors, walls, ceilings
  5. 1 inch thick, R-4 fiberglass insulation floor panels
  6. Leak tight floor
  7. Sound attenuation for fans and motors
  8. Access to each section via hinged doors with handle and latch closure
  9. Stainless steel drain pan in each fan and coil section with 2" floor drain and side outlet
  10. Exterior condensate drain
  11. Marine light with wire guard
  12. Outdoor enclosures shall be fully sealed by neoprene gaskets and caulk
  13. Knockouts for electrical and piping connections
  14. Duplex, 120V receptacle mounted on the outside of the cabinet and connected to the service side of the unit mounted disconnect.
  15. Safety Hasps secured to the unit with through bolts, do not weld.
  16. Accessibility to all bearings and lubrication joints
  17. Non-fused disconnect switch
  18. Phase protection that can detect voltage imbalance
  19. Mesh screens to protect from cottonwood seeds and birds
- Coil Section
  1. General Coil Specifications
     a. Aluminum or copper fins
     b. Coil velocity at maximum flow of 600 FPM.

c. Coils removable from the AHU by means of doors or removable panels.

d. Supply at the bottom and return at the top, drainable without air purging.

e. Any one coil shall be removable without disturbing the other coil.

f. 4 inches +/- space between heating and cooling coils.

g. Sealing strips between each coil frame and the casing to eliminate air bypass and moisture carryover.

2. Refrigerant Coil - Must have an equalizing type vertical distributor to ensure each coil circuit receives the same amount of refrigerant.

3. Water Coils – Must be pitched in the unit casing for proper drainage. Coils shall have metering orifices and a supply header to ensure distribution of water to each tube.

- Filter
  1. Provide 4-inch filters where possible
  2. Filters must meet MERV 11 efficiency rating
  3. Polyester blanket filters are not acceptable
- Fan Section
  1. Acceptable manufacturers of fans:
     a. Chicago Blower
     b. Blower Buffalo Forge
     c. New York
     d. Trane
     e. Twin City
     f. Greenheck
     g. CES Group
     h. Equipment recommended by project engineer and accepted by Jeffco Project Manager
- Mixing Economizer Section
  1. Provide outside, return, and relief dampers with damper actuator for proportional control and spring return motors. Outside air damper to fail to closed position.
  2. Provide 100% Outside Air Economizer: Outside air damper and exhaust air damper each sized for the full rated flow of the unit.
- Fans
  1. Acceptable manufacturers of fans:
     a. Chicago Blower

b. Blower Buffalo Forge
c. New York
d. Trane
e. Twin City
f. Greenheck
g. CES Group
h. Equipment recommended by project engineer and accepted by Jeffco Project Manager

2. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment.
3. Supply fan and motor assembly combinations larger than 7.5 hp or 22" diameter shall be internally isolated on spring isolators.
4. The supply fan shall be capable of airflow modulation from 30% to 100% of the scheduled designed airflow. The fan shall not operate in a state of surge at any point within the modulation range.

END SECTION 23 73 00

23 74 00 Packaged Outdoor HVAC Equipment – August 2021

- Packaged Outdoor HVAC Equipment shall meet the requirements of Section 23 73 00 and additional requirements outlined in this section.
- Additional Requirements for Rooftop Units
  1. General Description: Rooftop unit shall be factory-assembled and tested, designed for roof or slab installation and, consisting of compressors, condensers, evaporator coils, condenser and evaporator fans, refrigeration and temperature controls, filters, and dampers.
  2. Condensing Section:
     a. All Units shall provide the Energy Efficiency EER and IEER per the current version of the IECC or higher.
     b. Condenser Fans: Condenser fans shall be direct drive, axial type designed for low tip speed and vertical air discharge. Fan blades shall be constructed of steel and riveted to a steel center hub. Condenser fan motors shall be heavy-duty, with permanently lubricated ball bearing and integral rain shield.
     c. Each circuit shall be complete with a low pressure control, filter-drier, liquid moisture indicator/sight-glass, thermal expansion valve, and a manual reset high pressure safety switch. The thermal expansion valve shall be capable of modulation from 100% to 25% of its rated capacity. Sight-glasses shall be

accessible for viewing without disrupting unit operation. Each circuit shall be dehydrated and factory charged with Refrigerant 410A and oil.

3. Provide water detection device (safe-t-switch or similar) in the drain pan to shut unit down if primary drain becomes blocked.
4. Safety Controls:
   a. Low pressure cutout, manual reset;
   b. High pressure cutout, manual reset;
   c. Compressor motor overload protection, manual reset;
   d. Anti-recycling timing device;
   e. Adjustable low-ambient lockout;
   f. Oil pressure switch.
5. Gas Heat Exchangers: Provide Stainless Steel construction for gas-fired heat exchangers, designed for minimum of 5:1 turndown. Provide single gas connection.
   a. Controls:
      (1) Redundant gas valves;
      (2) pilot ignition;
      (3) Electronic spark ignition system;
      (4) High limit cutout;
      (5) Forced draft proving switch;
      (6) Flame roll-out switch.
6. Economizer Control: Return and outside air dampers, outside air filter, fully modulating electric control system with enthalpy control, and adjustable mixed-air thermostat. System shall have 100 percent outside air capability. Provide automatic changeover through adjustable enthalpy control device.

END SECTION 23 74 00

23 75 00 Custom-Packaged Outdoor HVAC Equipment – August 2021

1. Must meet the requirements outlined in Section 23 74 00.

END SECTION 23 75 00

23 76 00 Evaporative Air Cooling Equipment – August 2021

2. Not allowed.

END SECTION 23 76 00

23 80 00 Decentralized HVAC Equipment – August 2016

- Work in this section is open to any product or material meeting the requirements of this Technical Guideline.
- Packaged Rooftop Air Conditioning Units
  1. Units shall be supplied with controls by facility Building Automation System:
     a. Manufacturer's controls are not acceptable except for B. below and integral safety controls.
  2. For small units which will not accommodate Temperature Controls Contractor control components the manufacturers packaged controls may be used.
  3. Units shall include:
     a. Mixed air sensor
     b. Package safety controls
     c. Terminal interface strip for connection by Temperature Controls
     d. Package Controls
        (1) Damper operators shall be 0-10vDC, 4-20MA or 24v incremental Control.

END SECTION 23 80 00

23 82 00 Convection Heating & Cooling Units – August 2016

- Work in this section is restricted to specific manufacturers that have been previously approved by Jefferson County School District, R-1.
- Not to be used in 140 Deg F. EWT existing Finned Tube Systems.
- Finned-tube (Baseboard) Radiation
  1. Cabinets or enclosures: 16 gauge or maximum security steel with closed ends to resist abuse and vandalism.
     a. Slope the top to discourage the storage of materials.
  2. Design perforations to discourage vandalizing the fin tube or controls with sharp instruments.
  3. Cabinet paint:
     a. Baked on enamel or prime coating of a color selected by the Architect.
  4. Fin tubes:

a. ¾ inch, 1 inch or 1¼ inches copper with a safe working pressure of 200 psi at 250º F and 0.016 inches thick or heavier aluminum fins spaced no closer than 48 per foot.

5. Acceptable manufacturers:
   a. Standard
   b. Sterling
   c. Vulcan

- Unit Ventilators.
  1. Use only to replace in kind or when it is impossible to use an alternate HVAC system.
  2. Consult with District Project Manager and District Mechanical Engineer.
  3. Unit ventilators shall include:
     a. 100% outside air or return air economizer damper(s).
     b. Cabinet heaters are return air recirculation only.
     c. Readily accessible manually switched two-speed fan motor.
        (1) Cabinet heater motors may be single speed.
     d. Interior components accessible only through tamper resistant access panels or doors.
        (1) Tamper resistant hardware shall be operable using standard tools.
     e. Fin tube element or coil:
        (1) 5/8 inch OD copper tube(s)
        (2) 0.29 inch wall with fin spacing not exceeding 12 per inch.
     f. NC to satisfy criteria as defined HVAC Acoustic Criteria.
        (1) Cabinet extensions sized as necessary to accommodate mechanical or electrical control devices, and all valves, vents, etc.
     g. Plastic, Fiberglass, or similar composition material drive gears and blower assembly are prohibited.
  4. Classroom unit ventilators with self-contained refrigeration compressors are not permitted.
  5. Approved manufacturers are:
     a. Airedale
     b. American Air Filter
     c. Carrier
     d. Magic Aire
     e. Nesbitt

f. Trane

6. Unit mounted controls shall be:
   a. Manufactured by Building Automation System Manufacturer.
   b. Shall include manual reset freeze stats.
7. Water control valves:
   a. Brass or bronze
   b. 24 volt electric or pneumatic actuated
   c. 150 psi threaded or soldered
   d. Acceptable Manufacturers:
      (1) Honeywell
      (2) Powers
      (3) Johnson Controls
      (4) Belimo
      (5) Barber Coleman.
      (6) FCI
      (7) Danfoss
      (8) Nibco
      (9) Griswold
8. The Engineer shall include in the design scaled drawing details for location of valves, strainers, etc.
   a. Where there is cabinetry adjacent to the UV consider locating the valves within the cabinets instead of inside extensions of the UV cabinet.
   b. If there is more than one unit ventilator to be installed, complete the installation of one as a prototype for approval by the District.
   c. Access to elements of the piping within the cabinet is critical to maintenance but often overlooked by the installer.
9. Filters

PANEL FILTERS (UNIVENTS)

   a. 100% Polyester single layer media wrapped construction. (Non Pleated)
   b. Galvanized steel wire frame, consisting of a >= 10 gauge wire. Frame must be single piece construction (No Links).
   c. Sewn construction with seem sewn inside the perimeter of wire frame.
   d. Graduated density allowing for depth loading.

- Cabinet Unit
  1. Heaters located at entries.
  2. Install in vestibules.
- Heating Water Piping:
  1. Consider reverse return
  2. Two-way control valve, balancing valve and two isolation valves for each heating terminal unit or fin tube zone to permit removal of one terminal unit or fin tube zone without shutting down the system.
  3. Three-way control valve, strainer w/ drain at the end of each branch to keep the lines close to the service temperature and protect the pump from dead head shut off, or another engineer designed method to accomplish the same purpose.
  4. Locate valves and/or other controls above the ceiling or inside the cabinet behind tamper resistant access panels or doors.
  5. Conceal piping to the greatest extent possible.
  6. Provide each terminal unit with brass P/T taps in the supply and the return.
- Chilled Beams
  1. Shall be compatible with inhibited propylene glycol 30% hydronic fluid.
  2. Shall meet noise criteria in Section 23 00 02
  3. May be 2 pipe or pipe configuration to take advantage of existing conditions. 2 pipe configuration is preferred for new builds.
  4. Systems shall be predominantly composed of Active Chilled Beams. Hybrid VAV/CV and Chilled Beam systems are not allowed.
  5. Systems shall be supplied ventilation air by a Dedicated Outdoor Air System with heat recovery and dehumidification.
  6. Acceptable Manufacturers:
     a. Titus
     b. Swegon
     c. Dadanco
     d. Price

END SECTION 23 82 00