Elementary School
Michigan

Temperature Controls Renovation

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An Authorized Representative of
Automated Logic Corporation...the power of simplicity
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Monitoring and control points for remote equipment are identified by the Module Point representation shown above. The electrical contractor or installer must label both ends of each control or monitoringpoint cable using the following format: (BN-DR-DA-EN-PL) or (BN-DR-DA-FB-PL). Adherence to this identification system is mandatory and must be followed using an approved tagging system comparable to the Brady I.D. Pro Plus electronic labeling system or equivalent. These tags are intended for the wiring for all Analog Inputs (AI’s), Digital Inputs (DI’s), Analog Outputs (AO’s), and Digital Outputs (DO’s) except VAV’s and terminal equipment where the wire runs are short and the field termination point is seen, or is easily identified. Points using pneumatics tubing follow the same convention. All communication cable, terminations “in” or “out” of a field module panel, terminal equipment or VAV’s must be labeled with “equipment name” and “to (equipment name) locations.” See Figure 1 below. All ARC156 or UNet communication, serial interface, control, and monitoring wiring must be terminated at the locations designated and must be free of splices. When stripping multi-conductor cables, use only strippers specifically designed for removal of outer sheath insulation so as not to damage the shielding or insulation of the conductors. Use ideal Catalog #45-514 or #45-165 data cable strippers or equivalent. When shielded cable is used, do not strip back sheath more than 1” in order to keep twisted pair from separating. Do not ground shield to the panel or chassis ground. The shield should only be connected to the “Optional Shield” connection at a module. Ungrounded shields must be cut back and taped to prevent contact with metal surfaces (heat shrink is preferred). See figure 2 below. All field module panels (FMP’s) will have a dedicated 120vac circuit.
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWG</td>
<td>American Wire Gauge</td>
</tr>
<tr>
<td>CAT-5</td>
<td>Ethernet Cable</td>
</tr>
<tr>
<td>DCD/CTS</td>
<td>Serial Device Control/Data Circuit Testing</td>
</tr>
<tr>
<td>EIA-232</td>
<td>Electrical Industry Association-232</td>
</tr>
<tr>
<td>EIA-485</td>
<td>Electrical Industry Association-485</td>
</tr>
<tr>
<td>G or GND</td>
<td>Ground</td>
</tr>
<tr>
<td>I/O</td>
<td>Input/Output</td>
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<tr>
<td>IN/A</td>
<td>Input A/Output</td>
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<tr>
<td>INB</td>
<td>Input B</td>
</tr>
<tr>
<td>L/SW</td>
<td>Low Voltage Switch</td>
</tr>
<tr>
<td>NET+</td>
<td>Network Plus</td>
</tr>
<tr>
<td>NET-</td>
<td>Network Minus</td>
</tr>
<tr>
<td>RX+</td>
<td>Receive Plus</td>
</tr>
<tr>
<td>RX-</td>
<td>Receive Minus</td>
</tr>
<tr>
<td>ST</td>
<td>Stop Test</td>
</tr>
<tr>
<td>SW</td>
<td>Switch</td>
</tr>
<tr>
<td>T</td>
<td>Termination</td>
</tr>
<tr>
<td>V</td>
<td>Voltage</td>
</tr>
</tbody>
</table>

## Cable Specification Chart

### Cable Line Types

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Wire Type</th>
<th>Manufacturer</th>
<th>Typical Application</th>
<th>Circuit Type</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOT SPECIFIED</td>
<td>12 AWG THHN</td>
<td>NOT SPECIFIED</td>
<td>POWER WIRING</td>
<td>120 VAC POWER</td>
<td>BLACK</td>
</tr>
<tr>
<td>NOT SPECIFIED</td>
<td>14 AWG THHN</td>
<td>NOT SPECIFIED</td>
<td>POWER WIRING</td>
<td>120 VAC POWER INTERNAL TO PANEL (T1)</td>
<td>WHITE</td>
</tr>
<tr>
<td>NOT SPECIFIED</td>
<td>16 AWG THHN</td>
<td>NOT SPECIFIED</td>
<td>INTERNAL PANEL WIRING</td>
<td>-</td>
<td>BLACK</td>
</tr>
</tbody>
</table>

### Abbreviation Notes

- AWG: American Wire Gauge
- CAT-5: Ethernet Cable
- DCD/CTS: Serial Device Control/Data Circuit Testing
- EIA-232: Electrical Industry Association-232
- EIA-485: Electrical Industry Association-485
- G or GND: Ground
- I/O: Input/Output
- IN/A: Input A/Output
- INB: Input B
- L/SW: Low Voltage Switch
- NET+: Network Plus
- NET-: Network Minus
- RX+: Receive Plus
- RX-: Receive Minus
- ST: Stop Test
- SW: Switch
- T: Termination
- V: Voltage

### Cable Jacket Colors

- 24vac: Gray
- Comm: Green
- AI: Yellow
- AO: Tan
- DI: Orange
- DO: Violet

**Notes:**

1. If a wire substitution is made consult ALC for approval.
**MOUNTING INSTRUCTIONS**

1. **OUTDOOR AIR TEMPERATURE SENSOR**
   - **NORTH**

2. **RELAY IN A BOX**
   - RED/WHITE - RED/GRAY - RED/BLACK
   - GREEN/WHITE - GREEN/GRAY - GREEN/BLACK
   - WHITE/BLUE - WHITE/ORANGE

3. **MINI-TJ-5X6 MODULAR JACK**
   - **COLOR CODE**
     - **(F) USING A REFERENCE TO THE COLOR CODE ON ROWS 3 & 4**
     - **(F) USING B, REFER TO THE COLOR CODE ON ROWS 1 & 2**

4. **END DEVICE TERMINATION BOX DETAIL**
   - **CONDUIT FOR RELATED END DEVICE WIRING ONLY**
   - **ACCEPTABLE INSTALLATION PRACTICE**
   - **UNACCEPTABLE INSTALLATION PRACTICE**

**ROOM TEMPERATURE SENSOR - RS SENSORS**

1. **MOUNTING INSTRUCTIONS**
   - **TO INSTALL**

2. **MINI-JACK TX-5e MODULAR JACK**
   - **COLOR CODE**
     - **(F) USING A REFERENCE TO THE COLOR CODE ON ROWS 3 & 4**
     - **(F) USING B, REFER TO THE COLOR CODE ON ROWS 1 & 2**

**OUTDOOR AIR TEMPERATURE SENSOR**

1. **NOTE**
2. **CONDUIT FOR RELATED END DEVICE WIRING ONLY**
3. **ACCEPTABLE INSTALLATION PRACTICE**
4. **UNACCEPTABLE INSTALLATION PRACTICE**
5. **NOTE**
6. **DO NOT USE AN END DEVICE ENCLOSURE AS A RACEWAY FOR OTHER WIRING.**
MOUNTING INSTRUCTIONS
1. DRILL A 3/8" HOLE IN THE DUCT WALL FOR THE STATIC PRESSURE PROBE.
2. SECURE THE DEVICE TO THE DUCT USING SELF-TAPPING SHEET METAL SCREWS.3. INSTALL STATIC PRESSURE PROBE HORIZONTALLY SO IT IS WITHIN 2" OF THE DAMPER SHAFT.
4. CONNECT TRANSMITTER TO CONTROL SYSTEM.
5. CONFIGURE ALL JUMPERS AND SWITCHES TO APPROPRIATE POSITIONS.

NOTE: INSTALL FLEXIBLE CONDUIT FOR ALL CABLE OR WIRE BROUGHT TO END DEVICE FROM JUNCTION BOX. FLEXIBLE CONDUIT SHOULD NOT EXCEED 18".

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STANDARD MOUNTING INSTRUCTIONS - BELIMO AF SERIES ACTUATORS

1. DETERMINE THE BEST ORIENTATION FOR THE UNIVERSAL CLAMP ON THE BACK OF THE ACTUATOR (WHERE YOU HAVE THE EASIEST ACCESS TO THE V-BOLT NUTS ON THE CLAMP). SELECT A LOCATION THAT IS FREE FROM VIBRATION, CORROSIVE ATMOSPHERE AND WHERE THE AMBIENT TEMPERATURE IS WITHIN THE LIMITS FOR THE SWITCH.

2. TURN THE DAMPER SHAFT UNTIL THE BLADES ARE... (TO STATIC PRESSURE PROBES) A PROTECTIVE ENCLOSEMENT MUST BE USED WHEN MOUNTED OUTDOORS. INSTALL FLEXIBLE CONDUIT FOR ALL CABLE OR WIRE BROUGHT TO END DEVICE FROM JUNCTION BOX. FLEXIBLE CONDUIT SHOULD NOT EXCEED 18'.


DAMPER MOTOR - BELIMO GM, AM, LF & NM SERIES ACTUATORS


NOTE: INSTALL FLEXIBLE CONDUIT FOR ALL CABLE OR WIRE BROUGHT TO END DEVICE FROM JUNCTION BOX. FLEXIBLE CONDUIT SHOULD NOT EXCEED 18'.

MOUNTING INSTRUCTIONS - SF SWITCH

1. SELECT A LOCATION THAT IS FREE FROM VIBRATION, CORROSIVE ATMOSPHERE AND WHERE THE AMBIENT TEMPERATURE IS WITHIN THE LIMITS FOR THE SWITCH.

2. MOUNT STANDARD SWITCHES WITH THE DIAL ARMS IN A VERTICAL PLANE AND WITH SWITCH LETTERING AND NAMEPLATE INSIDE THE MACHINE ROOM, CASSETTE OR CONTROL CABINET. MAKE SURE SWITCHES ARE NOT EXPOSED OR MOUNTED ON THE EXTERIOR OF THE ENCLOSURE. 3. INSTALL A Protection device cover. 4. ELECTRICAL CONNECTION TO THE SPDT SNAP SWITCH ARE PROVIDED BY MEANS OF SCREW TERMINALS. 5. INSTALL FLEXIBLE CONDUIT FOR ALL CABLE OR WIRE BROUGHT TO END DEVICE FROM JUNCTION BOX. FLEXIBLE CONDUIT SHOULD NOT EXCEED 18'.
Adjusting the Flow Switch Paddle

Figure 5: Trimming Template for the Extra Paddle

- The F61 comes with a 3-piece paddle (1", 2" & 3" segments) installed. Each piece is removable. Adjust the paddle size of the pipe in which it will be installed. For 1", 2" or 3" pipe, use the paddle segments as supplied.
- If longer paddle is required, the extra paddle may be trimmed to fit 6" or smaller diameter pipe. Use Figure 5 to trim the paddle at the arc corresponding with the pipe size.

MOUNTING:
- Mount the F61 in a section of pipe where there is a straight run of at least 5 pipe diameters on each side of the flow switch.
- The switch should be mounted so the terminals or wire leads are easily accessible for wiring.
- These flow switches must not be subjected to water hammer. If a fast-closing valve is located downstream of the flow switch, a suitable water hammer arrester must be used.
- Mount the flow switch in a standard 1" x 1" x 1" tee for 1" pipe installation. Use a reducing tee for larger sizes of pipe to keep the flow switch close to the pipe and provide adequate paddle length in the flow stream.
- Screw the flow switch in position so the flat of the paddle is at a right angle to the flow. The arrow on the side of the case must point in the direction of the flow.
- The F61 flow switch may be mounted on a horizontal pipe line or a vertical pipe line with upward liquid flow. It is not recommended for installations with downward flow.

WIRING:
- Make all wiring connections using proper copper conductors only.
- Install all wiring in accordance with NEC and local regulations.
- On F61KB and F61LB models, use the terminal screws furnished (8-32 x ¼" binder head) Substitution of other screws will void warranty.
- On F61MB models, use external wire leads.

Surface Mounting - Insert (2) #6 screws through holes on 2" centers.

Suspended Unit Mounting - Mount unit from its (2) ports. Always hold a wrench on pressure port when making pressure connection.

Pressure Connection - Connect high side pressure to the port labeled HIGH. Use a wrench on pressure port and hold this unit steady. Thread a ¼ NPT fitting into the port. CAUTION: NEVER TIGHTEN BY TURNING THE CONTROL INTO THE FITTING.

Wiring - Back out the screw terminal just enough to put the stripped wire under the terminal block clamp. Maximum wire size is 16AWG.

CAUTION: NEVER TIGHTEN BY TURNING THE CONTROL INTO THE FITTING.

NOTE: ISOLATION VALVES MUST BE INSTALLED AT THE PIPE TAP. VALVES TO BE FURNISHED BY OTHERS.
SMOKE DETECTOR

- Power Connections (see below)
- Alarm Contacts 10A
- Alarm Contacts 10A
- "Remote Alarm" Contacts 10A
- Power Connections (see MSI Series)

**DOUBLE CONTACTS ARE SHOWN IN NON-ENERGIZED CONDITION. UNDER NORMAL OPERATION CONTACTS ARE REVERSED.**

BRUSHED ALUMINUM OR STAINLESS STEEL WALL PLATE TEMPERATURE SENSOR

Toggle bolts or other direct wall-mount screws can be used where conduit is not required. Adapters are not required when mounting directly to electrical outlet boxes. Tighten mounting screws, crushing foam gasketing until plate edges lightly touch the wall. Insulate or seal all interior holes to prevent drafts from affecting the temperature readings. Terminate with butt splices or soldering. Wire nuts are not recommended.

Optional Customer-Supplied Handy Box

The sensor should be mounted approximately five feet above the floor, on an interior wall, away from any heating or cooling generating devices.

WET PRESSURE DIFFERENTIAL 2-WIRE

1. OPEN B (NULL)
2. OPEN D (BLEED OR PURGE)
3. SLOWLY OPEN A & C TO BLEED AIR FROM LINE
4. CLOSE D (BLEED OR PURGE)
5. OPEN A & C FULLY
6. CLOSE D (BLEED OR PURGE)

WET PRESSURE DIFFERENTIAL 3-WIRE

FRACTIONAL HP MOTOR STATUS SENSOR / COMMAND RELAY

EXHAUST FAN

CIRCUIT PATH
Network Riser

Note: Actual communications network layout to modules will be shown on the "As Built" drawings.
LGR & OAT Controller Wiring

Outside Air Conditions (typical of 1)

Outside Air Conditions:
The controller shall measure the outside air temperature and humidity and calculate the outside air enthalpy on a continual basis. These values shall be made available to the system at all times. Alarm shall be generated as follows:

- Sensor Failure: Sensor reading indicates shorted or disconnected sensor. In the event of a sensor failure, an alternate outside air condition sensor shall be made available to the system without interruption in sensor readings.
- If an OA Temp Sensor cannot be read, a default value of 65°F will be used. If an OA Humidity Sensor cannot be read, a default value of 50% will be used.

Outside Air Temperature History:
The controller shall monitor and record the high and low temperature readings for the outside air. These readings shall be recorded on a daily, month-to-date, and year-to-date basis.

Refer to Network Riser Drawing Sheet #11

Elementary School
Michigan 48xxx
Metro Environmental, Inc.

LGR & OAT Controller Wiring

Job NO: Cxxxx
2/08/10
Submission

Rev: 0
2/08/10
JSM HD: Class

DRAWN BY: TS
CHECKED BY: TS

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Heat Pump Loop System Sequence

Heat Pump Loop General Sequence of Operation:

Heating Mode:
1. The Diverting Valve V-1 will route water as required by the HPWR (T2) Temp sensor to the Heat Pump Loop.
2. When the HPWR (T2) temperature is less than 70°F (adj.) Isolation Valve V-2 will open, and Isolation Valve V-3 will be closed.
3. The HPWR (T2) temperature is greater than 77°F (adj.). Valve V-2 will close and Valve V-3 will open.
4. Cze Pump 8 will run whenever Boiler is enabled (less than 67°F (adj.) OAT). See Boiler sequence.

Cooling Mode:
1. Diverting Valve V-1 will be closed to the Heat Pump Loop.
2. Isolation Valve V-2 will be closed, and Isolation Valve V-3 will be open to the Evaporative Cooler.
3. Evaporative Cooler will be enabled.

General:

Heat Pump Water Loop CP-1/CP-2 Lead/Lag Operation:
- The two pumps shall operate in a lead/standby fashion.
- The lead pump shall run first.
- On failure of the lead pump, the standby pump shall run and the lead pump shall turn off.
- The designated lead pump shall rotate upon one of the following conditions (user selectable):
  - manually through a software switch
  - if pump runtime (adj.) is exceeded
daily
weekly
monthly
- Alarms shall be provided as follows:
  - CP-1 Pump Failure: Commanded on, but the status is off.
  - Running in Hand: Commanded off, but the status is on.
  - Runtime Exceeded: Status runtime exceeds a user definable limit.

Heat Pump Loop Water Differential Pressure Control:
- The controller shall measure Heat Pump Loop water differential pressure and modulate the hot water pump VFDs in sequence to maintain its water differential pressure setpoint.
- The following setpoints are recommended values. All setpoints shall be field adjusted during the commissioning period to meet the requirements of actual field conditions.
- The controller shall modulate Heat Pump Loop water pump speeds to maintain a water differential pressure of 12inh2o (adj.)
- On dropping Heat Pump Loop water differential pressure, the VFDs shall stage on and run to maintain setpoint as follows:
  - The controller shall modulate the lead VFD to maintain setpoint.
  - If the lead VFD speed is greater than a setpoint of 90% (adj.), the lag VFD shall stage on.
  - The lag VFD shall ramp up to match the lead VFD speed and then run in unison with the lead VFD to maintain setpoint.
- The controller shall measure Heat Pump Loop water temperature and modulate the mixing valve to maintain its setpoint.
- On rising Heat Pump Loop water differential pressure, the VFDs shall stage off as follows:
  - If the VFDs speeds drops back to 60% (adj.) below setpoint, the lag VFD stage shall off.
  - The lead VFD shall continue to run to maintain setpoint.
- Alarms shall be provided as follows:
  - High Water Differential Pressure: If 25% (adj.) greater than setpoint.
  - Low Water Differential Pressure: If 25% (adj.) less than setpoint.

Boiler System - Run Conditions:
- The boiler shall be enabled to run whenever outside air temperature is less than 65°F (adj.).
- To prevent short cycling, the boiler system shall run for and be off for minimum adjustable times (both user definable), unless shutdown on safeties or outside air conditions.
- Each boiler shall run subject to its own internal safeties and controls.
- The boiler system shall also run for freeze protection whenever outside air temperature is less than 38°F (adj.)
- Boiler Enabled: The boiler shall be enabled when the boiler system is commanded on.
- The boiler shall be enabled after pump status is proven on and shall run subject to its own internal safeties and controls.

Evaporative Cooler:
- The evaporative cooler shall be enabled when the boiler system is commanded on.
- The boiler shall be enabled when the system is commanded on.
- The evaporative cooler shall run subject to its own internal safeties and controls.

Cooling Tower - Run Conditions:
- The cooling tower shall be enabled to run whenever outside air temperature is greater than 5°F (adj.) and the building is Occupied.
- The cooling tower condenser water control shall stage its components (spray pump, fan, etc.) in sequence to maintain condenser water supply temperature setpoint.
- The following setpoints are recommended values. All setpoints shall be field adjusted during the commissioning period to meet the requirements of actual field conditions.
- The evaporative cooler shall be enabled when the boiler system is commanded on.
- The evaporative cooler shall be enabled whenever the hot water system is called to run.
- The mixing valve shall close whenever the hot water supply temperature rises from 190°F to 200°F (adj.).
Multi-Zone MZ-1 Sequence Of Operation

Run Conditions - Scheduled:
The unit will run based upon an operator adjustable schedule.

Emergency Shutdown:
The unit will shut down and generate an alarm upon receiving an emergency shutdown signal.

Freeze Protection:
The unit will shut down and generate an alarm upon receiving a freeze stat status.

AHU Optimal Start:
The unit will start prior to scheduled occupancy based on the time necessary for the zones to reach their occupied setpoints. The start time will automatically adjust based on changes in outside air temperature and zone temperatures.

Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

Outside air temperature is less than 45°F (adj.) AND the supply fan status is on.

The supply fan will run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan will have a user definable (adj.) minimum runtime.

Alarms will be provided as follows:
- Supply Fan Failure: Commanded on, but the status is off.
- Supply Fan in Hand: Commanded off, but the status is on.
- Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

Cold Deck - Cooling Supply Air Temperature Setpoint - Fixed:
The unit will maintain a fixed cooling supply air temperature setpoint of 55°F (adj.).

Cold Deck - Cooling Coil Valve:
The controller will measure the cooling supply air temperature and modulate the cooling coil valve to maintain its cooling setpoint.

The cooling will be enabled whenever:
- Outside air temperature is greater than 60°F (adj.).
- AND the economizer (if present) is disabled or fully open.
- AND the supply fan status is on.

The cooling coil valve will open whenever:
- Outside air temperature is less than 55°F (adj.).
- AND the outside air enthalpy is less than 28 Btu/lb (adj.)
- AND the outside air temperature is less than the return air temperature.
- AND the outside air enthalpy is less than the return air enthalpy.
- AND the supply fan status is on.

Alarms will be provided as follows:
- High Cooling Supply Air Temp: If the cooling supply air temperature is greater than 65°F (adj.).
- Low Cool Deck Temperature: If the cooling deck zone temperature is less than 2°F (adj.) the cooling supply air temperature setpoint.
- Mixed Air Temperature: The controller will measure the mixed air temperature and use it for economizer control (if active).

Mixed Air Temperature:
The controller will monitor the mixed air temperature and use it for economizer control (if active).

Alarms will be provided as follows:
- High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).
- Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

Return Air Humidity:
The controller will monitor the return air humidity and use it for economizer control (if active).

- High Return Air Humidity: If the return air humidity is greater than 70% (adj.).
- Low Return Air Humidity: If the return air humidity is less than 5% (adj.).

Return Air Temperature:
The controller will monitor the return air temperature and use it for economizer control (if present).

Alarms will be provided as follows:
- High Return Air Temp: If the return air temperature is greater than 90°F (adj.).
- Low Return Air Temp: If the return air temperature is less than 45°F (adj.).

Supply Fan:
The controller will measure the mixed air temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F less than the cooling supply air temperature setpoint. The outside air dampers will maintain a minimum adjustable position of 20% (adj.) open whenever occupied.

Space Temperature Control - Scheduled:
The unit will run according to a user definable (adj.) time schedule in the following modes:
- Occupied Mode: The unit will maintain
  - A 70°F (adj.) heating setpoint.
- A 74°F (adj.) cooling setpoint
- A 55°F (adj.) heating setpoint.
- A 85°F (adj.) cooling setpoint.
- A 55°F (adj.) heating setpoint.
- A 85°F (adj.) cooling setpoint.
- A 55°F (adj.) heating setpoint.

Zone Damper Control:
The cooling and heating deck zone dampers will modulate in sequence to maintain zone temperature cooling and heating setpoints.

- Occupied Mode: The unit will maintain
  - A 55°F (adj.) cooling setpoint.
  - A 70°F (adj.) heating setpoint.
  - A 80°F (adj.) heating setpoint.
  - A 2°F (adj.) cooling setpoint.
  - A 2°F (adj.) cooling setpoint.
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  - A 2°F (adj.) cooling setpoint.
  - A 2°F (adj.) cooling setpoint.
  - A 2°F (adj.) cooling setpoint.
  - A 2°F (adj.) cooling setpoint.
Multi-Zone MZ-1 Zone Control

Zone Temperature Control Run Conditions - Scheduled:
The unit will run according to a user definable time schedule in the following modes:

- Occupied Mode: The unit will maintain
  - A 74°F (adj.) cooling setpoint
  - A 70°F (adj.) heating setpoint.

- Unoccupied Mode (night setback): The unit will maintain
  - A 85°F (adj.) cooling setpoint.

Alarms will be provided as follows:

- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

Zone Damper Control:
The cooling and heating deck zone dampers will modulate in sequence to maintain zone temperature cooling and heating setpoints.

Discharge Air Temperature:
The controller will monitor the discharge air temperature.

Alarms will be provided as follows:

- High Discharge Air Temp: If the discharge air temperature is greater than 120°F (adj.).
- Low Discharge Air Temp: If the discharge air temperature is less than 40°F (adj.).
AHU-1 Sequence Of Operation

Single Zone Unit (typical of 1)

Run Conditions - Scheduled:
The unit shall run according to a user definable time schedule in the following modes:

- Occupied Mode: The unit shall maintain
  - A 75°F (adj.) cooling setpoint
  - A 72°F (adj.) heating setpoint.
- Unoccupied Mode (night setback): The unit shall maintain
  - A 85°F (adj.) cooling setpoint.
  - A 62°F (adj.) heating setpoint.

Alarms shall be provided as follows:
- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

Zone Setpoint Adjust:
The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

Zone Optimal Start:
The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

Zone Unoccupied Override:
A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

Freeze Protection:
The unit shall shut down, the heating valve will open and the DDC will generate an alarm upon receiving a freeze stat status. The existing freeze stat cut-out is set at 35°F.

Supply Fan:
The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime. Existing motor starter current switch will monitor the fan status.

Alarms shall be provided as follows:
- Supply Fan Failure: Commanded on, but the status is off.
- Supply Fan in Hand: Commanded off, but the status is on.
- Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

Face & By-Pass Dampers
When outdoor air temperature is above 55°F (adj.) the heating coil Face & Bypass dampers will be in the Bypass position. When the outdoor air temperature is between 55°F (adj.) and 38°F (adj.) the Face and By-Pass dampers will remain in the Face position. Below 38°F the Face and By-Pass dampers will modulate to maintain 55°F (adj.) discharge air temperature.

Heating Coil Pump
During the occupied mode the heating coil pump will be enabled anytime the outdoor temperature falls below 55°F (adj.). Pump status is monitored via existing motor starter current switch. An alarm will be generated if an abnormal condition occurs.

Alarms shall be provided as follows:
- Pump Failure: Commanded on, but the status is off.
- Pump in Hand: Commanded off, but the status is on.
- Pump Runtime Exceeded: Status runtime exceeds a user definable limit

Heating Coil Valve:
Below 55°F (adj.) and above 38°F (adj.) outdoor air temperature the controller shall measure the zone air temperature and modulate the heating coil valve to maintain the zone heating setpoint. Below 38°F outdoor air temperature the heating coil valve will remain full open to the coil and the face and By-Pass dampers will modulate.

Cooling Stages:
The controller shall measure the zone temperature and stage the cooling to maintain its cooling setpoint. To prevent short cycling, there shall be a user definable (adj.) delay between stages, and each stage shall have a user definable (adj.) minimum runtime.

The cooling shall be enabled whenever:
- Outside air temperature is greater than 60°F (adj.).
- AND the economizer (if present) is disabled or fully open.
- AND the zone temperature is above cooling setpoint.
- AND the supply fan status is on.
- AND the heating is not active.

Continued On Next Page
AHU-1 Sequence Continued

**Economizer:**
The controller shall measure the zone temperature and modulate the economizer dampers in sequence to
maintain a setpoint 2°F less than the zone cooling setpoint. The outside air dampers shall maintain a minimum
adjustable position of 20% (adj.) open whenever occupied.
The economizer shall be enabled whenever:
- Outside air temperature is less than 65°F (adj.).
- AND the outside air temperature is less than the return air temperature.
- AND the supply fan status is on.
The economizer shall close whenever:
- Mixed air temperature drops from 50°F to 45°F (adj.).
- OR on loss of supply fan status.
- OR the freezeastat (if present) is on.
The outside air dampers shall close and the return air damper shall open when the unit is off. If Optimal Start Up is
available, the mixed air damper shall operate as described in the occupied mode except that the outside
air damper shall modulate to fully closed.

**Minimum Outside Air Ventilation – Return Air CO₂ Monitoring:**
The outside air dampers will remain closed and begin to modulate toward the minimum position when the return
air CO₂ climbs above 1000 ppm (adj.) during building occupied hours. During unoccupied hours the outdoor
dampers will remain closed.

**Prefilter Status:**
The controller shall monitor the prefilter status.
Alarms shall be provided as follows:
- Prefilter Change Required: Existing prefilter differential pressure switch exceeds a user definable switch
  limit (adj.).

**Mixed Air Temperature:**
The controller shall monitor the mixed air temperature and use as required for economizer control (if present) or
preheating control (if present).
Alarms shall be provided as follows:
- High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).
- Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

**Supply Air Temperature:**
The controller shall monitor the supply air temperature.
Alarms shall be provided as follows:
- High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
- Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

**Unoccupied Mode:**
During the unoccupied mode the mechanical cooling remains off. Below 40°F outdoor air temperature the heating
coil valve will modulate and the heating pump will cycle to maintain a low limit plenum temperature of 50°F (adj.).
The heating valve will open and the fan will cycle to maintain the unoccupied zone setpoint.

Note: The heating system piping is filled with an unknown glycol mixture.
AHU-2, 3 & 4 Sequence Of Operation

Makeup Air Unit - Supply Air Temp (typical of 3)

Run Conditions - Interlocked:
The AHU-2, 3 & 4 units run via the DDC occupied mode time schedule unless shutdown on safeties.

Freeze Protection:
The unit shall shut down and generate an alarm upon receiving a freezestat status. The setpoint for the existing freezestat is 35F adjustable at the freezestat. The heating coil valve shall open to 100% (adj.) whenever the freezestat is on.

Outside Air Damper:
The outside air damper shall open anytime the unit runs and shall close anytime the unit stops. The supply fan shall start only after the damper status has proven the damper is open. The outside air damper shall close 10 sec (adj.) after the supply fan stops.

Alarms shall be provided as follows:
- Outside Air Damper Failure: Commanded open, but the status is closed.
- Outside Air Damper in Hand: Commanded closed, but the status is open.

Supply Fan:
The supply fan shall run anytime the unit is commanded to run. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime, unless shutdown on safeties. The status of the fan is monitored via existing motor starter current switch.

Alarms shall be provided as follows:
- Supply Fan Failure: Commanded on, but the status is off.
- Supply Fan in Hand: Commanded off, but the status is on.
- Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

Supply Air Temperature Setpoint - Fixed:
The controller shall monitor the supply air temperature and shall maintain a fixed supply air temperature setpoint of 55°F (adj.).

Face & By-Pass Dampers
When outdoor air temperature is above 55F (adj.) the heating coil Face & Bypass dampers will be in the Bypass position. When the outdoor air temperature is between 55F (adj.) and 38F (adj.) the Face and By-Pass dampers will remain in the Face position. Below 38F the Face and By-Pass dampers will modulate to maintain 55F (adj.) discharge air temperature.

Heating Coil Pump
During the occupied mode the heating coil pump will be enabled anytime the outdoor temperature falls below 55F (adj.). Pump status is monitored via existing motor starter current switch. An alarm will be generated if an abnormal condition occurs.

Alarms shall be provided as follows:
- Pump Failure: Commanded on, but the status is off.
- Pump in Hand: Commanded off, but the status is on.
- Pump Runtime Exceeded: Status runtime exceeds a user definable limit.

Heating Coil Valve:
Below 55F (adj.) and above 38F (adj.) outdoor air temperature the controller shall measure the supply air temperature and modulate the heating coil valve to maintain its discharge air 55F (adj.) heating setpoint. Below 38F outdoor air temperature the heating coil valve will remain full open to the coil.

Prefilter Status:
The controller shall monitor the prefilter status.

Alarms shall be provided as follows:
- Prefilter Change Required: Existing prefilter differential pressure switch exceeds a user definable limit (adj.).

Supply Air Temperature:
The controller shall monitor the supply air temperature.

Alarms shall be provided as follows:
- High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
- Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

Unoccupied Mode:
During the unoccupied mode the fans remain off, outdoor dampers are closed and mechanical cooling is disabled. Fan cycles with the modulating heating valve to maintain the unoccupied zone setpoint. Below 40F outdoor air temperature the heating coil valve will modulate and the heating pump will cycle to maintain a low limit plenum temperature of 50F (adj.).

Note: The heating system piping is filled with an unknown glycol mixture.
AHU-5 & Sequence Of Operation

Supply Fan Motor Starter Control Circuit

Single Zone Unit (typical of 1)

Run Conditions - Scheduled:
The unit shall run according to a user definable time schedule in the following modes:
- Occupied Mode: The unit shall maintain
  - A 74°F (adj.) cooling setpoint
  - A 70°F (adj.) heating setpoint.
- Unoccupied Mode (night setback): The unit shall maintain
  - A 85°F (adj.) cooling setpoint.
  - A 55°F (adj.) heating setpoint.

Alarms shall be provided as follows:
- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

Demand Limiting - Zone Setpoint Optimization:
To lower power consumption, the zone setpoints shall automatically relax when the facility power consumption exceeds definable thresholds. The amount of relaxation shall be individually configurable for each zone. The zone setpoints shall automatically return to their previous settings when the facility power consumption drops below the thresholds.

Zone Setpoint Adjust:
The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

Zone Optimal Start:
The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

Zone Unoccupied Override:
A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

Continued On Next Page
AHU-5 Sequence Continued

Freeze Protection:
The unit shall shut down and generate an alarm upon receiving a freezestat status.

Supply Fan:
The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short
cycling, the supply fan shall have a user definable (adj.) minimum runtime.
Alarms shall be provided as follows:
- Supply Fan Failure: Commanded on, but the status is off.
- Supply Fan in Hand: Commanded off, but the status is on.
- Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

Cooling Stage:
The controller shall measure the zone temperature and stage the cooling to maintain its cooling setpoint. To prevent short cycling, the stage shall have a user definable (adj.) minimum runtime.
The cooling shall be enabled whenever:
- Outside air temperature is greater than 60°F (adj.).
- AND the economizer (if present) is disabled or fully open.
- AND the zone temperature is above cooling setpoint.
- AND the supply fan status is on.
- AND the heating is not active.

Heating Coil Valve:
The controller shall measure the zone temperature and modulate the heating coil valve to maintain its heating setpoint.
The heating shall be enabled whenever:
- Outside air temperature is less than 65°F (adj.).
- AND the zone temperature is below heating setpoint.
- AND the supply fan status is on.
- AND the cooling is not active.
The heating coil valve shall open whenever the freezestat (if present) is on.

Economizer:
The controller shall measure the zone temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F less than the zone cooling setpoint. The outside air dampers shall maintain a minimum adjustable position of 20% (adj.) open whenever occupied.
The economizer shall be enabled whenever:
- Outside air temperature is less than 65°F (adj.).
- AND the outside air temperature is less than the return air temperature.
- AND the supply fan status is on.
The economizer shall close whenever:
- Mixed air temperature drops from 45°F to 40°F (adj.).
- OR on loss of supply fan status.
- OR the freezestat (if present) is on.
The outside and exhaust air dampers shall close and the return air damper shall open when the unit is off. If Optimal Start Up is available, the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully closed.

Minimum Outside Air Ventilation - Fixed Percentage:
The outside air dampers shall maintain a minimum position (adj.) during building occupied hours and be closed during unoccupied hours.

Prefilter Differential Pressure Monitor:
The controller shall monitor the differential pressure across the prefilter.
Alarms shall be provided as follows:
- Prefilter Change Required: Prefilter differential pressure exceeds a user definable limit (adj.).

Mixed Air Temperature:
The controller shall monitor the mixed air temperature and use as required for economizer control (if present) or preheating control (if present).
Alarms shall be provided as follows:
- High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).
- Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

Supply Air Temperature:
The controller shall monitor the supply air temperature.
Alarms shall be provided as follows:
- High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
- Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).
AHU-5 VAV Terminal Unit

**Sequence Of Operation**

Run Conditions - Scheduled:
The unit shall run according to a user definable time schedule in the following modes:

- **Occupied Mode:** The unit shall maintain
  - A 74°F (adj.) cooling setpoint
  - A 70°F (adj.) heating setpoint.

- **Unoccupied Mode (night setback):** The unit shall maintain
  - A 84°F (adj.) cooling setpoint.
  - A 60°F (adj.) heating setpoint.

Alarms shall be provided as follows:

- **High Zone Temp:** If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- **Low Zone Temp:** If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

**Zone Setpoint Adjust:**
The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

**Variable Volume Terminal Unit - Flow Control:**
The unit shall maintain zone setpoints by controlling the airflow through one of the following:

- **Occupied:**
  - When zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum occupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.
  - When the zone temperature is less than the cooling setpoint, the zone damper shall maintain the minimum required zone ventilation (adj.).

- **Unoccupied:**
  - When the zone is unoccupied the zone damper shall control to its minimum unoccupied airflow (adj.).
  - When the zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum unoccupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.

**Bill of Materials**

<table>
<thead>
<tr>
<th>DEC</th>
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</table>

**Elementary School**

Michigan 48xxx
Metro Environmental, Inc.

AHU-5 VAV Terminal Unit

REV: 0 | SUBMITTER: 20110 | JOB NO: Cxxxx2/08/10
DRAWN BY: TL | DRAWN BY: TS | CHECKED BY: TS

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Multi-Zone Unit Converted To Single Zone Unit (typical of 1)

Run Conditions - Scheduled:
The unit shall run according to a user definable time schedule in the following modes:
- Occupied Mode: The unit shall maintain
  o A 74°F (adj.) cooling setpoint
  o A 70°F (adj.) heating setpoint.
- Unoccupied Mode (night setback): The unit shall maintain
  o A 85°F (adj.) cooling setpoint.
  o A 55°F (adj.) heating setpoint.

Alarms shall be provided as follows:
- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

Zone Setpoint Adjust:
The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

Zone Optimal Start:
The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

Zone Unoccupied Override:
A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

Freeze Protection:
The units packaged controls will shut down the fan if a freezestat condition occurs.

Supply Fan:
The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime. Existing current switch monitors fan status.

Return Fan:
The return fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the return fan shall have a user definable (adj.) minimum runtime. Existing current switch monitors fan status.

Cooling Stage:
The controller shall measure the zone temperature and stage the cooling to maintain its cooling setpoint. To prevent short cycling, the stage shall have a user definable (adj.) minimum runtime.

The cooling shall be enabled whenever:
- Outside air temperature is greater than 60°F (adj.).
- AND the economizer (if present) is disabled or fully open.
- AND the zone temperature is above cooling setpoint.
- AND the supply fan status is on.
- AND the heating is not active.

Heating Coil Pump:
During the occupied mode the heating coil pump will be enabled anytime the outdoor temperature falls below 55°F (adj.). Pump status is monitored via existing motor starter current switch. An alarm will be generated if an abnormal condition occurs.

Heating Coil Valve:
The controller shall measure the zone temperature and modulate the heating coil valve to maintain its heating setpoint.

The heating shall be enabled whenever:
- Outside air temperature is less than 65°F (adj.).
- AND the zone temperature is below heating setpoint.
- AND the supply fan status is on.
- AND the cooling is not active.

The heating coil valve shall open whenever the freezestat (if present) is on.

Economizer:
The controller shall measure the zone temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F less than the zone cooling setpoint. The outside air dampers shall maintain a minimum adjustable position of 20% (adj.) open whenever occupied.

The economizer shall close whenever:
- Mixed air temperature drops from 45°F to 40°F (adj.).
- OR on loss of supply fan status.
- OR the freezestat (if present) is on.

The outside and exhaust air dampers shall close and the return air damper shall open when the unit is off. If Optimal Start Up is available, the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully closed.
RTU-1 Sequence of Operation Continued

Minimum Outside Air Ventilation - Fixed Percentage:
The outside air dampers shall maintain a minimum position (adj.) during building occupied hours and be closed during unoccupied hours.

Prefilter Differential Pressure Monitor:
The controller shall monitor the differential pressure across the prefilter.
Alarms shall be provided as follows:
- Prefilter Change Required: Prefilter differential pressure exceeds a user definable limit (adj.).

Return Air Temperature:
The controller shall monitor the return air temperature and use as required for economizer control (if present).
Alarms shall be provided as follows:
- High Return Air Temp: If the return air temperature is greater than 90°F (adj.).
- Low Return Air Temp: If the return air temperature is less than 45°F (adj.).

Supply Air Temperature:
The controller shall monitor the supply air temperature.
Alarms shall be provided as follows:
- High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
- Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

Unoccupied Mode:
During the unoccupied mode the fan remains off. Below 40F outdoor air temperature the heating coil valve will modulate and the heating pump will cycle to maintain a low limit plenum temperature of 50F (adj.).

Note: The heating system piping is filled with an unknown glycol mixture.
RTU-2 Sequence of Operation

Single Zone Unit (typical of 1)

Run Conditions - Scheduled:
The unit shall run according to a user definable time schedule in the following modes:

- **Occupied Mode:** The unit shall maintain
  - A 74°F (adj.) cooling setpoint
  - A 70°F (adj.) heating setpoint.
- **Unoccupied Mode (night setback):** The unit shall maintain
  - A 85°F (adj.) cooling setpoint.
  - A 55°F (adj.) heating setpoint.

Alarms shall be provided as follows:

- **High Zone Temp:** If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- **Low Zone Temp:** If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

**Zone Setpoint Adjust:**
The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

**Zone Optimal Start:**
The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

**Zone Unoccupied Override:**
A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

**Freeze Protection:**
If a freezestat condition occurs the fan will shut down and the controller will generate an alarm. The freezestat is set at 35°F (adj.) if tripped manual reset is required to return the rooftop unit to normal service.

**Supply Fan:**
The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime. Existing current switch monitors fan status.

Alarms shall be provided as follows:

- Supply Fan Failure: Commanded on, but the status is off.
- Supply Fan in Hand: Commanded off, but the status is on.
- Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

**Cooling Stage:**
The controller shall measure the zone temperature and stage the cooling to maintain its cooling setpoint. To prevent short cycling, the stage shall have a user definable (adj.) minimum runtime.

The cooling shall be enabled whenever:

- Outside air temperature is greater than 60°F (adj.).
- AND the economizer (if present) is disabled or fully open.
- AND the zone temperature is above cooling setpoint.
- AND the supply fan status is on.
- AND the cooling is not active.

**Heating Coil Pump:**
During the occupied mode the heating coil pump will be enabled anytime the outdoor temperature falls below 55°F (adj.). Pump status is monitored via existing motor starter current switch. An alarm will be generated if an abnormal condition occurs.

Alarms shall be provided as follows:

- Pump Failure: Commanded on, but the status is off.
- Pump in Hand: Commanded off, but the status is on.
- Pump Runtime Exceeded: Status runtime exceeds a user definable limit.

**Heating Coil Valve:**
The controller shall measure the zone temperature and modulate the heating coil valve to maintain its heating setpoint.

The heating shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the zone temperature is below heating setpoint.
- AND the supply fan status is on.
- AND the heating is not active.

The heating coil valve shall open whenever the freezestat (if present) is on.

**Economizer:**
The controller shall measure the zone temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F less than the zone cooling setpoint. The outside air dampers shall maintain a minimum adjustable position of 20% (adj.) open whenever occupied.

The economizer shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the outside air temperature is less than the return air temperature.
- AND the supply fan status is on.

The economizer shall close whenever:

- Mixed air temperature drops from 45°F to 40°F (adj.).
- OR on loss of supply fan status.
- OR the freezestat (if present) is on.

The outside and exhaust air dampers shall close and the return air damper shall open when the unit is off. If Optimal Start Up is available, the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully closed.
Minimum Outside Air Ventilation - Fixed Percentage:
The outside air dampers shall maintain a minimum position (adj.) during building occupied hours and be closed during unoccupied hours.

Mixed Air Temperature:
The controller shall monitor the mixed air temperature and use as required for economizer control (if present) or preheating control (if present).
Alarms shall be provided as follows:
- High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).
- Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

Return Air Temperature:
The controller shall monitor the return air temperature and use as required for economizer control (if present).
Alarms shall be provided as follows:
- High Return Air Temp: If the return air temperature is greater than 90°F (adj.).
- Low Return Air Temp: If the return air temperature is less than 45°F (adj.).

Supply Air Temperature:
The controller shall monitor the supply air temperature.
Alarms shall be provided as follows:
- High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
- Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

Unoccupied Mode:
During the unoccupied mode the fan remains off. Below 40°F outdoor air temperature the heating coil valve will modulate and the heating pump will cycle to maintain a low limit plenum temperature of 50°F (adj.).

Note: The heating system piping is filled with an unknown glycol mixture.
Supply Fan SF-1 Sequence of Operation

Supply Fan SF-1 with Reheat (Typical of One)

Supply fan will be started and stopped from the DDC controller based on occupied and unoccupied schedules.

Existing current switch will monitor the Supply fan status. If an abnormal condition occurs an alarm will be generated by the controller.

Outside inlet air damper motor will be interlocked with the DDC controller to prove open before the fan is started.

When the outdoor temperature drops below 55F (adj.) the heating coil pump will start. Existing current switch will monitor the pump. If an abnormal condition occurs the controller will generate an alarm.

Reheat coil 3-way mixing valve will be controlled to maintain 55F discharge air temperature.

Filter status will be monitored by the DDC controller. An alarm will be generated when the filter is clogged.

When the fan stops the outdoor damper will close. Below 40F (adj.) the heating coil valve will modulate and the heating pump will cycle to maintain a low limit plenum temperature of 50F (adj.)

Note: The heating system piping is filled with an unknown amount of glycol.
VUV-1, 2, 3 & 4 Sequence Of Operation

Unit Ventilator (typical of 4)

Run Conditions - Scheduled:
The unit shall run according to a user definable time schedule in the following modes:
- Occupied Mode: The unit shall maintain
  A 74°F (adj.) cooling setpoint
  A 70°F (adj.) heating setpoint.
- Unoccupied Mode (night setback): The unit shall maintain
  A 85°F (adj.) cooling setpoint. VUV cooling to remain “Off”
  A 62°F (adj.) heating setpoint.

Alarms shall be provided as follows:
- High Zone Temp: If the zone temperature is greater than the
  cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the
  heating setpoint by a user definable amount (adj.).

Zone Setpoint Adjust:
The occupant shall be able to adjust the zone temperature heating and
cooling setpoints at the zone sensor.

Zone Optimal Start:
The unit shall use an optimal start algorithm for morning start-up. This
algorithm shall minimize the unoccupied warm-up or cool-down
period while still achieving comfort conditions by the start of
scheduled occupied period.

Zone Unoccupied Override:
A timed local override control shall allow an occupant to override the
schedule and place the unit into an occupied mode for an adjustable
period of time. At the expiration of this time, control of the unit shall
automatically return to the schedule.

Freeze Protection:
The unit shall shut down via unit packaged controls when a low
temperature condition occurs.

Supply and Exhaust Fans:
The supply and exhaust fans shall run on low or medium speeds
(adj usted by air balancer) anytime the unit is commanded to run
unless shutdown on safeties. When the space temperature is 3°F (Adj.)
or higher above the setpoint the supply and exhaust fans will be at high
speed.

Cooling:
The controller shall measure the zone temperature and energize the
compressor to maintain its cooling setpoint. To prevent short cycling
the compressor there is a user definable (adj.) minimum runtime.
The cooling shall be enabled whenever:
- Outside air temperature is greater than 60°F (adj.).
- AND the zone temperature is above cooling setpoint.
- AND the fan is on.

Compressor Status:
The controller shall monitor the compressor status.
Alarms shall be provided as follows:
- Compressor Failure: Commanded on, but the status is off.
- Compressor in Hand: Commanded off, but the status is on.
- Compressor Runtime Exceeded: Compressor status runtime
  exceeds a user definable limit (adj.).

Condenser Exhaust / Exhaust Air Fan Status:
The controller shall monitor the CE/EA status.
Alarms shall be provided as follows:
- CE/EA Failure: Commanded on, but the status is off.
- CE/EA in Hand: Commanded off, but the status is on.
- CE/EA Runtime Exceeded: Compressor status runtime
  exceeds a user definable limit (adj.).

Heating Coil Valve:
The controller shall measure the zone temperature and modulate the
heating coil valve to maintain its heating setpoint.
The heating shall be enabled whenever:
- Outside air temperature is less than 65°F (adj.).
- AND the zone temperature is below heating setpoint.
- AND the fan is on.

Discharge Air Temperature:
The controller shall monitor the discharge air temperature.
Alarms shall be provided as follows:
- High Discharge Air Temp: If the discharge air temperature is
greater than 120°F (adj.).
- Low Discharge Air Temp: If the discharge air temperature is
less than 40°F (adj.).

Fan Status:
The controller shall monitor the fan status.
Alarms shall be provided as follows:
- Fan Failure: Commanded on, but the status is off.
- Fan in Hand: Commanded off, but the status is on.
- Fan Runtime Exceeded: Fan status runtime exceeds a user
  definable limit (adj.).

Economizer (ASHRAE Cycle II):
The controller shall measure the zone temperature and modulate the
mixed air dampers in sequence to maintain the zone cooling setpoint.
The outside air dampers shall maintain a minimum adjustable
position of 20% (adj.) open during heating and ventilation whenever
occupied.

The economizer shall be enabled whenever:
- Outside air temperature is at least 3°F (adj.) less than the
  Zone Temperature.
- AND the outside air temperature is less than 65°F (adj.)

The economizer shall close whenever the freestat (if present) is on.
The outside air dampers shall close and the return air damper shall
open when the unit is off. If Optimal Start Up is available the mixed
air damper shall operate as described in the occupied mode except
that the outside air damper shall modulate to fully closed.

The controller shall monitor the discharge air temperature. Should
discharge temperature drop below a user definable temperature (adj.),
the controller shall enable the heating, close the outside damper and
open the return damper.

Minimum Outside Air Ventilation - Fixed Percentage:
The outside air dampers shall maintain a minimum position (adj.)
during building occupied hours and be closed during unoccupied
hours.
<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
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<td>RSPL</td>
<td>ROOM SENSOR WITH SETPOINT AND OVERRIDE</td>
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<td>IN-4</td>
<td>EF Status – Cable 11</td>
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<td>IN-5</td>
<td>Freezestat Low Limit – Cable 12</td>
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<td>Mixed Air Damper – Cable 8</td>
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<td>HW Valve 0/20 mA – Cable 7</td>
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<td>Supply Fan – Cable 3</td>
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<td>Cooling – Cable 1</td>
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<tr>
<td>DO-3</td>
<td>Exhaust Fan – Cable 2</td>
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**Bill of Materials**

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<td>C-1200</td>
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<td>ALC1020-2-D-6&quot;</td>
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<td>INVENSYS</td>
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<td></td>
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<tr>
<td>E-V1</td>
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<td>R net</td>
<td>AUTOMATION LOGIC</td>
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<td>IN-3</td>
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<td>MTR To Enable Unit Relay R3</td>
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<td>DO-5</td>
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<td>DO-6</td>
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<td>LogiStat</td>
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<tr>
<td>AO-4</td>
<td>Port</td>
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**Diagram of VUV-5 Control**

Mounted Inside VUV-5

![Diagram of VUV-5 Control](image-url)
Unit Ventilator (typical of 1)

Run Conditions - Scheduled:
The unit shall run according to a user definable time schedule in the following modes:
- Occupied Mode: The unit shall maintain
  A 74°F (adj.) cooling setpoint
  A 70°F (adj.) heating setpoint.
- Unoccupied Mode (night setback): The unit shall maintain
  A 85°F (adj.) cooling setpoint. VUV cooling to remain “Off”
  A 62°F (adj.) heating setpoint.

Alarms shall be provided as follows:
- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

Zone Setpoint Adjust:
The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

Zone Optimal Start:
The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

Zone Unoccupied Override:
A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

Freeze Protection:
The unit shall shut down and generate an alarm upon receiving a freezestat status.

Supply and Exhaust Fans:
The supply and exhaust fans shall run on low or medium speeds (adjusted by air balancer) anytime the unit is commanded to run unless shutdown on safeties. When the space temperature is 2°F (Adj.) or higher above the setpoint the supply and exhaust fans will be at high speed.

Cooling:
The controller shall measure the zone temperature and energize the compressor to maintain its cooling setpoint. To prevent short cycling the compressor there is a user definable (adj.) minimum runtime. The cooling shall be enabled whenever:
- Outside air temperature is greater than 60°F (adj.).
- AND the zone temperature is above cooling setpoint.
- AND the fan is on.

Compressor Status:
The controller shall monitor the compressor status. Alarms shall be provided as follows:
- Compressor Failure: Commanded on, but the status is off.
- Compressor in Hand: Commanded off, but the status is on.
- Compressor Runtime Exceeded: Compressor status runtime exceeds a user definable limit (adj.).

Condenser Exhaust / Exhaust Air Fan Status:
The controller shall monitor the CE/EA status. Alarms shall be provided as follows:
- CE/EA Failure: Commanded on, but the status is off.
- CE/EA in Hand: Commanded off, but the status is on.
- CE/EA Runtime Exceeded: Compressor status runtime exceeds a user definable limit (adj.).

Heating Coil Valve:
The controller shall measure the zone temperature and modulate the heating coil valve to maintain its heating setpoint. The heating shall be enabled whenever:
- Outside air temperature is less than 65°F (adj.).
- AND the zone temperature is below heating setpoint.
- AND the fan is on.

The heating coil valve shall open whenever the freeze stat (if present) is on.

Economizer (ASHRAE Cycle II):
The controller shall measure the zone temperature and modulate the mixed air dampers in sequence to maintain the zone cooling setpoint. The outside air dampers shall maintain a minimum adjustable position of 20% (adj.) open during heating and ventilation whenever occupied.

The economizer shall be enabled whenever:
- Outside air temperature is at least 3°F (adj.) less than the Zone Temperature.
- AND the outside air temperature is less than 65°F (adj.)

The economizer shall close whenever the freeze stat (if present) is on. The outside air dampers shall close and the return air damper shall open when the unit is off. If Optimal Start Up is available the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully closed.

The controller shall monitor the discharge air temperature. Should discharge temperature drop below a user definable temperature (adj.), the controller shall enable the heating, close the outside damper and open the return damper.

Minimum Outside Air Ventilation - Fixed Percentage:
The outside air dampers shall maintain a minimum position (adj.) during building occupied hours and be closed during unoccupied hours.

Discharge Air Temperature:
The controller shall monitor the discharge air temperature. Alarms shall be provided as follows:
- High Discharge Air Temp: If the discharge air temperature is greater than 120°F (adj.).
- Low Discharge Air Temp: If the discharge air temperature is less than 40°F (adj.).

Fan Status:
The controller shall monitor the fan status. Alarms shall be provided as follows:
- Fan Failure: Commanded on, but the status is off.
- Fan in Hand: Commanded off, but the status is on.
- Fan Runtime Exceeded: Fan status runtime exceeds a user definable limit (adj.).

Elementary School
Michigan 48xxx
Metro Environmental, Inc.

REV: 0
Submit: 2/21/10
ASME No.: Class
CHECKED BY: TL
CIRCULATING AIR FLOW: 5
Water Source Heat Pumps

CAUTION:
This product was designed to be mounted inside the building envelope. Warranty voided if mounted outside.

Power for D.O.'s

DO-3
DO-2
DO-1
BUSS

Pwr

BACnet

567
8
90 1 2
3
4
567
8
90 1 2
3
4

Rx
Tx

DO-4
DO-5
AO-1
Gnd

BT485
Net +
Net -
Shield

CMnet
Tens
Ones

Batt
+-
CR
2032
Sense
+12V
Rnet-
Rnet+
Gnd
Gnd
Rnet
Rnet +
Rnet -
+12V
IN-1
IN-2
IN-3
Gnd
IN-4
IN-5
LED

Inputs: 5V Max

Class 2
24 Vac, 50-60 Hz
20VA, 0.83A
24Vdc, 0.2A, 5W
Use Copper Conductors Only

ZN551 CONTROLLER

Thermistor/dry contact
0-5Vdc

IN-1
Thermistor/dry contact
0-5Vdc
IN-2

ZN551

Outputs
24V Max,
1A Max

T2
T1

24vac Control Power
By HP Unit Mfr.

RSPL

To Or From Next Network Module

ARCnet

TN551

24V Control Power
By HP Unit Mfr.

The controller provides 24V control power by HP unit mfr.

ZN551

24Vac Control Power
By HP Unit Mfr.

RSPL

DO-1 Fan S/S Relay

DO-3 Reversing Valve Heat/Cool Mode

DO-4 Open HPLS Water Isolation Valve

DO-5 Close Perimeter Heating Valve

DO-2 Compressor S/S Relay

ZN551

DO-1 Fan S/S

DO-3 Reversing Valve

DO-4 HPLS Valve

DO-5 Perimeter Heating Valve

ZN551

DO-2 Compressor Enable

DO-3 Reversing Valve

IN-1 Fan Status

IN-2 Compressor Status

IN-3 Discharge Air Temp

IN-4 Fan Status

IN-5 Compressor Status

Elementary School
Michigan 48xxx
Metro Environmental, Inc.
Water Source Heat Pumps

Bill of Materials

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<th>PART NUMBER</th>
<th>QTY</th>
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<td>CORE</td>
<td>CVR-11C</td>
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<td>AUTOMATED LOGIC</td>
<td>ZN551</td>
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Water Source Heat Pump Sequence

Water Source Heat Pump (typical of 23)
Run Conditions - Scheduled:
The unit shall run according to a user definable time schedule in the following modes:

- Occupied Mode: The unit shall maintain
  - A 75°F (adj.) cooling setpoint
  - A 72°F (adj.) heating setpoint

- Unoccupied Mode (night setback): The unit shall maintain
  - A 85°F (adj.) cooling setpoint.
  - A 62°F (adj.) heating setpoint.

Alarms shall be provided as follows:
- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

Zone Setpoint Adjust:
The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

Zone Optimal Start:
The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

Zone Unoccupied Override:
A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

Fan:
The fan shall run anytime the unit is occupied, cycles during unoccupied with a call for heat and cool unless shutdown on safeties.

Heating and Cooling - 1 Compressor Stage:
The controller shall receive a signal from the loop water source monitor indicating that there is water flow and that the water temperature is within acceptable limits for a minimum of two minutes.
The controller shall measure the zone temperature, open the isolation valve and cycle the compressor to maintain its setpoint. To prevent short cycling, the stage shall have a user definable (adj.) minimum runtime. The compressor shall run subject to its own internal safeties and controls. The isolation valve will close when the compressor cycles off.

The heating shall be enabled whenever:
- Outside air temperature is less than 65°F (adj.).
- AND the fan is on.
- AND the reversing valve is in heat mode.

The cooling shall be enabled whenever:
- Outside air temperature is greater than 60°F (adj.).
- AND the fan is on.
- AND the reversing valve is in cool mode.

Alarms shall be provided as follows:
- Compressor Runtime Exceeded: The compressor runtime exceeds a user definable limit (adj.).
- Compressor Status:
The controller shall monitor the compressor status.

Filter Hours:
The controller shall monitor the fan runtime.

Discharge Air Temperature:
The controller shall monitor the discharge air temperature.

Fan Status:
The controller shall monitor the fan status.

Perimeter radiation heating valve will open whenever:
- Outside air temperature is less than 55°F (adj.) and there is a call for heat greater than 10% in either occupied or unoccupied mode.
Radiant Ceiling Panel Loop Control

Radiant Ceiling Panel Loop HWHS Reset Schedule

<table>
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<tr>
<td>≤ 0F</td>
<td>180F</td>
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<tr>
<td>≥ 55F</td>
<td>120F</td>
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Sequence of Operation

Radiant ceiling panel circulating pump activates when outdoor air temperature drops below 55F (adj.)

DDC monitors pump status via current switch and generates an alarm if an abnormal condition occurs.

DDC modulates 3-way mixing valve to maintain loop supply water temperature based on outdoor reset temperature schedule.
Sequence Of Operation

Cabinet Unit Heater (typical of 13)

Run Conditions - Scheduled:
The unit shall run according to a user definable time schedule in the following modes:
- Occupied Mode: The unit shall maintain a heating setpoint of 68°F (adj.).
- Unoccupied Mode (night setback): The unit shall maintain a heating setpoint of 55°F (adj.).

Alarms shall be provided as follows:
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

Zone Optimal Start:
The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

Fan:
The fan will run anytime the zone temperature drops below the heating setpoint and hot water is available as sensed by the pipe mounted aquastat after relay R is enabled. When relay R is disabled the fan will stop.

Heating Coil Valve:
The cabinet unit heaters do not have valves.
Exhaust Fans Serving Pre-School Wing

Sequence of Operation

Exhaust fans are started and stopped based on an occupied time schedule. DDC controller will monitor the exhaust fan statuses via current switches. If an abnormal condition occurs the controller will generate an alarm.
Exhaust Fans Serving Northwest Rooms

**Sequence of Operation**

Exhaust fans are started and stopped based on an occupied time schedule.

DDC controller will monitor the exhaust fan statuses via current switches. If an abnormal condition occurs the controller will generate an alarm.
Additional Exhaust Fans

Sequence of Operation

Exhaust fans are started and stopped based on an occupied time schedule.

DDC controller will monitor the exhaust fan status via current switch. If an abnormal condition occurs the controller will generate an alarm.

Typical Exhaust Fan Control In The Following Areas:

1) Preschool West Bathroom.
2) Toilets South of Teachers Lounge
3) Art Room Storage
4) To Be Determined (TBD).
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<th>QTY</th>
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<td>127</td>
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**Summary Bill of Materials**

- **Elementary School**
- **Metro Environmental, Inc.**
- **Docket No:** 123456
- **Location:** Michigan 48xxx

**Calculated Quantities:**

- **Total Parts:** 1234
- **Total Units:** 12345

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**Note:** The above table is a summary of the bill of materials for the listed components, detailing their description, manufacturer, part number, and quantity. The table is designed to provide a clear and organized view of the inventory required for the project.