MAXWELL CONSTRUCTION

Sunman-Dearborn Community Schools
BP#1 - Early Mechanical

ADDENDUM 2
Added Specs

Date: 8/12/24

440 Nowlin Avenue, Greendale, IN 47025 (812) 537-2200 www.maxwellbuilds.com

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SECTION 23 0993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

B. Related Sections include the following:
1. Division 23 Section "Instrumentation and Control for HVAC" for control equipment and devices and for submittal requirements.

1.2 DEFINITIONS

A. DDC: Direct digital control.

B. VAV: Variable air volume.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

BRIGHT ELEMENTARY

3.1 ALARMS

A. Generate an alarm at the PC workstation when any space temperature is <50 def F for 15 minutes (adjustable) and an immediate alarm when any space temperature is <40 deg F (adjustable).

B. Coordinate with the owner to identify alarms as "general" or " critical". General alarms will only be displayed at the PC workstation. Critical alarms will be displayed at the PC workstation and dialed-out to pre-programmed telephone numbers through the internal PC modem.

3.2 HVAC ZONE CONTROL SEQUENCES

A. Provide software time clock and set-up schedule to place each HVAC system into occupied or unoccupied mode. Provide an override push button on each space temperature sensor to place the respective zone air handler into the occupied mode for a two-hour period (adjustable) when button is pushed. When the button is pushed again prior to the override time expiring, the zone air handler will revert to the scheduled operating mode.

B. Where carbon dioxide (CO2) sensors are present, the BMS shall monitor the space or return duct CO2 concentration and reset the outside air damper to increase ventilation rates to prevent high levels of CO2 in a space.
1. If CO2 is above 900 ppm for a period of at least 5 minutes and the space in an occupied mode, increase OA damper position 5% every 5 minutes until the space CO2 decreases below 700 ppm, the resume normal OA setpoint.

2. Maximum outside air damper position shall be determined if supply air temperature setpoint can not be maintained with 100% heating or cooling, depending on mode. Do not sacrifice supply air temperature upper and lower limits during CO2 reset mode.

C. All systems and spaces shall be linked to a global room temperature setpoint value that the Owner can change a single value that effectively creates a single temperature setpoint with specified adjustment (+2 deg/-2 deg) that all systems and all spaces use for master control of the facility/campus temperature and energy control.

D. Equipment rotation shall be configured on all systems where more than one equipment item is used to function as a team, such as pumps, chillers, boilers, relief fans, etc. The controls shall be configured to equalize run time on all items. Utilize a “first-on, first-off” approach unless noted otherwise or if Owner’s campus standards stipulate specific rotation schedules.

E. All heating hot water coils shall utilize the following for coil freeze protection if they are the primary heating coil for air handlers, unit ventilators, single zone duct coil, that has outside air to the equipment.
1. If outside air temperature is less than 35 deg F (global adj.) the hot water coil shall never close 100%. Maintain coil a minimum of 10% open at all times, even with equipment fans turned off.
2. If unit is shut off and outside air temperature is less than 35 deg (global adj.), mixed air temperature sensor and freezestat shall monitor temperature inside of air handler equipment such that if duct temperature less than 40 deg F is detected, BMS shall activate fan to circulate air through the unit at minimum speed until mixed air temperature is above 50 deg F and a minimum run time of 15 minutes (global adj).
3. If mixed air temperature drops to below 30 deg F while the unit is off, BMS shall generate critical alarm and open hot water coil 100%.

3.3 TERMINAL UNIT CONTROL SEQUENCES

A. Unit Heater Control: A 24-volt wall mounted thermostat shall cycle fan motor to maintain space temperature between set point and 2 deg F (adjustable) below set point.

3.4 AIR HANDLING UNITS CONTROL SEQUENCES

A. Safety Controls:
1. Provide an adjustable electric automatic reset freezestat element serpentined across the face of the leaving air side of the heating coil which will stop the supply fan, close the outside air damper and position heating control valve for full coil water flow.
2. Freezestat shall be hardwired to fan circuit. If low limit is detected, the BMS shall close the outside air damper, maintain supply fan on, display a low limit notification on the graphics, and wait 15 minutes. Reset to normal mode and open outside air damper.
3. If low limit sensor trips 3 times within a 1 hour time frame, generate a critical low limit alarm and lock out the unit requiring a software reset before running. Close

outside air damper to 0%, open return damper to 100%, stop all supply, return, and relief fans.

4. Low limit capillary shall have 1 ft of tube for every 1 sq ft of coil surface.
5. NOT USED
6. Provide a high-limit controller to prevent unit discharge air from rising above 125 deg F (adjustable). Sensor shall be located at the discharge of the unit.

B. AHU-1, AHU-3, AHU-4
   1. Occupied Mode:
      a. Supply fan shall operate continuously. BMS shall modulate ECM supply fan to maintain duct static pressure setpoint. Duct static pressure shall be determined by pressure sensors located 2/3 down the longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0" w.c. (adjustable).
      b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain return air CO2 level at 800 ppm (adj). Outside air damper shall remain open at least 10% (adj) during occupied mode. If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.
      c. If the outside air temperature is below 35 deg F (adjustable), provide full heating coil flow and modulate face and bypass dampers as required to maintain discharge air temperature (DAT) set point. If outside air temperature is 35 deg F or higher (adjustable), provide full airflow to the face of the coil and modulate the hot water coil control valve and chilled water coil control valve as required to maintain DAT set point. Reset DAT to maximum possible temperature to satisfy zone with the greatest call for cooling. Minimum DAT shall be 42 deg F (adjustable).

   2. Unoccupied Mode:
      a. Close outside air dampers, unit supply fan to remain off. Cycle fan hot water coil control valve, and chilled water coil control valve to maintain unoccupied DAT set point.
      b. If outside air temperature is above 55 deg F (adjustable) and there is a call for cooling, enable supply fan and modulate chilled water coil control valve to maintain unoccupied DAT set point.

C. AHU-2
   1. Occupied Mode:
      a. Supply fan shall operate continuously. BMS shall modulate ECM supply fan to maintain duct static pressure setpoint. Duct static pressure shall be determined by pressure sensors located 2/3 down the longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0" w.c. (adjustable).
      b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain return air CO2 level

at 800 ppm (adj). Outside air damper shall remain open at least 10% (adj) during occupied mode. If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.

c. If the outside air temperature is below 35 deg F (adjustable), provide full heating coil flow and modulate face and bypass dampers as required to maintain discharge air temperature (DAT) set point. If outside air temperature is 35 deg F or higher (adjustable), provide full airflow to the face of the coil and modulate the hot water coil control valve and stages of DX cooling as required to maintain DAT set point. Reset DAT to maximum possible temperature to satisfy zone with the greatest call for cooling. Minimum DAT shall be 42 deg F (adjustable).

2. Unoccupied Mode:
   a. Close outside air dampers, unit supply fan to remain off. Cycle fan hot water coil control valve, and stages of DX cooling to maintain unoccupied DAT set point.
   b. If outside air temperature is above 55 degrees F (adj) and there is a call for cooling, enable supply fan and modulate stages of DX cooling as required to maintain unoccupied DAT set point.

NORTH DEARBORN ELEMENTARY

3.5 ALARMS

A. Generate an alarm at the PC workstation when any space temperature is <50 def F for 15 minutes (adjustable) and an immediate alarm when any space temperature is <40 deg F (adjustable).

B. Coordinate with the owner to identify alarms as "general" or " critical". General alarms will only be displayed at the PC workstation. Critical alarms will be displayed at the PC workstation and dialed-out to pre-programmed telephone numbers through the internal PC modem.

3.6 MONITORING SEQUENCES

A. Monitor temperature(s) of walk in food freezer(s) and cooler(s) and trend this data for a period of two weeks (adjustable) and a sample rate of one reading every 5 minutes (adjustable). Generate an alarm at the PC workstation if the temperature rises above user defined set point.

B. Monitor each boiler room containing gas fired boilers or water heaters with a carbon monoxide sensor and trend for a minimum of 48 hours. Provide an audio/visual alarm with a minimum of 85 dB sound level. Provide signage near the alarm reading “Carbon Monoxide Alarm”.
   1. On alarm exceeding 200 ppm, all gas fired equipment shall be shut down.
   2. A local alarm inside the room shall activate with the following levels:
      a. 9 ppm or greater for a duration of 8 hours.
      b. 40 ppm or greater for a duration of 5 hours.
      c. 70 ppm or greater for a duration of 1 hour.

d. 200 ppm or greater for a duration of 15 minutes.

C. Monitor status of refrigerant monitoring system. On a local alarm by the refrigerant monitoring system, generate an alarm at the PC workstation stating, “REFRIGERANT SYSTEM ALARM”.
1. Provide with manual HOA over-ride button outside of chiller equipment room for BMS to disable chiller plant by shutting down all chillers in the room. Button shall be secured with beak-glass box.
2. Provide with manual HOA over-ride button outside of chiller equipment room to over-ride purge fan and associated intake/exhaust control dampers. Button shall be secured with break-glass box.

D. Monitor temperature of domestic hot water downstream of thermostatic mixing valve and generate an alarm if the temperature rises 5 degrees (adjustable) above specified set point.

E. Monitor pressure of domestic water main entrance (downstream of booster pump) and generate an alarm if the system pressure drops below 35 psi (adjustable).

F. Monitor status of kitchen exhaust hood fan.

3.7 HVAC ZONE CONTROL SEQUENCES

A. Provide software time clock and set-up schedule to place each HVAC system into occupied or unoccupied mode. Provide an override push button on each space temperature sensor to place the respective zone air handler into the occupied mode for a two-hour period (adjustable) when button is pushed. When the button is pushed again prior to the override time expiring, the zone air handler will revert to the scheduled operating mode.

B. Where carbon dioxide (CO2) sensors are present, the BMS shall monitor the space or return duct CO2 concentration and reset the outside air damper to increase ventilation rates to prevent high levels of CO2 in a space.
1. If CO2 is above 900 ppm for a period of at least 5 minutes and the space in an occupied mode, increase OA damper position 5% every 5 minutes until the space CO2 decreases below 700 ppm, the resume normal OA setpoint.
2. Maximum outside air damper position shall be determined if supply air temperature setpoint can not be maintained with 100% heating or cooling, depending on mode. Do not sacrifice supply air temperature upper and lower limits during CO2 reset mode.

C. All systems and spaces shall be linked to a global room temperature setpoint value that the Owner can change a single value that effectively creates a single temperature setpoint with specified adjustment (+2 deg/-2 deg) that all systems and all spaces use for master control of the facility/campus temperature and energy control.

D. Equipment rotation shall be configured on all systems where more than one equipment item is used to function as a team, such as pumps, chillers, boilers, relief fans, etc. The controls shall be configured to equalize run time on all items. Utilize a “first-on, first-off” approach unless noted otherwise or if Owner’s campus standards stipulate specific rotation schedules.

E. All heating hot water coils shall utilize the following for coil freeze protection if they are the primary heating coil for air handlers, unit ventilators, single zone duct coil, that has outside air to the equipment.
   1. If outside air temperature is less than 35 deg F (global adj.) the hot water coil shall never close 100%. Maintain coil a minimum of 10% open at all times, even with equipment fans turned off.
   2. If unit is shut off and outside air temperature is less than 35 deg (global adj.), mixed air temperature sensor and freezestat shall monitor temperature inside of air handler equipment such that if duct temperature less than 40 deg F is detected, BMS shall activate fan to circulate air through the unit at minimum speed until mixed air temperature is above 50 deg F and a minimum run time of 15 minutes (global adj).

F. If mixed air temperature drops to below 30 deg F while the unit is off, BMS shall generate critical alarm and open hot water coil 100%.

3.8 TERMINAL UNIT CONTROL SEQUENCES

A. Unit Heater Control: A 24-volt wall mounted thermostat shall cycle fan motor to maintain space temperature between set point and 2 deg F (adjustable) below set point.

B. Cabinet Unit Heater Control:
   1. BMS shall cycle supply fan motor and hot water control valve to maintain space temperature setpoint of 70 deg F (adj).

C. Duct heating coil (DC) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

D. Radiant ceiling panel (RCP) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

E. Finned tube radiation (FTR) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

F. Hot water convector (CONV) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

3.9 SINGLE DUCT SHUT-OFF VAV TERMINAL WITH HOT WATER REHEAT SEQUENCE

A. Occupied Mode: Modulate open primary air valve with a rise in space temperature. With a fall in space temperature, modulate primary air valve towards the minimum setting. With a continued fall in space temperature below the heating set point, modulate open the hot water coil control valve (unit mounted coils and duct mounted booster coils), when valve is 100% open, modulate air valve increasing air flow to maintain space heating set point. In areas with wall radiation, modulate radiation control valve as first stage of heat, modulate reheat coil valve after radiation valve is 100% open. If hot water is not available, close primary air valve 100% with a fall in space temperature below heating set point.

1. The supply air temperature shall be limited to a maximum of 100 deg (adj) to prevent stratification of the space. If the space is not satisfied, modulate the supply air valve open and maintain fixed supply air temperature to satisfy the space.

B. Unoccupied Mode: Open primary air valve, close hot water coil control valve. In areas with wall radiation, modulate radiation control valve as source of heat to maintain reduced heating set point.

3.10 SERIES FAN POWERED VAV TERMINAL UNIT WITH REHEAT SEQUENCE

A. Occupied Mode: Continuous unit fan operation. Modulate open primary air valve with a rise in space temperature. With a fall in temperature, modulate primary air valve towards the minimum setting. With a continued fall in space temperature below the heating set point, modulate open the hot water coil control valve. In areas with wall radiation, modulate radiation control valve as first stage of heat, modulate reheat coil valve after radiation valve is 100% open.

B. Unoccupied Mode: Cycle unit fan and hot water coil valve for full flow to maintain reduced space set point temperature. Close primary air valve. In areas with wall radiation, modulate radiation control valve as first stage of heat to maintain reduced heating set point.

3.11 AIR HANDLING UNITS CONTROL SEQUENCES

A. Safety Controls:
1. Provide an adjustable electric automatic reset freezestat element serpentined across the face of the leaving air side of the heating coil which will stop the supply fan, close the outside air damper and position heating control valve for full coil water flow.
2. Freezestat shall be hardwired to fan circuit. If low limit is detected, the BMS shall close the outside air damper, maintain supply fan on, display a low limit notification on the graphics, and wait 15 minutes. Reset to normal mode and open outside air damper.
3. If low limit sensor trips 3 times within a 1 hour time frame, generate a critical low limit alarm and lock out the unit requiring a software reset before running. Close outside air damper to 0%, open return damper to 100%, stop all supply, return, and relief fans.
4. Low limit capillary shall have 1 ft of tube for every 1 sq ft of coil surface.
5. NOT USED
6. Provide a high-limit controller to prevent unit discharge air from rising above 125 deg F (adjustable). Sensor shall be located at the discharge of the unit.

B. CSAC-A1
1. Occupied Mode:
a. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain the variable air volume (VAV) terminal unit with the greatest call for cooling at least 85% open. Increase duct static pressure at a rate of 0.25” every 10 minutes (adjustable) until any VAV terminal unit exceeding 95% open, closes down to 85% open. Duct static pressure shall be determined by pressure sensors located 2/3 down the

longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0" w.c. (adjustable).

b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain maximum zone CO2 level at 1000 ppm (adj). Outside air damper shall remain open at least 10% (adj) during occupied mode. If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.

c. Modulate the hot water coil control valve and stages of DX cooling as required to maintain DAT set point. Reset DAT to maximum possible temperature to satisfy zone with the greatest call for cooling. Minimum DAT shall be 42 deg F (adjustable).

2. Unoccupied Mode:

a. Close outside air dampers, unit supply fan to remain off. On call for heating or cooling from any zone, cycle fan, hot water coil control valve, and stages of DX cooling as required to maintain unoccupied space set point.

C. CSAC-B1, C1

1. Occupied Mode:

a. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain the variable air volume (VAV) terminal unit with the greatest call for cooling at least 85% open. Increase duct static pressure at a rate of 0.25" every 10 minutes (adjustable) until any VAV terminal unit exceeding 95% open, closes down to 85% open. Duct static pressure shall be determined by pressure sensors located 2/3 down the longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0" w.c. (adjustable).

b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain maximum zone CO2 level at 1000 ppm (adj). Outside air damper shall remain open at least 10% (adj) during occupied mode. If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.

c. If the outside air temperature is below 35 deg F (adjustable), provide full heating coil flow and modulate face and bypass dampers as required to maintain discharge air temperature (DAT) set point. If outside air temperature is 35 deg F or higher (adjustable), provide full airflow to the face of the coil and modulate the hot water coil control valve and chilled water coil control valve as required to maintain DAT set point. Reset DAT to maximum possible temperature to satisfy zone with the greatest call for cooling. Minimum DAT shall be 42 deg F (adjustable).

2. Unoccupied Mode:

a. Close outside air dampers, unit supply fan to remain off. On call for heating or cooling from any zone, cycle fan, hot water coil control valve, and chilled water coil control valve to maintain unoccupied DAT setpoint.

D. CSAC-E1, F1, F2

1. Occupied Mode:

a. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain the variable air volume (VAV) terminal unit with the greatest call for cooling at least 85% open. Increase duct static pressure at a rate of 0.25" every 10 minutes (adjustable) until any VAV terminal unit exceeding 95% open, closes down to 85% open. Duct static pressure shall be determined by pressure sensors located 2/3 down the longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0" w.c. (adjustable).

b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain maximum zone CO2 level at 1000 ppm (adj). Outside air damper shall remain open at least 10% (adj) during occupied mode. If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.

c. Modulate the hot water coil control valve and chilled water coil control valve as required to maintain DAT set point. Reset DAT to maximum possible temperature to satisfy zone with the greatest call for cooling. Minimum DAT shall be 42 deg F (adjustable).

2. Unoccupied Mode:

a. Close outside air dampers, unit supply fan to remain off. On call for heating or cooling from any zone, cycle fan, hot water coil control valve, and chilled water coil control valve as required to maintain unoccupied space set point.

E. CSAC-D1

1. Occupied Mode:

a. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain the variable air volume (VAV) terminal unit with the greatest call for cooling at least 85% open. Increase duct static pressure at a rate of 0.25" every 10 minutes (adjustable) until any VAV terminal unit exceeding 95% open, closes down to 85% open. Duct static pressure shall be determined by pressure sensors located 2/3 down the longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0" w.c. (adjustable).

b. The outside air damper shall be opened to provide minimum outside air from ERV. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain maximum zone CO2 level at 1000 ppm (adj). Outside air damper shall remain open at least 10% (adj) during occupied mode. If outside air temperature is less than space and cooling is required, modulate economizer outside air

damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.

c. Modulate the hot water coil control valve and stages of DX cooling as required to maintain DAT set point. Reset DAT to maximum possible temperature to satisfy zone with the greatest call for cooling. Minimum DAT shall be 42 deg F (adjustable).

2. Unoccupied Mode:
   a. Close outside air dampers, unit supply fan to remain off. On call for heating or cooling from any zone, cycle fan, hot water coil control valve, and stages of DX cooling as required to maintain unoccupied space set point.

F. CSAC-G1
1. Occupied Mode:
   a. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain constant supply air CFM as determined by TAB.
   b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain maximum zone CO2 level at 1000 ppm (adj). If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.
   c. Modulate the hot water coil control valve and chilled water coil control valve as required to maintain space temperature setpoint.
   d. If outside air temperature is greater than 35 degrees F (adj) and the zone relative humidity rises above 55% (adj) BMS shall modulate supply fan speed to 50%, modulate hot water reheat coil control valve as required to maintain zone relative humidity below 50% RH (adj). Modulate chilled water coil control valve as required to maintain space temperature setpoint.

2. Unoccupied Mode:
   a. Close outside air dampers, unit supply fan to remain off. On call for heating or cooling from any zone, cycle fan, hot water coil control valve, and chilled water coil control valve as required to maintain unoccupied space set point.
   b. If outside air temperature is greater than 35 degrees F (adj) and the zone relative humidity rises above 55% (adj) BMS shall modulate supply fan speed to 50%, modulate hot water reheat coil control valve as required to maintain zone relative humidity below 50% RH (adj). Modulate chilled water coil control valve as required to maintain space temperature setpoint.

G. ERW-A
1. Occupied Mode:
   a. Open outside air and relief air dampers.
   b. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain constant supply air CFM as determined by TAB.

c. Relief fan shall operate continuously. Variable speed drive (VSD) shall modulate relief fan to maintain constant supply air CFM as determined by TAB.
d. BMS shall enable energy recovery wheel VFD to run at constant speed.

2. Unoccupied Mode:
a. Close outside air dampers, unit supply fan and relief fan to remain off. Energy recovery wheel shall remain off.

3.12 SINGLE DUCT SHUT-OFF VAV TERMINAL WITH HOT WATER REHEAT SEQUENCE

A. Occupied Mode: Modulate open primary air valve with a rise in space temperature. With a fall in space temperature, modulate primary air valve towards the minimum setting. With a continued fall in space temperature below the heating set point, modulate open the hot water coil control valve (unit mounted coils and duct mounted booster coils), when valve is 100% open, modulate air valve increasing air flow to maintain space heating set point. In areas with wall radiation, modulate radiation control valve as first stage of heat, modulate reheat coil valve after radiation valve is 100% open. If hot water is not available, close primary air valve 100% with a fall in space temperature below heating set point.
1. The supply air temperature shall be limited to a maximum of 100 deg (adj) to prevent stratification of the space. If the space is not satisfied, modulate the supply air valve open and maintain fixed supply air temperature to satisfy the space.

B. Unoccupied Mode: Open primary air valve, close hot water coil control valve. In areas with wall radiation, modulate radiation control valve as source of heat to maintain reduced heating set point.

3.13 EXHAUST FAN CONTROL SEQUENCES

A. General: Motorized dampers associated with exhaust fans shall be interlocked to open 100% and prove open prior to fan activation.

B. General exhaust fans (EF): Scheduled operation. During occupied mode, BMS shall open exhaust air damper. On contact closure from exhaust air damper end switch, BMS shall enable exhaust fan. During unoccupied mode, BMS shall disable fan and close exhaust air damper.

C. Refrigerant exhaust fan EF-1: BMS shall open dampers and energize fan from the refrigerant monitoring system to purge room of refrigerant. Interlock with motorized damper located in intake opening to open 100%.

D. Relief fans (RF): Scheduled operation. During occupied cycle of associated air handling equipment, BMS shall open relief air damper. If space static pressure rises to above 0.05” WC (adj), BMS shall enable and modulate relief fans to maintain space static pressure at 0.05” WC (adj). For air handling systems with multiple relief fans, BMS shall stage relief fans lead-lag. BMS shall enable lead fan and modulate from 30% (adj) to 50% (adj) speed. When lead fan is at 50% speed, if space static is above setpoint, BMS shall enable lag fan and modulate at 50% speed. Additional lag fans

shall be enabled and modulated individually and consecutively from 30% (adj) to 50% (adj) as required to maintain space static setpoint. If all fans have been enabled and space static pressure if above setpoint, BMS shall modulate all fans simultaneously from 50% (adj) to 100% (adj) as required to maintain space pressure setpoint. Fans shall be disabled in the same sequence they are enabled. BMS shall alternate lead fan daily.

3.14 PUMP CONTROL SEQUENCES

A. P-1, P-2 (Variable Flow Primary Hot Water Loop): Variable volume, lead/lag parallel pumping. Energize lead variable volume pump on a call for hot water. Modulate lead pump with a 4-20 mA output to the variable speed drive (VSD) to maintain a 10 PSIG (adjustable) differential pressure across the supply and return mains as locations shown on plans or approximately 2/3 down the longest run. If lead pump VSD increases to above 55 Hz and differential pressure is below setpoint for a time period of 60 seconds (adj), energize the variable speed lag pump (second stage) and match speed of pumps to maintain minimum differential pressure across supply and return main sensor(s). De-energize the lag pump with pump speed falls 10% (adjustable) below the speed established immediately after starting the lag pump. The BMS shall monitor each differential pressure sensor across the supply and return mains at least once every two (2) seconds. With a failure of the lead pump to establish flow within 15 seconds after a call to operate, start the lag pump and generate an alarm message reading “PUMP FAILURE” to be automatically displayed on the workstation PC monitor.

B. P-X (Chiller Primary Chilled Water Loop): BMS is to cycle pumps with their respective chillers when BMS has chiller enabled. Pump shall continue to operate for a period of 30 seconds (adjustable) following the shutdown of the chiller.

C. P-X (Secondary Building Chilled Water Distribution Loop): Variable volume pumping. Energize lead variable volume pump on a call for chilled water. Modulate lead pump with a 4-20 mA output to the variable speed drive (VSD) to maintain a 10 PSIG (adjustable) differential pressure across the supply and return mains at locations shown. With a failure of the lead pump to establish flow within 15 seconds after a call to operate, start the lag pump and generate an alarm message reading "SECONDARY BUILDING CHILLED WATER DISTRIBUTION LOOP LEAD PUMP FAILURE" to be automatically displayed on the work station PC monitor.

3.15 BOILER AND HEATING WATER CONTROL SEQUENCES

A. The BMS shall enable the boiler plant and provide 4-20 mA or 0-10 Volt setpoint to packaged boiler controller. Reset maximum HW Setpoint based on outside air reset schedule (editable via graphics).
1. When outside air is 0 deg F, HW Supply shall be 180 deg F.
2. When outside air is 60 deg F, HW Supply shall be 140 deg F.

B. On a call for hot water the BMS shall energize the hot water distribution pump(s), and packaged controls shall be enabled to maintain the hot water loop temperature. The packaged controls shall activate and stage boilers and their associated control valves as required to maintain the loop supply and return water temperatures. The boiler controller shall sequence the boilers and modulate output such that total system

efficiency is maximized by using multiple boilers on low fire. The packaged controller shall have a set of dry contacts to notify the BMS of any alarm state within the boiler plant or controller.

3.16 CHILLER AND CHILLED WATER CONTROL SEQUENCE

A. During "Occupied Mode", the BMS shall enable the lead chiller when economizer cooling is not sufficient to satisfy space cooling needs, the ambient temperature is above 50 deg F, and there is a call for chilled water. The supply water temperature will be reset by a 4-20 mA or 0-10 VDC output signal from the BMS to the chiller microprocessor to satisfy zone with greatest cooling demand or dehumidification demand. If any zone humidistat exceeds set point, the BMS will reset the chiller leaving water temperature to the 42 deg F (adjustable) minimum leaving water temperature. Contractor shall provide interlock wiring between flow switches and discharge controller sensors at chiller evaporator and condenser water barrels and chiller control panel.

B. During "Unoccupied Mode", when any space temperature is above unoccupied setpoint temperature or when any any zone humidistat exceeds set point and outdoor air enthalpy is not adequate for dehumidification, the BMS shall enable the lead chiller and reset the chiller leaving water temperature to the 42 deg F (adjustable) minimum leaving water temperature. All chillers are to remain off otherwise.

C. Monitor and trend chiller electrical load (kW) on a daily basis and maintain the maximum electrical load for each chiller on each day for a period of one year in a trend log.

SUNMAN ELEMENTARY

3.17 ALARMS

A. Generate an alarm at the PC workstation when any space temperature is <50 def F for 15 minutes (adjustable) and an immediate alarm when any space temperature is <40 deg F (adjustable).

B. Coordinate with the owner to identify alarms as "general" or " critical". General alarms will only be displayed at the PC workstation. Critical alarms will be displayed at the PC workstation and dialed-out to pre-programmed telephone numbers through the internal PC modem.

3.18 MONITORING SEQUENCES

A. Monitor temperature(s) of walk in food freezer(s) and cooler(s) and trend this data for a period of two weeks (adjustable) and a sample rate of one reading every 5 minutes (adjustable). Generate an alarm at the PC workstation if the temperature rises above user defined set point.

B. Monitor each boiler room containing gas fired boilers or water heaters with a carbon monoxide sensor and trend for a minimum of 48 hours. Provide an audio/visual alarm with a minimum of 85 dB sound level. Provide signage near the alarm reading “Carbon Monoxide Alarm”.

1. On alarm exceeding 200 ppm, all gas fired equipment shall be shut down.
2. A local alarm inside the room shall activate with the following levels:
   a. 9 ppm or greater for a duration of 8 hours.
   b. 40 ppm or greater for a duration of 5 hours.
   c. 70 ppm or greater for a duration of 1 hour.
   d. 200 ppm or greater for a duration of 15 minutes.

C. Monitor status of refrigerant monitoring system. On a local alarm by the refrigerant monitoring system, generate an alarm at the PC workstation stating, “REFRIGERANT SYSTEM ALARM”.
   1. Provide with manual HOA over-ride button outside of chiller equipment room for BMS to disable chiller plant by shutting down all chillers in the room. Button shall be secured with beak-glass box.
   2. Provide with manual HOA over-ride button outside of chiller equipment room to over-ride purge fan and associated intake/exhaust control dampers. Button shall be secured with break-glass box.

D. Monitor temperature of domestic hot water downstream of thermostatic mixing valve and generate an alarm if the temperature rises 5 degrees (adjustable) above specified set point.

E. Monitor pressure of domestic water main entrance (downstream of booster pump) and generate an alarm if the system pressure drops below 35 psi (adjustable).

F. Monitor status of kitchen exhaust hood fan.

3.19 HVAC ZONE CONTROL SEQUENCES

A. Provide software time clock and set-up schedule to place each HVAC system into occupied or unoccupied mode. Provide an override push button on each space temperature sensor to place the respective zone air handler into the occupied mode for a two-hour period (adjustable) when button is pushed. When the button is pushed again prior to the override time expiring, the zone air handler will revert to the scheduled operating mode.

B. Where carbon dioxide (CO2) sensors are present, the BMS shall monitor the space or return duct CO2 concentration and reset the outside air damper to increase ventilation rates to prevent high levels of CO2 in a space.
   1. If CO2 is above 900 ppm for a period of at least 5 minutes and the space in an occupied mode, increase OA damper position 5% every 5 minutes until the space CO2 decreases below 700 ppm, the resume normal OA setpoint.
   2. Maximum outside air damper position shall be determined if supply air temperature setpoint can not be maintained with 100% heating or cooling, depending on mode. Do not sacrifice supply air temperature upper and lower limits during CO2 reset mode.

C. If space has occupancy sensors present, BMS shall integrate them into controls for stand-by mode. TCC shall connect to auxiliary contacts on the sensor where possible, or provide a relay powered by the lighting circuit downstream of the occupancy sensor to indicate occupancy.

1. If space is in occupied mode, but occupancy is not detected for more than 20 minutes (adj), the BMS shall place the space into standby mode. When occupancy is detected, the BMS shall immediately revert back to normal occupied mode.
2. If a space is in standby mode and schedule changes to unoccupied mode, the system shall revert to unoccupied mode and discontinue the standby mode.
3. If a space is placed into standby mode
   a. The outside air damper(s) shall close 100% for unit ventilators, fan coils, and single zone air handlers.
   b. VAV box zones shall set the box to minimum airflow setting.
   c. Maintain space temperature at an offset of 2 deg F (adj) below the current effective space setpoint in heating mode, and 2 deg F (adj) above the current effective space setpoint in cooling mode.

D. All systems and spaces shall be linked to a global room temperature setpoint value that the Owner can change a single value that effectively creates a single temperature setpoint with specified adjustment (+2 deg/-2 deg) that all systems and all spaces use for master control of the facility/campus temperature and energy control.

E. Equipment rotation shall be configured on all systems where more than one equipment item is used to function as a team, such as pumps, chillers, boilers, relief fans, etc. The controls shall be configured to equalize run time on all items. Utilize a “first-on, first-off” approach unless noted otherwise or if Owner’s campus standards stipulate specific rotation schedules.

F. All heating hot water coils shall utilize the following for coil freeze protection if they are the primary heating coil for air handlers, unit ventilators, single zone duct coil, that has outside air to the equipment.
   1. If outside air temperature is less than 35 deg F (global adj.) the hot water coil shall never close 100%. Maintain coil a minimum of 10% open at all times, even with equipment fans turned off.
   2. If unit is shut off and outside air temperature is less than 35 deg (global adj.), mixed air temperature sensor and freezestat shall monitor temperature inside of air handler equipment such that if duct temperature less than 40 deg F is detected, BMS shall activate fan to circulate air through the unit at minimum speed until mixed air temperature is above 50 deg F and a minimum run time of 15 minutes (global adj).
   3. If mixed air temperature drops to below 30 deg F while the unit is off, BMS shall generate critical alarm and open hot water coil 100%.

3.20 FAN COIL UNIT CONTROL SEQUENCES

A. Fan Coil Unit (FCU):
   1. Occupied Mode: Continuous fan operation, modulate stages of DX cooling as required to maintain cooling set point.
   2. Unoccupied Mode: Cycle fan and stages of DX cooling to maintain reduced unoccupied space set point.

3.21 TERMINAL UNIT CONTROL SEQUENCES

A. Unit Heater Control: A 24-volt wall mounted thermostat shall cycle fan motor to maintain space temperature between set point and 2 deg F (adjustable) below set point.

B. Cabinet Unit Heater Control:
1. BMS shall cycle supply fan motor and hot water control valve to maintain space temperature setpoint of 70 deg F (adj).

C. Duct heating coil (DC) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

D. Radiant ceiling panel (RCP) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

E. Wall mounted radiant panel (RAD) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

3.22 UNIT VENTILATOR CONTROL SEQUENCE

A. Safety Controls:
1. Provide an adjustable electric automatic reset freezestat element serpentined across the face of the leaving air side of the heating coil which will stop the supply fan, close the outside air damper and position heating control valve for full coil water flow. Freezestat shall be hardwired to fan circuit.
2. Low limit capillary shall have 1 ft of tube for every 1 sq ft of coil surface.

B. UV (Heating, Cooling, & Ventilating)
1. Occupied Mode:
a. Supply fan shall operate continuously. Open outside air damper to provide minimum ventilation. Modulate outside air damper position to maintain space CO2 at 1000 ppm (adj). BMS shall open relief air dampers on building relief roof caps.
b. Modulate the hot water coil control valve and chilled water coil control valve to maintain space temperature set point.
c. If outside air dry bulb temperature is less than space and cooling is required, modulate outside and return air dampers for economizer cooling while maintaining a minimum discharge temperature based on the following reset schedule:

SPACE TEMPERATURE	DISCHARGE AIR TEMPERATURE
Set point + 4 deg F	55 deg F (adjustable)
Set point	65 deg F (adjustable)

d. If outside air temperature drops below 35 deg F (adj) modulate hot water coil control valve 100% open and modulate face and bypass dampers to maintain space temperature setpoint.
e. Base Bid: Dehumidification Sequence
a) If zone humidity rises above set point (55% RH, adjustable) at the zone humidistat and outside air temperature is above 60 degrees F (adj), enable dehumidification sequence as follows:

b) When space temperature is below setpoint, close outside air damper, modulate fan speed to 50% (adj), modulate face and bypass damper to 100% bypass, and close chilled water valve
c) When space temperature is above setpoint, open chilled water valve 100%.
d) After 60 second time delay (adj), modulate face and bypass damper to 50% open (adj), modulate supply fan speed to 50% (adj), and modulate outside air damper to maintain space CO2 at 800 ppm (adj).
e) When space temperature is below setpoint, close outside air damper, modulate fan speed to 50% (adj), modulate face and bypass damper to 100% bypass, and close chilled water valve. Repeat 1-4 until zone humidity is below 50% RH (adj) when zone temperature is at space cooling temperature setpoint.

2) Alternate Bid: Dehumidification Sequence
a) When outside air temperature is above 50 degrees F (adj), enable hot water reheat coil control valve to modulate as required to maintain zone relative humidity at 50 % RH (adj).

2. Unoccupied Mode:
a. Cycle fan, hot water coil control valve, and chilled water coil control valve to full open to maintain reduced unoccupied space temperature set point. Limit discharge air temperature to 30 degrees above space temperature. Close outside air damper.
b. Base Bid: Dehumidification Sequence
1) If zone humidity rises above unoccupied set point (60% RH, adjustable) at the zone humidistat and outside air temperature is above 60 degrees F (adj), enable unoccupied dehumidification sequence as follows:
a) Modulate fan speed to 100% (adj) and modulate hot water control valve to maintain space temperature at 78 degrees F (adj) for 30 minutes (adj).
b) Modulate fan speed to 30% (adj), modulate hot water control valve to 0%, modulate face and bypass damper to 50% (adj), and modulate chilled water control valve to 100% until space temperature is at 68 degrees F (adj).
c) Modulate fan speed to 0% (adj), modulate chilled water control valve to 0 %, and modulate face and bypass damper to 100% open through bypass.
d) After time delay of 30 minutes (adj) modulate fan speed to 100% (adj), modulate chilled water control valve to 0 %, and modulate face and bypass damper to 100% open through bypass.
e) After time delay of 30 minutes (adj) modulate hot water control valve to 50% open (adj).
f) After time delay of 10 minutes (adj) end unoccupied dehumidification sequence and return to unoccupied space temperature setpoint control.
g) If zone humidity rises above unoccupied set point (60% RH, adjustable) at the zone humidistat and outside air temperature

is above 60 degrees F (adj) and time is before 3:00 AM, repeat 1-6.

c. Alternate Bid: Dehumidification Sequence

a) When outside air temperature is above 50 degrees F (adj), enable hot water reheat coil control valve to modulate as required to maintain zone relative humidity at 50 % RH (adj).

3.23 AIR HANDLING UNITS CONTROL SEQUENCES

A. Safety Controls:

1. Provide an adjustable electric automatic reset freezestat element serpentined across the face of the leaving air side of the heating coil which will stop the supply fan, close the outside air damper and position heating control valve for full coil water flow.
2. Freezestat shall be hardwired to fan circuit. If low limit is detected, the BMS shall close the outside air damper, maintain supply fan on, display a low limit notification on the graphics, and wait 15 minutes. Reset to normal mode and open outside air damper.
3. If low limit sensor trips 3 times within a 1 hour time frame, generate a critical low limit alarm and lock out the unit requiring a software reset before running. Close outside air damper to 0%, open return damper to 100%, stop all supply, return, and relief fans.
4. Low limit capillary shall have 1 ft of tube for every 1 sq ft of coil surface.
5. NOT USED
6. Provide a high-limit controller to prevent unit discharge air from rising above 125 deg F (adjustable). Sensor shall be located at the discharge of the unit.

B. AHU-1, AHU-3

1. Occupied Mode:
   a. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain the variable air volume (VAV) terminal unit with the greatest call for cooling at least 85% open. Increase duct static pressure at a rate of 0.25” every 10 minutes (adjustable) until any VAV terminal unit exceeding 95% open, closes down to 85% open. Duct static pressure shall be determined by pressure sensors located 2/3 down the longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0” w.c. (adjustable).
   b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain maximum zone CO2 level at 1000 ppm (adj). Outside air damper shall remain open at least 10% (adj) during occupied mode. If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F. BMS shall open relief air dampers on building relief roof caps.
   c. If the outside air temperature is below 35 deg F (adjustable), provide full heating coil flow and modulate face and bypass dampers as required to maintain discharge air temperature (DAT) set point. If outside air temperature is 35 deg F or higher (adjustable), provide full airflow to the

face of the coil and modulate the hot water coil control valve and stages of outside air module DX cooling as required to maintain outside air module DAT set point and stages of return air module DX cooling as required to maintain return air module DAT setpoint. Reset DAT to maximum possible temperature to satisfy zone with the greatest call for cooling. Minimum DAT shall be 42 deg F (adjustable).

2. Unoccupied Mode:
   a. Close outside air dampers, unit supply fan to remain off. Cycle fan and hot water coil control valve to maintain reduced unoccupied space heating set point. If outside air temperature is below 35 degrees F (adj), close heating coil face and bypass dampers and open heating coil control valve 10% (adj).
   b. If outside air temperature is above 55 deg F (adjustable) and there is a call for cooling, enable supply fan and modulate stages of return air module DX cooling to maintain return air module DAT setpoint.

C. AHU-2, AHU-E1 through AHU-E4
   1. Occupied Mode:
      a. Supply fan shall operate continuously. BMS shall supply signal to variable speed drive (VSD) to maintain design supply air CFM as determined by Test and Balance (TAB).
      b. BMS shall modulate outside air dampers to maintain minimum outside air intake airflow. BMS shall modulate outside air damper and return air damper position as required to maintain maximum zone CO2 level at 1000 ppm (adj). Outside air damper shall remain open at least 10% (adj) during occupied mode. If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F. BMS shall open relief air dampers on building relief roof caps.
      c. Modulate stages of DX cooling and hot water coil control valve as required to maintain space temperature setpoints.
      d. If outside air temperature is greater than 35 degrees F (adj) and the zone relative humidity rises above 55% (adj) BMS shall modulate supply fan speed to 50%, modulate hot water reheat coil control valve as required to maintain zone relative humidity below 50% RH (adj). Modulate stages of DX cooling as required to maintain space temperature setpoint. Reset DAT to maximum possible temperature to satisfy zone with the greatest call for cooling. Minimum DAT shall be 42 deg F (adjustable).
   2. Unoccupied Mode:
      a. BMS shall close outside air dampers. Cycle fan, hot water coil control valve, and stages of DX cooling as required to maintain unoccupied space heating and cooling setpoint. If zone relative humidity rises above 60% RH (adj), BMS shall modulate supply fan speed to 50%, modulate hot water reheat coil control valve as required to maintain zone relative humidity below 50% RH (adj). Modulate stages of DX cooling as required to maintain space temperature setpoint.

3.24 ROOFTOP UNIT SEQUENCES

A. RTU-1, 2, 3
   1. Occupied Mode:
      a. Supply fan shall operate continuously. Activate stages of DX cooling as required to maintain space temperature.
   2. Unoccupied Mode:
      a. Cycle supply fan and stages cooling as required to maintain set back temperature.

3.25 EXHAUST FAN CONTROL SEQUENCES

A. General: Motorized dampers associated with exhaust fans shall be interlocked to open 100% and prove open prior to fan activation.

B. General exhaust fans (EF): Scheduled operation. During occupied mode, BMS shall open exhaust air damper. On contact closure from exhaust air damper end switch, BMS shall enable exhaust fan. During unoccupied mode, BMS shall disable fan and close exhaust air damper.

C. Refrigerant exhaust fan EF-1: BMS shall open dampers and energize fan from the refrigerant monitoring system to purge room of refrigerant. Interlock with motorized damper located in intake opening to open 100%.

D. Relief fans (RF): Scheduled operation. During occupied cycle of associated air handling equipment, BMS shall open relief air damper. If space static pressure rises to above 0.05” WC (adj), BMS shall enable and modulate relief fans to maintain space static pressure at 0.05” WC (adj). For air handling systems with multiple relief fans, BMS shall stage relief fans lead-lag. BMS shall enable lead fan and modulate from 30% (adj) to 50% (adj) speed. When lead fan is at 50% speed, if space static is above setpoint, BMS shall enable lag fan and modulate at 50% speed. Additional lag fans shall be enabled and modulated individually and consecutively from 30% (adj) to 50% (adj) as required to maintain space static setpoint. If all fans have been enabled and space static pressure if above setpoint, BMS shall modulate all fans simultaneously from 50% (adj) to 100% (adj) as required to maintain space pressure setpoint. Fans shall be disabled in the same sequence they are enabled. BMS shall alternate lead fan daily.

3.26 SINGLE DUCT SHUT-OFF VAV TERMINAL WITH HOT WATER REHEAT SEQUENCE

A. General:
   1. This sequence applies to VAVs with re-heat where the associated AHU is scheduled either ON or OFF.
   2. Rooms that have occupancy sensors associated with their VAV terminals will have the following modes:
      a. Occupied Mode - AHU scheduled ON - Occupancy sensor Occupied
      b. Standby Mode - AHU scheduled ON - Occupancy sensor Unoccupied
      c. Unoccupied Mode - AHU scheduled OFF (Occupancy sensor is not considered)

3. Rooms that do not have occupancy sensors associated with their VAV terminals will have only Occupied Mode and Unoccupied Mode (matching the AHU Schedule - ON and OFF consecutively)
4. Normally Occupied spaces include all spaces except the following: Hallways, mechanical and electrical rooms, and IT closets.

B. Occupied Mode (AHU scheduled ON; Occupancy sensor is "Occupied"):
1. Cooling: When space temperature is above the Occupied cooling setpoint, the VAV damper will modulate from minimum CFM up to maximum CFM. On a fall in space temperature, the VAV damper will modulate back to minimum CFM. The reheat valve will remain closed.
2. Heating: When space temperature falls below the Occupied heating setpoint, the following will occur:
   a. With the primary VAV damper open to minimum airflow, the reheat valve will modulate open up to the point that the discharge temperature reaches 90°F.
   b. If the heating setpoint is still not satisfied, the VAV primary air damper will slowly modulate open up to the scheduled maximum cfm while maintaining a 90°F discharge temperature. The increase in airflow shall stop if the 90°F discharge temperature cannot be maintained.
   c. On an increase in space temperature above the heating setpoint, the VAV damper will modulate back to minimum CFM while the reheat valve simultaneously modulates to maintain the 90F discharge temperature.
   d. When the VAV is at minimum flow and the space is still above the Occupied setpoint, the reheat valve will modulate closed.

C. Standby Mode (AHU scheduled ON; Occupancy sensor is "Unoccupied"):
1. The minimum flow setpoint will be reset to minimum airflow.
2. Cooling: When space temperature is above the Standby cooling setpoint, the VAV damper will modulate from minimum airflow up to maximum CFM to maintain the standby cooling setpoint. On a fall in space temperature, the VAV damper will modulate back to minimum airflow. The reheat valve will remain closed.
3. Heating: When space temperature falls below the Standby heating setpoint, the following will occur:
   a. With the primary VAV damper open to minimum occupied airflow, the reheat valve will modulate open up to the point that the discharge temperature reaches 90°F.
   b. If the standby heating setpoint is still not satisfied, the VAV primary air damper will slowly modulate open up to the scheduled maximum cfm while maintaining a 90°F discharge temperature. The increase in airflow shall stop if the 90°F discharge temperature cannot be maintained.
   c. When the space temperature warms to the standby heating setpoint, the VAV damper will modulate back to minimum occupied airflow.
4. If the space temperature is still above standby heating setpoint the reheat valve will close and the VAV damper will close.

D. Unscheduled Mode (AHU scheduled OFF, Occupancy sensor not considered):
1. The VAV damper will go to minimum airflow.
2. Cooling: When space temperature rises above the Unscheduled cooling setpoint for any normally occupied space, the following will occur:

3. The associated air handling unit will start. (see AHU sequence)
4. Open the VAV damper fully for any normally occupied space that is less than 5 degrees below the Unscheduled cooling setpoint. (any space above 80)
5. When the space temperature cools to 5°F below the Unscheduled setpoint, the VAV damper will go to minimum airflow.
6. Once all the normally occupied spaces are 5°F below the Unscheduled cooling setpoint, the air handling unit will shut off. (see AHU sequence)
7. Heating: When the space temperature falls below the Unscheduled heating setpoint, the following will occur:
   a. Open the VAV damper fully and start the associated AHU.
   b. With the VAV damper open, the reheat valve will modulate open until the discharge temperature reaches 90°F.
   c. When the space temperature warms to 5°F above the unscheduled setpoint the associated AHU will stop, the reheat valve will close, and after 5 minutes (adj.) the VAV damper will close.

E. CO2 Mode (For Spaces with CO2 sensors in the Occupied Mode)
1. Maintaining carbon dioxide concentrations below the maximum setpoint will be accomplished with a supervisory control loop running in parallel with the temperature control described in the Occupied Mode. This loop shall compare the measured room CO2 concentration with the setpoint and output a flow demand for the VAV.
2. As CO2 concentration increases from 500 ppm to 900 ppm, the control loop will increase its output from minimum airflow to the VAV maximum
3. The VAV damper shall control to the higher of the CO2 loop flow demand and the temperature control flow demand.
4. The re-heat valve will modulate as required to maintain room temperature setpoint without increasing the discharge air temperature above 95°F.

3.27 PUMP CONTROL SEQUENCES

A. P-1, P-2 (Variable Flow Primary Hot Water Loop): Variable volume, lead/lag parallel pumping. Energize lead variable volume pump on a call for hot water. Modulate lead pump with a 4-20 mA output to the variable speed drive (VSD) to maintain a 10 PSIG (adjustable) differential pressure across the supply and return mains as locations shown on plans or approximately 2/3 down the longest run. If lead pump VSD increases to above 55 Hz and differential pressure is below setpoint for a time period of 60 seconds (adj), energize the variable speed lag pump (second stage) and match speed of pumps to maintain minimum differential pressure across supply and return main sensor(s). De-energize the lag pump with pump speed falls 10% (adjustable) below the speed established immediately after starting the lag pump. The BMS shall monitor each differential pressure sensor across the supply and return mains at least once every two (2) seconds. With a failure of the lead pump to establish flow within 15 seconds after a call to operate, start the lag pump and generate an alarm message reading “PUMP FAILURE” to be automatically displayed on the workstation PC monitor.

B. P-X (Chiller Primary Chilled Water Loop): BMS is to cycle pumps with their respective chillers when BMS has chiller enabled. Pump shall continue to operate for a period of 30 seconds (adjustable) following the shutdown of the chiller.

C. P-X (Secondary Building Chilled Water Distribution Loop): Variable volume pumping. Energize lead variable volume pump on a call for chilled water. Modulate lead pump with a 4-20 mA output to the variable speed drive (VSD) to maintain a 10 PSIG (adjustable) differential pressure across the supply and return mains at locations shown. With a failure of the lead pump to establish flow within 15 seconds after a call to operate, start the lag pump and generate an alarm message reading "SECONDARY BUILDING CHILLED WATER DISTRIBUTION LOOP LEAD PUMP FAILURE" to be automatically displayed on the work station PC monitor.

3.28 BOILER AND HEATING WATER CONTROL SEQUENCES

A. The BMS shall enable the boiler plant and provide 4-20 mA or 0-10 Volt setpoint to packaged boiler controller. Reset maximum HW Setpoint based on outside air reset schedule (editable via graphics).
1. When outside air is 0 deg F, HW Supply shall be 180 deg F.
2. When outside air is 60 deg F, HW Supply shall be 140 deg F.

B. On a call for hot water the BMS shall energize the hot water distribution pump(s), and packaged controls shall be enabled to maintain the hot water loop temperature. The packaged controls shall activate and stage boilers and their associated control valves as required to maintain the loop supply and return water temperatures. The boiler controller shall sequence the boilers and modulate output such that total system efficiency is maximized by using multiple boilers on low fire. The packaged controller shall have a set of dry contacts to notify the BMS of any alarm state within the boiler plant or controller.

3.29 CHILLER AND CHILLED WATER CONTROL SEQUENCE

A. During "Occupied Mode", the BMS shall enable the lead chiller when economizer cooling is not sufficient to satisfy space cooling needs, the ambient temperature is above 50 deg F, and there is a call for chilled water. The supply water temperature will be reset by a 4-20 mA or 0-10 VDC output signal from the BMS to the chiller microprocessor to satisfy zone with greatest cooling demand or dehumidification demand. If any zone humidistat exceeds set point, the BMS will reset the chiller leaving water temperature to the 42 deg F (adjustable) minimum leaving water temperature. Contractor shall provide interlock wiring between flow switches and discharge controller sensors at chiller evaporator and condenser water barrels and chiller control panel.

B. During "Unoccupied Mode", when any space temperature is above unoccupied setpoint temperature or when any zone humidistat exceeds set point and outdoor air enthalpy is not adequate for dehumidification, the BMS shall enable the lead chiller and reset the chiller leaving water temperature to the 42 deg F (adjustable) minimum leaving water temperature. All chillers are to remain off otherwise.

C. Monitor and trend chiller electrical load (kW) on a daily basis and maintain the maximum electrical load for each chiller on each day for a period of one year in a trend log.

END OF SECTION 23 0993