

SECTION 23 09 93

SEQUENCE OF OPERATION

6/18/2018: Revisions for addendum 2 are shown in red and underlined.

PART 1 GENERAL

SECTION INCLUDES

- A. Provide all labor and services to accomplish the sequence specified below.
- B. Provide all cabinets, sensors, actuators, wiring, tubing, graphics and software, in addition to all equipment required in order to accomplish the sequence below.

RELATED SECTIONS

- A. Section 23 09 23 – Direct Digital Control System for HVAC

PART 2 PRODUCTS – NOT USED.

PART 3 EXECUTION

SEQUENCE OF OPERATION

- A. General System Sequences:
 - 1. System shall include 365 day, 24 hour per day programmable capability with ability to program holidays.
 - 2. When in occupied mode, mechanical equipment shall be enabled.
 - 3. When in the unoccupied mode, all equipment shall be normally disabled and shall cycle on only to maintain unoccupied setback temperatures. Provide user adjustable setback temperatures for Winter (set initially at 55°F) and Summer (set initially at 85°F).
 - 4. Each room thermostat shall be equipped with a button to switch from unoccupied mode to occupied mode. When any of these buttons is depressed, the system shall switch to occupied mode for a user adjustable time period (set initially at 2 hours). After the time period has passed, the system shall return to the unoccupied mode.
 - 5. Thermostatic controls shall be capable of having a 5°F dead band between the heating and cooling set point.
- B. All setpoints are user adjustable by the system operator.
- C. Exhaust Fans:
 - 1. Roof mounted exhaust fans serving toilet rooms and the Nurses Suite:
 - a. Exhaust fans operate during occupied hours. Fans are cycled on and off by the BAS. Provide starters or relays as required to control fans.
 - b. Provide status by current sensor. Provide an alarm to the BAS if current sensor indicates that the exhaust fan is not operating.
 - 2. Exhaust fans serving Science Labs, Science Prep Rooms, Art Rooms, Maker Space, Ware-Washing, Custodial 1826 and the Kiln Room:
 - a. Exhaust fan shall be on/off with a wall switch located in the space served.
 - b. Provide fan status by current sensor. Provide an alarm to the BAS if current sensor indicates that the exhaust fan status does not match the command.
 - c. Provide on/off override by the BAS.
 - 3. Kitchen Grease Hood Exhaust Fans
 - a. Kitchen grease hood exhaust fans are on/off by switches located on the hoods.
 - b. Provide fan status by current sensor. Provide an alarm to the BAS if current sensor indicates that the exhaust fan status does not match the command.
 - 4. Ceiling mounted cabinet style exhaust fans serving toilets:
 - a. Ceiling mounted cabinet style exhaust fans are on/off with a wall switch.
 - 5. Ceiling mounted cabinet style exhaust fans serving janitor closets:
 - a. Exhaust fan shall be on/off with a wall switch located in the space served.

- b. Provide on/off override by the BAS.
- 6. Exhaust fan serving Electrical 1319:
 - a. Provide a wall mounted thermostat and hand/off/auto switch.
 - b. When the HOA switch is in auto, the fan shall cycle on for room temperature above setpoint.
 - c. When the HOA switch is in off, the fan shall be off. When the HOA switch is in the on position, the fan shall be on.
 - d. Provide fan status by current sensor. Provide an alarm to the BAS if current sensor indicates that the exhaust fan status does not match the command.

D. Unitary Rooftop Units:

1. Controls internal to the rooftop units will control the operation of the units.
2. Space temperature sensors and CO₂ sensors are provided by the RTU manufacturer.
3. The units will be equipped with BACnet communications interfaces. The interface will make available all points that are standard with the manufacturer's standard interface. All points (inputs, outputs, configuration properties) from this interface are to be mapped to the building management system.
4. Provide graphical interface for each unit.
5. Occupied mode: Rooftop units shall cycle on and controls internal to the unit will maintain the space temperature and relative humidity to the user adjustable setpoints. Units will be capable of cooling, dehumidification (cooling with hot gas reheat), CO₂ demand controlled ventilation, dry bulb economizing and single zone variable air volume operation.
 - a. Space temperature setpoint is by the local setpoint adjuster on the zone temperature sensor. Provide override by the BAS.
 - b. Set maximum indoor relative humidity initially to be 55%. Enable the dehumidification feature (cooling with hot gas reheat) in each RTU.
 - c. Enable the CO₂ demand controlled ventilation in all units except RTU-11 and those listed in the next item. Set maximum indoor CO₂ level initially to be 1000 PPM.
 - d. Enable the dry bulb economizer. Set the outdoor temperature for economizing initially to be 60°F. Disable the economizing sequence at RTU-11.
 - e. Enable the single zone variable air volume feature in all RTUs except RTU 11.
 - f. For RTU 11, provide outdoor air in accordance with the matrix provided on the unit schedule on the construction drawings.
6. CO₂ demand controlled ventilation is disabled in rooftop units 4, 8, 9 and 10. Demand controlled ventilation at these units is by the associated energy recovery ventilator.
7. Unoccupied mode: RTUs are normally off during unoccupied mode. Outside air dampers remain closed. If space temperature rises above the unoccupied setpoint (set initially at 85°F), the unit shall cycle on and cool until the unoccupied space temperature setpoint is satisfied. If space temperature falls below the unoccupied setpoint (set initially at 55°F), the unit shall cycle on and heat until the unoccupied space temperature setpoint is satisfied.
8. Smoke Sequence: Unit(s) shall shut down upon signal from fire alarm system.
9. Morning warmup: During morning warm up, outside air dampers remain closed. The units shall cycle on and heat, cool or dehumidify as needed to bring the space temperature and relative humidity occupied set points.
10. Provide the following control points minimum:

Analog Output
Space temperature setpoint
Space temperature setpoint override
Space temperature
Space relative humidity setpoint
Space relative humidity
Space CO ₂ setpoint
Space CO ₂ concentration

Unoccupied heating setpoint
Unoccupied cooling setpoint
Morning warmup setpoint
Outdoor air temperature
Outdoor air humidity
Outdoor air minimum flow or economizer minimum setpoint

Analog Input
Space temperature cooling setpoint input
Space temperature heating setpoint input
Space temperature local setpoint
Morning warmup setpoint temperature
Discharge air temperature
Cooling capacity status
Heat first stage status
Heat second stage status
Reheat capacity status
Supply fan speed command
Outdoor airflow or economizer minimum
Space CO2 concentration
Dehumidification high limit setpoint

Digital Output
Shut down for smoke alarm
Occupied/unoccupied command
Heat cool mode request
Morning warm up command

Digital Input
Filter status
Condensate drain pan high level

E. Energy Recovery Ventilators

1. Install a CO2 sensor in the return duct from the space, upstream of outside air supplies.
2. The energy recovery ventilators respond to indoor CO2 levels.
3. Set indoor maximum CO2 level initially to 1000 PPM. These values are user adjustable.
4. If indoor CO2 level is below setpoint, the ERV is off.
5. If indoor CO2 level rises above setpoint, the ERV shall cycle on with supply and exhaust fans at 50% speed, and intake and exhaust motorized dampers cycle to open position.
6. Indoor CO2 levels shall be sampled every 10 minutes. If after 10 minutes, the indoor CO2 level is still above setpoint, the ERV supply and exhaust fan speeds shall go to 100%.
7. If fans are operating at 100% and CO2 levels fall 100 PPM below setpoint, the fans shall go to 50%. If fans are operating at 50% and CO2 levels fall 100 PPM below setpoint, the ERV shall cycle off, and intake and exhaust motorized dampers shall cycle to closed position.
8. Frost control sequence: This sequence is integral to the ERV factory controls. On high alarm from wheel mounted pressure sensor, in conjunction with low temperature signal from wheel mounted outdoor air thermostat: unit shall enter timed exhaust sequence.
- 7-9. Filter differential pressure sensor shall signal 'dirty filter' alarm to BAS when differential pressure exceeds setpoint.

F. Type I grease hood and make up air units:

1. The kitchen equipment supplier will provide packaged kitchen hoods and make up air units.

2. The hoods will have a manual hood switch to index the interlocked hood exhaust and make-up air units on and off.
 3. The make-up air unit is a 100% outside air unit with filters and direct fired heat. A differential pressure switch shall be provided across the filters of the make-up air unit. The BAS shall be alarmed when the pressure drop across the filter exceeds the setpoint.
 4. Heating Control: A proportional temperature controller with sensor mounted in the hood supply duct shall be provided. The controller shall modulate the gas control valve to control the supply air leaving temperature to a setpoint of 55 F (adj.). The manufacturer shall provide all required safeties, including an air flow switch.
 5. Provide a smoke detector in the make-up air duct. Activation of the smoke detector, an alarm of the hood fire extinguishing system, or a building fire alarm shall shut down the make-up air unit, while the exhaust fan shall remain in operation. Coordinate with the Electrical Contractor and the Hood supplier. Provide a manual switch in the fire panel to override fan operation in fire mode. The Controls Subcontractor shall be responsible for coordinating all control work and shall provide all wiring, relays, switches, etc., for a complete and operational system.
 6. Provide the following status points:
 - a. Fan status
 - b. Fan start/stop
 - c. High/Low Temp Alarm
- G. Electric Unit Heaters.
1. Unit heaters shall be controlled by local thermostats only.
 2. Upon the space temperature falling below the setpoint (60 deg (adj.)), the unit heater shall be energized and remain so until the space temperature has risen above the setpoint.
- H. Filters:
1. Provide magnehelic style differential pressure gages across filter banks.
 2. Provide filter status (clean/replace) to the BAS. The differential pressure across the filter shall be displayed on the fan coil unit graphic. The differential pressure point for replace status shall be user adjustable.
- I. Ductless Mini-Split systems:
1. Units are controlled by controls integral to the units.
 2. Provide a separate space temperature sensor in rooms served by these units.
 3. Provide space temperature and high temperature alarm to the BAS.
- J. Domestic Hot Water System:
1. Provide on/off control for the domestic hot water circulating pump(s) and for the domestic water heater(s).
 2. During the unoccupied mode, the water heater(s) and circulating pump(s) are off.
 3. The water heater and circulating pump shall cycle on two hours prior to the start of occupied hours. The cycle on start time is user adjustable.
 4. Provide user override of timed operation so that Owner may set water heater and circulating pump to operate continuously.
- K. Smoke Detector Operation
1. Upon alarm by duct mounted smoke detectors or room smoke detectors, roof top units shall shut down.
 2. Smoke detectors and sampling tubes shall be furnished by the electrical contractor for installation by the mechanical contractor. Smoke detectors shall be connected under electrical and installed under the mechanical section of this specification.
- L. Fire Alarm Interface
1. The BAS shall shut-down all air handling equipment as required by code upon contact closure by a remote fire alarm relay located adjacent to the BAS control panel. The HVAC equipment shall de-energize based on whether the dedicated smoke detector or the general

alarm contact is in alarm. The equipment shall include, but not be limited to the following:

- a. Roof top units
2. The BAS shall monitor fire alarm system via BACnet/IP interface in the fire alarm control panel.

END OF SECTION