

SECTION 15975 - SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. Sequence of operation is hereby defined as the manner and method by which controls function. Requirements for each type of control system operation are specified in this section.
- B. Operating equipment, devices, and system components required for control systems are specified in other Division 15 Controls' sections of these specifications.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS:

- A. Provide control systems consisting of thermostats, control valves, dampers, operators, indicating devices, interface equipment, and other apparatus required to operate mechanical system and to perform functions specified.
- B. Provide necessary materials and field work necessary to connect control components factory supplied as part of equipment controlled, unless specified otherwise. Generally, self-contained valves, filter gauges, liquid level controllers and similar instruments, are not to be installed under this section.
- C. Unless specified otherwise, provide fully proportional components.
- D. Provide all necessary relays and signal boosters to make the system a full and operable system as required by the sequence of operation.

PART 3 - EXECUTIONS

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| Edit each item for job needs. |
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| NOTE: Provide normally open control valves for heating system with the exception of animal facilities or special areas, which require a normally closed valve. |
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3.1 TERMINAL UNITS' CONTROL SEQUENCES:

- A. Hot Water/Steam Heating Finned Tube/Baseboard/Radiation Convector: Provide wall mounted thermostat to automatically modulate a normally open/closed two-way control valve to maintain the thermostat setting. In rooms, which also have a terminal-heating coil, thermostat shall sequence the FTR valve with the heating coil valve to maintain stat set temperature.
- B. Hot water/Steam Unit Heater: Provide wall/unit-mounted thermostat to automatically modulate a normally/open/closed/two way control valve/cycle the fan motor to maintain the thermostat setting.

- C. Hot Water/Steam Cabinet Unit Heaters: Provide wall/unit-mounted thermostat to automatically modulate a normally/open/closed/two way control valve/cycle the fan motor to maintain the thermostat setting.
- D. Hot Water/Steam/Chilled Water Fan Coil Units: Provide wall/unit mounted thermostat to automatically modulate the normally open two-way heating and normally closed cooling coils control valves and cycle the fan motor/and the fan shall run continuously to maintain the space thermostat heating and cooling settings.
- E. Hot Water/Steam Unit Ventilators: Provide ASHRAE [Cycle I, 100% outside air at all times except during warm up state.] [Cycle II, a minimum amount of outdoor air (25%) (50%) is admitted during the heating and ventilating state and is increased to 100% as needed during the ventilation cooling stage.] [Cycle III, a variable amount of outdoor air is admitted, except during the warm-up state, as required to maintain a fixed temperature of air entering the heating coil. Air admission is controlled by an airstream thermostat set at 55°F (13°C) to provide cooling as needed.]
1. Cooling and Ventilating Stage: As space temperature rises above the thermostat setting, the normally open heating valve closes, the outdoor air damper modulates open from the air stream thermostat to maintain thermostat setting.
 2. Warm-up Stage: The normally open heating control valve opens to 100% and the outdoor air damper is 100% closed until the space temperature setting is reached.
 3. Heating and Ventilating Stage: As space temperature rises above the thermostat setting, the outdoor air is closed. On drop in temperature the reverse occurs.
- F. Hot Water Heating Duct Coil: Provide wall-mounted thermostat to automatically modulate a normally open two-way valve to maintain the thermostat setting.
- G. Gas Fired Propeller Unit Heater: Provide a line voltage unit/wall mounted thermostat to cycle the burner and fan motor on and off to maintain the thermostat setting.
- H. Gas Fired Makeup Air Units: Provide a discharge air duct temperature sensor to cycle the burner on and off to maintain 55°F [] discharge air temperature.
- I. Gas Fired Infrared Heaters: Provide a wall-mounted thermostat to cycle the infrared heater[s] burner on and off to maintain thermostat setting.
- J. Electric Baseboard Radiation/Convectors: Provide a concealed/unit mounted/wall mounted thermostat to cycle the electric heating element on and off to maintain the thermostat setting.
- K. Electric Cabinet/Unit Heaters: Provide a concealed/unit/wall-mounted thermostat to cycle the electric heating element and fan motor on and off to maintain thermostat setting.
- L. Electric Wall Mounted/Toe Space Heaters: Provide concealed unit mounted thermostat to cycle the electric heating element and fan motor on and off to maintain thermostat setting.
- M. Electric Radiant Ceiling Panel Heater: Provide a wall-mounted thermostat to cycle the electric radiant ceiling panel[s] on and off to maintain thermostat setting.
- N. Electric Ceiling Heater/Exhaust Fan/Light: Provide all mounted separate on-off controllers for all functions and programmable timer switch/in line thermostat to control the heating cycle only.

3.2 TERMINAL BOX CONTROL SEQUENCES:

- A. Constant Air Volume Without Reheat: The constant volume, pressure independent terminal box shall supply the scheduled air quantity independent of supply duct static pressure and temperature.
- B. Constant Air Volume With Reheat: The constant volume, pressure independent terminal box shall supply the scheduled air quantity independent of supply duct static pressure. On a drop in temperature below set point, the thermostat shall modulate the reheat coil normally open/closed two-way control valve to meet set point.
- C. Variable Air Volume Without Reheat: The thermostat shall control the damper operator on the variable volume, pressure independent terminal box. On a drop or rise in temperature below or above set point, the thermostat shall modulate the airflow between minimum and maximum scheduled air quantities to satisfy the thermostat set point.
- D. Variable Air Volume with Reheat: The thermostat shall control the damper operator on the variable volume, pressure independent terminal box. On a drop in room temperature below thermostat set point, the thermostat shall modulate the airflow minimum scheduled air quantity to satisfy thermostat cooling set point. On further drop in room temperature below thermostat heating set point, the thermostat shall modulate the reheat coil normally open/closed two-way control valve and increase the air flow to satisfy thermostat set point. On rise in temperature above the thermostat set point, the thermostat shall close the normally open/closed two-way control valve and modulate the airflow to maximum scheduled air quantity.
- E. Variable Air Volume With Reheat Interlocked With Finned Tube Radiation: The thermostat shall control the damper operator on the variable volume, pressure independent terminal box. On a drop in temperature below cooling set point, the thermostat shall modulate the airflow to minimum scheduled air quantity to satisfy cooling set point. On further drop in temperature below heating set point, the thermostat shall modulate the VAV box reheat normally open/closed two-way heating control valve and the finned tube radiation normally open/closed control valve to satisfy heating set point.

3.3 AIR CURTAIN CONTROL SEQUENCES:

- A. Air Curtain: The air curtain fan shall run continuously and the two-way normally open/closed control valve shall be controlled by a thermostat. On demand for heat, the normally open/closed two-way control valve shall modulate open to satisfy set point. Above set point, the normally open/closed two-way heating control valve shall be closed.

3.4 HEAT TRANSFER CONTROL SEQUENCES:

A. Preheat Glycol:

1. The heat exchanger/pump assembly shall be controlled by a local DDC control panel interfaced with the Building Automation System/panel controller to start, stop and reset supply water temperature. The system shall be complete with H-O-A switch and lead-lag capability accessible from local and remote terminals.
2. Whenever the H-O-A is in the "A" mode, the system shall function as follows:
 - a. When the outside air temperature is below 55°F (adjustable) the lead pump shall cycle on. When the outside air temperature rises to above 57°F (adjustable), the lead pump shall cycle off.
 - b. On proof of water flow through a differential pressure switch, the 1/3 two-way normally open/closed steam control valve shall open to maintain supply water

temperature setting. If the temperature cannot be maintained, the 2/3 two-way normally open/closed steam control valve shall modulate open to maintain the supply water set point according to reset schedule of 200°F LWT at 0°F OAT and 120°F [°F] LWT at 50°F OAT.

- c. On variation of supply water temperature plus or minus 5°F (adjustable) from the reset schedule set point, software in the BAS shall indicate, an alarm condition shall be indicated in the engineer's office/_____.
 - d. If anytime after start-up the lead pump fails to prove flow, the lag pump shall be cycled on and on alarm shall be sent to the Engineer's office. If anytime after start-up the lead and lag pumps fail to prove flow, all of the two-way normally open/closed modulating steam valves shall close and an alarm shall be sent to the Engineer's office/_____.
 - e. Manual lead-lag control of the pumps shall be provided.
3. Whenever the H-O-A is in the "H" mode, the lead pump shall run continuously, the 1/3 two-way normally closed/open modulating steam control valve shall modulate open and the 2/3 two-way modulating steam control valve shall modulate open if the supply water temperature setting can not be maintained.
 4. Whenever the H-O-A is in the "O" mode, both pumps shall be off and all of the two-way normally open/closed modulating steam control valve shall be closed.

B. Reheat

1. The heat exchanger/pump assembly shall be controlled by a local DDC control panel interfaced with the Building Automation System/panel controller. The system shall be complete with H-O-A switch and lead-lag capability accessible from local/and/remote terminals.
2. Whenever the H-O-A is in the "A" mode, the system shall function as follows:
 - a. The lead pump shall run continuously.
 - b. On proof of water flow through a differential pressure switch, the 1/3 two-way normally closed/open modulating steam control valve shall open to maintain supply water temperature setting. If the temperature can not be maintained, the 2/3 two-way normally closed/open modulating steam control valve shall modulate open to maintain supply water set point.
 - c. On variation of supply water temperature plus or minus 5F° (adjustable) from set point software in the BAS shall indicate an alarm condition shall be indicated in the Engineer's office/_____.
 - d. If anytime after start-up the lead pump fails to prove flow, the lag pump shall be cycled on and an alarm shall be sent to the Engineer's office. If anytime after start-up the lead and lag pumps fail to prove flow, all of the two-way normally open/closed modulating steam valves shall close and an alarm shall be sent to the Engineer's office/_____.
 - e. Manual lead-lag control of the pumps shall be provided.
3. Whenever the H-O-A's in the "H" mode, the lead pump shall run continuously, the 1/3 two-way normally open/closed modulating steam control valves shall modulate to meet

set point and the 2/3 two-way normally closed/open modulating steam control valve shall modulate open if the supply water temperature setting cannot be maintained.

4. Whenever the H-O-A is in the "O" mode, both pumps shall be off, and all of the two way normally open/closed modulating steam control valve shall be closed.

3.5 LAB BENCH EXHAUST CONTROL SEQUENCE:

- A. The ceiling exhaust control damper and the bench exhaust control damper shall be pneumatically interlocked and controlled by a pneumatic variable volume control switch, equal in function to a Johnson Control S-224-G4. At zero line pressure, the ceiling damper shall be open and the bench exhaust damper shall be closed with revised conditions at 100% line pressure.

3.6 AIR HANDLER CONTROL SEQUENCES:

A. Air Handling Unit [_____]

1. The air-handling unit shall be controlled by a local DDC control panel interfaced with the Building Automation System. The system shall be complete with access through local or remote terminals.
2. Whenever air handling unit air fan is started, the outside and exhaust air dampers shall open to their minimum positions and the supply and return/exhaust shall cycle on through an interlock.
3. The supply fan speed shall be modulated by the duct static pressure controller through the local control panel and the variable frequency drive.
4. The return fan speed shall be modulated through the local control panel and variable frequency drive to maintain a fixed (adjustable) air flow differential between supply and return air quantities as sensed by the supply and return air flow measuring stations.
5. Below an outside air temperature of 55°F (adjustable), the outside air, return air and exhaust air dampers shall modulate to maintain a 55°F (adjustable) mixed air set point.
6. Above an outside air temperature greater than the temperature of the return air, the dampers shall set minimum outside air conditions.
7. Under minimum outside air conditions, the damper shall modulate to maintain the constant outside air quantity as scheduled and as sensed by the outside airflow measuring station.
8. When the supply air temperature falls to below 55°F, the preheat glycol coil pump shall cycle on and the preheating glycol normally open/closed control valve shall modulate to maintain set point.
9. When the supply air temperature rises to above 55°F, the chilled water control valve shall modulate to meet set point.
10. When the air temperature downstream of the preheat coil is 40°F or less, the supply and return air fans shall continue to run/cycle off, the outside air and exhaust air dampers shall close 100% and the return air damper shall open 100% coil circulating pump shall continue to run, the normally open/closed control valves shall open 100% to primary water flow and an alarm shall be sent to the Engineer's office/_____.

11. On detection of smoke from the unit mounted smoke detectors or on signal from the fire alarm system, the supply and return fans shall cycle off and the outside air, return air and exhaust air dampers shall close, and an alarm shall be sent to the Engineer's office/_____.
12. On detection of high static pressure in the supply air or return air ductwork, the supply and return fans shall cycle off, the outside air and exhaust air dampers shall close 100% the return air damper shall open 100% and an alarm shall be sent to Engineer's Office/_____.

B. Air Handling Unit [____]:

1. The air handler shall be controlled by a DDC/local panel with a Building Management System interface.
2. Whenever the air handler is started the outside and exhaust air dampers shall open to their minimum position and the return/exhaust fan shall cycle on through an interlock.
3. The supply and return/exhaust fan speeds shall be modulated independently by respective duct static pressure controllers through the local control panel and the variable frequency drives to maintain constant scheduled supply and exhaust air quantities independent of differential pressure changes.
4. The pitch of the heat pipe heat recovery assembly shall be varied by the tilt control motor to maintain a minimum exhaust air temperature of 33 F (adjustable), and to maintain a supply air temperature of 55°F (adjustable).
5. When the supply air temperature falls to below 55°F, the preheat glycol coil pump shall cycle on and the preheat glycol three-way control valve shall modulate to satisfy set point.
6. When the supply air temperature rises to above 55°F, the chilled water coil pump shall cycle on and the chilled water three-way control valve shall modulate to satisfy set point.
7. When the air temperature downstream of the preheat coil is 40°F or less, the supply and return fans shall cycle off/continue to run and the outside and exhaust air dampers shall close 100%. The return air dampers shall open 100% and an alarm shall be sent to the Engineer's office/_____.
8. Through a dry contact on the emergency power transfer switch, the power transfer switch, the BMS shall detect an emergency power condition and shall reset the supply and exhaust fan speeds through the preset speed circuit in the variable frequency drives. The speeds shall be set to maintain the scheduled minimum air quantities.
9. On detection of smoke from the unit-mounted smoke detectors or on signal from the fire alarm system, the supply and return/exhaust fans shall cycle off and the outside and exhaust air dampers shall close 100%.
10. On detection of high static pressure in the supply air return/exhaust air ductwork, the supply and return/exhaust fans shall cycle off, the outside air and exhaust air dampers shall close 100%, the return air damper open 100%, the return air damper open 100% and an alarm sent to the Engineer's Office/_____.

C. Air Handling Unit(s) [____]:

1. The supply fan shall run continuously with automatic start/stop capability from the DDC controlling system, and local hand-off-auto override switches at the DDC/local panel for manual operation. Red indicating pilot lights at the DDC/local panel will indicate the run status of the fan. Fan differential pressure switches will be used for proof of status.
2. The system preheat and reheat coils will be controlled by discharge air controllers/the DDC panel to maintain a coil discharge temperatures as scheduled on the drawings. The preheat and reheat coils recirculating pumps will run when outside air temperature is below 55°F. Hand-off-auto switches at the DDC/local panel will provide manual override of the pumps if needed. Red indicating pilot lights at the DDC/local panel will indicate the run status of the pumps.
3. The evaporative cooling section shall be cycled in sequence with the outside air dampers, the chilled water cooling coil and recirculating pump as needed to maintain a system return air relative humidity set point as reset by outside air temperature conditions. On a call for humidity, the outside air dampers shall be at a minimum position, and the evaporative cooler will be cycled to maintain humidity conditions. On a call for dehumidification, the evaporative cooler will be off. The outside air dampers will be modulated open providing the outside air enthalpy conditions are less than the return air conditions. If not, the chilled water coil valve will be modulated open to provide dehumidification. A discharge air humidity high limit will override all controls if the discharge humidity exceeds 60%RH (adjustable).
4. The system chilled water coil will be controlled by the DDC/local panel to modulate the three-way valve to maintain a coil discharge temperature as scheduled on the drawing. The chilled water coil recirculation pump will run whenever outside air temperature is above 55°F. (Adjustable) or if low limit sensor senses a temperature of below 40°F. (Adjustable). Hand-off-auto switches at DDC/local panel will provide manual override of pump if needed. Red indicating pilot light at DDC/local panel will indicate the run status of the pump.
5. The space relative humidity set point shall be reset from outside air temperature. Below 10°F. (Adjustable) outside air temperature, the return air humidity shall be reset from [50%RH] to [45%RH] (adjustable).
6. The preheat and reheat coil valves, the evaporative cooling section, and the chilled water coil valve shall all be controlled by the DDC/local panel controller to maintain a supply air temperature as determined by the outdoor and return air reset schedule.
7. On a call for cooling, the preheat and reheat coil valves shall be closed, then the evaporative cooler shall be cycled on providing the relative humidity is not holding it off. If that condition exists, the chilled water coil valve shall be opened to provide cooling. On a call for heat, the chilled water valve is closed, the evaporative cooler is off, and the preheat and reheat coil valves will be open to maintain the desired supply air temperature.
8. In the event that humidity and temperature are below set point, the humidity control loop can have the evaporative cooler on, and the temperature control loop will have the preheat and reheat valves open.
9. In the event that humidity is above set point, and temperature is below set point, the humidity control loop can either bring in outside air, or open the chilled water valve while at the same time, the temperature control loop will have the preheat and reheat valves open.

10. In the event that humidity is below set point and temperature is above set point, the evaporative cooler will be used to try to satisfy both conditions. However, if the temperature cannot be satisfied, then the chilled water coil valve shall be controlled to help maintain temperature.
11. Outside air temperature and humidity must both be monitored with readout at the DDC/local panel. The DDC/local panel must be able to calculate the outside air wet bulb temperature with readout at the DDC panel.
12. Upon the DDC system/local panel sensing the unit fan is off, the outside air dampers shall close full, the evaporative cooler shall be disabled, the chilled water valve shall close and the reheat valves shall open.

D. Air Handling Unit(s) []:

1. The return/exhaust air fans shall be interlocked to run with the respective supply air fan. The supply and return/exhaust air fans shall run continuously with automatic start/stop capability from the DDC controlling system, and have local hand-off-auto/override switches at the DDC/local panel for manual operation. Red indicating pilot lights at the DDC/local panel will indicate the run status of the fans. Fan differential pressure switches will be used for proof of status of fans.
2. The system preheat and reheat coils will be controlled by the DDC/local panel to maintain coil discharge temperatures as scheduled on the drawings. The preheat and reheat coil recirculating pumps will run when outside air temperature is below 55°F. (Adjustable). Hand-off-auto switches at the DDC/local panel will provide manual override of the pumps if needed. Red indicating pilot lights at the DDC/local panel will indicate the run status of the pumps.
3. The evaporative cooling section shall be cycled in sequence with the outside air dampers, the chilled water cooling coil and recirculating pump, as needed to maintain a system return air relative humidity set point as reset by outside air temperature conditions. On a call for humidity, the outside air dampers shall be at a minimum position, and the evaporative cooler will be cycled to maintain humidity conditions. On a call for dehumidification, the evaporative cooler will be off. The outside air dampers will be modulated open providing the outside air enthalpy conditions are less than the return air conditions. If not, the chilled water coil valve will be modulated open to provide dehumidification. A discharge air humidity high limit can override all controls if the discharge humidity exceeds [60%RH] [] (adjustable).
4. The system chilled water coil will be controlled by/from the DDC/local panel to modulate the three-way valve to maintain a coil discharge temperature as scheduled on the drawing. The chilled water coil recirculating pump will only run when outside air temperature is above 55°F. (Adjustable) or if low limit sensor senses a temperature of below 40°F. (Adjustable). Hand-off-auto switches at DDC/local panel will provide manual override of pump if needed. Red indicating pilot light at DDC/local panel will indicate the run status of the pumps.
5. The return air relative humidity set point shall be reset from outside air temperature. Below 10°F. (Adjustable) outside air temperature, the return air humidity shall be reset from [50%RH] to [45%RH] (adjustable).
6. The preheat and reheat coil valves, the evaporative cooling section, and the chilled water coil valve shall all be controlled by the DDC/local panel controller to maintain a supply air temperature as determined by the outdoor and return air reset schedule.

7. On a call for cooling, the preheat and reheat valves shall be closed, then the evaporative cooler shall be cycled on providing that the relative humidity is not holding it off. If that condition exists, the chilled water coil valve shall be opened to provide cooling. On a call for heat, the chilled water valve is closed, the evaporative cooler is off, and the preheat and reheat coil valves will be open to maintain the desired supply air temperature.
8. In the event that humidity and temperature are below set point, the humidity control loop can have the evaporative cooler on, and the temperature control loop will have the reheat valve open.
9. In the event that humidity is above set point, and temperature is below set point, the humidity control loop can either bring in outside air, or open the chilled water valve while at the same time, the temperature control loop will have the reheat valve open.
10. In the event that humidity is below set point and temperature is above set point, the evaporative cooler will be used to try to satisfy both conditions. However, if the temperature cannot be satisfied, then the chilled water coil valve shall be controlled to help maintain temperature.
11. Outside air temperature and humidity must both be monitored with readout at the DDC/local panel. The DDC/local panel must be able to calculate the outside air wet bulb temperature with readout at the DDC panel.
12. Upon the DDC system/local panel for each individual unit sensing that the unit fan is off, the outside air dampers shall close full, the evaporative cooler shall be disabled, the chilled water valve shall close and the reheat coil valves shall open.

E. Air Handling Unit(s) [_____]:

1. The exhaust fans shall be interlocked to run with the supply fan. The supply fan shall run continuously with automatic start/stop capability from the DDC controlling system, and have local hand-off-auto override switches at the DDC/panel for manual operation. Red indicating pilot lights at the DDC will indicate the run status of the fans. Fan differential pressure switches will be used for proof of status of the fans.
2. The exhaust air fans will each have automatic start/stop capability from the DDC/local controller with local hand-off-auto override switches at the DDC/local panel for manual operation. In the auto position, the three exhaust fans will be staged in sequence from the position of the outside air dampers. At 60% open, the first exhaust fan will start. At 75% open the second exhaust fan will start. At 90% open the third fan will start. The set points for the three exhaust fans shall be adjustable at the DDC/local panel controller. The differential at which the fans turn off shall be adjustable at the DDC/local panel controller. Auxiliary contacts at the fan magnetic starters will be used for fan status. All fans will have on/off status at the DDC/local panel controller.
3. The system preheat and reheat coils will be controlled by the DDC/local panel to maintain a coil discharge temperatures as scheduled on the drawings. The preheat and reheat coils recirculating pumps will run when outside air temperature is below 40°F. (Adjustable). Hand-off-auto switches at the DDC/local panel will provide manual override of the pump if needed. Red indicating pilot light at the DDC/local panel will indicate the run status of the pumps.
4. The evaporative cooling section shall be cycled in sequence with the outside air dampers and the chilled water cooling coil and recirculating pump, as needed to maintain a system return air relative humidity set point as reset by outside air

temperature conditions. On a call for humidity, the outside air dampers shall be at a minimum position, and the evaporative cooler will be cycled to maintain humidity conditions. On a call for dehumidification, the evaporative cooler will be off. The outside air dampers will be modulated open providing the outside air enthalpy conditions are less than the return air conditions. If not, the chilled water coil valve will be modulated open to provide dehumidification. A discharge air humidity high limit can override all controls if the discharge humidity exceeds [60%RH] [] (adjustable).

5. The system chilled water coil will be controlled by/from the DDC/local panel to modulate the three-way valve to maintain a coil discharge temperature as scheduled on the drawing. The chilled water coil recirculating pump will only run when outside air temperature is above 55°F. (Adjustable) or if low limit sensor senses a temperature of below 40°F. (Adjustable). Hand-off-auto switches at DDC/local panel will provide manual override of pump if needed. Red indicating pilot light at DDC/local panel will indicate the run status of the pump.
6. The return air relative humidity set point shall be reset from outside air temperature. Below 10°F. (Adjustable) outside air temperature, the return air humidity should be reset from [50%RH] to [45%RH] (adjustable).
7. The preheat and reheat coil valves, the evaporative cooling section, and the chilled water coil valve shall all be controlled by the DDC/local panel controller to maintain a supply air temperature as determined by the outdoor and return air reset schedule.
8. On a call for cooling, the preheat and reheat valves shall be closed, then the evaporative cooler shall be cycled on providing that the relative humidity is not holding it off. If that condition exists, then the chilled water coil valve shall be opened to provide cooling. On a call for heat, the chilled water valve is closed, the evaporative cooler is off, and the preheat and reheat coil valves will be open to maintain the desired supply air temperature.
9. In the event that humidity and temperature are below set point, the humidity control loop can have the evaporative cooler on, and the temperature control loop will have the preheat and reheat valves open.
10. In the event that humidity is above set point, and temperature is below set point, the humidity control loop can either bring in outside air, or open the chilled water valve while at the same time, the temperature control loop will have the preheat and reheat valves open.
11. In the event that humidity is below set point and temperature is above set point, the evaporative cooler will be used to try to satisfy both conditions. However, if the temperature cannot be satisfied, then the chilled water coil valve shall be controlled to help maintain temperature.
12. Outside air temperature and humidity must both be monitored with readout at the DDC/local panel. The DDC/local panel must be able to calculate the outside air wet bulb temperature with readout at the DDC panel.
13. Upon the DDC system/local panels for each individual unit sensing that the unit fan is off, the outside air dampers shall close full, the evaporative cooler shall be disabled, the chilled water valve shall close and the reheat coil valves shall open.

F. Air Handling Unit(s) []:

1. The supply fan(s) shall run continuously with automatic start/stop capability from the DDC/local panel controlling system, and have local hand-off-auto override switches at the DDC/local panel for manual operation. Red indicating pilot light at the DDC/local panel will indicate the run status of the fan. Fan differential pressure switch will be used for proof of status of the fan.
2. The system preheat coil shall be controlled by the DDC/local panel to maintain a coil discharge temperature as scheduled on the drawings. The preheat coil recirculating pump will only run when outside air temperature is below 55°F (adjustable). Hand-off-auto switches at the DDC/local panel will provide manual override of the pump if needed. Red indicating pilot light at the DDC/local panel will indicate the run status of the pump.
3. The chilled water coil valve shall be controlled by the DDC/local panel controller to maintain a supply air temperature as determined to maintain a 65°F (adjustable) room temperature. The chilled water coil recirculating pump will only run when outside air temperature is above 55°F (adjustable) or if low limit sensor senses a temperature of below 40°F (adjustable).
4. On a call for cooling, the preheat valve shall be closed, and on call for heating, the chilled water valve shall be closed.
5. Upon the DDC system sensing that the unit fan is off, the outside air damper shall close fully, the preheat coil valve shall open and the chilled water valve shall close.

3.7 EXHAUST FANS:

- A. EF-[____]: Exhaust air fan(s) shall run continuously with manual ON/OFF control through the Building Management System [_____].
- B. EF-[____]: On rise in space temperature to above the temperature set point, the intake damper shall open and the exhaust fan shall cycle on. On drop in space temperature, the reverse will occur.
- C. EF-[____]: Exhaust air fan(s) shall be interlocked with the space light switch and shall run only when light switch is into ON position.

3.8 HOISTWAY VENTS:

- A. RA-1: The normally open roof hood damper shall be closed under normal conditions. Upon smoke detection by an elevator lobby detector or power failure, the damper shall open.

3.9 HUMIDIFIERS:

- A. AIR HANDLING UNIT [____]:
 1. On call for humidity from a system humidistat, the two-way, modulating, normally closed steam control valve shall modulate open to satisfy set point.
 2. On high humidity, as sensed by a duct humidistat, the two-way modulating control valve shall close and an alarm sent to the Engineer's Office [_____].

3.10 PACKAGE TERMINAL UNITS CONTROL SEQUENCE:

- A. Provide unit/wall mounted thermostat to provide automatically change over continuous fan operation during the occupied setting/cycling of the fan motor, cycling of the refrigeration

system for cooling, cycling of the electric heating element for heating and night setback controls.

3.11 CABINET UNIT HEATERS:

- A. A wall mounted pneumatic type room thermostat will modulate the cabinet unit heater control valve and cycle the fan motor to maintain room thermostat temperature setting.

3.12 BUILDING HOT WATER BOILERS B-1, B-2 AND B-3:

- A. The hot water boilers and its respective two-position control valve will be enabled from the DDC system. Each of the boilers will be sequenced on and off or opened and closed from supply water temperature as required to maintain 180°F. (Adjustable) supply water temperature. Each of the boilers internal factory mounted controls will control the firing of its own boiler. Whenever each boiler is shut off, its respective two-position control valve shall close and whenever each boiler is activated, its respective two-position control valve shall open.
- B. The hot water pumps will be controlled by the DDC panel. If either of the two operating pumps stop, the third pump will be started from differential pressure switch located between the discharge and suction of each pump. Two pumps will run continuously. The DDC panel will generate an alarm if any of the two running pumps stop.
- C. Two pumps will be started anytime any of the boilers are activated. The pumps shall have hand-off-auto switches and pilot light on indication at the DDC panel for easy manual override operation.
- D. Building hot water supply and return temperatures will be indicated at the DDC panel.

3.13 BUILDING CHILLED WATER CHILLERS RWC-1 AND RWC-2 AND COOLING TOWERS CT-1 AND CT-2:

- A. The two chillers will be enabled from the DDC system. The two chillers will be enabled above 55°F. (Adjustable) outside air temperature, or from any one of the air handling units if any one of the air handling unit sequences requires cooling or dehumidification and neither outside air intake nor the evaporative coolers can handle the requirement. Hand-off-auto switches and pilot light on indication will be provided at the DDC panel. Differential pressure switches in the chilled water and condenser water loops will not allow the chillers to start until flow has been proven.
- B. The two chilled water pumps and two condenser water pumps will operate anytime there is a call for mechanical cooling.
- C. Once the chillers have been enabled from the DDC system, each of the chillers will be controlled from their own internal factory mounted controls.
- D. Chilled water supply, chilled water return, condenser water supply, condenser water return temperatures will all be indicated at the DDC panel.
- E. The condenser water temperature will be controlled by the DDC system to maintain the proper condenser water temperature by cycling the cooling tower fans and modulating the two-way condenser water bypass valves.
- F. Whenever the chillers are not operating or, the outside air temperature is below 40°F. (Adjustable) the two way condenser water bypass valve shall be closed to bypass the cooling towers and the two position condenser water return drain valve shall be opened to drain the

water out of the condenser water return piping between the two position bypass valve and the cooling towers inlet piping to drain the piping exposed to outside air conditions.

3.14 DOMESTIC HOT WATER CONVERTORS:

- A. Provide a temperature sensors in the domestic hot water supply water pipe from each domestic hot water convertor which shall modulate each of the normally closed two way hot water heating supply water/low pressure steam valves as required to maintain a domestic water supply temperature as scheduled on the drawing.
- B. Domestic hot water circulating pump will run continuously. Hand-off-auto switch at the DDC panel will provide manual override of the pump if needed. Red indicating pilot light at the DDC will indicate the run status of pump.

3.15 OPERABLE GLASS CONTROL:

- A. The digital controller, through single dry type contacts in the temperature control panels, shall modulate the operable sections of glass at the top of the main pyramid and the north pyramid to prevent excessive temperature or humidity levels at the top of the structure. Temperature and humidity sensors shall be located as high as possible, but below the operable sections of glass.

3.16 CHILLER ROOM VENTILATION CONTROL:

- A. The exhaust air fan shall start and the outside air damper shall open any time the chiller is activated and shall run continuously until chiller is deactivated. Fan differential pressure switch will be used for proof of status of fan.

3.17 OZONE SYSTEM EMERGENCY EXHAUST FAN EF-11:

- A. The exhaust air fan EF-11 shall be interlocked with the ozone equipment room monitor system and the exhaust fan EF-11 shall start any time the room monitor senses an alarm condition.

END OF SECTION 15975