SECTION 15958
(23 0993)
SEQUENCE OF OPERATION

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PART I. GENERAL

1.01 SECTION INCLUDES
A. Air Handling Units
B. Glycol Recovery System
C. Steam to Hot Water Converter
D. Central Plant Monitoring

1.02 RELATED DOCUMENTS:
A. Drawings and general provisions of Contract, including the General Conditions and Supplementary Conditions and other Division-1 Specification Sections, apply to this Section.
B. Section 15010 - Basic Mechanical Requirements
C. Section 23 0500 – Common Work Results for HVAC
D. Section 15950 - Building Automation System (BAS) General
E. Section 23 0900 - Building Automation System (BAS) General
F. Section 15951 - BAS Basic Materials, Interface Devices, and Sensors
G. Section 23 0913 – BAS Basic Materials, Interface Devices, and Sensors
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K. Section 23 0904 - BAS Communication Devices
L. Section 15955 - BAS Software
M. Section 23 0905 - BAS Software and Programming
N. Section 15959 – BAS Commissioning
O. Section 23 0801 - BAS Commissioning

1.03 SYSTEM DESCRIPTION
A. This Section defines the manner and method by which controls operate and sequence the controlled equipment. Included in this section are general requirements and logic strategies that expand on the specific sequences shown on the drawings. Specific drawing sequences refer to this section and reference the logic strategies as required.
B. Refer to the control drawings for specific sequences for individual systems.

1.04 SUBMITTALS
A. Refer to Section 15950 (23 0900) and Division 1 for requirements for control shop drawings, product data, Users Manual, etc.
PART II. PRODUCTS

Not Used
PART III.  EXECUTION

3.01  GENERAL

A. Sequences specified herein indicate the functional intent of the systems operation and may not fully detail every aspect of the programming that may be required to obtain the indicated operation. Contractor shall provide all programming necessary to obtain the sequences/system operation indicated.

B. When an air handling unit is not in operation, control devices shall remain in their “off” positions. “Off” positions may differ from the “normal” (meaning failed) position. Except as specified otherwise, “off” and “normal” positions of control devices shall be as follows:

<table>
<thead>
<tr>
<th>Device</th>
<th>“Off” Position</th>
<th>“Normal” Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating coil valves</td>
<td>closed</td>
<td>open</td>
</tr>
<tr>
<td>Cooling coil valves</td>
<td>closed</td>
<td>closed</td>
</tr>
<tr>
<td>Outside air damper</td>
<td>closed</td>
<td>closed</td>
</tr>
<tr>
<td>Return air damper</td>
<td>open</td>
<td>open</td>
</tr>
<tr>
<td>Exhaust/relief air damper</td>
<td>closed</td>
<td>closed</td>
</tr>
<tr>
<td>Var. Freq. Drive</td>
<td>Off</td>
<td>Min. Speed</td>
</tr>
</tbody>
</table>

C. Unless specified otherwise, throttling ranges, proportional bands, and cycle differentials shall be centered on the associated setpoint. All modulating feedback control loops shall include the capability of having proportional, integral, and derivative action. Unless the loop is specified “proportional only” or “P+I”, Contractor shall apply appropriate elements of integral and derivative gain to each control loop which shall result in stable operation, minimum settling time, and shall maintain the primary variable within the specified maximum allowable variance.

D. Scheduling Terminology: When air handlers are scheduled throughout the day, the following defines the terminology used:

*Coordinate occupancy schedules with UCB on a per building basis.*

1. Occupied Period: period of time when the building is in use and occupied. Unless indicated otherwise, this period is defined as X:XX AM - X:XX PM weekdays and X:XX AM to XX:XX PM weekends. Exclude all national holidays. Generally systems will be fully operational throughout this period and ventilation air shall be continuously introduced. Space temperature setpoints will generally be in the “normal” range of 69°-77°F.

2. Unoccupied Period: period of time when the building or zone is not in use and unoccupied. Ventilation air shall not be introduced.

3. Preoccupancy Period: Time prior to the Occupied period when the systems are returning the space temperatures from setback to “normal” or occupied setpoints (warm-up and cool-down). Ventilation air shall not be introduced unless outside air conditions permit free-cooling. Time period shall be determined by an optimum start strategy unless otherwise specified.

4. Setback Period: Setback will typically coincide start with the end of the occupied period and end with the start of the preoccupancy period, however it shall be provided with its own schedule. Generally systems will be off except to maintain a “setback” temperature.
E. Where any sequence or occupancy schedule calls for more than one motorized unit to start simultaneously, the BAS start commands shall be staggered by 5 second (adj.) intervals to minimize inrush current.

F. Alarm messages specified throughout the sequences are assigned to discrete priority levels. Priority levels dictate the handling and destination of alarm reports, and are defined in Section 15955 [23 0905] - ATC System Software and Programming.

G. Wherever a value is indicated as adjustable (adj.), it shall be modifiable, with the proper password level, from the operator interface or via a function block menu. For these points, it is unacceptable to have to modify programming statements to change the setpoint.

H. When a power failure is detected in any phase, the BAS start commands shall be retracted immediately from all electrically powered units served by the failed power source. If the associated primary control unit (PCU) is powered by normal or emergency power, it may monitor its own power source as an indication of power status. If the PCU is powered by uninterruptable power supply (UPS), or if PCU is not capable of monitoring its own power for use in sequences, Contractor shall provide at least one voltage monitor (three phase when applicable) per building. When the BAS detects that power has been restored, all equipment for which the BAS start command had been retracted shall be automatically restarted on staggered 5 second intervals to minimize inrush current. When loss of equipment status coincides with a power failure, system shall not alarm individual equipment failures. Instead, only a single Level 2 alarm shall be enunciated.

I. Where reset action is specified in a sequence of operation, but a reset schedule is not indicated on the drawings, one of the following methods shall be employed:

1. Contractor shall determine a fixed reset schedule which shall result in stable operation and shall maintain the primary variable within the specified maximum allowable variance.

2. A floating reset algorithm shall be used which increments the secondary variable setpoint (setpoint of control loop being reset) on a periodic basis to maintain primary variable setpoint. The recalculation time and reset increment shall be chosen to maintain the primary variable within the specified maximum allowable variance.

J. Where a supply air temperature or duct pressure setpoint is specified to be reset by the space temperature of the zones calling for the most cooling/heating, the following method shall be employed:

1. A floating reset algorithm shall be used which increments the secondary variable (e.g., supply air temperature or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g. space temperature) setpoint. The reset increment shall be determined by the quantity of “need heat” or “need cool” requests from individual SCU’s. A SCU’s “need heat” virtual point shall activate whenever the zone’s space temperature falls below the currently applicable (occupied or unoccupied) heating setpoint throttling range. A SCU’s “need cool” virtual point shall activate whenever the zone’s space temperature rises above the currently applicable (occupied, unoccupied, or economy) cooling setpoint throttling range. The recalculation time and reset increment shall be chosen to maintain the primary variable within the specified maximum allowable variance while
minimizing overshoot and settling time. Reset range maximum and minimum values shall limit the setpoint range.

**K.** Where a supply air temperature, duct pressure, or differential water pressure setpoint is specified to be reset by valve or damper position of the zone or zones calling for the most cooling/heating, the following method shall be employed:

1. A floating reset algorithm shall be used which increments the secondary variable (e.g., supply air temperature, pipe or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g. cooling valve, heating valve, damper position) setpoint of 85% open. The reset increment shall be calculated based on the average position of the quantity of the worst (most open valve/damper) zone(s) as specified. The recalculation time, reset increment and control device position influence shall be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and settling time. The BAS analog output value shall be acceptable as indicating the position of the control device.

2. Alternatively to continuously calculating the average of the quantity of worst valve/damper positions, a method similar to the one described above may be employed whereby the “need heat” or “need cool” virtual point shall increment by one unit each time a zone’s valve/damper position rises to greater than 95%. The quantity of “need heat” or “need cool” points shall then be the basis for reset.

**L.** Where “prove operation” of a device (generally controlled by a digital output) is indicated in the sequence, it shall require that the BAS shall, after an adjustable time delay after the device is commanded to operate (feedback delay), confirm that the device is operational via the status input. If the status point does not confirm operation after the time delay or anytime thereafter for an adjustable time delay (debounce delay) while the device is commanded to run, an alarm shall be enunciated audibly and via an alarm message at the operator interface and print at the alarm printers. A descriptive message shall be attached to the alarm message indicating the nature of the alarm and actions to be taken. Contractor shall provide messages to meet this intent. Upon failure, run command shall be removed and the device shall be locked out until the alarm is manually acknowledged unless specified otherwise.

**M.** BAS shall provide for adjustable maximum rates of change for increasing and decreasing output from the following analog output points:

1. Speed control of variable speed drives
2. Chiller supply water temperature setpoint reset
3. Chiller demand limit
4. Travel rate of tower isolation and chiller isolation valves

**N.** Wherever a value is indicated to be dependent on another value (i.e.: setpoint plus 5°F) BAS shall use that equation to determine the value. Simply providing a virtual point that the operator must set is unacceptable. In this case three virtual points shall be provided. One to store the parameter (5°F), one to store the setpoint, and one to store the value which is the result of the equation.

### 3.02 DEMAND LIMITING CONTROL:

**A.** BAS shall monitor kW demand over a 15-minute sliding window period.
B. Demand limiting shall be disabled during the winter billing period. When demand limiting is enabled, it shall be possible for the operator to disable it on a daily basis during, but it shall be automatically re-enabled each day at 12 midnight.

C. On a rise in kW to within 200 kW (adj.) of setpoint, a Level 4 alarm shall be enunciated and BAS shall begin to make one “load shed” command every 3 minutes (adj.). On a fall in kW to 200 kW less than the demand setpoint, BAS shall begin to broadcast one ”load restore” command every 3 (adj.) minutes on a first shed, first restored basis. If demand exceeds the demand setpoint and there are no more loads left to shed, the demand setpoint shall be increased to the maximum demand experienced. Demand setpoint shall be automatically reset to an adjustable value at the beginning of each billing period.

D. “Loads” available for shedding are defined elsewhere in this specification section.

E. On a rise in kW to within 50 kW (adj.) of setpoint, a Level 3 and Level 4 alarm shall be enunciated.

3.03 AIR HANDLING UNITS - GENERAL

A. Logic Strategies: The BAS shall fully control the air handlers. Generally the BAS shall energize the AH (start the fans and activate control loops) as dictated for each air handle. The following indicates when and how the BAS shall energize the AHs and control various common aspects of them. The following “logic strategies” shall be included by reference, if required, from each AHU sequence of operation:

1. Scheduled Occupancy: BAS shall determine the occupancy periods (occupied, unoccupied, preoccupancy, and setback) as defined above. The following details the common control aspects related to the scheduled occupancy.
   a) Occupied Period: BAS shall energize the AH during all occupied periods. Note that the beginning of the occupancy period shall be set sufficiently before the actual start of occupancy to obtain the required building component of ventilation per ASHREA 62. Minimum OA flow setpoint shall be as scheduled on the drawings. “Normal” setpoints shall apply.
   b) Unoccupied Period: Minimum OA flow shall be 0 CFM or the minimum OA damper position shall be 0%. If during the unoccupied period there is a request for occupancy override, the occupancy mode shall become active for an adjustable period. The unoccupied period and the preoccupancy period will typically overlap.
   c) Setback Period: the BAS shall deenergize the unit except as required to maintain a setback temperature as indicated in the individual sequences with a 5°F cycle differential. Generally, where setback temperatures apply in multiple zones, the worst zone shall control the system. Setback setpoints generally apply except during preoccupancy [and night purge]. If during the unoccupied period there is a request for occupancy override, the occupancy mode shall become active for an adjustable period.
d) **Preoccupancy**: BAS shall energize the AH continuously during the preoccupancy period. Minimum OA flow shall be 0 CFM or the minimum OA damper position shall be 0%. “Normal” setpoints shall apply. Preoccupancy duration shall be one of the following as specified by reference:

1) **Fixed**: The duration of the preoccupancy period shall be fixed as scheduled by the operator.

2) **Optimum**: The duration of the morning warm-up period shall vary according to outside air temperature and space temperature such that the space temperature rises to occupied period heating setpoint at the beginning of, but not before, the scheduled occupied period. The duration of the cool-down period shall vary according to outside air temperature and space temperature such that the space temperature falls to the occupied period cooling setpoint at the beginning of, but not before, the scheduled occupied period.

2. **Night Purge Cycle**: The night purge cycle shall configure the AH for 100% fresh air intake operation and will be enabled/disabled manually via a graphic icon. While the mode is enabled and during the unoccupied period, BAS shall energize the unit (and associated exhaust/relief fans) when the OA temperature falls to 10°F below space temperature AND space temperature is greater than the occupied heating setpoint AND outdoor air enthalpy is below 24 Btu/#. BAS shall de-energize AH when the space temperature falls to within 5°F of OA temperature OR the space temperature falls below the occupied heating setpoint OR outdoor air enthalpy rises to 25 Btu/.#. During the night purge cycle any applicable terminal units shall be indexed to their normal setpoints.

3. **Minimum OA Control**: BAS shall maintain minimum ventilation during the occupied period. The following strategies may apply:

a) **Balanced Position**: During the occupied period, applicable mixing and OA dampers shall never be positioned less than the position set for the required minimum OA ventilation rate. If the air handler has a single OA damper that is capable of economizer, the minimum position output shall be determined by the balancer. If the AH has a two position minimum OA damper, that position shall be fully open to its balanced position. This logic strategy is only applicable to constant volume AHSs.

b) **Reset Balanced Position**: During the occupied period, applicable mixing and OA dampers shall never be positioned less than the minimum position. Minimum position shall be reset between limits of a position delivering system exhaust make-up air CFM and the design minimum position delivering design minimum CFM to maintain a CO₂ setpoint of 900 ppm (adj.). Loop shall be a “sample and bump” or dynamic proportional only loop tuned for the slow response. The balancer shall determine the minimum position outputs at both extreme points. This logic strategy is only applicable to constant volume AHSs.

c) **Damper Controlled Fixed**: During the occupied period, applicable mixing dampers shall be modulated to maintain an OA flow rate of no less than the MVR as dictated in the design and required by ASHRAE 62. Setpoint flow rates shall be provided by the A/E. Flow rate shall be
determined in any of the following ways as specified for the particular AH:

1) Measured directly by an OA flow station
2) As determined by CO₂ mixing equations using the SA, OA, and RA CO₂ sensors

d) **Damper Controlled Reset:** During the occupied period, applicable mixing dampers shall be modulated to maintain an OA flow rate setpoint. Setpoint shall be reset between limits of system exhaust make-up air CFM and the design minimum CFM to maintain an RA CO₂ setpoint of 900 ppm (adj.). Loop shall be a “sample and bump” or dynamic proportional only loop tuned for the slow response. Setpoint flow rates shall be provided by the A/E. Flow rate shall be determined in any of the following ways as specified for the particular AH:

1) Measured directly by an OA flow station
2) As determined by CO₂ mixing equations using the SA, OA, RA, and/or Space CO₂ sensors

e) **Mixed Air Temperature Control:** Minimum position of the OA damper shall be set to obtain the design required minimum OA. This balanced minimum position shall remain fixed. Whenever the minimum loop is active BAS shall control the dampers to maintain a mixed air temperature setpoint which will be 2°F below discharge air temperature cooling setpoint (adj.).

4. **VAV Return Fan Capacity Control:** BAS shall control the output of the return fan as follows:

a) **Flow Tracking:** The return air fan shall run to maintain a return flow setpoint of the supply flow minus an offset value. The offset value shall be determined as follows:

1) **Fixed Differential:** It shall be fixed at the design minimum OA value.

2) **Differential Reset From RA CO₂:** It shall be reset between limits of system exhaust make-up air CFM and the design minimum CFM to maintain an RA CO₂ setpoint of 900 ppm (adj.). Loop shall be a “sample and bump” or dynamic proportional only loop tuned for the slow response. Setpoint flow rates shall be provided by the A/E

3) **Differential Reset From Measured OA to Maintain Fixed OA:** It shall be reset to maintain the measured minimum OA flow at the design value any time the economizer mode is inactive. Whenever it is inactive, it shall be set to the value that existed when the unit became active.

4) **Differential Reset From Measured OA to Maintain Reset OA**
When the economizer mode is inactive, it shall be reset to maintain the measured OA flow setpoint. The OA setpoint shall be reset between limits of system exhaust make-up air CFM and the design minimum CFM to maintain a CO₂ setpoint of 900 ppm (adj.). Loop shall be a “sample and bump” or dynamic proportional only loop tuned for the slow response. Setpoint flow rates shall be provided by the A/E. Whenever the
economizer is active, it shall be set to the value that existed when the unit became active.

b) **Rescaled Output Capacity Control**: The output for the return fan capacity control shall be rescaled from the output of the to the supply device such that the design minimum OA temperature is maintained at both maximum and 50% flow conditions. The balancing contractor shall determine the coordinated output.

5. **Airside Economizer**: BAS shall modulate the mixing dampers to provide “free cooling” when conditions merit. The free cooling shall generally be staged before any mechanical cooling. While conditions merit, dampers shall be modulated in a DA PID loop to maintain mixed air temperature at a setpoint as specified for the individual unit. Economizer logic shall remain enabled during setback cooling where applicable. One of the following strategies shall be used to enable the economizer mode:

a) **Dry Bulb Comparison**: Economizer mode shall be active while the unit is energized AND when OA enthalpy fall below 28 btu/# AND outside air temperature falls below return air temperature (with 2°F cycle differential). Economizer mode shall be inactive when OA enthalpy rises above 29 btu/# OR outside air temperature rises above return air temperature (with 2°F cycle differential), dampers shall return to their scheduled minimum positions as specified above. Economizer shall remain enabled during setback cooling.

b) **Dry Bulb Switch**: Economizer mode shall be active while the unit is energized AND when OA enthalpy fall below 28 btu/# AND outside air temperature falls below the switching setpoint of 70°F (adj.) (with 5°F cycle differential). Economizer mode shall be inactive when OA enthalpy rises above 29 btu/# OR outside air temperature rises above switching setpoint, dampers shall return to their scheduled minimum positions as specified above.

c) **Enthalpy Comparison**: Economizer mode shall be active while the unit is energized AND when outside air enthalpy falls below return air enthalpy (with 2btu/# cycle differential). Economizer mode shall be inactive when outside air enthalpy rises above return air enthalpy, dampers shall return to their scheduled minimum positions as specified above.

6. **Sequenced Heating and Cooling**: BAS shall control the heating and cooling coils and air side economizer as detailed for the particular AH. Program logic shall directly prohibit the heating and cooling valves as well as the heating valve and economizer damper to be open (or above minimum) simultaneously. This does not apply to cooling and reheat valves that are used simultaneously for dehumidification.

7. **Mixed Air Low Limit Override**: BAS shall override the signal to the OA damper via a proportional only loop to maintain a minimum mixed air temperature of 45°F (adj.) (loop shall output 0% at 45°F which shall be passed to the output via a low selector).

8. **Freeze Safety**: Upon operation of a freezestat the following sequence shall occur:
a) The unit fans shall be deenergized. Typically supply and return fans where applicable shall be deenergized via a hardwired interlock, and an indication of the operation shall be displayed by the BAS.

b) All hot water valves and chilled water valves will be commanded to 100% open.

c) All hot water coil pumps and chilled water coil pumps will be commanded to run.

d) Outside air dampers shall fully close and return air dampers shall fully open.

e) BAS shall enunciate appropriate alarm and remove and lock out the start command, which shall initiate "fan failure" alarms.

9. **Smoke Safety**: Upon indication of smoke by a smoke detector, FAC shall deenergize the AH. Smoke detector shall notify the fire alarm system and BAS, shut down the fans, and close the smoke dampers via hard-wired interlock.

10. **High or Low Pressure Safety**: Upon activation of a high or low pressure safety switch, AH shall be deenergized, fans shall be deenergized via a hard wired interlock, and an indication of the operation shall be sensed by the BAS. BAS shall enunciate appropriate alarm and remove and lock out the start command, which shall initiate "fan failure" alarms.

11. **Vibration Safety (Applicable To Units >50,000 cfm)**: Upon activation of a vibration safety switch, respective fan shall be deenergized, fan shall be deenergized via a hard wired interlock and an indication of the operation shall be sensed by the BAS. BAS shall enunciate appropriate alarm and remove and lock out the start command.

B. The detailed “logic strategies” above shall be required by reference to them in each of the individual sequences specified elsewhere.

### 3.04 AIR HANDLING UNIT DIAGNOSTICS - GENERAL

A. **Diagnostic Strategies**: In addition to the standard alarm limits specified for all sensed variables the BAS monitor and diagnose anomalies in the operation of the air handlers. The following “diagnostic strategies” shall be included by reference with each air handler with any specific clarifications required:

1. **Run Time Limit**: BAS shall accumulate the runtime of the status of associated rotating equipment and enunciate a level 5 alarm to indicate that the unit is in need of service.

2. **Filter Monitoring**: BAS shall monitor the differential pressure transmitter across the filter bank(s). A level 5 alarm shall be reported when pressure drop exceeds the transmitter’s setting.

3. **Start Monitoring**: BAS shall accumulate the starts of cycling equipment. BAS shall further enunciate a level 5 alarm when the number of starts exceeds the specified value within the specified time period. (ie: more than 3 starts in a 30 min period)
3.05 AIR HANDLER MONITORING AND MANAGEMENT

A. General: The BAS shall monitor various aspects of the air handling systems and calculate parameters as specified below to facilitate operations and management.

1. Trending: The BAS shall continuously monitor, calculate and display the following parameters at the intervals indicated. These values shall be stored initially in the buffer of the controlling control unit, and then be uploaded periodically and stored on a specified hard disc.

2. Parameters to be trended:
   a) All temperature sensors at 1 hour intervals
   b) All relative humidity sensors at 1 hour intervals
   c) All pressure sensors at 1 hour intervals
   d) All run requests and statuses on a change in value
   e) All analog loop outputs on 1 hour intervals
   f) Calculated enthalpies in 2 hour intervals
   g) Summed cooling and heating requests on 2 hour intervals

3.06 GLYCOL HEAT RECOVERY RUN AROUND LOOP

A. General: BAS shall control the glycol heat recovery system and equipment and provide monitoring and diagnostic information for management purposes.

   a) System Enable: System shall be enabled whenever the following criteria are met:
      1) System manually enabled by the operator at the operator interface, AND
      2) Air systems served by recovery system are operational, AND
      3) The criteria for efficient operation of the system as written below are met.

   b) System Disable: System shall be disabled whenever any of the following occurs:
      1) System manually disabled by the operator at the operator interface, OR
      2) Air systems served by the recovery system are off, OR
      3) The criterion for efficient operation of the system as written below is not met.

B. Enable Criteria:
   1. Outside air temperature must be lower than the exhaust air temperature entering the heat recovery coil.
   2. Outside air temperature must be higher than the lower limit temperature of the glycol system.

C. Circulating Pump Control
   1. Whenever the system is enabled, circulating pump shall run continuously.
   2. BAS shall prove operation of the pump. Upon failure of a pump, an alarm shall be enunciated.
   3. BAS shall monitor pump status and accumulate runtime of the pump.
3.07 STEAM TO HW CONVERTERS WITH VV PUMPS

A. **General**: BAS shall control the hot water systems and equipment and provide monitoring and diagnostic information for management purposes.

B. **Heating Enable**: Heating shall be enabled when:
   1. Any hot water valve opens to more than 50% continuously for 10 min. (adj.).
   2. OR, the Outside Air temperature is below 55°F
   3. OR, whenever manually enabled by the operator at the operator interface. Once enabled, the Heating Water System shall run for a minimum of 1 hour.

C. **HW Pump Control**:
   1. Whenever the system is enabled, a minimum of one heating water pump shall run continuously.
   2. BAS shall use a PID loop to maintain the differential pressure setpoint across the remote differential pressure sensor. The differential pressure setpoint shall initially be set at 15 psi (adj. as determined by the balance contractor).
   3. The output of this loop shall control the starting, stopping, and speed of the pumps as follows:
      a) On a PID output of greater than 95% for 5 min (adj.), the BAS shall start an additional pump. The new pump shall ramp to speed per adjustable acceleration rates.
      b) If more that one pump is running, on a PID output of less than 40% for 5 min (adj.), the BAS shall stop a pump.
   4. The output of the PID loop shall control the VSD’s of all operating pumps at the same speed.
   5. BAS shall prove operation of each pump individually. Upon failure of a pump, the standby shall be started (if not already running) and an alarm shall be enunciated.
   6. BAS shall monitor pump status and accumulate runtime of the pumps. The BAS shall rotate the lead and lag pumps as follows:
      a) Whenever a pump is started, the BAS shall start the pump with the least runtime.
   7. Whenever a pump is stopped, the BAS shall stop the pump with the highest runtime.

D. **Heating Water Temperature Control**: BAS shall reset the hot water supply temperature setpoint via linear reset from 180°F (adj.) to 110°F (adj.) as the OA temperature rises from 20°F (adj.) to 60°F (adj.)
   1. The BAS shall modulate the 1/3 [and 2/3 steam] valves to the Heat Exchanger in sequence via a PID loop to maintain the HW supply temperature setpoint.
   2. The valves shall remain closed until pump status is proven.
   3. Steam supply pressure to the Heat Exchanger shall be monitored by the BAS and enunciate an alarm if it falls below 5 psi (adj.)
3.08 CENTRAL PLANT MONITORING AND MANAGEMENT

A. **General:** The BAS shall monitor various aspects of the heating and cooling systems and calculate parameters as specified below to facilitate plant operations and management.

B. **Trending:** The BAS shall continuously monitor, calculate and display the following parameters at the intervals indicated. These values shall be stored initially in the buffer of the controlling control unit, and then be uploaded periodically and stored on a specified hard disc. Contractor shall format reports from this data to support one of the following data formats:
   1. Quote (text strings) and Comma delimited
   2. Microsoft EXCEL

C. **Parameters to be Trended:**
   1. Load on the secondary systems in MBH per the following equation: \((\text{Return Temp-Supply Temp}) \times \text{(GPM)} / .5\). This shows cooling as a positive heat load and heating as a negative heat load. Note that multipliers on this value to accommodate the BAS processors are acceptable as long as they are clearly indicated. This value shall be trended and stored every two hours.
   2. All temperature sensors at 1 hour intervals.
   3. All relative humidity sensors at 1 hour intervals.
   4. All pressure sensors at 1 hour intervals.
   5. All run requests and statuses on a change in value.
   6. All analog loop outputs on 1 hour intervals.
   7. Calculated enthalpies in 2 hour intervals.
   8. Summed cooling and heating requests on 2 hour intervals.

END OF SECTION 15958 \{23 0993\}