

ANCHOR BAY SCHOOL DISTRICT
Exhibit D. Sequence of Operations
Vertical Unit Ventilators

7/28/2026

PART 1 – GENERAL

This sequence establishes the operational requirements for all vertical unit ventilators connected to the Automated Logic Building Automation System (BAS). All controllers shall operate as stand-alone BACnet devices while maintaining full integration with the district-wide WebCTRL Building Automation System.

The control sequence shall maximize occupant comfort while minimizing energy consumption and maintaining ventilation requirements in accordance with current mechanical codes and ASHRAE recommendations.

PART 2 – CONTROL MODES

Each unit ventilator shall automatically operate in one of the following modes:

- Morning Warm-Up
- Occupied
- Occupancy Standby
- Cooling Recovery
- Economizer Cooling
- Unoccupied
- Night Setback
- Night Setup
- Freeze Protection
- Emergency Shutdown
- Smoke Control (where applicable)

Mode selection shall occur automatically through the BAS schedule unless overridden by a higher priority command.

Priority of operation shall be:

1. Fire Alarm
2. Emergency Shutdown
3. Freeze Protection
4. BAS Occupancy Schedule
5. Local Temporary Override
6. Manual Operator Command

PART 3 – OCCUPIED MODE

When the BAS places the unit into Occupied Mode:

The controller shall:

- Enable the unit
- Verify fan proof
- Open outside air damper to minimum ventilation position
- Open return air damper accordingly
- Enable room temperature control
- Enable economizer operation when permitted

The controller shall modulate, in sequence:

1. Fan Speed
2. Outside Air Damper
3. Cooling Valve
4. Heating Valve

to maintain the occupied space temperature setpoint.

Simultaneous heating and cooling shall not be permitted.

PART 4 – MORNING WARM-UP

Prior to occupied operation, the BAS shall determine optimum start time.

During Morning Warm-Up:

- Outside air damper closed
- Return air damper fully open
- Fan operates continuously
- Heating valve modulates to maintain discharge air temperature

Morning Warm-Up shall terminate when either:

- Room reaches occupied heating setpoint

OR

- Maximum warm-up timer expires.

Default timer: 90 minutes (adjustable)

PART 5 – COOLING RECOVERY

When space temperature exceeds occupied cooling setpoint prior to occupancy:

- Fan shall operate continuously.
- Outside air damper shall maintain minimum ventilation.
- Cooling valve shall modulate.
- Economizer shall operate whenever outdoor conditions permit.

Recovery shall terminate upon achieving occupied cooling setpoint.

PART 6 – ECONOMIZER OPERATION

Economizer cooling shall be enabled whenever:

- Cooling demand exists
- Outdoor air enthalpy is below return air enthalpy
- Outdoor air temperature is below adjustable lockout
- Mixed air temperature remains above freeze protection limits

Economizer shall modulate outdoor air between minimum and maximum positions before enabling mechanical cooling.

Economizer shall be disabled when:

- Heating mode is active

- Freeze protection is active
- Outdoor humidity exceeds adjustable limits
- Outdoor air exceeds economizer lockout temperature

PART 7 – OCCUPANCY STANDBY

When occupancy sensors indicate an unoccupied classroom during scheduled occupied hours:

The BAS shall:

- Close outside air damper
- Disable ventilation
- Cycle fan only upon heating or cooling demand
- Maintain standby heating and cooling setpoints

PART 8 – UNOCCUPIED MODE

During scheduled unoccupied periods:

1. Outside air damper shall remain closed.
2. Return air damper shall remain open.
3. Supply fan shall cycle only upon heating or cooling demand.

PART 9 – SUPPLY AIR TEMPERATURE RESET

The BAS shall automatically reset discharge air temperature based upon:

- Outdoor air temperature
- Room temperature deviation
- Heating valve position
- Cooling valve position

Typical discharge temperatures:

Heating:

90°F–110°F

Cooling:

55°F–60°F

Reset values shall be operator adjustable.

PART 10 – FAN CONTROL

The BAS shall provide variable speed fan control.

Fan speed shall automatically modulate to:

- Maintain room temperature
- Maintain required airflow
- Offset filter loading
- Reduce electrical consumption

Fan proof shall be verified.

Failure to prove airflow within 30 seconds shall:

- Generate alarm
- Disable heating and cooling valves
- Close outside air damper

PART 11 – HEATING CONTROL

Heating shall utilize proportional-integral control.

Heating valve shall modulate from 0–100%.

Heating shall be disabled whenever:

- Cooling demand exists
- Economizer satisfies load

Heating valve shall fully open during freeze protection.

PART 12 – COOLING CONTROL

Cooling valve shall remain closed until:

Economizer reaches full outdoor air position and additional cooling is required.

Mechanical cooling shall modulate to maintain room temperature.

Cooling shall be disabled during heating mode.

PART 13 – FREEZE PROTECTION

Primary freeze protection shall utilize:

Mixed Air Temperature Sensor

If mixed air temperature falls below 45°F:

- Outside air damper shall close.
- Return air damper shall open.
- Heating valve shall open 100%.
- Cooling valve shall close.
- BAS shall generate alarm.

If discharge temperature continues below 35°F:

- Fan shall stop.
- Freeze alarm shall latch.
- Manual reset shall be required.

PART 14 – FILTER MONITORING

Differential pressure shall continuously monitor filter condition.

When pressure exceeds adjustable limit, BAS to generate - Dirty Filter Alarm

Fan airflow shall compensate within allowable operating range.

PART 15 – DEMAND-CONTROLLED VENTILATION (CO₂ CONTROL)

15.01 General

The controller shall continuously monitor indoor CO₂ concentration and automatically adjust the outside air ventilation rate to maintain acceptable indoor air quality while minimizing unnecessary ventilation energy.

Demand-Controlled Ventilation (DCV) shall operate only during Occupied Mode.

15.02 CO₂ Sensor Requirements

Each CO₂ sensor shall:

- Be non-dispersive infrared (NDIR) technology.
- Provide BACnet compatible input to the BAS controller.
- Have an accuracy of ±50 ppm or better.

- Include automatic baseline calibration.
- Have an operating range of 0–2,000 ppm minimum.
- Be field-calibratable.
- Be mounted approximately 42–60 inches above the finished floor, away from supply air diffusers, return grilles, doors, and windows.

Sensor values shall be displayed on the BAS graphics.

15.03 Minimum Ventilation

During Occupied Mode, each unit ventilator shall maintain the minimum outdoor airflow required by:

- ASHRAE Standard 62.1
- Michigan Mechanical Code
- Design ventilation schedules

Minimum ventilation shall not be reduced below code-required values.

15.04 Ventilation Reset Strategy

The BAS shall continuously determine the required outdoor air ventilation rate using both the classroom occupancy status and the measured indoor carbon dioxide concentration.

Ventilation shall automatically reset to the lowest allowable outdoor airflow while maintaining compliance with ASHRAE Standard 62.1 and the Michigan Mechanical Code.

The controller shall evaluate the following operating conditions in order of priority:

1. Fire Alarm or Emergency Mode
2. Freeze Protection
3. Occupancy Status
4. CO₂ Concentration
5. Economizer Cooling Requirements
6. Minimum Code Ventilation

The controller shall always satisfy the greatest ventilation requirement generated by these operating conditions.

15.05 Occupied Classroom

When the BAS schedule indicates Occupied and the room occupancy sensor detects occupancy:

The unit ventilator shall:

- Enable Demand-Controlled Ventilation.
- Maintain minimum code-required outdoor ventilation.
- Continuously monitor room CO₂ concentration.
- Modulate the outside air damper between the minimum ventilation position and the design maximum ventilation position based on indoor CO₂ concentration.
- Coordinate ventilation with economizer operation whenever outdoor conditions permit.

Recommended default control values:

Indoor CO ₂	Outdoor Air Position
Less than 700 ppm	Minimum Design Ventilation
700–900 ppm	Modulate Proportionally
900–1,000 ppm	Increase Ventilation
Above 1,000 ppm	Maximum Design Ventilation

All values shall be operator adjustable.

15.06 Occupied Schedule – Classroom Vacant

If:

- BAS Schedule = Occupied

AND

- Occupancy Sensor = Vacant

for an adjustable time delay (default 15 minutes), the controller shall place the classroom into Occupancy Standby Mode.

The BAS shall:

- Reduce heating and cooling to standby setpoints.
- Reduce fan speed to standby airflow or cycle the fan as required.
- Close the outdoor air damper to the minimum code-permitted standby position.
- Suspend CO₂-based ventilation reset.
- Continue monitoring occupancy and CO₂ concentration.

If occupancy is detected at any time, the controller shall immediately return to Occupied Mode.

15.07 Classroom Reoccupied

Upon detection of occupancy:

The BAS shall immediately:

- Restore occupied heating and cooling setpoints.
- Resume normal fan operation.
- Reopen the outdoor air damper to the occupied minimum ventilation position.
- Re-enable CO₂-based ventilation control.
- Resume economizer operation when applicable.

The controller shall not require the CO₂ concentration to increase before restoring occupied ventilation.

15.08 High CO₂ Override

If the classroom becomes occupied and CO₂ concentration exceeds the adjustable High CO₂ threshold (default 1,000 ppm), the BAS shall temporarily override the normal Demand-Controlled Ventilation sequence.

The BAS shall:

- Increase outdoor air ventilation above the occupied minimum as required.
- Modulate the outdoor air damper to reduce indoor CO₂ concentration.
- Continue ventilation until CO₂ concentration falls below the adjustable reset value (default 800 ppm).
- Return to normal DCV operation once acceptable indoor air quality has been restored.

This override shall operate regardless of previous occupancy status.

15.09 Economizer Coordination

Economizer control shall always take precedence whenever outdoor conditions can satisfy the cooling load.

When economizer operation requires additional outdoor air beyond the Demand-Controlled Ventilation requirement:

- The outside air damper shall modulate to satisfy economizer cooling.
- The BAS shall continue monitoring indoor CO₂ concentration.
- Upon termination of economizer operation, ventilation shall automatically return to the higher of:
 - Code-required minimum ventilation.
 - CO₂ demand.
 - Occupancy ventilation requirement.

15.10 Sensor Failure

Occupancy Sensor Failure

If the occupancy sensor fails:

- Generate a BAS alarm.
- Assume Occupied whenever the BAS schedule is Occupied.
- Continue CO₂-based Demand-Controlled Ventilation.
- Restore normal operation when the sensor is repaired.

CO₂ Sensor Failure

If the CO₂ sensor fails:

- Generate a BAS alarm.
- Disable Demand-Controlled Ventilation.
- Maintain the design minimum outdoor air ventilation rate.
- Continue normal temperature control.

Simultaneous Sensor Failure

If both sensors fail:

- Generate Critical Alarm.
- Operate using occupied minimum ventilation during occupied schedules.
- Continue freeze protection and temperature control.

15.11 Energy Optimization

To minimize heating and cooling energy while maintaining indoor air quality, the BAS shall continuously optimize ventilation by evaluating:

- Scheduled occupancy
- Actual room occupancy
- Indoor CO₂ concentration
- Outdoor air temperature
- Outdoor air humidity (if available)
- Economizer availability
- Space temperature
- Mixed air temperature
- Freeze protection requirements

The BAS shall always select the operating mode that provides the lowest energy consumption while maintaining occupant comfort, equipment protection, and code-required ventilation.