# Instrumentation and Control for HVAC

# BAS Master Sequence of Operations
# VAV/Parallel FPB - AHU Building

## Prepared By:
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## SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

### 1.1 VAV-AHU (typical)

Run Conditions - Requested:
The unit shall run whenever:

- Any zone is occupied.
- OR a definable number of unoccupied zones need heating or cooling.

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

High Static Shutdown:
The unit shall shut down and generate an alarm upon receiving an high static shutdown signal

Low Static Shutdown:
The unit shall shut down and generate an alarm upon receiving an low static shutdown signal.

Return Air Smoke Detection:
The unit shall shut down and generate an alarm upon receiving a return air smoke detector status.

Supply Air Smoke Detection:
The unit shall shut down and generate an alarm upon receiving a supply air smoke detector status.

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

Demand Limiting - Setpoint Adjust:
To lower power consumption, the supply air temperature setpoint shall automatically relax (raised for cooling; lowered for heating) when the facility power consumption exceeds definable thresholds. The amount of relaxation shall be accomplished by both of the following methods:

- The supply air temperature setpoint shall relax by 2°F (adj.) for each demand threshold exceeded.
- The setpoints in the zones supplied by this unit shall be relaxed as specified in the Sequence of Operations for the zones. This shall in turn relax the unit's supply air temperature setpoint by a user definable amount.

All setpoints shall automatically return to their previous settings when the facility power consumption drops below the thresholds, per operator command.

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.
- Multiple Fan Systems – All Fan's Status' will be individually monitored

Supply Air Duct Static Pressure Control:
The controller shall measure duct static pressure and modulate the supply fan VFD speed to maintain a duct static pressure setpoint. The speed shall not drop below a TAB furnished minimum % (adj.). The static pressure setpoint shall be reset based on zone cooling requirements.

- The initial duct static pressure setpoint shall be TAB furnished minimum (adj.).
- As cooling demand increases, the setpoint shall incrementally reset up to a maximum of TAB furnished minimum (adj.).
- As cooling demand decreases, the setpoint shall incrementally reset down to a minimum of TAB furnished minimum (adj.).

Alarms shall be provided as follows:

- High Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) greater than setpoint.
- Low Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) less than setpoint.
- Supply Fan VFD Fault.

Return Fan:
The return fan shall run whenever the supply fan runs.

Alarms shall be provided as follows:

- Return Fan Failure: Commanded on, but the status is off.
- Return Fan in Hand: Commanded off, but the status is on.
- Return Fan VFD Fault.

Building Static Pressure Control:
The controller shall measure building static pressure and modulate the return fan VFD speed to maintain a building static pressure setpoint of 0.05in $H_2O$ (adj.). The return fan VFD speed shall not drop below 20% (adj.).

Alarms shall be provided as follows:

- High Building Static Pressure: If the building air static pressure is 25% (adj.) greater than setpoint.
- Low Building Static Pressure: If the building air static pressure is 25% (adj.) less than setpoint.

Supply Air Temperature Setpoint - Optimized:
The controller shall monitor the supply air temperature and shall maintain a supply air temperature setpoint reset based on zone cooling requirements.

The supply air temperature setpoint shall be reset based on zone cooling requirements as follows:

- The initial supply air temperature setpoint shall be 55°F (adj.).
- As cooling demand increases, the setpoint shall incrementally reset down to a minimum of 53°F (adj.).
- As cooling demand decreases, the setpoint shall incrementally reset up to a maximum of 65°F (adj.) .

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

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 supply fan status is on.
- AND the heating (if present) is not active.

The cooling coil valve shall open to 50% (adj.) whenever the freezestat (if present) is on.

Alarms shall be provided as follows:

- High Supply Air Temp: If the supply air temperature is 5°F (adj.) greater than setpoint.

Low Supply Air Temperature Alarm:
The controller shall alarm if the supply air temperature is less than 45°F (adj.).

Economizer:
The controller shall measure the mixed air temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F (adj.) less than the supply air temperature 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 enthalpy is less than 22Btu/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.

The economizer shall close whenever:

- Mixed air temperature drops from 40°F to 39°F (adj.)
- OR the freezestat (if present) is on.
- OR on loss of supply fan status.

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 - Carbon Dioxide (CO2) Control:
When in the occupied mode, the controller shall monitor zone CO2 levels served by this air handling unit. The controller shall take the highest zone CO2 level and modulate the outside air dampers open on rising CO2 concentrations, overriding normal damper operation to maintain a CO2 setpoint of 1000 ppm (adj.).

Alarms shall be provided as follows:

- High Zone Carbon Dioxide Concentration: If the highest zone CO2 concentration is greater than 1200 ppm (adj.).

Dehumidification:
The controller shall measure the return air humidity and override the cooling sequence to maintain return air humidity at or below 65% rh (adj.). Dehumidification shall be enabled whenever the supply fan status is on.

Final Filter Differential Pressure Monitor:
The controller shall monitor the differential pressure across the final filter.

Alarms shall be provided as follows:

- Final Filter Change Required: Final filter 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.).

Return Air Temperature:
The controller shall monitor the return air temperature and use as required for setpoint control or economizer control (if present).

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 75°F (adj.).
- Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

Leak Detector:

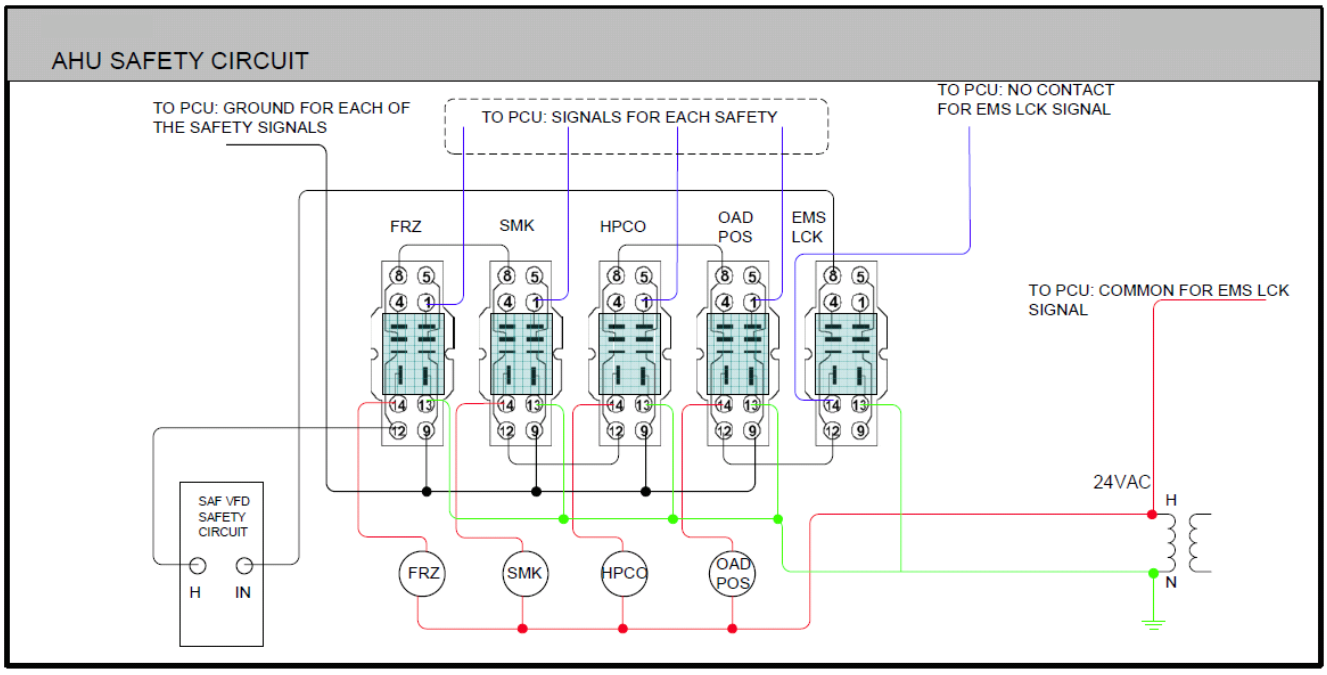
The controller shall monitor leak detector status.

Alarms shall be provided as follows:

- System shall alarm upon leak detection and be configurable to text and/or email (at Owner's discretion) either individually or with groups setup to notify personnel.

Safety Circuit Wiring:

The Safety Circuit will follow this template below. Any adjustment by vendor must be approved prior to implementation by Owner.




**1.2 Variable Air Volume - Terminal Unit (typical)**

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.

If occupancy sensor is used, use these parameters in addition too

- Unoccupied Mode (occupancy sensor): The unit shall maintain
    - A 78°F (adj.) cooling setpoint.
    - A 65°F (adj.) heating setpoint.

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 (120 min adj.). At the expiration of this time, control of the unit shall automatically return to the schedule.

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.

Reheating Coil Valve:
The controller shall measure the zone temperature and modulate the reheating coil valve open on dropping temperature to maintain its heating setpoint.

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

### 1.3 Fan Coil Unit (typical)

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 73°F (adj.) cooling setpoint
  - A 71°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 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 commanded to run, unless shutdown on safeties.

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

The cooling shall be enabled whenever:

- AND the zone temperature is above cooling setpoint.
- AND the fan is on.

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

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

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.

**1.4 Exhaust Fan - Toilet/General (typical)**

Run Conditions - Interlocked:
The fan(s) Toilet/General EF shall be interlocked to run whenever (associated) Air Handling Unit runs unless shutdown on safeties.

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.

**1.6 Exhaust Fan - Crawl Space (typical)**

Run Conditions The fan shall run according space humidity and temperature set point

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.

**1.7 Steam to Hot Water Converter (typical) (Hydronic)**

Heat Exchanger System Run Conditions:
The heat exchanger system shall be enabled to run under set point control.

Hot Water Pump Lead/Lag Operation:
The two hot water pumps shall operate in a lead/lag fashion.

- The lead pump shall run first.
- On failure of the lead pump, the lag pump shall run and the lead pump shall alarm.
- On decreasing hot water differential pressure, the lag pump shall stage on and run in unison with the lead pump to maintain hot water differential pressure setpoint.

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

Alarms shall be provided as follows:

- Hot Water Pump 1
  - Failure: Commanded on, but the status is off.
  - Running in Hand: Commanded off, but the status is on.
  - VFD Fault.

- Hot Water Pump 2
  - Failure: Commanded on, but the status is off.
  - Running in Hand: Commanded off, but the status is on.
  - VFD Fault.

Hot Water Differential Pressure Control:
The controller shall measure hot water differential pressure and modulate the hot water pump VFDs in sequence to maintain its hot 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 hot water pump speeds to maintain a hot water differential pressure of $12 lb_f/in^2$ (adj.). The VFDs minimum speed shall not drop below 33% or 20 HZ(adj.).

On dropping hot 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.) for 5 min. (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 differential pressure setpoint.

On rising hot water differential pressure, the VFDs shall stage off as follows:

- If the VFDs speeds drops back to 60% (adj.) for 5 min. (adj.) below setpoint, the lag VFD shall stage off.
- The lead VFD shall continue to run to maintain setpoint.

Alarms shall be provided as follows:

- High Hot Water Differential Pressure: If 25% (adj.) greater than setpoint.
- Low Hot Water Differential Pressure: If 25% (adj.) less than setpoint.

Hot Water Supply Temperature Setpoint Reset:
The hot water supply temperature setpoint shall reset using a trim and respond algorithm based on heating requirements.

As the facility's hot water valves open beyond a user definable threshold (90% open, typ.), the setpoint shall reset to a higher value (adj.). Once the hot water coils are satisfied (valves closing) then the setpoint shall gradually lower over time to reduce heating energy use.

Alarms shall be provided as follows:

- High Hot Water Supply Temp: If greater than 200°F (adj.).
- Low Hot Water Supply Temp: If less than 100°F (adj.).

Heat Exchanger Steam Valve - Hot Water Control:
The controller shall measure the hot water supply temperature and modulate the steam valve to maintain its setpoint.

The steam valve shall be enabled whenever:

- The heat exchanger is called to run.
- AND hot water supply temperature is below setpoint.

The steam valve shall close whenever the hot water supply temperature rises above 200°F (adj.).

**1.8 Chilled Water Loop Pump (typical)**

Chilled Water Pump System - Run Conditions:
The chilled water pumps shall be enabled whenever:

- A definable number of chilled water coils need cooling.
- AND the outside air temperature is greater than 54°F (adj.).

To prevent short cycling, the chilled water pump system shall run for and be off for minimum adjustable times (both user definable).

The pumps shall run for freeze protection anytime the outside air temperature is less than 38°F (adj.).

Chilled Water Pump:
The chilled water pump shall run anytime it is requested to run. The chilled water pump shall also run for freeze protection whenever the outside air temperature is less than a user definable setpoint (adj.).

The chilled water pump shall have:

- A user adjustable delay on start.
- AND a user adjustable delay on stop.

The delay times shall be set appropriately to allow for orderly chilled water system start-up, shutdown and sequencing.

Alarms shall be provided as follows:

- Chilled Water Pump Failure: Commanded on, but the status is off.
- Chilled Water Pump Running in Hand: Commanded off, but the status is on.

- Chilled Water Pump VFD Fault.

Chilled Water Differential Pressure Control:
The controller shall measure chilled water differential pressure and modulate the chilled water pump VFD to maintain its chilled 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 chilled water pump speed to maintain a chilled water differential pressure of $12 lb_f/in^2$ (adj.). The VFD minimum speed shall not drop below 33% or 20 HZ(adj.)..

Alarms shall be provided as follows:

- High Chilled Water Differential Pressure: If the chilled water differential pressure is 25% (adj.) greater than setpoint.
- Low Chilled Water Differential Pressure: If the chilled water differential pressure is 25% (adj.) less than setpoint.

Chilled Water Temperature Monitoring:
The following temperatures shall be monitored:

- Chilled water supply.
- Chilled water return.

Alarms shall be provided as follows:

- High Chilled Water Supply Temp: If the chilled water supply temperature is greater than 55°F (adj.).
- Low Chilled Water Supply Temp: If the chilled water supply temperature is less than 38°F (adj.).

### 1.9 Hot Water Loop Pumps (typical)

Hot Water Pump Run Conditions:
The hot water pumps shall be enabled whenever:

- A definable number of hot water coils need heating.

The pumps shall run for freeze protection anytime outside air temperature is less than 38°F (adj.).

To prevent short cycling, the pump shall run for a minimum time and be off for a minimum time (both user adjustable).

Hot Water Pump Lead/Lag Operation:
The two variable speed hot water pumps shall operate in a lead/lag fashion.

- The lead pump shall run first.
- On failure of the lead pump, the lag pump shall run and the lead pump shall alarm.
- On decreasing hot water differential pressure, the lag pump shall stage on and run in unison with the lead pump to maintain hot water differential pressure setpoint.

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

Alarms shall be provided as follows:

- Hot Water Pump 1
    - Failure: Commanded on, but the status is off.
    - Running in Hand: Commanded off, but the status is on.
    - VFD Fault.

- Hot Water Pump 2
    - Failure: Commanded on, but the status is off.
    - Running in Hand: Commanded off, but the status is on.
    - VFD Fault.

Hot Water Differential Pressure Control:
The controller shall measure hot water differential pressure and modulate the hot water pump VFDs in sequence to maintain its hot 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 hot water pump speeds to maintain a hot water differential pressure of $12 lb_f/in^2$ (adj.). The VFDs minimum speed shall not drop below 33% or 20 HZ(adj.).

On dropping hot 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.

On rising hot water differential pressure, the VFDs shall stage off as follows:

- If the VFDs speeds drops back to 60% (adj.) below setpoint, the lag VFD shall stage off.
- The lead VFD shall continue to run to maintain setpoint.

Alarms shall be provided as follows:

- High Hot Water Differential Pressure: If 25% (adj.) greater than setpoint.
- Low Hot Water Differential Pressure: If 25% (adj.) less than setpoint.

Hot Water Temperature Monitoring:
The following temperatures shall be monitored:

- Hot water supply.
- Hot water return.

Alarms shall be provided as follows:

- High Hot Water Supply Temp: If the hot water supply temperature is greater than 200°F (adj.).
- Low Hot Water Supply Temp: If the hot water supply temperature is less than 100°F (adj.).

**1.10 BTU Meter (typical)**

BTU Meter:
The controller shall monitor the BTU meter for energy consumption on a continual basis. These values shall be made available to the system at all times.

Alarm shall be generated as follows:

- Invalid Reading: Sensor reading indicates an invalid value from the BTU meter.

Peak Demand History:
The controller shall monitor and record the peak (high and low) demand readings from the BTU meter. Peak readings shall be recorded on a daily, month-to-date, and year-to-date basis.

Usage History:
The controller shall monitor and record BTU meter readings so as to provide an energy consumption history. Usage readings shall be recorded on a daily, month-to-date, and year-to-date basis.

**1.11 Electric Meter (typical of 1)**

Electric Meter:
The controller shall monitor the electric meter for electric consumption on a continual basis. These values shall be made available to the system at all times.

Alarm shall be generated as follows:

- Meter Alarm: Sensor reading indicates an invalid value from the electric meter.

Peak Demand History:
The controller shall monitor and record the peak (high and low) demand readings from the electric meter. Peak readings shall be recorded on a daily, month-to-date, and year-to-date basis.

Usage History:
The controller shall monitor and record electric meter readings so as to provide a power consumption history. Usage readings shall be recorded on a daily, month-to-date, and year-to-date basis.

Demand Levels:
The controller shall set the system demand level (adj.) based on the current power consumption readings from the electric meter. There shall be six daily time periods in which the demand shall be adjusted on three levels. These demand levels shall be available for facility equipment to utilize for demand limiting.

- Demand Level 1: Power consumption has exceeded the first demand level threshold (adj.).
- Demand Level 2: Power consumption has exceeded the second demand level threshold (adj.).
- Demand Level 3: Power consumption has exceeded the third demand level threshold (adj.).

**1.12 Indoor Lighting (typical)**

Run Conditions - Scheduled:
The lighting shall be turned on or off based on a user definable schedule.

Occupant Override:
A timed local override control will allow an occupant to override the schedule and turn the lighting on for an adjustable period of time. At the expiration of this time, control of the lighting will automatically return to the schedule

Warning Flash:
The output will cycle off (flash) 5 times (adj) to warn occupants when the lights are about to turn off. This flashing will occur 5 minutes (adj) before the the lights turn off.

Alarm shall be provided as follows:

- Output Runtime Exceeded: Lighting runtime exceeds a user definable limit (adj.).

**1.13 Outdoor Lighting (typical of 1)**

Run Conditions:
The lighting output shall turn on and off based upon the local sunrise and sunset times. The transitions shall be configurable as follows:

Output turns OFF (adj) at 30 minutes (adj) BEFORE (adj) sunrise.

Output turns ON (adj) at 30 minutes (adj) AFTER (adj) sunset.

## 1.14 Point Summary

| SMU BAS Master Points List | | | | | | | Date: 07.31.09 Rev#2.1 |
|---|---|---|---|---|---|---|---|
| | | Input/Output Point Summary | | | | | |
| Description | Function | DI | DO | AI | AO | Qty | Device/Comment |
| **Building Plant Points (Typ)** | | | | | | | |
| Building Chilled Water Pump | Enable/Disable | | 1 | | | 1 | IDEC RH2B control relay |
| Building Chilled Water Pump | Amps | | | 1 | | 1 | *** dry contact from VFD |
| Building Chilled Water Pump | Speed Modulate | | | | 1 | 1 | onboard 0-10 VDC control signal |
| Building Chilled Water Supply | Temperature | | | 1 | | 1 | Immersion Temp Sensor |
| Building Chilled Water Return | Temperature | | | 1 | | 1 | Immersion Temp Sensor |
| Building Chilled Water Supply | GPM | | | 1 | | 1 | Onicon F-3100 |
| Building BTUs | BTU | | | 1 | | 1 | Onicon System 10 BTU Meter |
| Building Chilled Water | Diff. Pressure | | | 1 | | 1 | |
| Building Steam | Pressure | | | 1 | | 1 | Onicon F-3100 |
| Building Steam Meter | lbs/hr | | | 1 | | 1 | |
| Building Steam Solenoid | On/Off | | 1 | | | 1 | Steam Solenoid, Steam Valve by others |
| Steam Condensate High Level Alarm | Status | 1 | | | | 1 | Dry Contact |
| Steam Heat Exchanger Valve | Modulate | | | | 2 | 2 | |
| Building Hot Water Pump | Enable/Disable | | 2 | | | 2 | IDEC RH2B control relay |
| Building Hot Water Pump | Amps | | | 2 | | 2 | *** dry contact from VFD |
| Building Hot Water Pump | Speed Modulate | | | | 2 | 2 | onboard 0-10 VDC control signal |
| Bldg Hot Water Supply | Temperature | | | 1 | | 1 | Immersion Temp Sensor (Interlocked to BTU) |
| Bldg Hot Water Return | Temperature | | | 1 | | 1 | Immersion Temp Sensor (Interlocked to BTU) |
| Bldg Hot Water | Diff. Pressure | | | 1 | | 1 | |
| Bldg Domestic Hot Water Supply | Temperature | | | 1 | | 1 | Immersion Temp Sensor |
| Water Meter<br>Gas Meter (where app) | Gal.<br>LB/hr | 1 | | | | 1 | (See Water Meter Section, PBO) |
| Sump Pump Alarm | Alarm Status | 1 | | | | 1 | Aux. Contact |
| Sewage Ejector Pump Alarm | Alarm Status | 1 | | | | 1 | Aux. Contact |
| Building Static | Pressure | | | 1 | | 1 | |
| Electric Vault Water Detection | Status | 1 | | | | 1 | |
| Mech Room Water Detection | Alarm Status | 1 | | | | 2 | |
| Bldg Electric Demand | KW | 1 | | | | 1 | |
| Shark CT's | KW | | | | | 3 | |
| Bldg Fire Alarm | Alarm Status | 1 | | | | 1 | monitor aux. Contacts |
| Bldg Fire Alarm Trouble (test) | Alarm Status | 1 | | | | 1 | monitor aux. Contacts |
| Lighting (ext) | On/Off | | 5 | | | 5 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Lighting (ext) | Normal/Override | 5 | | | 5 | |
| **Exhaust Fans (Typ)** | | | | | | |
| Toilet/General Exhaust Fan | Start/Stop | | 1 | | 1 | |
| Toilet/General Exhaust Fan | Status | | | 1 | 1 | |
| Mech Rm Exhaust Fan | Start/Stop | | 1 | | 1 | |
| Mech Rm Exhaust Fan | Amps Status | | | 1 | 1 | |
| **VAV AHU (Typ)** | | | | | | |
| Supply Fan VFD | Enable/Disable | | 1 | | 1 | IDEC RH2B control relay |
| Supply Fan VFD | Status | | | 1 | 1 | *** dry contact from VFD |
| Supply Fan VFD | Speed Modulate | | | 1 | 1 | onboard 0-10 VDC control signal |
| Relief Fan VFD | Enable/Disable | | 1 | | 1 | IDEC RH2B control relay |
| Relief Fan VFD | Status | | | 1 | 1 | *** dry contact from VFD |
| Relief Fan VFD | Speed Modulate | | | 1 | 1 | onboard 0-10 VDC control signal |
| Supply Air | Static Pressure | | | 1 | 1 | |
| Supply Air | High Static Alarm | 1 | | | 1 | |
| Supply Air | Low Static Alarm | 1 | | | 1 | |
| Supply Air | Temperature | | | 1 | 1 | |
| Mixed Air | Temperature | | | 1 | 1 | |
| Mixed Air | Low Limit Safety Status | | | | 1 | monitor aux. contacts |
| Mixed Air | Low Limit Safety Interlock | 1 | | | 1 | |
| Return Air | Temperature | | | 1 | 1 | |
| | | | | ~~1~~ | ~~1~~ | |
| | | | | ~~1~~ | ~~1~~ | |
| Return Air Damper | Modulate | | | 1 | 1 | |
| Return Air Damper End Switch | | 1 | | | 1 | |
| Relief Air Damper | Modulate | | | | 1 | |
| Outside Air Damper | Modulate | | | 1 | 1 | |
| Outside Air Damper End Switch | | 1 | | | 1 | |
| Filter Status | Diff. Pressure | | | 1 | 1 | |
| Chill Water Valve | Modulate | | | 1 | 1 | |
| Smoke Detector | Alarm Status | 1 | | | 1 | detector by others, monitor aux. Contacts |
| Smoke Detector | Interlock | | | | 2 | interlock aux. contacts |
| Safety Cutout | EMS Lockout | 1 | 1 | | 2 | |
| **Fan Coil Unit (Typ)** | | | | | | |
| Fan | Start/Stop | | 1 | | 1 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Fan | Status | 1 | | | 1 | |
| Chilled Water Valve | Modulate | | | 1 | 1 | |
| Space | Temperature | | 1 | | 1 | |
| Supply Air | Temperature | | 1 | | 1 | |
| Lighting Occ Sens (POB, where app) | Provided by others | 1 | | | | Sensor provided by others |
| Emergency Drain Pan (where app) | Detector | 1 | | | 1 | WD-1B |
| | | | | | | |

**VAV Box (Typ)**

| | | | | | | |
|---|---|---|---|---|---|---|
| Space | Temperature | | 1 | | | |
| Override Request | Status | | 1 | | 1 | LCD/LED Thermostat w/setpoint adjustment and override control |
| Lighting Occ Sens (POB, where app) | Provided by others | 1 | | | | |
| Setpoint Adjust | Increase/Decrease | | 1 | | | |
| Reheat/Supply Air | Temperature | | 1 | | 1 | |
| Reheat Valve | Modulate | | | 1 | 1 | |
| Primary Air | CFM | | 1 | | 1 | onboard velocity transducer |
| VAV Damper | Modulate | | | 1 | 1 | integral actuator |
| | | | | | | |

**Parrallal FPB Box (Typ)**

| | | | | | | |
|---|---|---|---|---|---|---|
| Space | Temperature | | 1 | | | |
| Override Request | Status | | 1 | | 1 | LCD/LED Thermostat w/setpoint adjustment and override control |
| Lighting Occ Sens (POB, where app) | Provided by others | 1 | | | | |
| Setpoint Adjust | Increase/Decrease | | 1 | | | |
| Reheat/Supply Air | Temperature | | 1 | | 1 | |
| Reheat Valve | Modulate | | | 1 | 1 | |
| Primary Air | CFM | | 1 | | 1 | onboard velocity transducer |
| VAV Damper | Modulate | | | 1 | 1 | integral actuator |
| Fan | Start/Stop | | 1 | | 1 | |
| Fan | Status | 1 | | | 1 | |
| Fan Speed | Modulate | | | 1 | 1 | |
| | | | | | | |

## APPENDIX A: Glossary of Terms

**Terms used within the Specification Text:**

- **Advanced Application Controller (AAC):**

  A fully programmable control module. This control module may be capable of some of the advanced features found in Building Controllers (storing trends, initiating read and write requests, etc.) but it does not serve as a master controller. Advanced Application Controllers may reside on either the Ethernet/IP backbone or on a subnet.

- **Application Specific Controller (ASC):**

  A pre-programmed control module which is intended for use in a specific application. ASCs may be configurable, in that the user can choose between various pre-programmed options, but it does not support full custom programming. ASCs are often used on terminal equipment such as VAV boxes or fan coil units. In many vendors' architectures ASCs do not store trends or schedules but instead rely upon a Building Controller to provide those functions.

- **BACnet/IP:**

  An approved BACnet network type which uses an Ethernet carrier and IP addressing.

- **BACnet MS/TP:**

  An approved BACnet network type which uses a Master-Slave Token Passing configuration. MS/TP networks are unique to BACnet and utilize EIA485 twisted pair topology running at 9600 to 76,800 bps.

- **Building Controller (BC):**

  A fully programmable control module which is capable of storing trends and schedules, serving as a router to devices on a subnet, and initiating read and write requests to other controllers. Typically this controller is located on the Ethernet/IP backbone of the SMU BMS Network. In many vendors' architectures a Building Controller will serve as a master controller, storing schedules and trends for controllers on a subnet underneath the Building Controller.

- **Direct Digital Control (DDC):**

  A control system in which a digital computer or microprocessor is directly connected to the valves, dampers, and other actuators which control the system, as opposed to indirectly controlling a system by resetting setpoints on an analog pneumatic or electronic controller.

- **PICS - Protocol Implementation Conformance Statement:**

  A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device.

- **Smart Actuator (SA):**

  An actuator which is controlled by a network connection rather than a binary or analog signal. (0-10v, 4-20mA, relay, etc.)

- **Smart Sensor (SS):**

  A sensor which provides information to the BAS via network connection rather than a binary or analog signal. (0-10000 ohm, 4-20mA, dry contact, etc.)

- **Web services:**

  Web services are a standard method of exchanging data between computer systems using the XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services can be used at any level within a Building Automation System (BAS), but most commonly they are used to transfer data between BAS using different protocols or between a BAS and a non-BAS system such as a tenant billing system or a utility management system.

**Terms used within the Sequences of Operation:**

- **adj.**

  Adjustable by the end user, through the supplied user interface.

- **AI, AO, etc. (Column Headings on Points List)**

  **AI** = Analog Input. A physical input to the control module.
  **AO** = Analog Output. A physical output from the control module.
  **AV** = Analog Value. An intermediate (software) point that may be editable or read-only. Editable AVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only AVs are typically used to display the status of a control operation.
  **BI** = Binary Input. A physical input to the control module.
  **BO** = Binary Output. A physical output from the control module.
  **BV** = Binary Value. An intermediate (software) point that may be editable or read-only. Editable BVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only BVs are typically used to display the status of a control operation.
  **Sched** = Schedule. The control algorithm for this equipment shall include a user editable schedule.
  **Trend**. The control system shall be configured to collect and display a trend log of this object. The trending interval shall be no less than one sample every 5 minutes. (Change of Value trending, where a sample is taken every time the value changes by more than a

user-defined minimum, is an acceptable alternative.)
**Alarm**. The control system shall be configured to generate an alarm when this object exceeds user definable limits, as described in the Sequence of Controls.

**Note:** If the specifications require use of the BACnet protocol, all of the above shall be provided as BACnet objects.

- **KW Demand Limiting: ***

  An energy management strategy that reduces energy consumption when a system's electric power meter exceeds an operator-defined threshold.

  When power consumption exceeds defined levels, the system automatically adjust setpoints, de-energizes low priority equipment, and takes other pre-programmed actions to avoid peak demand charges. As the demand drops, the system restores loads in a predetermined manner.

- **Occupant Override Switch, or Timed Local Override:**

  A control option that allows building occupants to override the programmed HVAC schedule for a limited period of time.

  When the override time expires, the zone returns to its unoccupied state.

- **Occupant Setpoint Adjustment:**

  A control option that allows building occupants to adjust - within limits set by the HVAC control system - the heating and cooling setpoints of selected zones. Typically the user interface for this function is built into the zone sensor.

- **Optimal Start-Up: ***

  A control strategy that automatically starts an HVAC system at the latest possible time yet ensures comfort conditions by the time the building becomes occupied.

  In a typical implementation, a controller measures the temperature of the zone and the outside air. Then, using design heating or cooling capacity at the design outside air temperature, the system computes how long a unit must run at maximum capacity to bring the zone temperature to its occupied setpoint.

  The optimal start algorithm often includes a self-learning feature to adjust for variations from design capacity.

  A distributed system must use Run on Request with Optimal Start. (See below.)

- **Requested, or Run on Request: ***

  A control strategy that optimizes the runtime of a source piece of equipment that supplies one or more receiving units - such as an air handler unit supplying zone

terminal units with heating, cooling, ventilation, or similar service. Source equipment runs only when needed, not on a fixed schedule.

The source equipment runs when one or more receiving units request its services. An operator determines how many requests are required to start the source equipment.

For example, if all the zones in a building are unoccupied and the zone terminal units do not need heating or cooling, the AHU will shut down. However, if a zone becomes occupied or needs cooling, the terminal unit will send a run request to the AHU to initiate the start-up sequence. If this AHU depends on a central chiller, it can send a run request to the chiller.

The run on request algorithm also allows an operator to schedule occupancy for individual zones based on the needs of the occupants without having to adjust the schedules of related AHUs and chillers.

- **Trim and Respond, or Setpoint Optimization: ***

  A control strategy that optimizes the setpoint of a source piece of equipment that supplies one or more receiving units - such as an air handler unit supplying zone terminal units with heating, cooling, ventilation, or similar service.

  The source unit communicates with receiving units to determine heating, cooling, and other requirements, and then adjusts its setpoint.

  For example, if all zones are comfortable and do not request cooling, the AHU will gradually increase (trim) its supply air setpoint. When a zone requests cooling, the AHU responds by dropping its setpoint. The more zones that request cooling, the more it drops the setpoint. The AHU repeats this process throughout the day to keep zones cool, but with a supply air setpoint that is no cooler than necessary.

**Contracting Terms:**

- **Furnished or Provided:**

  The act of supplying a device or piece of equipment as required meeting the scope of work specified and making that device or equipment operational. All costs required to furnish the specified device or equipment and make it operational are borne by the division specified to be responsible for providing the device or equipment.

- **Install or Installed:**

  The physical act of mounting, piping or wiring a device or piece of equipment in accordance with the manufacturer's instructions and the scope of work as specified. All costs required to complete the installation are borne by the division specified to include labor and any ancillary materials.

- **Interface:**

  The physical device required to provide integration capabilities from an equipment vendor's product to the control system. The equipment vendor most normally furnishes the interface device. An example of an interface is the chilled water temperature reset interface card provided by the chiller manufacturer in order to allow the control system to integrate the chilled water temperature reset function into the control system.

- **Integrate:**

  The physical connections from a control system to all specified equipment through an interface as required to allow the specified control and monitoring functions of the equipment to be performed via the control system.

## APPENDIX B: Abbreviations

**The following abbreviations may be used in graphics, schematics, point names, and other UI applications where space is at a premium.**

**AC -** Air Conditioning
**ACU -** Air Conditioning Unit
**AHU -** Air Handling Unit
**AI -** Analog Input
**AO -** Analog Output
**AUTO -** Automatic
**AUX -** Auxiliary
**BI -** Binary Input
**BO -** Binary Output
**C -** Common
**CHW -** Chilled Water
**CHWP -** Chilled Water Pump
**CHWR -** Chilled Water Return
**CHWS -** Chilled Water Supply
**COND -** Condenser
**CW -** Condenser Water
**CWP -** Condenser Water Pump
**CWR -** Condenser Water Return
**CWS -** Condenser Water Supply
**DA -** Discharge Air
**EA -** Exhaust Air
**EF -** Exhaust Fan
**EVAP -** Evaporators
**FCU -** Fan Coil Unit
**HOA -** Hand / Off / Auto
**HP -** Heat Pump
**HRU -** Heat Recovery Unit
**HTEX -** Heat Exchanger
**HW -** Hot Water
**HWP -** Hot Water Pump
**HWR -** Hot Water Return
**HWS -** Hot Water Supply
**MAX -** Maximum
**MIN -** Minimum
**MISC -** Miscellaneous
**NC -** Normally Closed
**NO -** Normally Open
**OA -** Outdoor Air
**PIU -** Powered Induction Unit
**RA -** Return Air
**RF -** Return Fan
**RH -** Relative Humidity
**RTU -** Roof-top Unit
**SA -** Supply Air

**SF -** Supply Fan
**SP -** Static Pressure
**TEMP -** Temperature
**UH -** Unit Heater
**UV -** Unit Ventilator
**VAV -** Variable Air Volume
**VVTU -** Variable Volume Terminal Unit
**W/ -** with
**W/O -** without
**WSHP -** Water Source Heat Pump