SECTION 23 0993
SEQUENCE OF OPERATIONS FOR BUILDING CONTROLS

PART 1 GENERAL

1.01 SECTION INCLUDES
A. This section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other sections.
B. Sequence of operation for:
   1. Freezers and Coolers
   2. Chillers & Cooling Towers
   3. Air Cooled Chillers
   4. Generators
   5. Heat Exchangers
   6. Heat Pump Loops & Towers
   7. Heat Pumps
   8. Miscellaneous Monitoring Points
   9. Air Handling Units (AHUs)
   10. Steam Stations
   11. Variable Air Volume (VAV) Boxes with Reheats and Radiation
   12. VAVs with Second Stage Cooling (Liebert Units)
   13. Cabinet Heaters
   14. Security Systems (Building or Area Security, Duress, etc.)
   15. Fire Alarm Monitoring (Fire Alarm, Supervisory, Smoke Evac, etc.)
   16. Plumbing System Monitoring (Sumps, Cond, Moisture, Sewage, Steam, etc.)
   17. Elevator Emergency Alarms (Phones for new and how to deal with decommissioning old)
   18. Integration or Decommissioning Existing Systems....

1.02 RELATED SECTIONS
A. Section 01 9113 - General Commissioning Requirements: Commissioning requirements that apply to all types of work.
B. Section 23 0943 - Pneumatic Control System for HVAC.
C. Section 23 0923 - Direct-Digital Control System for HVAC.
D. Section 23 0913 - Instrumentation and Control Devices for HVAC.
E. Section 26 2717 - Equipment Wiring: Electrical characteristics and wiring connections.

1.03 SUBMITTALS
A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. Sequence of Operation Documentation: Submit written sequence of operation for entire HVAC system and each piece of equipment. Controls contractor is to submit their sequence of operation as the system is to be programmed with shop drawings (list timeframe to receive) to the engineer for owner review. Allow owner a minimum of [5 to 10 working days to review]. At end of project full as-built sequence of operations must be submitted with all programming safeties, delays, etc. included in final as-built sequence of operations.
   1. Preface: 1 or 2 paragraph overview narrative of the system describing its purpose, components and function.
   2. State each sequence in small segments and give each segment a unique number for referencing in Functional Test procedures; provide a complete description regardless of the completeness and clarity of the sequences specified in the contract documents.
   3. Include at least the following sequences:
      a. Start-up.
      b. Warm-up mode.
      c. Normal operating mode.
      d. Unoccupied mode.
e. Shutdown.
f. Capacity control sequences and equipment staging.
g. Temperature and pressure control, such as setbacks, setups, resets, etc.
h. Detailed sequences for all control strategies, such as economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
i. Effects of power or equipment failure with all standby component functions.
j. Sequences for all alarms and emergency shut downs.
k. Seasonal operational differences and recommendations.
l. Interactions and interlocks with other systems.

4. Include initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.

5. For packaged controlled equipment, include manufacturer's furnished sequence of operation amplified as required to describe the relationship between the packaged controls and the control system, indicating which points are adjustable control points and which points are only monitored.

6. Include schedules, if known.

C. Control System Diagrams: Submit graphic schematic of the control system showing each control component and each component controlled, monitored, or enabled.
1. Label with settings, adjustable range of control and limits.
2. Upon request, include flow diagrams for each control system, graphically depicting control logic.
3. Include the system and component layout of all equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
4. Upon request, include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.
5. Include all monitoring, control and virtual points.
6. Include a key to all abbreviations.

D. Points List: Submit list of all control points indicating at least the following for each point.-Clarify submission format.
1. Name of controlled system.
2. Point abbreviation.
3. Point description; such as dry bulb temperature, airflow, etc.
4. Display unit.
5. Control point or setpoint (Yes / No); i.e. a point that controls equipment and can have its setpoint changed.
6. Monitoring point (Yes / No); i.e. a point that does not control or contribute to the control of equipment but is used for operation, maintenance, or performance verification.
7. Intermediate point (Yes / No); i.e. a point whose value is used to make a calculation which then controls equipment, such as space temperatures that are averaged to a virtual point to control reset.
8. Calculated point (Yes / No); i.e. a “virtual” point generated from calculations of other point values.

E. Project Record Documents: Record actual locations of components and setpoints of controls, including changes to sequences made after submission of shop drawings. Add location wiring drawings and topology. At end of project need true/accurate as-builts.

1.04 QUALITY ASSURANCE
A. Design system under direct supervision of a Professional Engineer experienced in design of this Work and licensed at the State in which the Project is located.
PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 FREEZERS AND COOLERS

A. Kitchen and dining freezer and cooler temperatures shall be monitored and alarm to the front-end system. An alarm shall be generated when each cooler or freezer temperature exceeds its alarm limits. Alarm limits are unique as to what is stored in the cooler or freezer. The alarm limits and an alarm response procedure will need to be coordinated with UND Facilities Management and the Director of Dining Services.

B. Monitoring of freezers and coolers for research or other purposes needs to be reviewed by UND Facilities Management prior to design. UND Facilities Management will need to evaluate what is being monitored for liability purposes; and coordinate alarm limits and create an alarm response procedure with the research department before proceeding with monitoring. Points that are monitored shall alarm to the front-end system. An alarm shall be generated when each cooler or freezer temperature exceeds its alarm limits.

C. Sensors for Freezers and Coolers shall be located in areas that aren’t obstructed by boxes and other miscellaneous objects. Sensors shall not be located directly beside doors or light bulbs as these objects hinder accurate readings of sensors.

D. The temperature points shall reference the building number and system number or name. The point’s descriptor shall reference the system number or name and the room location of the system. This is a code yellow point and this shall be noted in this point’s descriptor at the front-end system. The following point names shall be used:
   1. ###Freezer#Temp
   2. ###Cooler#Temp

3.02 CHILLER & COOLING TOWER

A. Chiller Enable (Based on Outside Air Only):
   1. The chiller shall be enabled when the outside air temperature is above the chiller enable setpoint of 58* degrees F. The chiller shall be disabled when the outside air temperature falls 1* degree F below the chiller enable setpoint.
   2. Once the chiller has been enabled, the chiller manufacturer’s control panel (chiller’s independent controls), shall start the chilled water pump and condenser water pump. When the chiller is disabled the chiller’s independent controls shall cycle off and shut down the chilled water pump and condenser water pump.
   3. Monitoring shall be provided for the chilled water supply and return temperatures. Both sensors shall be configured to alarm with the following alarm limits: Note: If only one set of alarm limits are used, the low and high warning limit values shall be used.

<table>
<thead>
<tr>
<th>Point Name</th>
<th>Low Alarm Limit</th>
<th>Low Warning Limit</th>
<th>High Warning Limit</th>
<th>High Alarm Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>###ChillerCWSTemp</td>
<td>36 Deg F *</td>
<td>39 Deg F *</td>
<td>48 Deg F *</td>
<td>50 Deg F *</td>
</tr>
<tr>
<td>###ChillerCWRTemp</td>
<td>36 Deg F *</td>
<td>39 Deg F *</td>
<td>60 Deg F *</td>
<td>63 Deg F *</td>
</tr>
</tbody>
</table>

4. These sensors shall be programmed with alarm limits that are adjustable from the UND Facilities Management’s existing front-end automation system.

5. Status sensors shall be installed to monitor the chilled water pump and the condenser water pump from the front-end automation system. These pumps shall alarm if the chiller is enabled and the pump statuses are off for 5 minutes or more. The pumps shall not alarm if the chiller is not enabled.

6. Points displayed on UND Facilities Management existing front end automation system shall include:
### SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

**A. Chiller Enable**

a. ###ChEnable
b. ###ChStatus
c. ###ChAlarm
d. ###ChEnableSp
e. ###ChOaTempSig
f. ###CwPump#Status
g. ###CwSupTemp
h. ###CwRetTemp
i. ###CondPumpStatus

**B. Chiller Enable (Based on Outside Air and Number of AHUs Running)**

1. The chiller shall be enabled when the outside air temperature is above the chiller enable setpoint of 58° degrees F and a minimum number of air handling units (AHUs) are running. The fan status must read on for project specified (#) of AHUs before the chiller can be enabled. The chiller shall not enable until the outside air temperature is above the chiller enable setpoint and the cumulative number of AHUs running is greater than or equal to the number required for the chiller to operate. The chiller shall be disabled when the outside air temperature falls 1° degree F below the chiller enable setpoint or the cumulative number of air handlers is less than the number required for the chiller to operate.

2. Once the chiller has been enabled, the chiller manufacturer’s control panel (chiller’s independent controls) shall start the chilled water pump and condenser water pump. When the chiller is disabled the chiller’s independent controls shall cycle down and shut down the chilled water pump and condenser water pump.

3. Monitoring shall be provided for the chilled water supply and return temperatures. Both sensors shall be configured to alarm with the following alarm limits: Note: If only one set of alarm limits are used, the low and high warning limit values shall be used.

<table>
<thead>
<tr>
<th>Point Name</th>
<th>Low Alarm Limit</th>
<th>Low Warning Limit</th>
<th>High Warning Limit</th>
<th>High Alarm Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChillerCWS Temp</td>
<td>36 Deg F</td>
<td>39 Deg F</td>
<td>48 Deg F</td>
<td>50 Deg F</td>
</tr>
<tr>
<td>ChillerCWR Temp</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

4. These sensors shall be programmed with alarm limits that are adjustable from UND Facilities Management’s existing front-end automation system.

5. Status sensors shall be installed to monitor the chilled water pump and the condenser water pump from UND Facilities Management’s existing front-end automation system. These pumps shall alarm if the chiller is enabled and the pump statuses are off for 5 minutes or more. The pumps shall not alarm if the chiller is not enabled.

a. ###ChEnable
b. ###ChStatus
c. ###ChAlarm
d. ###ChEnableSp
e. ###ChOaTempSig
f. ###CwPump#Status
g. ###CwSupTemp
h. ###CwRetTemp
i. ###CondPumpStatus

**C. Cooling Tower Fan VFD Control:**
1. When the chiller is enabled, the cooling tower shall be enabled. When the cooling tower is enabled, the tower fan variable frequency drive (VFD) shall be modulated from 0% to 100% to maintain the condenser water supply temperature at its setpoint of 80* degrees F.

2. The cooling tower fan shall turn on when the condenser water temperature is 2* degrees F above the condenser water supply temperature setpoint. The cooling tower fan shall turn off when the condenser water temperature is 5* degrees F below the condenser water supply temperature setpoint.

3. Note: The VFD shall be configured so that the minimum speed for the cooling tower fan motor is 20 Hz. This is done for the protection of the cooling tower fan motor and cooling tower's transmission.

4. Monitoring shall be provided for the condenser water supply and return temperatures. Both sensors shall be configured to alarm with the following alarm limits: Note: If only one set of alarm limits are used, the low and high warning limit values shall be used.

<table>
<thead>
<tr>
<th>Point Name</th>
<th>Low Alarm Limit</th>
<th>Low Warning Limit</th>
<th>High Warning Limit</th>
<th>High Alarm Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>###CondCWSTemp</td>
<td>55 Deg F</td>
<td>60 Deg F</td>
<td>90 Deg F</td>
<td>100 Deg F</td>
</tr>
<tr>
<td>###CondCWRTemp</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

5. These sensors shall be programmed with alarm limits that are adjustable from UND Facilities Management’s existing front-end automation system.

6. An alarm shall be generated if the cooling tower fan fails to follow the start/stop command from the program. Also, the hardware alarm point from the VFD shall be monitored from the front-end automation system to show if there is a fault on the VFD.

7. Points:
   a. ###CondSupTemp
   b. ###CondSupTempSp
   c. ###CondRetTemp
   d. ###CtFan
   e. ###CtFanStatus
   f. ###CtFanAlarm
   g. ###CtFanVFD
   h. ###CtFanVFDAIm

D. Cooling Tower Multiple Fan Control (Turns on each fan as needed):

1. When the chiller is enabled, the cooling tower shall be enabled. When the cooling tower is enabled, the tower fan #1 shall turn on to maintain the condenser water supply temperature at its setpoint of 80* degrees F. Additional tower fans shall turn on as the condenser water temperature is increased and more cooling is needed.

2. The cooling tower fan shall turn on when the condenser water temperature is 2* degrees F above the condenser water supply temperature setpoint. The cooling tower fan shall turn off when the condenser water temperature is 5* degrees F below the condenser water supply temperature setpoint.

3. Monitoring shall be provided for the condenser water supply and return temperatures. Both sensors shall be configured to alarm with the following alarm limits: Note: If only one set of alarm limits are used, the low and high warning limit values shall be used.

<table>
<thead>
<tr>
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<th>High Warning Limit</th>
<th>High Alarm Limit</th>
</tr>
</thead>
</table>

xxx / BAC Project Specs  23 0993 - 5 SEQUENCE OF OPERATIONS FOR HVAC CONTROLS
###CondCW

<table>
<thead>
<tr>
<th>Temp</th>
<th>55 Deg F</th>
<th>60 Deg F</th>
<th>90 Deg F</th>
<th>100 Deg F</th>
</tr>
</thead>
<tbody>
<tr>
<td>STemp</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

###CondCW

<table>
<thead>
<tr>
<th>Temp</th>
<th>55 Deg F</th>
<th>60 Deg F</th>
<th>90 Deg F</th>
<th>100 Deg F</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTemp</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. These sensors shall be programmed with alarm limits that are adjustable from UND Facilities Management's existing front-end automation system.
5. An alarm(s) shall be generated if the cooling tower fan(s) fails to follow the start/stop command from the program.
6. Points...
   a. ###CondSupTemp
   b. ###CondSupTempSp
   c. ###CondRetTemp
   d. ###CtFan
   e. ###CtFanStatus
   f. ###CtFanAlarm
   g. ###CtFanVFD
   h. ###CtFanVFDAlm

E. Cooling Tower Fan Off, High and Low Speed Control:
   1. When the chiller is enabled, the cooling tower shall be enabled. When the cooling tower is enabled, the tower fan shall be commanded to low speed to maintain the condenser water supply temperature at its setpoint of 80* degrees F.
   2. The cooling tower fan low speed setting shall run at low speed when the condenser water temperature is 2* degrees F above the condenser water supply temperature setpoint. The cooling tower fan shall turn off when the condenser water temperature is 5* degrees F below the condenser water supply temperature setpoint. The cooling tower fan high speed setting shall run at high speed when the condenser water temperature is 4* degrees F above the condenser water supply temperature setpoint. The cooling tower fan shall turn off when the condenser water temperature is 2* degrees F below the condenser water supply temperature setpoint.
   3. Monitoring shall be provided for the condenser water supply and return temperatures. Both sensors shall be configured to alarm with the following alarm limits: Note: If only one set of alarm limits are used, the low and high warning limit values shall be used.

<table>
<thead>
<tr>
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<th>Low Alarm Limit</th>
<th>Low Warning Limit</th>
<th>High Warning Limit</th>
<th>High Alarm Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>###CondC WSTemp</td>
<td>55 Deg F</td>
<td>60 Deg F</td>
<td>90 Deg F</td>
<td>100 Deg F</td>
</tr>
<tr>
<td>###CondC WRTemp</td>
<td>55 Deg F</td>
<td>60 Deg F</td>
<td>90 Deg F</td>
<td>100 Deg F</td>
</tr>
</tbody>
</table>

4. These sensors shall be programmed with alarm limits that are adjustable from UND Facilities Management's existing front-end automation system.
5. An alarm(s) shall be generated if the cooling tower fan(s) fails to follow the start/stop command from the program.
6. Points....
   a. ###CondSupTemp
   b. ###CondSupTempSp
   c. ###CondRetTemp
   d. ###CtFan [Off, high or low speed]
3.03 C. CHILLER ENABLE (BASED ON OUTSIDE AIR ONLY):

A. The chiller shall be enabled when the outside air temperature is above the chiller enable setpoint of 58* degrees F and the building automation system has received a “Mechanical Cooling Ready” from the chiller. The chiller shall be disabled when the outside air temperature falls 1* degree F below the chiller enable setpoint.

B. Once the chiller has been enabled, the chiller manufacturer’s control panel (chiller’s independent controls) shall start the chilled water pump. When the chiller is disabled the chiller’s independent controls shall cycle down and shut down the chilled water pump.

C. Monitoring shall be provided for the chilled water supply and return temperatures. Both sensors shall be configured to alarm with the following alarm limits: Note: If only one set of alarm limits are used, the low and high warning limit values shall be used.

<table>
<thead>
<tr>
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<th>Low Alarm Limit</th>
<th>Low Warning Limit</th>
<th>High Warning Limit</th>
<th>High Alarm Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChWtSupTemp</td>
<td>36 Deg F</td>
<td>39 Deg F</td>
<td>48 Deg F</td>
<td>50 Deg F</td>
</tr>
<tr>
<td>ChWtRetTemp</td>
<td>36 Deg F</td>
<td>39 Deg F</td>
<td>60 Deg F</td>
<td>63 Deg F</td>
</tr>
</tbody>
</table>

D. These sensors shall be programmed with alarm limits that are adjustable from UND Facilities Management’s existing front-end automation system.

E. Status sensors shall be installed to monitor the chilled water pump from the front-end automation system. The pump shall alarm if the chiller is enabled and the pump status is off for 1 minute or more. The pumps shall not alarm if the chiller is not enabled.

F. Insert points info
1. ChMechClgReady
2. ChEnable
3. ChStatus
4. ChAlarm
5. ChEnableSp
6. ChOaTempSig
7. ChWtPump#Status
8. ChWtSupTemp
9. ChWtRetTemp

3.04 GENERATOR CONTROLS AND MONITORING:

A. First describe when to monitor and when not to monitor a generator. Engineer’s responsibility to discuss with UND Facilities Management and department occupying the building. Maybe split into load shed control and critical system monitoring sections. The generator controls shall be monitored for load shed control. The generator shall be configured to be enabled at the operators request (GenStartStop) from the front-end system. When the generator is started, the breaker for that circuit shall close. The breaker position (GenBrkrPos) for the generator’s circuit shall be monitored for status. Any faults or alarms (GenAlm) on the generator manufacturer’s controls shall be monitored.

B. When the generator is on, the generator production shall be able to be regulated by modulating (GenModulation) the generator from 0-100% from the front-end system. The generator production (GenProduction) shall be monitored in kilowatts.
C. The electricity used on the circuit shall be measured from the Xcel Energy meter by circuit pulse counts (###Circuit#PulseCt). These pulse counts shall be converted to amperage (###Circuit#Amps), kilowatts (###Circuit#Kw) and kilowatt hours (###Circuit#Kwh) for monitoring purposes. Accuracy of these values is very important, therefore the values need to be verified with Xcel Energy and UND Facilities Management. These values need to be integrated into existing campus calculations.

D. The following point names shall be used:
   1. ###Gen#StartStop
   2. ###Gen#BrkrPos
   3. ###Gen#Alm
   4. ###Gen#Modulation
   5. ###Gen#Production
   6. ###Circuit#PulseCt
   7. ###Circuit#Amps
   8. ###Circuit#Kw
   9. ###Circuit#Kwh

E. Generators not used for peak demand generation, will only be monitored when approved by UND Facilities Management and the department occupying the area. For those type of critical applications, the generator alarm (common alarm), status and breaker position will be monitored (if requested).

3.05 HEAT EXCHANGER (clarify when to select each pump sequence) (also, at beginning of section tell them how to number equipment, pumps, AHUS, HPs, VAVS, etc…)

A. Hot Water/Glycol Heating Pumps Lead/Lag Sequence: The pumps are set up in a lead lag sequence. The pump select indicates which pump is running. The lead pump shall be enabled to run when the outside air temperature is below the pump outside air enable setpoint of ## degrees F*. If the status of the lead pump goes off when it is being commanded on, the pump will alarm. When the lead pump status fails to follow the start/stop command, the lead/lag sequence will generate an alarm that will remain until the system is reset. The lag pump will then be enabled and commanded to start. If the lag pump fails to start, the lag pump will also alarm, but it will not try to start the lead pump again, since it has already failed. Also, if either pump is commanded off and the status still senses the pump is on, an alarm will be generated for that pump.
   1. ###Hx#LeadEnable
   2. ###Hx#LagEnable [Optional Point]
   3. ###Hx#PumpSel
   4. ###Hx#LeadLagAlm
   5. ###Hx#Pump1
   6. ###Hx#Pump1Status
   7. ###Hx#Pump1Alm
   8. ###Hx#Pump2
   9. ###Hx#Pump2Status
   10. ###Hx#Pump2Alm
   11. ###Hx#OaTempSig
   12. ###Hx#PumpEnableSp

B. Hot Water/Glycol Heating Pump: The pump shall turn on when the outside air temperature is below the pump outside air enable setpoint of ## degrees F*. The pump shall have a 5 degree F* deadband and turn off when the outside air temperature is 5 degrees F* above the pump outside air enable setpoint. If the pump is commanded on or off and does not follow that command, an alarm shall be generated for the pump.
   1. ###Hx#Pump1
2. ###Hx#Pump1Status
3. ###Hx#Pump1Alm
4. ###Hx#OaTempSig
5. ###Hx#PumpEnableSp

C. Variable Frequency Drive (VFD) with Differential Pressure Control: The VFD shall modulate between 0 and 100% to maintain the differential pressure setpoint. The balancer shall determine the proper setpoint.
1. ###Hx#Pump1VFD
2. ###Hx#Pump1VFDAlm
3. ###Hx#Pump2VFD [Use with Lead/Lag Sequence]
4. ###Hx#Pump2VFDAlm [Use with Lead/Lag Sequence]
5. ###Hx#DiffPress
6. ###Hx#DiffPressSp

D. Heat Exchanger Steam Valve: The steam valve shall be closed when the statuses of the heating pumps are off. When one pump status is proven on, the steam valve shall modulate to maintain the hot water auto setpoint. The hot water auto supply setpoint is reset accordingly from outside air temperature. If more than one valve is used, the engineers design shall determine the sequence of operation based on sizing of both valves.
1. ###Hx#SteamVlv

E. Hot Water Supply Auto Setpoint Reset Schedule:
1. The hot water supply temperature auto setpoint is reset by outside air temperature (OSA). The hot water supply setpoint shall be determined by the following reset schedule. All reset schedule setpoints must be adjustable from the front-end: (values to be determined by the mechanical engineer)

<table>
<thead>
<tr>
<th>Outside Air Temperature</th>
<th>## Degrees F*</th>
<th>## Degrees F*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water Supply Setpoint</td>
<td>## Degrees F*</td>
<td>## Degrees F*</td>
</tr>
</tbody>
</table>

2. The hot water return temperature shall be monitored and will alarm if the water temperature becomes either too hot or too cold.
3. Points...
   a. ###Hx#HWSTempSp
   b. ###Hx#HwOaHiSp
   c. ###Hx#HwOaLowSp
   d. ###Hx#HwSupHiSp
   e. ###Hx#HwSupLowSp
   f. ###Hx#HWSTemp
   g. ###Hx#HWRTemp

F. Steam Load Shed: When the steam load shed is indexed on, the heat exchanger hot water auto setpoint shall be reduced by 20%.
1. ###Hx#StmLoadShed

3.06 HEAT PUMP LOOP & TOWER SEQUENCE

A. Heat Pump Loop Circulation Pumps: The heat pump loop circulation pumps shall be setup in a lead lag sequence. The lead loop pump shall run continuously. If the status of the lead pump goes off when it is being commanded on, the pump will alarm. When the lead pump status fails to follow the start/stop command, the lead/lag sequence will generate an alarm that will remain until the system is reset. The lag pump will then be commanded to start. If the lag pump fails to start the lag pump will also alarm, but it will not try starting the lead pump again, since it has already failed. Also, if either pump is commanded off and the status still senses the pump is on, an alarm will be generated for that pump. Note: There should always be two heat pump loop circulation pumps per loop to provide redundancy.
B. Points:
1. ###HPLPump1
2. ###HPLPump1Stat
3. ###HPLPump1Alm
4. ###HPLPump2
5. ###HPLPump2Stat
6. ###HPLPump2Alm
7. ###HPLPumpSel
8. ###HPLLeadEnable
9. ###HPLLeadLagAlm

B. Heat Pump Loop Heat Exchanger: The steam valve shall modulate to maintain the heat pump water loop temperature setpoint of 72 degrees (adjustable) if the outdoor air temperature is below 50 degrees. Above 50 degrees outdoor air temperature the steam valve shall remain closed.

Points:
1. ###HPLEnableSp
2. ###HPLStmVlv
3. ###HPLHWSSupSp
4. Add separate OSA point for HX Program

C. Cooling Tower Fan Emergency Shutdown with an Electrical Interlock: If both heat pump loop pumps fail, the tower fans shall be disabled. A flow sensor shall be installed in the heat pump loop and if it senses no flow, then power to the tower fans shall be turned off and the tower dampers shall close.

D. Cooling Tower Fan Emergency Shutdown with a Software Interlock: If both heat pump loop pumps fail, the tower fans shall be disabled. If the flow sensor reads no flow, then a digital output signal shall be sent to a relay in the cooling tower controls to turn off the tower fans and the tower dampers shall close. (Clarify C and D and make them stand on their own if only one is used.)

1. ###HPLFlowSwitch
2. ###CtFanShutdown

E. Cooling Tower Fan VFD Control:
1. The tower fan variable frequency drive (VFD) shall be modulated from 0% to 100% to maintain the heat pump loop supply temperature at its setpoint of 78* degrees F (adjustable).
2. The cooling tower fan shall turn on when the heat pump loop supply temperature is 2* degrees F above the heat pump loop supply temperature setpoint. The cooling tower fan shall turn off when the condenser water temperature is 5* degrees F below the condenser water supply temperature setpoint.
3. Note: The VFD shall be configured so that the minimum speed for the cooling tower fan motor is 20% of the drive’s total hertz. This is done for the protection of the cooling tower fan motor and cooling tower’s transmission.
4. Monitoring shall be provided for the condenser heat pump loop supply and return temperatures. Both sensors shall be configured to alarm with the following alarm limits:

<table>
<thead>
<tr>
<th>Point Name</th>
<th>Low Alarm Limit</th>
<th>Low Warning Limit</th>
<th>High Warning Limit</th>
<th>High Alarm Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>###HPLSupTemp</td>
<td>60 Deg F</td>
<td>65 Deg F*</td>
<td>90 Deg F*</td>
<td>100 Deg F*</td>
</tr>
<tr>
<td>###HPLRetTemp</td>
<td>60 Deg F</td>
<td>65 Deg F*</td>
<td>90 Deg F*</td>
<td>100 Deg F*</td>
</tr>
</tbody>
</table>
5. These sensors shall be programmed with alarm limits that are adjustable from UND Facilities Management’s existing front-end automation system.

6. An alarm shall be generated if the cooling tower fan fails to follow the start/stop command from the program. Also, the hardware alarm point from the VFD shall be monitored from the front-end automation system to show if there is a fault on the VFD.
   a. ###HPLSupTemp
   b. ###HPLRetTemp
   c. ###CtFan
   d. ###CtFanStatus
   e. ###CtFanAlarm
   f. ###CtFanVFD
   g. ###CtFanVFDAlm

F. Cooling Tower Fan High and Low Speed Control Setpoint Sequence by Hard Setpoints

1. The heat pump loop supply temperature shall have a setpoint of 78 degrees. When the tower system is enabled for summer mode, the heat pump loop supply temperature shall be maintained by using the following sequence to cycle the cooling tower dampers, the two speed cooling tower fans and the spray pump. As the heat pump loop temperature drops the reverse sequence shall occur. In the winter mode the dampers and fan shall still cycle, but the spray pump shall remain off. The operation of the cooling tower to control the heat pump loop supply temperature shall be as follows:
   a. If the HPLSupTemp is 77 degrees F, then the dampers shall close.
   b. If the HPLSupTemp is 78 degrees F, then the dampers shall open.
   c. If the HPLSupTemp is 79 degrees F, then the spray pump shall turn off.
   d. If the HPLSupTemp is 80 degrees F, then the spray pump shall turn on.
   e. If the HPLSupTemp is 81 degrees F, then the low fan speed shall turn off.
   f. If the HPLSupTemp is 82 degrees F, then the fan low speed shall turn on.
   g. If the HPLSupTemp is 83 degrees F, then the fan high speed shall turn off.
   h. If the HPLSupTemp is 84 degrees F, then the fan high speed shall turn on.

2. If both heat pump loop pumps fail, the tower fans shall be disabled and the tower dampers shall close.

3. Points:
   a. ###CtFanLowSpeed
   b. ###CtFanHighSpeed
   c. ###CtFanStatus
   d. ###CtFanAlarm
   e. ###CtDmpr
   f. ###CtDmprStatus

G. Cooling Tower Sump: (Non-standard. Please check what standards we want.)

1. The cooling tower system shall be switched from summer to winter mode from a relay switch (manual) in the building automation panel. The tower sump shall fill if the cooling tower system is in summer mode and the outside air temperature is above 40 degrees F. Once the sump is filled, the cooling tower spray pump can cycle to maintain the heat pump loop supply temperature. If the sump is not filled, the spray pump shall be off.
   a. ###CtSummerWinter

2. The tower sump shall have four water level sensors: a low water level alarm, a low water fill level, a full level (water shutoff level) and a high water level alarm. The main water valve shall open and fill the sump until the water reaches the full level sensor. Then the main water valve shall close when the full level is met. If the water in the sump goes down to the water fill level sensor, then the main water valve shall open and fill to the full level sensor. In the summer mode, alarms shall be generated for low and high levels if the sump is not filling or the water level in the sump is too high. In the winter mode, the level alarms shall not generate an alarm.
   a. ###CtSumpHiLevel
b. ###CtSumpLoLevel

c. ###CtSumpFillLevel

d. ###CtSumpShutLevel

e. ###CtSumpWtrVlv

3. Once the tower sump is full, it shall remain filled until the outside air temperature reaches 29 degrees F. When the outside air temperature drops below 29 degrees F, the sump drain valve and spray pump housing (volute) valve shall open and the makeup water valve shall close to drain the water in the sump and spray pump. Then the cooling tower system shall operate as a dry cooler by modulating the dampers and cycling fans to maintain heat pump water loop temperature.

a. ###CtSumpDrainSp

b. ###CtOaTempSig

c. ###CtSprayPmp

d. ###CtSprayPmpStat

e. ###CtSprayPmpAlm

f. ###CtSprayPmpVlv

g. ###CtSumpDrainVlv

H. Chemical Feed System: [Tower chemical feed systems shall be located in an indoor temperature controlled area; the following sequence should be in place.]

1. The tower sump has a chemical feed system that needs to be enabled and disabled through a relay from the building automation system. If the cooling tower system is in summer mode and the spray pump is on the chemical feed system shall enable after 60 minutes. When the cooler spray pump stops, the chemical feed system shall be disabled. Note: Seasonally, the chemical feed system will be manually drained by maintenance personnel. See the speciation on the mechanical system for necessary valves, etc.

2. If the project restricts the chemical feed system from being in an indoor temperature controlled area, the following setup shall be in place to prevent any freeze-up problems. The tower sump has a chemical feed system that needs to be enabled and disabled through a relay from the building automation system. If the cooling tower system is in summer mode and the spray pump is on the chemical feed system shall enable after 60 minutes. When the cooler spray pump stops, the chemical feed system shall be disabled. In addition, when the automatic sump valve opens to drain down and empty the sump, the chemical line valve, sensing line valve and bleed line valve shall open and remain open for 30 minutes or until sump begins to fill. When the outside air temperature is above 40 degrees the reverse sequence shall occur.

a. ###CtChemFeedEna

3. 07 HEAT PUMP SEQUENCE

A. Time Schedule:

1. Each heat pump controller shall be indexed from occupied to unoccupied automatically from a time program located in its associated building controller. Time schedules for heat pumps must be coordinated with the UND Facilities Department.

B. Occupied:

1. The fan shall run continuously. On a call for heating the compressor shall cycle the heating stage(s) to maintain actual setpoint. On a call for cooling the compressor shall cycle the cooling stage(s) to maintain actual setpoint. Time delays for cycling stages shall follow the heat pump manufacturer’s specifications.

2. The high and low setpoint knob limits shall be 68 degrees F and 75 degrees F (adjustable). The high and low limits do not need to be displayed at the front-end, but do need to be accessible parameters in the program.

C. Unoccupied:

1. Fan and compressor shall cycle to maintain the space temperature between the unoccupied heating and cooling setpoints. The unoccupied heating space temperature
D. Standby:
   1. If an occupancy sensor is used in the space, the occupancy sensor shall determine occupied and standby modes. If the occupancy sensor detects no motion, the heat pump shall follow standby setpoints. The standby heating space temperature setpoint shall be 64 degrees F (adjustable setpoint) and the standby cooling setpoint shall be 78 degrees F (adjustable setpoint).

E. A heat pump fan status sensor shall be installed to monitor the status of the fan. A discharge air sensor shall be installed in the duct after the heat pump to monitor the discharge air from the heat pump.

F. Electrical Demand Control:
   1. Each heat pump controller shall allow for individual lockout of fans and/or compressors for electrical demand control.

G. Anytime multiple thermostats are used in a single space, the sequence must be approved by UND Facilities Management.

G. Monitored Points: Also somewhere in the HP, VAV, radiation, etc. sections it would be good to list what to do when multiple stats are in a room, including when they have large event rooms where they can open or close partitions to make one or two+ rooms.
   1. The following points shall be viewable at the front-end system:
      a. ###H##RmTemp
      b. ###H##HtgOccSp
      c. ###H##SaFanStatus
      d. ###H##HtgUnoccSp
      e. ###H##RmTempActSp
      f. ###H##OccMode
      g. ###H##RmTempSpOvr
      h. ###H##ManOccOvr
      i. ###H##ClgStageOn
      j. ###H##SaFan
      k. ###H##HtgStageOn
      l. ###H##StatusMode
      m. ###H##DiaSpEnable
      n. ###H##DaTemp
      o. ###H##ClgOccSp
      p. ###H##ClgUnoccSp
      q. ###H##ClgStandbySp
      r. ###H##HtgStandbySp

3.08 MISCELLANEOUS MONITORING POINTS
A. Sump Pump:
   1. Sump pump alarm points shall be monitored and alarm to the front-end system. An alarm shall be generated when the water level in the sump pump pit is too high. The alarm level shall be set at a level that gives personnel time to respond to the alarm before the pit would overflow.
   2. The sump pump point shall reference the pump number. The sump pump descriptor shall reference the pump number and the room location of the pump and its sensor. This is a code yellow point and this shall be noted in this point’s descriptor at the front-end system. The following point name shall be used:
a. ###SumpPmp#Rm###Alm

B. Condensate Pump:
1. Condensate pump alarm points shall be monitored and alarm to the existing front-end system at UND Facilities Management. An alarm shall be generated when the water level in the condensate tank is too high. The alarm level shall be set at a level that gives personnel time to respond to the alarm before the tank would overflow. Also, an alarm shall be generated when steam fills up the condensate tank.
2. The condensate pump point shall reference the condensate tank/system number. The condensate pump descriptor shall reference the condensate tank/system number and the room location of the tank and its sensor. This is a code yellow point and this shall be noted in this point’s descriptor at the front-end system. The following point name shall be used:
   a. ###StmCondPmp#Rm###Alm

C. Sewage Backup Pump:
1. Sewage backup pump alarm points shall be monitored and alarm to the existing front-end system at UND Facilities Management. An alarm shall be generated when sewage backs up in the main sewage line. The sensor placement shall be at a location that gives personnel time to respond to the alarm before sewage would overflow.
2. The descriptor for the sewage backup alarm shall reference the room location of the sewage backup sensor. This is a code yellow point and this shall be noted in this point’s descriptor at the front-end system. The following point name shall be used:
   a. ###SewBackupPmp#Rm###Alm

D. Sewage Ejector Pump:
1. Sewage ejector pump alarm points shall be monitored and alarm to the existing front-end system at UND Facilities Management. An alarm shall be generated when the level in the pit is too high. The alarm level shall be set at a level that gives personnel time to respond to the alarm before the pit would overflow.
2. The sewage backup pump point shall reference the pump number. The sewage backup pump descriptor shall reference the pump number and the room location of the sewage backup pump and its sensor. This is a code yellow point and this shall be noted in this point’s descriptor at the front-end system. The following point name shall be used:
   a. ###SewEjecPmp#Rm###Alm

E. Moisture Sensor:
1. Moisture sensor alarm points shall be monitored and alarm to the existing front-end system at UND Facilities Management. For most applications, an alarm shall be generated when the water is sensed on the floor at a level of approximately one-eighth of an inch. Engineer is to coordinate details with UND Facilities Management and the department who will occupy that space.
2. The moisture sensor point shall reference the sensor number. The moisture sensor descriptor shall reference the sensor number and the room location of the sensor. This is a code yellow point and this shall be noted in this point’s descriptor at the front-end system. The following point name shall be used:
   a. ###MoistureSenRm###

F. Temperature Control Air Compressor (TCAC):
1. The TCAC shall generate an alarm if the pressure falls below the local pneumatic setpoint of 40 psi. (Reference technical section instead of sequence of operation.)
2. The TCAC point shall reference the TCAC number. The TCAC descriptor shall reference the TCAC number and the room location of the TCAC and its sensor. This is a code yellow point and this shall be noted in this point’s descriptor at the front-end system. The following point name shall be used:
   a. ###TCAC#Rm###Alarm

G. Domestic Hot Water:
1. Domestic hot water supply temperature shall be monitored and alarm to the front-end system. An alarm shall be generated when the domestic hot water temperature goes beyond its alarm limits.

2. If there is more than one domestic hot water supply temperature per building, each point shall reference the system number or name. The each point’s descriptor shall reference the system number or name, if there is one, and the room location of the system. This is a code yellow point and this shall be noted in this point’s descriptor at the front-end system. The following point name shall be used:
   a. ###DomHwSupTemp
   b. ###DomPumpAlarm – used only when there is not enough pressure to get water to higher locations.

H. Outside Air Temperature:
   1. Outside air temperature points shall be monitored and alarm to the front-end system. Each mechanical system with a controller program shall have a software point derived from this point to allow for troubleshooting one system without affecting the rest.
      a. ###OaTemp

3.09 AHU SEQUENCE PARTS
A. Time Schedule: The Air Handling Unit (AHU) shall be indexed from occupied to unoccupied automatically from a time schedule located in the DDC controller.
   1. ###Ah#OccUnocc
   2. ###Ah#SaFan
   3. ###Ah#SaFanStatus
   4. ###Ah#SaFanAlarm
   5. [If a return fan is monitored, it shall be enabled off of Supply Fan Status]
   6. ###Ah#RaFan [Optional]
   7. ###Ah#RaFanStatus [Optional]
   8. ###Ah#RaFanAlarm [Optional]
B. Select one of the following four space sensor configurations if a space sensor is to be used. Select for small areas with low use and inconsistent occupancy. The occupants are to enable the AHU at the thermostat upon entering the room. Signage on occupant procedure shall be installed next to the thermostat:
   1. AHU Enable by Occupants on Local Room Thermostat with OccupiedModes (space temperature control with onsite thermostat dial and push-button override): There shall be an override button on the space sensor for the occupants to override the time schedule and put the AHU into occupied mode for 120 minutes (adjustable setpoint). In the occupied mode the space temperature setpoint shall follow the dial setpoint. Software limit stops of 60 degrees F and 80 degrees F shall be provided. In the unoccupied mode the heating setpoint shall be 60 degrees F and the cooling setpoint shall be 80 degrees F.
      a. ###Ah#RmTemp
      b. ###Ah#RmTempDialSp
      c. ###Ah#UnoccOvrd
   2. Space Wall Module (Sensor with Occ/Unocc Button and Dial): The space wall module shall include sensor, thermostat setpoint dial and override button. When the override button is depressed and the system is in unoccupied, the system shall go into occupied for a period of 60 minutes (adjustable setpoint).
      a. ###Ah#RmTemp
      b. ###Ah#UnoccOvrd
   3. Space Wall Module (Sensor with Occ/Unocc Button): The space wall module shall include sensor and override button. When the override button is depressed and the system is in unoccupied, the system shall go into occupied for a period of 60 minutes (adjustable setpoint).
      a. ###Ah#RmTemp
b. #Ah#RmTempSp

c. #Ah#UnoccOvrd

4. Space Wall Module (Sensor with Dial): The space wall module shall include sensor and thermostat setpoint dial.

a. #Ah#RmTemp
b. #Ah#RmTempDialSp
c. #Ah#UnoccOvrd

C. If space temperature is used to control the AHU, select one occupied/unoccupied configuration from below:

1. Occupied/Unoccupied Modes (space temperature control with onsite thermostat dial and push-button override):

   a. In the occupied mode, the fan shall run continuously. The space temperature shall be maintained at the space temperature dial setpoint. An adjustable dial shall be provided within the space displaying the temperature in degrees F. There shall be a 1.0 degree deadband on either side of the setpoint. Software limit stops of 60 degrees F and 80 degrees F shall be provided.

      1) #Ah#RmTemp
      2) #Ah#RmTempDialSp

   b. In the unoccupied mode, the supply [add exhaust or return fans as applicable] fan(s) shall cycle. The fan(s) shall cycle on for heating when the space temperature falls below the unoccupied heating space temperature setpoint of 60 degrees F (adjustable setpoint). The fan(s) shall cycle on for cooling when the space temperature rises above the unoccupied cooling space temperature setpoint of 80 degrees F (adjustable setpoint). The fan(s) shall be off when the space temperature is between the unoccupied setpoints. There shall be a 1.0 degree deadband on the operation of both setpoints. Also, there shall be an override button on the space sensor for the occupants to override the time schedule and put the AHU into occupied mode for 60 minutes (adjustable setpoint).

      1) #Ah#RmTemp
      2) #Ah#HtgUnoccSp
      3) #Ah#ClgUnoccSp
      4) #Ah#UnoccOvrd

2. Occupied/Unoccupied Modes (space temperature control with onsite thermostat dial): 

   a. In the occupied mode, the fan shall run continuously. The space temperature shall be maintained at the space temperature setpoint. An adjustable dial shall be provided within the space displaying the temperature in degrees F. There shall be a 1.0 degree deadband on either side of the setpoint. Software limit stops of 60 degrees F and 80 degrees F shall be provided.

      1) #Ah#RmTemp
      2) #Ah#RmTempDialSp

   b. In the unoccupied mode, the supply [add exhaust or return fans as applicable] fan(s) shall cycle. The fan(s) shall cycle on for heating when the space temperature falls below the unoccupied heating space temperature setpoint of 60 degrees F (adjustable setpoint). The fan(s) shall cycle on for cooling when the space temperature rises above the unoccupied cooling space temperature setpoint of 80 degrees F (adjustable setpoint). The fan(s) shall be off when the space temperature is between the unoccupied setpoints. There shall be a 1.0 degree deadband on the operation of both setpoints.

   c. #Ah#RmTemp
   d. #Ah#HtgUnoccSp
   e. #Ah#ClgUnoccSp

3. Occupied Modes (space temperature control without dial setpoint - one occupied setpoint in controller):
a. In the occupied mode, the fan shall run continuously. The space temperature shall be maintained at the space temperature setpoint of 72 degrees F (adjustable setpoint). There shall be a 1.0 degree deadband on either side of the setpoint.
   1) ###Ah#RmTemp
   2) ###Ah#RmTempSp

b. In the unoccupied mode, the supply [add exhaust or return fans as applicable] fan(s) shall cycle. The fan(s) shall cycle on for heating when the space temperature falls below the unoccupied heating space temperature setpoint of 60 degrees F (adjustable setpoint). The fan(s) shall cycle on for cooling when the space temperature rises above the unoccupied cooling space temperature setpoint of 80 degrees F (adjustable setpoint). The fan(s) shall be off when the space temperature is between the unoccupied setpoints. There shall be a 1.0 degree deadband on the operation of both setpoints.
   1) ###Ah#RmTemp
   2) ###Ah#HtgUnoccSp
   3) ###Ah#ClgUnoccSp

4. Occupied/Unoccupied Modes (space temperature control without dial setpoint – heating and cooling occupied setpoints in controller):
   a. In the occupied mode, the fan shall run continuously. When cooling is enabled for the AHU, the space temperature shall be maintained at its cooling occupied setpoint of 73 degrees F. When cooling is not enabled for the AHU, the space temperature shall be maintained at its heating occupied setpoint of 71 degrees F. The temperature shall be maintained at its setpoint within 0.5 degree F on either side of the active setpoint. (adjustable setpoints in degrees F).
      1) ###Ah#RmTemp
      2) ###Ah#HtgOccSp
      3) ###Ah#ClgOccSp

   b. In the unoccupied mode, the supply [add exhaust or return fans as applicable] fan(s) shall cycle. The fan(s) shall cycle on for heating when the space temperature falls below the unoccupied heating space temperature setpoint of 60 degrees F (adjustable setpoint). The fan(s) shall cycle on for cooling when the space temperature rises above the unoccupied cooling space temperature setpoint of 80 degrees F (adjustable setpoint). The fan(s) shall be off when the space temperature is between the unoccupied setpoints. There shall be a 1.0 degree deadband on the operation of both setpoints.
      1) ###Ah#RmTemp
      2) ###Ah#HtgUnoccSp
      3) ###Ah#ClgUnoccSp

D. If space temperature is not used to control the AHU in the occupied mode, select one occupied configuration from below:
   1. Occupied Mode (return air temperature control): In the occupied mode, the fan shall run continuously. The return air temperature shall be maintained at the return air temperature setpoint of 72 degrees F (adjustable setpoint). There shall be a 1.0 degree deadband on either side of the setpoint.
      a. ###Ah#RaTemp
      b. ###Ah#RaTempSp

   2. Occupied Mode (discharge air temperature control): In the occupied mode, the fan shall run continuously. The discharge air temperature shall be maintained at the discharge air temperature auto setpoint (display on the front-end in degrees F). There shall be a 1.0 degree deadband on either side of the setpoint.
      a. ###Ah#DaTemp
      b. ###Ah#DaTempSp

   3. Occupied Mode (hot deck and cold deck temperature control based on OSA): In the occupied mode, the fan shall run continuously. The hot deck and cold deck shall be...
SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

maintained at their setpoints. There shall be a 1.0 degree deadband on either side of the setpoints.

a. ###Ah#HdTemp
b. ###Ah#HdAutoSp
c. ###Ah#CdTemp
d. ###Ah#CdAutoSp

4. Occupied Mode (mixed air temperature control): In the occupied mode, the fan shall run continuously. The hot deck and cold deck shall be maintained at their setpoints. There shall be a 1.0 degree deadband on either side of the setpoints.

a. ###Ah#MaTemp
b. ###Ah#MaTempSp

e. If space temperature is not used to control the AHU in the occupied mode, but space temperature is used to enable the AHU in unoccupied, select the following configuration:

1. Unoccupied Mode (for systems not controlled by space temperature in the occupied mode, but which use space temperature to enable the system in the unoccupied mode): In the unoccupied mode, the supply [add exhaust or return fans as applicable] fan(s) shall cycle. The fan(s) shall cycle on for heating when the space temperature falls below the unoccupied heating space temperature setpoint of 60 degrees F (adjustable setpoint). The fan(s) shall cycle on for cooling when the space temperature rises above the unoccupied cooling space temperature setpoint of 80 degrees F (adjustable setpoint). The fan(s) shall be off when the space temperature is between the unoccupied setpoints. There is a 1.0 degree deadband on the operation of both setpoints.

a. ###Ah#RmTemp
b. ###Ah#HtgUnoccSp
c. ###Ah#ClgUnoccSp

F. If the speed of the fan is changed by the occupancy, select the following configuration. This is to be used in areas where continuous day and night make-up air or bathroom exhaust is needed, but there are high and low use timeframes:

1. Time Schedule with Occupied Day/Occupied Night/Unoccupied Modes (fans high speed, fans low speed and fans off [or VFDs 100%, 50% and 0%]): The Air Handling Unit (AHU) shall be indexed from occupied day, to occupied night and to unoccupied automatically from a time schedule located in the DDC controller. In the occupied mode, the supply and exhaust fans shall run continuously. When in daytime occupancy, the fans shall run at high speed [100% for VFDs]. When in nighttime occupancy, the fans shall run at low speed [50% for VFDs]. When the area served is not in use, there shall be an unoccupied mode to turn the fans and associated AHU equipment off. In the occupied mode (day or night), the discharge air temperature shall be maintained at the discharge air temperature auto setpoint (display on the front-end in degrees F). In the unoccupied mode the system shall be off.

g. If the AHU has a VFD(s) then select the appropriate fan configuration(s):

1. Supply Fan Variable Frequency Drive (VFD) with Static Pressure Control (for VAV Systems): A static pressure sensor shall be located in supply plenum two-thirds down the longest duct without airflow obstructions [for multi-zone to VAV conversion projects, install the static pressure sensor ahead of the cold deck]. The static pressure controller shall modulate the speed of the variable frequency drive for the supply fan in order to maintain the static pressure setpoint of 1.0 inches of water (The static pressure setpoint shall be determined by the engineer or mechanical designer. Also, it shall be verified with the balancer at the end of the project and adjusted, if necessary.)

a. ###Ah#DuctStatic
b. ###Ah#DuctStaticSp
c. ###Ah#SaFanVFD

2. Return Fan Variable Frequency Drive (VFD) with Static Pressure Control (for VAV Systems): A static pressure sensor shall be located in return plenum without airflow obstructions. The static pressure controller shall modulate the speed of the variable
frequency drive for the return fan in order to maintain the static pressure setpoint of 1.0 inches of water (The static pressure setpoint shall be determined by the engineer or mechanical designer. Also, it shall be verified with the balancer at the end of the project and adjusted, if necessary.)

- ####Ah#RaDuctStatic
- ####Ah#RaDuctStaticSp
- ####Ah#RaFanVFD

~~~ PROJECT NOTE ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Sequence Information for UND Internal Reference Only –
These configurations are used on campus, but should not be used in future installations. Instead, a static pressure sensor shall be installed to modulate the VFD based on a measured value.

**Return Fan Variable Frequency Drive (VFD) Tracking the Supply Fan:**

The return fan VFD shall track the supply fan VFD. An offset setpoint shall be available for the return fan tracking. The tracking offset shall be adjustable from 0% to 100% of the supply fan speed. (The tracking offset shall be verified with the balancer at the end of the project and adjusted to balance the system.)

**Return Fan Variable Frequency Drive (VFD) Tracking the Outside Air Dampers:**

The return fan VFD shall track the outside air dampers. An offset setpoint shall be available for the return fan tracking. The offset shall be able to be changed with a multiplier from a minimum of 50% to 100%.

~~~ END OF PROJECT NOTE ~~~~~~~~~~~~~~~~~~~~~~~~~

H. Select the appropriate configuration for discharge air control, mixed air control or heat recovery system:

1. Discharge Air Temperature Control (discharge air reset schedule based on space temperature control): The discharge air setpoint is reset between the low limit discharge air temperature setpoint of 55 degrees F (adjustable setpoint) and the high limit discharge air temperature setpoint of 95 degrees F (adjustable setpoint), based on the requirements of the space temperature to maintain the space temperature setpoint. There shall be a 1.0 degree deadband on the operation of space temperature setpoint.
   - ####Ah#DaHiSpReset
   - ####Ah#DaLowSpReset
   - ####Ah#RmTemp
   - ####Ah#DaTempSp

2. Discharge Air Temperature Control (discharge air reset schedule based on return air temperature control): The discharge air setpoint is reset between the low limit discharge air temperature setpoint of 55 degrees F (adjustable setpoint) and the high limit discharge air temperature setpoint of 95 degrees F (adjustable setpoint), based on the requirements of the return air temperature to maintain the return temperature setpoint. There is a 1.0 degree deadband on the operation of return air temperature setpoint.
   - ####Ah#RaTemp
   - ####Ah#RaTempSp
   - ####Ah#DaHiSpReset
   - ####Ah#DaLowSpReset
   - ####Ah#DaHiSpReset

3. The discharge air temperature auto setpoint is reset by outside air temperature (OSA).
a. Discharge Air Temperature Auto Setpoint Reset Schedule (adjustable setpoints):
b. Discharge Air Temperature Control (discharge air temperature control based on outside air reset schedule):

<table>
<thead>
<tr>
<th>Outside Air Temperature</th>
<th>65 Degrees F</th>
<th>0 Degrees F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge Air Setpoint</td>
<td>55 Degrees F</td>
<td>70 Degrees F</td>
</tr>
</tbody>
</table>

c. There is a 1.0 degree deadband on the operation of discharge air temperature setpoint.
   1) ###Ah#DaTemp
   2) ###Ah#DaHiSpReset
   3) ###Ah#DaLowSpReset
   4) ###Ah#DaOaHiReset
   5) ###Ah#DaOaLoReset

4. Mixed Air Temperature Control (outside air reset schedule based on mixed air temperature control): The mixed air setpoint is reset between the low limit mixed air temperature setpoint of 55 degrees F (adjustable setpoint) at 55 degrees F outside air temperature (adjustable setpoint), and the high limit mixed air temperature setpoint of 95 degrees F (adjustable setpoint) at 0 degrees F outside air temperature (adjustable setpoint). There is a 1.0 degree deadband on the operation of mixed air temperature setpoint.
   a. ###Ah#MaTemp
   b. ###Ah#MaTempSp
   c. ###Ah#MaHiSpReset
   d. ###Ah#MaLowSpReset
   e. ###Ah#MaOaHiReset
   f. ###Ah#MaOaLoReset

5. [Note on Discharge Air Reset Setpoints: Discharge [or Mixed] air high and low reset setpoints are normally 55 degrees F for the low limit and the high limit depends on the type of system. VAV systems are normally 65 degrees F for a high. Make-up air systems normally vary from 55 to 75 degrees F for a high. Other systems are dependent on the AHU for heating the space range from 95 to 120 dependent on the space. The mechanical engineer, mechanical designer or HVAC supervisor needs to provide these values.]

6. Heat Recovery System (Coils with Glycol Loop):
   a. The circulating pump for the heat recovery loop shall run when the outside air temperature is below 50 degrees F or above 75 degrees F. [If the unit does not have cooling, the pump shall be disabled when the outside air temperature is above 50 degrees F.] Between those temperatures the pump shall remain off. If the pump fails to start or stop when commanded, an alarm shall be generated.
   b. A sensor for the supply heat recovery coil leaving air temperature shall modulate the heat recovery loop’s 3-way valve to maintain the AHU’s supply air discharge air setpoint. Below the low pump enable setpoint, the heat recovery system shall be in heating mode and modulate the 3-way valve (100% open = full heating) to maintain discharge setpoint. Above the high pump enable setpoint, the heat recovery system shall be in cooling mode and modulate the 3-way valve (100% open = full cooling) to maintain discharge setpoint.
   c. A sensor for the exhaust heat recovery coil leaving air temperature shall override the discharge control and close the heat recovery valve when the exhaust heat recovery coil leaving air temperature reaches 36 degrees F and below, to prevent exhaust coil frosting.
   d. In addition to those listed above, the following sensors will be added to each system for the purpose of monitoring and energy evaluation:
1) Supply Heat Recovery Coil Entering Air Temperature (or Outside Air Temperature can be used in some situations.)
2) Exhaust Heat Recovery Coil Entering Air Temperature
3) Exhaust Heat Recovery Coil Leaving Air Temperature
4) Supply Heat Recovery Coil Entering Glycol Temperature
5) Exhaust Heat Recovery Coil Entering Glycol Temperature
6) Exhaust Heat Recovery Coil Leaving Glycol Temperature
   (a) ###Hr#P#
   (b) ###Hr#P#Status
   (c) ###Hr#P#Alarm
   (d) ###Hr#P#HiOaEnaSp
   (e) ###Hr#P#LoOaEnaSp
   (f) ###Hr#HtgVlv
   (g) ###Hr#SaEntTemp or ###Hr#OaTempSig
   (h) ###Hr#EaEntTemp
   (i) ###Hr#EaLvgTemp
   (j) ###Hr#ExhEntGlyTmp
   (k) ###Hr#SupEntGlyTmp
   (l) ###Hr#ExhLvgGlyTmp

I. Heat Recovery System (Wheel with Two Speed Fan):
   1. The wheel for the heat recovery system shall run when the outside air temperature is below 50 degrees F or above 75 degrees F. [If the unit does not have cooling, the wheel shall be disabled when the outside air temperature is above 50 degrees F.] Between those temperatures the wheel shall remain off. If the wheel fails to start or stop when commanded, an alarm shall be generated.
   2. A sensor for the supply heat recovery coil leaving air temperature shall turn off the wheel if its temperature is within 7° degrees F of the heat recovery coil entering air temperature. (This value shall be provided by the mechanical engineer or manufacturer’s specifications. The value shall reflect the point at which heat recovery is no longer efficient.)
   3. A differential pressure sensor shall measure the airflow across the wheel for frost/ice detection. If the pressure across the wheel drops below 15° inches of water for 2° minutes, the defrost cycle shall enable for ten minutes.
   4. In addition to those listed above, the following sensors will be added to each system for the purpose of monitoring and energy evaluation:
      a. Supply Heat Recovery Wheel Entering Air Temperature (or Outside Air Temperature can be used in some situations.)
      b. Supply Heat Recovery Wheel Leaving Air Temperature
      c. Exhaust Heat Recovery Wheel Entering Air Temperature
      d. Exhaust Heat Recovery Wheel Leaving Air Temperature
      e. System On/Off Command (Unoccupied)
      f. Supply Fan Low Speed Command (Occupied Night Mode)
      g. Supply Fan High Speed Command (Occupied Day Mode)
      h. Supply Fan Status
      i. Supply Fan Alarm
      j. Exhaust Fan Low Speed Command (Occupied Night Mode)
      k. Exhaust Fan High Speed Command (Occupied Day Mode)
      l. Exhaust Fan Status
      m. Exhaust Fan Alarm
      n. Wheel Rotation Status
      o. Heat Recovery Mode (summer, winter, disable?)

J. Select the appropriate configuration for heating valve control:
   1. Heating Valve: The heating valve shall modulate to maintain the discharge temperature setpoint. The heating valve is closed when the supply fan is off or when the DX cooling is enabled. [Add this statement for systems with cooling]
Sequence Information for UND Internal Reference Only –
The discharge air temperature low limit control is used for some systems on campus, but should not be used for new installations. Where this is used is to put a safety in for areas where there is damper leakage. When this is done there should also be a request to replace/correct the dampers.

~~~ END OF PROJECT NOTE ~~~~~~~~~~~~~~~~~~~~~~~~~

2. Heating Valve (with discharge air temperature low limit control when AHU is off): The heating valve shall modulate to maintain the discharge temperature setpoint. If the discharge air temperature falls below 50 degrees F, the heating valve shall open to maintain 50 degrees F to prevent freezing the coil. Otherwise, the heating valve is closed when the system is off or when the DX cooling is enabled. [Add this statement for systems with cooling]
   a. ###Ah#DaLowLimitSp

~~~ PROJECT NOTE ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Sequence Information for UND Internal Reference Only –
The face and bypass configurations are used on campus, but should not be used in future installations.

~~~ END OF PROJECT NOTE ~~~~~~~~~~~~~~~~~~~~~~~~~

3. Heating Valve with Face & Bypass: When the outside air temperature is above the face and bypass change over setpoint of 40 degrees F (adjustable setpoint), the heating valve shall modulate to maintain the discharge temperature at its setpoint and the face and bypass damper shall be open 100% (full face to the coil). Below the face and bypass change over setpoint, the discharge air temperature shall be maintained at its setpoint by modulating the face and bypass damper with the heating valve 100% open. The heating valve is closed when the unit is off or when the DX cooling is enabled. [Add this statement for systems with cooling]
   a. ###Ah#HdHtgVlv
   b. ###Ah#HdTemp

4. Hot Deck Heating Valve: The heating valve is modulated to maintain the hot deck temperature auto setpoint. The hot deck temperature auto setpoint is reset by outside air temperature (OSA).
   a. Hot Deck Reset Schedule (adjustable setpoints):
      
      | Outside Air Temperature | Hot Deck Setpoint |
      |-------------------------|-------------------|
      | -30 Degrees F           | 110 Degrees F     |
      | 70 Degrees F            | 80 Degrees F      |

   b. The heating valve shall be closed when the OSA temperature is above 70 degrees F(adjustable setpoint). A 1 degree deadband shall be applied to the setpoint. The heating valve is closed when the supply fan is off.
      1) ###Ah#HdHtgVlv
      2) ###Ah#HdTemp
      3) ###Ah#HdAutoSp
      4) ###Ah#HdHiSpReset
5)  ###Ah#HdLowSpReset
6)  ###Ah#HdOaHiReset
7)  ###Ah#HdOaLowReset

[Note on Hot Deck Reset Setpoints: The hot deck temperature high and low reset setpoints depend on the equipment and area served. The mechanical engineer, mechanical designer or HVAC supervisor needs to provide these values.]

K. Select the appropriate configuration for cooling control:

1. Cooling Valve: The cooling valve shall modulate to maintain the discharge temperature setpoint, if the chiller sequence has enabled the chilled water system. The cooling valve is closed when the supply fan is off.
   a.  ###Ah#ClgVlv
   b.  ###Ah#ClgEnable

2. DX Cooling: The DX cooling (one stage [List appropriate number of stages]) shall enable to maintain the discharge air setpoint if the mechanical cooling ready is on and the outside air temperature is above the cooling enable setpoint of 58 degrees F (adjustable setpoint). The DX cooling is off when the supply fan is off.
   a. Note: The mechanical cooling ready is a status from the DX cooling unit showing the DX cooling systems is ready to run when commanded on. Configuration of this must be coordinated with UND’s Systems Department (or the contractor installing the HVAC system) for relay placement. The relay is to be placed after all the DX unit’s safeties are met. When the relay’s contact closes, the cooling system’s status is seen as mechanically ready to run. This status is to prevent commanding the DX stages on when the system is not ready to run and also to prevent the AHU dampers from closing if the cooling system is not ready to run.
      1)  ###Ah#DxClgStage1 (For each additional cooling stage there should be a separate point labeled with the appropriate cooling stage number.)
      2)  ###Ah#ClgEnableSp
      3)  ###Ah#MechClgReady

3. Cold Deck Cooling Valve: The cooling shall be enabled if the chilled water pump status is on and the outside air temperature is above the cooling enable setpoint of 58 degrees F (adjustable setpoint). When the cooling is enabled, the cooling valve shall modulate to maintain the cold deck temperature auto setpoint. The cold deck temperature auto setpoint is reset by outside air temperature.
   a. Cold Deck Reset Schedule (adjustable setpoints):

<table>
<thead>
<tr>
<th>Outside Air Temperature</th>
<th>Cold Deck Setpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 Degrees F</td>
<td>56 Degrees F</td>
</tr>
<tr>
<td>85 Degrees F</td>
<td>55 Degrees F</td>
</tr>
</tbody>
</table>

   b. A 1 degree deadband shall be applied to the setpoint. The cooling valve is closed when the supply fan is off.
      1)  ###Ah#CdClgVlv
      2)  ###Ah#CdTemp
      3)  ###Ah#CdAutoSp
      4)  ###Ah#CdHiSpReset
      5)  ###Ah#CdLowSpReset
      6)  ###Ah#CdOaHiReset
      7)  ###Ah#CdOaLowReset

c. [Note on Cold Deck Reset Setpoints: The cold deck temperature high and low reset setpoints depend on the equipment and area served. The mechanical engineer, mechanical designer or HVAC supervisor needs to provide these values.]

4. Cold Deck with DX Cooling: The DX cooling (one stage [List appropriate number of stages]) shall enable to maintain the cold deck temperature setpoint if the mechanical cooling ready is on and the outside air temperature is above the cooling enable setpoint of
58 degrees F (adjustable setpoint). The DX cooling is off when the supply fan is off. The cold deck temperature auto setpoint is reset by outside air temperature.

a. Cold Deck Reset Schedule (adjustable setpoints):

<table>
<thead>
<tr>
<th>Outside Air Temperature</th>
<th>Cold Deck Setpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 Degrees F</td>
<td>55 Degrees F</td>
</tr>
<tr>
<td>85 Degrees F</td>
<td>55 Degrees F</td>
</tr>
</tbody>
</table>

b. A 1 degree deadband shall be applied to the setpoint. The cooling valve is closed when the supply fan is off. A [Note on Cold Deck Reset Setpoints: The cold deck temperature high and low reset setpoints depend on the equipment and area served. The mechanical engineer, mechanical designer or HVAC supervisor needs to provide these values.]

c. Note: The mechanical cooling ready is a status from the DX cooling unit showing the DX cooling systems is ready to run when commanded on. Configuration of this must be coordinated with UND’s Systems Department (or the contractor installing the HVAC system) for relay placement. The relay is to be placed after all the DX unit’s safeties are met. When the relay’s contact closes, the cooling system’s status is seen as mechanically ready to run. This status is to prevent commanding the DX stages on when the system is not ready to run and also to prevent the AHU dampers from closing if the cooling system is not ready to run.

1) ###Ah#DxClgStage1 (For each additional cooling stage there should be a separate point labeled with the appropriate cooling stage number.)
2) ###Ah#CdTemp
3) ###Ah#CdAutoSp
4) ###Ah#CdHiSpReset
5) ###Ah#CdLowSpReset
6) ###Ah#CdOaHiReset
7) ###Ah#CdOaLowReset

L. Humidifier Valve: The humidifier valve shall modulate to maintain a return [or space] humidity setpoint if the fan is running and cooling is not enabled. The humidity valve shall be limited to not open past the humidity valve high limit setpoint of 50%. The discharge air relative humidity sensor shall backoff the valve if the discharge air relative humidity goes above the discharge air relative humidity high limit setpoint of 60%. The humidifier valve shall be closed [during cooling mode or] when the supply fan is off. Humidity shall be controlled for all spaces occupied by people or for spaces with equipment that is electrostatic sensitive.

1. Return (or Space) Relative Humidity Setpoint Reset Schedule (adjustable setpoints):

<table>
<thead>
<tr>
<th>Outside Air Temperature</th>
<th>Relative Humidity Setpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>-30 Degrees F</td>
<td>20%</td>
</tr>
<tr>
<td>30 Degrees F</td>
<td>30%</td>
</tr>
</tbody>
</table>

2. ###Ah#RaRh or ###Ah#RmRh
3. ###Ah#RhAutoSp
4. ###Ah#RhHiSpReset
5. ###Ah#RhLowSpReset
6. ###Ah#RhOaHiReset
7. ###Ah#RhOaLowReset
8. ###Ah#HiVlvPos
9. ###Ah#HumVlv

M. Dehumidification:
1. Dehumidification shall be controlled for all spaces with artwork, musical instruments, ice rinks, historically archived documents or other valuable materials that are humidity sensitive.

2. Dehumidification shall be achieved by choosing the greater need/demand between the discharge air temperature and the relative humidity sensor.

N. [Select the appropriate configuration for damper control:]

1. 100% Outside Air Systems Supply and Exhaust Damper Controls:
   a. This is a 100% outside air unit. When in occupied, the outside and exhaust air dampers shall open. A damper end switch shall provide statuses to prove the supply and exhaust dampers are open. Once the dampers are open, there is a 20 to 30 second delay before the supply and exhaust fans are commanded on. If the supply or exhaust fans fail to start, the dampers shall close and all fans should shut off. If the damper fails to open or any of the fans fail to start, an alarm shall be generated.
   b. In the unoccupied mode, the supply and exhaust fans shall be commanded off and the outside air and exhaust air dampers shall close.
      1) ###Ah#OaDmprPos
      2) ###Ah#OaDmprStatus
      3) ###Ah#EaDmpr

2. Mixed Air Damper with Minimum Damper Setpoint:
   a. In the occupied mode, the mixed air dampers shall open to the minimum outside air (OSA) damper position of 15% (adjustable setpoint) when the unit is running and in occupied mode. The dampers will open above the minimum position for cooling to maintain the mixed air setpoint, when the OSA is below the economizer setpoint of 70 degrees F (adjustable setpoint). When the OSA is above the economizer setpoint or the mechanical cooling ready is on, the dampers shall go to the minimum position. The mixed air setpoint shall follow the discharge air setpoint. [If there is no discharge air setpoint, the mixed air setpoint would be created off of a mixed air verses outside air temperature reset schedule.]
   b. To protect the heating coil, if the mixed air temperature falls below the mixed air low limit setpoint of 50 degrees F (adjustable setpoint) the mixed air low limit control would over ride the minimum outside air damper position setpoint. The dampers would then modulate or close in order to maintain the mixed air setpoint.
   c. The outside air and exhaust air dampers shall close when the AHU is off.
      1) ###Ah#MaDmprPos
      2) ###Ah#MaDmprMinPos
      3) ###Ah#MaTemp
      4) ###Ah#MaLowLimitSp
      5) ###Ah#MaAutoSp

3. Mixed Air Damper with Minimum Damper Setpoint and Cold Deck Control:
   a. In the occupied mode, the mixed air dampers shall open to the minimum outside air (OSA) damper position of 15% (adjustable setpoint) when the unit is running and in occupied mode. The dampers shall open above the minimum position for cooling to maintain the cold deck setpoint, when the OSA is below the cold deck setpoint. When the OSA is above the cold deck setpoint or the mechanical cooling ready is on, the dampers shall go to the minimum position.
   b. To protect the heating coil, if the mixed air temperature falls below the mixed air low limit setpoint of 50 degrees F (adjustable setpoint) the mixed air low limit control would over ride the minimum outside air damper position setpoint. The dampers would then modulate or close in order to maintain the mixed air setpoint.
   c. The outside air and exhaust air dampers shall close when the AHU is off.
      1) ###Ah#MaDmprPos
      2) ###Ah#MaDmprMinPos
      3) ###Ah#MaTemp
      4) ###Ah#MaLowLimitSp
5) ###Ah#MaAutoSp

4. Mixed Air Damper with Carbon Dioxide (CO2) Sensor Control:
   a. The mixed air dampers shall modulate to maintain the CO2 setpoint of 750 PPM (adjustable setpoint) when the unit is running and in occupied mode. The damper position needed to maintain the CO2 setpoint shall be displayed as the minimum outside air (OSA) damper position. The dampers will open above the minimum position for cooling to maintain the mixed air setpoint when the OSA is below the economizer setpoint of 70 degrees F (adjustable setpoint). When the OSA is above the economizer setpoint or the mechanical cooling ready is on, the dampers shall go to the minimum position. The mixed air setpoint shall follow the discharge air setpoint. [If there is no discharge air setpoint, the mixed air setpoint would be created off of a mixed air versus outside air temperature reset schedule.]
   
   b. To protect the heating coil, if the mixed air temperature falls below the mixed air low limit setpoint of 50 degrees F (adjustable setpoint) the mixed air low limit control would over ride the minimum outside air damper position setpoint. The dampers would then modulate or close in order to maintain the mixed air setpoint.
   
   c. The outside air and exhaust air dampers shall close when the AHU is off.
      1) ###Ah#MaDmprPos
      2) ###Ah#MaDmprMinPos
      3) ###Ah#MaTemp
      4) ###Ah#MaLowLimitSp
      5) ###Ah#MaAutoSp
      6) ###Ah#MaCo2SP
      7) ###Ah#MaCo2

5. Mixed Air Damper with Carbon Dioxide (CO2) Sensor Control and Cold Deck Control:
   a. The mixed air dampers shall modulate to maintain the CO2 setpoint of 750 PPM (adjustable setpoint) when the unit is running and in occupied mode. The damper position needed to maintain the CO2 setpoint shall be displayed as the minimum outside air (OSA) damper position. The dampers will open above the minimum position for cooling to maintain the cold deck setpoint when the OSA is below the cold deck setpoint. When the OSA is above the cold deck setpoint or the mechanical cooling ready is on, the dampers shall go to the minimum position.
   
   b. To protect the heating coil, if the mixed air temperature falls below the mixed air low limit setpoint of 50 degrees F (adjustable setpoint) the mixed air low limit control would over ride the minimum outside air damper position setpoint. The dampers would then modulate or close in order to maintain the mixed air setpoint.
   
   c. The outside air and exhaust air dampers shall close when the AHU is off.
      1) ###Ah#MaDmprPos
      2) ###Ah#MaDmprMinPos
      3) ###Ah#MaTemp
      4) ###Ah#MaLowLimitSp
      5) ###Ah#MaAutoSp
      6) ###Ah#MaCo2SP
      7) ###Ah#MaCo2

O. The following sequence shall be used for all mixed air systems controlled by a discharge air setpoint or a mixed air setpoint:
   1. Unoccupied Mode Free Cooling (allows system to use outside air for cooling in the unoccupied mode): If the discharge air setpoint [or mixed air setpoint or cold deck setpoint] is calling for cooling in the unoccupied mode and the supply fan is on. Outside air free cooling shall be allowed. Otherwise, the outside air and exhaust air dampers shall close when the supply fan is off and in the in the unoccupied mode. Outside air free cooling shall allow the outside air dampers to open for cooling if the outside air temperature is below the discharge air setpoint [or mixed air setpoint or cold deck setpoint].
P. The following sequence shall be used for all mixed air systems controlled by a discharge air setpoint or a mixed air setpoint:

1. Mixed Air Damper with Enthalpy Control:
   a. In the occupied or unoccupied modes, when the AHU is running and the dampers are open for cooling, enthalpy shall be used. The outside air dampers shall modulate for cooling beyond the minimum outside air damper position to maintain the discharge air setpoint, unless the outside air relative humidity is greater than the enthalpy enable setpoint. The enthalpy enable setpoint shall be created from the following reset schedule.
   b. Enthalpy Enable Setpoint Reset Schedule (adjustable setpoints):

<table>
<thead>
<tr>
<th>Outside Air Temperature</th>
<th>30 Degrees F</th>
<th>80 Degrees F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enthalpy Relative Humidity</td>
<td>100%</td>
<td>40%</td>
</tr>
</tbody>
</table>

   a. ###Ah#EnEnableSp
   b. ###Ah#EnAutoSp
   c. ###Ah#EnHiSpReset
   d. ###Ah#EnLowSpReset
   e. ###Ah#EnOaHiReset
   f. ###Ah#EnOaLowReset

Q. Freeze Protection (on-site freeze status sensor without monitoring):

1. The low limit sensor (duct freeze stat) located in the discharge of the heating coil shall shut down the fan and close the outside air and exhaust air dampers if the discharge temperature from the heating coil drops below its local setpoint of 35-40 degrees F (setpoint adjustable onsite on the sensor itself). The low limit controller shall be resettable onsite.

2. Freeze status sensor shall be an averaging element installed without obstruction on the discharge of the heating coil. Air stratification shall be taken into account and the averaging element shall be placed accurately reflect the temperature to prevent mechanical damage.

R. Freeze Protection (On-site freeze status sensor with monitoring/alarm and remote reset. Use for rooftop AHUs, hard to access AHUs and others per request.):

1. The low limit sensor (duct freeze stat) located in the discharge of the heating coil shall shut down the fan and close the outside air damper if the discharge temperature from the heating coil drops below its setpoint of 35-40 degrees F (setpoint adjustable from the front-end). When the temperature drops below the setpoint and the system is shutdown, the controller shall send an alarm to the front-end automation system. The low limit controller shall be resettable from the front-end automation system.

2. Freeze status sensor shall be an averaging element installed without obstruction on the discharge of the heating coil. Air stratification shall be taken into account and the averaging element shall be placed accurately reflect the temperature to prevent mechanical damage.

   a. ###Ah#FreezeAlarm
   b. ###Ah#FreezeReset
   c. ###Ah#FreezeSp

S. Fire Protection: On-site fire protection shall be provided separate from the DDC HVAC controller. Fire protection shall be provided to shut down the supply fan(s) run the exhaust fan(s) and close the supply outside air dampers through the building fire alarm system.

T. Filter Alarm Monitoring: Monitoring shall be provided across each filter bank to provide a digital alarm of normal or alarm if airflow is not as specified across the filter when the associated fan is running.

1. ###Ah#FilterAlarm
U. Electrical Demand (Load-Shed) Control: [with load-shed] Electrical demand control applies to this AHU. The load shed classification for this AHU is...(add classification criteria here).

V. Electrical Demand (Load-Shed) Control: [without load-shed] No electrical demand control applied to this AHU.

W. Steam Demand (Load-Shed) Control: [with load-shed] Steam demand control applies to this AHU. The load shed classification for this AHU is...(add classification criteria here).
   1. ###Ah#StmLoadShed
   2. The dampers shall be closed when the steam loadshed is indexed to on. The steam load shed is a digital software point that must have the ability to be commanded from the front-end when steam load shed programs are initiated.

X. Steam Demand (Load-Shed) Control: [without load-shed] No steam demand control applied to this AHU.

Y. Note: All system setpoints and reset schedules listed within the sequence need to be accessible to command and view from the front-end system. All software limit stops and parameter setpoints must be accessible within the program that can later be accessed by the owner.

3.10 STEAM STATION

A. Steam Station Pressure Monitoring:
   1. The steam pressure for each building pressure reducing station shall be monitored after the steam station. (Please make sure the appropriate minimum pipe lengths are referenced in the technical spec.) An alarm shall be generated if the steam pressure sensor goes beyond its alarm limits. These sensors shall be programmed with alarm limits that are adjustable from UND Facilities Management’s existing front-end automation system. Alarm limits should be verified with the engineer and UND Plumbing Supervisor.
      a. ###SteamStation#

B. Steam Station Valve Control to Maintain a Pressure:
   1. The steam pressure for each low pressure reducing station shall be monitored after the steam station. An alarm shall be generated if the steam pressure sensor goes beyond its alarm limits. These sensors shall be programmed with alarm limits that are adjustable from UND Facilities Management’s existing front-end automation system. Alarm limits should be verified with the engineer and UND Plumbing Supervisor.
   2. The steam valve for each low pressure reducing station shall be modulated to maintain the steam pressure setpoint at ## psi *. Steam pressure setpoints are to be provided by the project’s mechanical engineer. For heating and cooling systems served by the low pressure steam, the steam pressure setpoint shall be maintained if the systems are in use.
      a. ###StmStation#
      b. ###StmStation##Sp*
      c. ###StmStation##Vlv

C. Valve Control for Steam Heating Systems:
   1. Valves for steam stations serving steam heating systems would open and close based on the steam station outside air enable setpoint*. The steam station valve would open when the outside air is 5 degrees F above the heat exchanger enable setpoint. To prevent cycling of the valve, a 30 minute delay would be incorporated to open or close the valve.
      a. ###StmStat##OaTemp
      b. ###StmStat##EnblSp *

D. Valve Control for Heat Exchanger Systems:
   1. Valves for steam stations serving heat exchanger systems would open and close based on the heat exchanger outside air enable setpoint. The steam station valve would open when the outside air is 5 degrees F above the heat exchanger enable setpoint. To prevent cycling of the valve, a 30 minute delay would be incorporated to open or close the valve.
      a. ###Hx#OaTempSig
b. ###Hx#PumpEnableSp

E. Valve Control for Absorption Chiller Systems:
1. Steam stations serving cooling systems would open and close based on the chiller outside air enable setpoint. The steam station valve would open when the outside air is 5 degrees F below the chiller enable setpoint. To prevent cycling of the valve, a 30 minute delay would be incorporated to open or close the valve.
   a. ###ChEnableSp
   b. ###ChOaTempSig

3.11 VARIABLE AIR VOLUME (VAV) BOX WITH REHEAT AND RADIATION

A. Time Schedule:
1. The time schedule will be dependent on the controller for the AHU serving the area. A time schedule signal must be sent from the AHU system to the VAV controllers to switch its occupied/unoccupied status. By switching between occupied and unoccupied mode, the VAV controllers will follow the appropriate occupied/unoccupied setpoints.
   a. ###V##OccMode

B. Occupied Mode:
1. During the occupied mode, the space temperature shall be controlled at its dial setpoint. The occupied heating setpoint shall be 71 degrees F and the occupied cooling setpoint shall be 73 degrees F with a 1 degree F deadband. Dial setpoints shall be used in all office areas and non-public areas. The high and low setpoint knob limits shall be 60 degrees F and 80 degrees F (adjustable). The high and low limits do not need to be displayed at the front-end, but do need to be accessible parameters in the program.
   a. ###V##RmTemp
   b. ###V##RmTempSpOvrd
   c. ###V##RmTempActSp
   d. ###V##ClgOccSp
   e. ###V##HtgOccSp
   f. ###V##OccSpSelect (States to select between are dial and software)

C. Unoccupied:
1. During the unoccupied mode the space temperature shall be controlled at its unoccupied setpoints. The unoccupied heating setpoint shall be 60 degrees F (adjustable setpoint) and the unoccupied cooling setpoint shall be 80 degrees F (adjustable setpoint).
   a. ###V##ClgUnoccSp
   b. ###V##HtgUnoccSp

D. Pressure Independent Air Flow Control:
1. Air flow measuring sensors at the air terminal inlet will provide a signal to control the VAV box airflow between the maximum & minimum CFM setpoints regardless of upstream duct pressure.
2. On a call for cooling, the VAV damper shall modulate to satisfy the space temperature setpoint with the required airflow for cooling up to the maximum airflow setpoint.
3. On a call for heating, the VAV damper shall modulate to maintain its minimum airflow setpoint.
   a. ###V##DmprPos
   b. ###V##AirFlow
   c. ###V##AirFlowSp

E. Heating Control (reheat only):
1. The reheat valve shall modulate to maintain the space temperature setpoint. Reheat coils and valves shall be installed for all VAV boxes. [The only exception to this is if there is a hot deck or other heat source in the air stream to the area served. Radiation shall not be used instead of reheats. Radiation shall be installed for all rooms with outside walls.]
   a. ###V##ReheatVlv (what about terminal heating or cooling
F. Heating Control (reheat and radiation):
Put the project note at the end of the reheat section. Also,

~~~ PROJECT NOTE ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
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Sequence Information for UND Internal Reference Only –
The hot deck is used in lieu of reheat control for some multi-zone to VAV retrofit systems on campus, but should not be used for new installations.

Heating Control (hot deck instead of a reheat):
The zone damper actuator shall modulate the dampers open to the hot deck to maintain the space temperature setpoint. [There must be a reheat, hot deck or other heat source in the air stream to the area served. Radiation shall not be used instead of reheats. Radiation shall be installed for all rooms with outside walls.]

Heating Control (hot deck instead of a reheat and radiation):
The zone damper actuator shall modulate the dampers open to the hot deck to maintain the space temperature setpoint, the radiation valve will modulate to maintain the space temperature setpoint if the space temp falls 2 degrees F (adjustable) below the space temperature setpoint. Reheat coils and valves shall be installed for all VAV boxes. [There must be a reheat, hot deck or other heat source in the air stream to the area served. Radiation shall not be used instead of reheats. Radiation shall be installed for all rooms with outside walls.]

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~~~ END OF PROJECT NOTE ~~~~~~~~~~~~~~~~~~~~~~~~~

1. The reheat valve shall modulate to maintain the space temperature setpoint. If the space temperature cannot maintain the space temperature setpoint using the reheat valve, the radiation valve will modulate to maintain the space temperature setpoint if the space temp falls 2 degrees F (adjustable) below the space temperature setpoint. Reheat coils and valves shall be installed for all VAV boxes. [The only exception to this is if there is a hot deck or other heat source in the air stream to the area served. Radiation shall not be used instead of reheats. Radiation shall be installed for all rooms with outside walls.]

G. Discharge Air Monitoring:
1. A discharge air temperature sensor shall be installed after the VAV box for monitoring of the temperature of the air leaving the VAV box. This value shall be displayed on the front-end system in degrees F.
   a. ###V##DaTemp

3.12 VAV WITH SECOND STAGE COOLING (LIEBERT UNIT)

A. Variable Air Volume Box:
1. The space wall module in the room senses the space temperature for the VAV application specific controller. The space sensor includes a pushbutton override, override indication and dial setpoint, but the dial setpoint has been overridden by setpoints in the controller. The room also has a Liebert cooling unit with a thermostat. In order to maintain consistent setpoints on one unit, the VAV application specific controller setpoints were entered into the controller as software setpoints rather than the using the dial. Setpoints for the AC unit can be adjusted onsite (password access to change). The setpoints the VAV controls are (adjustable):
   a. Occupied Heating Setpoint: 72 F
   b. Occupied Cooling Setpoint: 74F
   c. Unoccupied Heating Setpoint: 60 F
   d. Unoccupied Cooling Setpoint: 80 F
2. The VAV uses pressure independent control. On a call for cooling the reheat valve shall close and the damper shall modulate to maintain the maximum air setpoint. On a call for
heating the damper shall modulate and maintain the minimum air setpoint and modulate the reheat valve to maintain space temperature setpoint.

3. The VAV controller shall maintain the space temperature setpoint and airflow setpoint based on heating/cooling mode of operation.

B. A/C Unit Sequence of Operation:

1. The A/C unit serving the room shall be used as a second stage of cooling. An additional application specific controller shall be installed to enable/disable the A/C unit. The existing VAV space temperature and space temperature setpoint shall be globalized to the A/C controller for enabling/disabling the A/C unit. In the event the VAV space thermostat exceeds the cooling space temperature setpoint by more than one (1) degree, the A/C unit cooling shall be enabled. The A/C unit cooling shall be disabled once the cooling setpoint has been satisfied. (The controller for the A/C unit enables/disables the A/C cooling unit through the remote shutdown contacts if provided.

2. The A/C cooling unit will have its own thermostat installed next to the VAV thermostat. The A/C unit thermostat has its own control package to sequence and control the A/C unit.

3.13 CABINET HEATERS

A. Single temperature room thermostat set at 68 degrees F maintains constant space temperature by cycling unit fan motor and electric heating elements.

END OF SECTION