1 Sequences of Operation

1.1 A written sequence of operation for all Direct Digital Control equipment shall be submitted to the Energy and Utilities (E&U) department for review. A finalized version of the sequences of operations will be submitted to the E&U department in either word or .pdf format for reference and archiving purposes. The E&U department is available for consultation while developing these sequences of operation.

1.2 Identify the sequences by the individual mechanical system number and provide sequences for all air handling equipment, hydronic heating/cooling systems, individual room level control and any miscellaneous mechanical equipment monitored or controlled by E&U.

1.3 The sequence of operation for each piece of equipment should contain a description of the task of all input and output DDC points for monitoring or control, address the operation of the equipment as engineered, designed, and intended for DDC programming and contain, at the minimum, the following:

1. Run conditions
2. Occupied/Unoccupied cycle
3. 38°F Freeze protection alarm
4. Economizer cycle
5. Cooling control
6. Return Chilled Water control
7. Heating control
8. Humidification and Dehumidification control
9. Building Dedicated OAT
10. Delta P for Campus Chilled Water
11. Steam Pressure (Not Delta P)
12. Steam Temperature Sensor
13. Pressure control
14. Building static
15. AHU Systems
16. Hydronics water
17. Set points
18. Pressure
19. Temperatures
20. Humidity
21. Minimum Outdoor Air
22. Alarms
23. Set points for Alarming (When to alarm)

1.4 Contact the Controls Design Group to discuss programming in correlation with existing programming techniques utilized on campus.

1.5 Sequences of Operations should be written in outline format for ease of referencing and discussion. The following format should be adhered to:

   I. Section
      A. Section parts
         1. Subsection parts
            i. Subset Category
               a. Subset

2 Sequence for a Safety on a Mixed Air System

2.1 When physical low limit sensor (set to 38°F) trips, hard wiring through the low limit sensor shall stop the fan.

2.2 The BAS shall immediately close the outside air dampers, relief damper and open the return damper.

2.3 The return fan shall remain energized with a 50% speed reference and an alarm shall be generated.

2.4 Chilled water control valve operation

The BAS system will monitor the entering air temperature, leaving air temperature and interior water temperature of the cooling coil. If any of the three temperatures starts to drop below 40°F (adj.), the output will increase in a direct linear fashion (NO LOOP CONTROL) to the chilled water control valve, opening the valve to allow circulation of water through the chilled water coil in order to avoid freezing. The chilled water control valve shall achieve full open position if any of the three temperatures reaches 35°F (adj.). All three temperatures (entering air temperature, leaving air temperature and interior water temperature) must be 40°F (adj.) or above before the chilled water cooling coil valve will be shut.

2.5 If this is a rooftop unit then the temperatures listed above for safety purposes shall be increased by a factor of +3°F.

3 Sequence for a Safety on a Dedicated OA Unit

3.1 When physical low limit sensor (set to 38°F) trips, hard wiring through the low limit sensor shall stop the supply fan.

3.2 The BAS shall immediately close the outside air dampers and fully open the preheat coil control valve(s).

3.3 Chilled water control valve operation

The BAS system will monitor the entering air temperature, leaving air temperature and interior water temperature of the cooling coil. If any of the three temperatures starts to drop below 40°F (adj.), the output will increase in a direct linear fashion (NO LOOP CONTROL) to the chilled water control valve, opening
the valve to allow circulation of water through the chilled water coil in order to avoid freezing. The chilled water control valve shall achieve full open position if any of the three temperatures reaches 35°F. (adj.). All three temperatures (entering air temperature, leaving air temperature and interior water temperature) must be 40°F (adj.) or above before the chilled water cooling coil valve will be shut.

3.4 If this is a rooftop unit then the temperatures listed above for safety purposes shall be increased by a factor of +3°F.

4 Sequence for Enthalpy Economizer Control

4.1 Economizer cooling is enabled/disabled based on the return air and outside air enthalpy differential switchover set point with a 1.5BTU/lb. dead band.

4.2 When the outside air enthalpy is no more than 1.0 BTU/lb. below the return air enthalpy, economizer cooling is disabled.

4.2.1 When economizer cooling is disabled the maximum outside air and relief dampers are fully closed, the return air damper is positioned for minimum outside air ventilation.

4.3 When the outside air enthalpy is below return air enthalpy by at least 2.5 BTU/lb., economizer cooling is enabled.

4.3.1 When economizer cooling is enabled maximum outdoor air, return air and relief air dampers modulate together to maintain a mixed air set point of 53°F. The dampers are allowed to modulate from full opened to full close.

5 Sequence for Cold Deck Chilled Water Control

5.1 Chilled water control valve shall modulate to meet the cold deck setpoint (typically 55°F).

5.2 A sensor installed in the last pass of the cooling coil shall monitor the return water temperature from the coil.

5.3 If the space humidity rises to 50% RH then discharge air temperature set point is reset downward utilizing the following reset:

<table>
<thead>
<tr>
<th>RH setpoint</th>
<th>Chilled water low limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-50%</td>
<td>55°F</td>
</tr>
<tr>
<td>60-100%</td>
<td>52° F</td>
</tr>
</tbody>
</table>

6 Sequence for Chilled Water Pumping Systems

6.1 Chilled water pumping systems shall be start/stopped by a campus chilled water differential sensor and shall be modulated by a differential pressure sensor installed across a cooling coil indicated on the blueprints.

7 Sequence for Static Pressure Reset

7.1 The static pressure will be reset based on the damper position in the control boxes served by the unit.

7.2 One damper position will be maintained at 95% open (adj.) at all times.

7.2.1 Polling of all associated control boxes will occur at five minute intervals (adj.) to determine which damper is the furthest open.

7.2.2 If no damper position is at 95% open (adj.) then the output to the supply fan speed control will reduce until a box’s damper is driven to 95% open (adj.).

7.2.3 If more than one damper position is at 95% open (adj.) the supply fan speed control will ramp up until there is only one damper at 95% open (adj.).

7.3 If a damper position is at 100% open for more than 30 minutes (adj.) the damper position will be locked out of the polling, a default value of the damper position set point minus 3% issued for the box and an alarm will be generated. This lock out will remain until the control box is reviewed to determine the cause of the reading. If it is determined to be unrepairable the box in question will be permanently locked out the polling process. This will be termed a rogue zone box.

7.4 The static pressure reset will operate with a low limit of 0.5” wc (adj.) and a high limit of 2.0” wc (adj.) as determined by the Balancing Contractor.

7.5 High and low limit dead bands are utilized to maintain controlling damper between dead band limits.

8 Sequence for Discharge Temperature Reset

8.1 The discharge temperature set point will be reset based on the three factors

1. Fan speed
2. Outside air temperature
3. Cooling demand

8.2 If the supply fan speed reference signal is less than 40% (4 volts) then the discharge temperature reset mode shall be enabled.
8.3 The base line discharge temperature set point will be established with the following reset table:

<table>
<thead>
<tr>
<th>Outside Air Temperature</th>
<th>Discharge Air Temperature Set point</th>
</tr>
</thead>
<tbody>
<tr>
<td>40°F (adj)</td>
<td>65°F (adj)</td>
</tr>
<tr>
<td>70°F (adj)</td>
<td>55°F (adj)</td>
</tr>
</tbody>
</table>

8.4 Once the baseline temperature set point is established then polling of the spaces served for cooling requests will adjust the set point by adding a factor established from the following reset table:

<table>
<thead>
<tr>
<th>Cooling Request</th>
<th>Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>-5</td>
</tr>
</tbody>
</table>

8.5 Discharge temperature set point reset mode will be disabled if the return humidity exceeds 50% RH and the cooling coil discharge temperature reset schedule activates to maintain the humidity levels in the space. When the return humidity reaches 40% RH then discharge temperature set point control may resume.