SECTION 230993 - SEQUENCES OF OPERATION FOR HVAC CONTROLS GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems, sub-systems and equipment.

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. Set-points: In general, stated set-points are intended to be a starting programming value with the final setup adjustable from BAS.

C. BAS: Building Automation System.

1.4 RTU AIR SYSTEM (RTU-1 & RTU-2)

A. The Building Automation System (BAS) shall perform the following RTU Air System (RTU) control strategies, appropriate to the given occupancy mode of the system, as determined by the user-adjustable time-of-day schedule for the system. Optimal start and unoccupied mode applies only to HVAC with time of day scheduled operation. Verify time schedule during Owner's training.

B. Optimal Start Mode:

1. The BAS shall initiate the Optimal Start mode such that the RTU is started and Air terminal units served by the RTU are enabled prior to when the space being served by the RTU is scheduled to be occupied, to allow the zone temperature to reach the pending occupied heating or cooling set-point. The system shall wait as long as possible before starting, so that the temperature in each zone reaches the occupied set-point just in time for scheduled occupancy. Ventilation functions shall be disabled when the RTU is in Optimal Start mode and outside air dampers shall be closed.
2. The BAS shall use a self-adjusting algorithm to calculate the actual time to initiate Optimal Start for the Air System based on the occupied set-point, space temperature, outside air temperature, historical optimal start performance data and the associated heating or cooling optimal start rate.
3. An early start limit shall be provided to prevent the RTU from starting prior to 120 minutes (adjustable) before scheduled occupancy.
4. The RTU shall transition from Optimal Start mode to occupied mode when the current time is equal to the scheduled start time.
   a. Cooling:
      1) The BAS shall initiate the Optimal Start – Cooling mode when Optimal Start mode for the RTU has been initiated and the average temperature of the space (as sensed by the average temperature of all terminal unit temperature sensors) is warmer than its occupied cooling set-point. All ventilation functions are disabled while operating in Optimal Start mode and the outside air dampers shall be closed.
      2) The BAS shall determine the length of time required to lower the space temperature to the occupied cooling set-point when the mode of the RTU is cooling and the space temperature is above the occupied cooling set-point.
      3) Each air terminal unit in the VAV Air System shall control to its occupied cooling set-point, and shall modulate box airflow to maintain the space temperature set-point

for the zone being served by the Air terminal unit. Auxiliary heat in the Air terminal unit is disabled.

4) The air handler shall modulate its airflow to maintain the duct static pressure set-point.

b. Heating:

1) The BAS shall initiate the Optimal Start – Heating mode, Air terminal unit local heat, when Optimal Start mode has been initiated and the average space temperature (as sensed by the average temperature of all terminal unit temperature sensors) is cooler than its occupied heating set-point. All ventilation functions are disabled while operating in Optimal Start mode and the outside air dampers shall be closed.

2) The BAS shall determine the length of time required to raise the average space temperature to the occupied heating set-point when the mode of the RTU is heating and the average space temperature is below the set-point.

3) Each Air terminal unit in the VAV Air System shall control to its occupied heating set-point, and shall modulate box airflow to maintain the space temperature set-point for the zone being served by the Air terminal unit. Auxiliary heat in the Air terminal unit is enabled.

4) The air handler shall modulate its airflow to maintain the duct static pressure set-point.

C. Unoccupied Mode:

1. The BAS shall place the members of the Air System into Off/Standby mode, include VAV terminal units, as determined by the user-adjustable time-of-day schedule for the system. The Air terminal units shall control to their individual unoccupied temperature set-points, and all ventilation functions shall be disabled and outside air dampers shall be closed.
2. After the Air terminal units have been commanded to unoccupied, the RTU shall command the associated AHU to Unoccupied mode. Supply fan shall be shut down, heating, if present in RTU, shall fail to open, cooling shall be disabled, outdoor air damper shall be closed, and all ventilation functions shall be disabled.

D. Night Setback Mode: During scheduled unoccupied hours, the VAV Air System shall be controlled by the BAS to maintain the unoccupied heating and cooling set-points, as appropriate. Ventilation functions are disabled, the outdoor air damper shall remain closed, unless outdoor air is used for economizing during unoccupied zone cooling. Unless otherwise stated, the RTU supply fan shall operate in the automatic control mode, cycling on only when heating or cooling is needed.

1. Heating:
   a. RTU supply fan energized, Air terminal unit local reheat is used.
   b. The BAS shall initiate the Night Heating mode when the temperature for the space being served by the RTU is less than 55 degrees F (adjustable) in a minimum of 3 rooms, (adjustable). Night heating shall terminate when the space temperature rises above the Unoccupied Heating set-point plus the unoccupied heating differential (4 degrees F, adjustable).
   c. Each Air terminal unit that is associated with the RTU shall control to its occupied heating set-point, and shall modulate box airflow to maintain the space temperature set-point for the zone being served by the Air terminal unit.
   d. The air handler shall operate to maintain duct static pressure while in Night Heat mode.
   e. The Air terminal unit shall control its airflow to its maximum heat set-point.
2. Cooling:
   a. RTU supply fan energized
   b. The BAS shall initiate the Night Cooling mode when the temperature for the space being served by the RTU is greater than 85 degrees F, (adjustable) for a minimum of three rooms (adjustable). Night cooling shall terminate when the space temperature falls below the Unoccupied Cooling set-point plus the unoccupied cooling differential (4 degrees F, adjustable).

c. Each Air terminal unit that is associated with the RTU shall control to its occupied cooling set-point, and shall modulate box airflow to maintain the space temperature set-point for the zone being served by the Air terminal unit.
d. The air handler shall operate to maintain duct static pressure while in Night Cooling mode.

E. Static Pressure Optimization:
1. The building automation system (BAS) shall continuously monitor the damper position of all air terminal units. The discharge duct static pressure shall be sensed 2/3 of the distance from the discharge of each rooftop/air handling unit. The sensor must be mounted in a non-turbulent location. Label the location of the sensor on the ceiling. The BAS shall also read the status on the supply air sensor and display the pressure reading on the status screen. Provide a high pressure switch at the unit with a setpoint between 4" and 6" (adjustable).
2. The building automation system shall monitor the damper position of all air terminal units and determine the air terminal critical zone VAV terminal (CZ), which is the air terminal unit that is the widest open.
3. When any air terminal damper is more than 75 percent (adj.) open, the supply fan discharge duct static pressure set-point shall be reset upward by 0.3 in W.C. (adj.), at a frequency of 15 minutes (adj.), until no damper is more than 75 percent open or the static pressure set-point has reset upward to the system maximum duct static pressure set-point or the supply fan variable-frequency drive is at the maximum speed setting.
4. When all air terminal dampers are less than 65 percent (adj.) open, the supply fan discharge duct static pressure set-point shall be reset downward by 0.3 in W.C. (adj.), at a frequency of 15 minutes (adjustable), until at least one damper is more than 65 percent open or the static pressure set-point has reset downward to the system minimum duct static pressure set-point.
5. Air terminal units in calibration or auto commissioning mode shall not impact the critical zone calculation.
6. The control bands, set-point increment values, set-point decrement values and adjustment frequencies shall be adjusted to maintain maximum static pressure optimization with stable system control and maximum comfort control.

F. Occupied Mode Cooling Control: The compressors shall energize to maintain the discharge air temperature at the discharge cooling set-point for the RTU. The VAV's shall modulate the air flow to maintain the zone temp per the cooling set point.

G. Occupied Mode Heating Control: Heating during Occupied Mode shall be controlled via the Air Terminal Unit section of this specification.

H. Economizer - Enthalpy Enable – (Controlled through the BAS):
1. The mixed air temperature set point shall be 2°F (adj.) less than the supply air temperature set point. The controller shall measure the mixed air temperature and modulate the economizer dampers in sequence to maintain this set point.
2. The outside air damper shall close and the return air damper shall open when the unit is off.
3. The economizer shall be enabled whenever:
   a. Outside air temperature is less than 65°F (adj.).
   b. AND the outside air enthalpy is less than 22Btu/lb (adj.)
   c. AND the outside air temperature is less than the return air temperature.
   d. AND the outside air enthalpy is less than the return air enthalpy.
   e. AND the fan status is on.
4. The economizer shall close to 0% (adj.) whenever:
   a. the mixed air temperature is less than 35°F (adj.).
   b. OR on loss of fan status.
5. Alarms shall be provided as follows:
   a. High Mixed Air Temp: If the mixed air temperature is 5°F (adj.) greater than set point.
   b. Low Mixed Air Temp: If the mixed air temperature is 5°F (adj.) less than set point.

I. Dehumidification:
1. Provide all necessary sensors for dehumidification control at each air handler.
2. The controller shall measure the return air humidity, as sensed by a single humidity sensor in the return to the RTU, and override the cooling sequence to maintain a return air humidity setpoint of 60% rh (adj.). The dehumidification shall turn off whenever the return air humidity drops below 55% rh (adj.).
   a. When dehumidification mode is engaged per the requirements above, the unit shall go to cooling mode with the terminal units providing space temperature control.
3. Dehumidification shall be enabled whenever:
   a. Fan status is on
   b. Return air humidity exceeds 60% (adj.) relative humidity in unoccupied mode.
4. Alarms shall be provided as follows:
   a. High Return Air Humidity: If the return air humidity is 10% rh (adj.) greater than setpoint.
   b. Low Return Air Humidity: If the return air humidity is 10% rh (adj.) less than setpoint.

J. Safety Interlock: The following shall de-energize the RTU supply fan: Duct smoke detector, emergency stop button, low limit thermostat activation, high Pressure switch (4”-6” adjustable).

K. Building Pressurization

1. The exhaust/relief damper shall modulate open to maintain a building pressurization of +0.05” (adj.) SP as measured by a space pressurization sensor.
2. There shall be one space pressurization sensor per air handler.
3. There shall be an alarmed condition for space pressurization rising more than 25% (adj.) above the setpoint and for space pressurization falling more than 25% (adj.) below the setpoint.

L. Demand Control Ventilation During Occupied Mode

Outside air intake shall be provided with a motorized damper. On unit start up, the outside air intake damper shall remain closed until the return air temperature rises above 65° f (adj) or falls below 75° f. (adj). Once return air temperature is satisfied, the outside air damper shall open to the occupied minimum setpoint. Outside air dampers shall modulate as required to maintain minimum outside air flow. the outside air intake damper shall be closed while unit is in the unoccupied mode or optimal start. BAS shall be capable of opening and closing outside air dampers. CO2 sensors shall modulate the outside air damper based on CO2 levels in the space. Damper shall modulate open from the occupied minimum setpoint of 800 ppm to design maximum at 1200 ppm. An alarm shall be activated if the space CO2 level rises above 1500 ppm. See RTU schedule for minimum and design outside air setpoints.

Variable Air Volume - RTU DX

	Hardware Points				Software Points						
Point Name	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
Building Static Pressure	x								x		x
Mixed Air Temp	x				x				x		x
Carbon Dioxide PPM	x								x		x
Return Air Humidity	x				x				x		x
Return Air Temp	x				x				x		x
Supply Air Static Pressure	x				x				x	x	x
Supply Air Temp	x				x				x		x
Exhaust Air Damper		x									x

Mixed Air Dampers		x			x				x		x
Supply Fan VFD Speed		x							x		x
Exhaust Air Damper Status			x						x		x
Outside air intake airflow rate	x										
High Static Shutdown			x						x	x	x
Smoke Detector			x						x	x	x
Fan Status (depended on number / type of fans)			x			x			x		x
Supply Fan VFD Fault			x							x	x
Cooling Stage 1		x			x				x		x
Cooling Stage 2		x			x				x		x
Cooling Stage 3		x			x				x		x
Cooling Stage 4		x			x				x		x
Supply Fan Start/Stop				x					x		x
Building Static Pressure Setpoint					x						x
Dehumidification Setpoint					x				x		x
Economizer Mixed Air Temp Setpoint					x				x		x
CO2 Setpoint					x				x		x
Supply Air Static Pressure Setpoint					x				x		x
Supply Air Temp Setpoint					x				x		x
Emergency Shutdown						x				x	x
Exhaust Air Damper Failure										x	
High Air Carbon Dioxide Concentration										x	
High Return Air Humidity										x	
High Supply Air Temp										x	
High Zone Carbon Dioxide Concentration										x	
Supply Fan Failure										x	
Supply Fan in Hand										x	

1.5 CONSTANT VOLUME ROOFTOP DX UNIT OPERATON (RTU-3)

A. The Building Automation System (BAS) shall perform the following control strategies, appropriate to the given occupancy mode of the system, as determined by the user-adjustable time-of-day schedule for the system. Optimal start and unoccupied mode applies only to HVAC with time of day scheduled operation. Verify time schedule during Owner's training.

B. Optimal Start Mode:
1. The BAS shall initiate the Optimal Start mode such that the unit is started and enabled prior to when the space being served by the unit is scheduled to be occupied, to allow the zone temperature to reach the pending occupied heating or cooling set-point. The system shall wait as long as possible before starting, so that the temperature reaches the occupied set-point just in time for scheduled occupancy. Ventilation functions shall be disabled when the unit is in Optimal Start mode and outside air dampers shall be closed.
2. The BAS shall use a self-adjusting algorithm to calculate the actual time to initiate Optimal Start for the unit based on the occupied set-point, space temperature, outside air temperature, historical optimal start performance data and the associated heating or cooling optimal start rate.
3. An early start limit shall be provided to prevent the unit from starting prior to 120 minutes (adjustable) before scheduled occupancy.
4. The unit shall transition from Optimal Start mode to occupied mode when the current time is equal to the scheduled start time.
   a. Cooling:
      1) The BAS shall initiate the Optimal Start – Cooling mode when Optimal Start mode for the unit has been initiated and the temperature of the space is warmer than its occupied cooling set-point. All ventilation functions are disabled while operating in Optimal Start mode and the outside air dampers shall be closed.
      2) The BAS shall determine the length of time required to lower the space temperature to the occupied cooling set-point when the mode of the unit is cooling and the space temperature is above the occupied cooling set-point.
      3) The unit shall control to its occupied cooling set-point, and shall modulate compressor(s) to maintain the space temperature set-point for the zone being served.
   b. Heating:
      1) The BAS shall initiate the Optimal Start – Heating mode, when Optimal Start mode has been initiated and the space temperature is cooler than its occupied heating set-point. All ventilation functions are disabled while operating in Optimal Start mode and the outside air dampers shall be closed.
      2) The BAS shall determine the length of time required to raise the average space temperature to the occupied heating set-point when the mode of the unit is heating and the average space temperature is below the set-point.
      3) The unit shall control to its occupied heating set-point, and shall modulate the gas heating section to maintain the space temperature set-point for the zone being served.

C. Unoccupied Mode:
1. The BAS shall place the unit into Off/Standby mode as determined by the user-adjustable time-of-day schedule for the system. The unit shall control to the unoccupied temperature set-point, and all ventilation functions shall be disabled and outside air dampers shall be closed.

D. Night Setback Mode: During scheduled unoccupied hours, the unit shall be controlled by the BAS to maintain the unoccupied heating and cooling set-points, as appropriate. Ventilation functions are disabled, the outdoor air damper shall remain closed, unless outdoor air is used for economizing during unoccupied zone cooling. Unless otherwise stated, the supply fan shall operate in the automatic control mode, cycling on only when heating or cooling is needed.
1. Heating:
   a. RTU supply fan energized, gas heat is used.
   b. The BAS shall initiate the Night Heating mode when the temperature for the space being served by the unit is less than 55 degrees F (adjustable). Night heating shall terminate when the space temperature rises above the Unoccupied Heating set-point plus the unoccupied heating differential (4 degrees F, adjustable).
2. Cooling:
   a. RTU supply fan energized
   b. The BAS shall initiate the Night Cooling mode when the temperature for the space being served by the unit is greater than 85 degrees F, (adjustable). Night cooling shall terminate

when the space temperature falls below the Unoccupied Cooling set-point plus the unoccupied cooling differential (4 degrees F, adjustable).

E. Occupied Mode Cooling Control: The compressors shall modulate to maintain the space temperature. Occupied Mode Heating Control: Heating during Occupied Mode shall be controlled via the gas heating section.

F. Economizer - Enthalpy Enable (Controlled through the BAS):
1. The mixed air temperature set point shall be 2°F (adj.) less than the supply air temperature set point. The controller shall measure the mixed air temperature and modulate the economizer dampers in sequence to maintain this set point.
2. The outside air damper shall close and the return air damper shall open when the unit is off.
3. The economizer shall be enabled whenever:
   a. Outside air temperature is less than 65°F (adj.).
   b. AND the outside air enthalpy is less than 22Btu/lb (adj.)
   c. AND the outside air temperature is less than the return air temperature.
   d. AND the outside air enthalpy is less than the return air enthalpy.
   e. AND the fan status is on.
4. The economizer shall close to 0% (adj.) whenever:
   a. The mixed air temperature is less than 35°F (adj.).
   b. OR on loss of fan status.
5. Alarms shall be provided as follows:
   a. High Mixed Air Temp: If the mixed air temperature is 5°F (adj.) greater than set point.
   b. Low Mixed Air Temp: If the mixed air temperature is 5°F (adj.) less than set point.

G. Demand Control Ventilation During Occupied Mode
1. Outside air intake shall be provided with a motorized damper. On unit start up, the outside air intake damper shall remain closed until the return air temperature rises above 65° f (adj) or falls below 75° f. (adj). Once return air temperature is satisfied, the outside air damper shall open to the occupied minimum setpoint. Outside air dampers shall modulate as required to maintain minimum outside air flow. the outside air intake damper shall be closed while unit is in the unoccupied mode or optimal start. BAS shall be capable of opening and closing outside air dampers. CO2 sensors shall modulate the outside air damper based on CO2 levels in the space. Damper shall modulate open from the occupied minimum setpoint of 800 ppm to design maximum at 1200 ppm. An alarm shall be activated if the space CO2 level rises above 1500 ppm. See RTU schedule for minimum and design outside air setpoints.

H. Safety Interlock: The following shall de-energize the supply fan: Duct detector, emergency stop button.

Single Zone Unit - DX

	Hardware Points				Software Points						
Point Name	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
Mixed Air Temp	x								x		x
Outside Air Humidity	x								x		x
Outside Air Temp	x								x		x
Space Carbon Dioxide PPM	x								x		x
Return Air Humidity	x								x		x

Return Air Temp	x								x		x
Supply Air Temp	x								x		x
Zone Setpoint Adjust	x										x
Zone Temp	x								x		x
Mixed Air Dampers		x							x		x
Outside air airflow rate	x										
Smoke Detector			x						x	x	x
Fan Status (depended on number / type of fans)						x			x		x
Zone Override			x						x		x
Cooling Stage 1				x					x		x
Cooling Stage 2				x					x		x
Cooling Stage 3				x					x		x
Cooling Stage 4				x					x		x
Supply Fan Start/Stop				x					x		x
Cooling Setpoint					x				x		x
Economizer Zone Temp Setpoint					x				x		x
Heating Setpoint					x				x		x
Carbon Dioxide PPM Setpoint					x				x		x
Emergency Shutdown						x				x	x
High Return Air Carbon Dioxide Concentration										x	
High Return Air Humidity										x	
Supply Fan Failure										x	
Supply Fan in Hand										x	

1.6 AIR TERMINAL UNIT OPERATION

A. Direct Digital Controls: DDC controls, actuators and costs to mount, calibrate and test the system shall be the responsibility of controls Contractor.

B. Terminal Unit Control:
1. The terminal box units shall be individually controlled by one DDC terminal controller per terminal unit.
2. The BAS shall perform the following terminal unit control strategies and provide the points as listed on the DDC terminal point list and the specified monitoring and diagnostics.
   a. Set point Control: The BAS shall edit the zone space temperature set-point of each terminal box. The zone temperature set-point shall be operator adjustable. Individual zone set-point and control logic shall reside at the zone level and shall not be dependent upon the BAS for control. In the event of communication loss, the box shall continue to control to current set-points.

b. Cooling Valve Control: The BAS shall control the cooling air valve to a fully open, fully closed (only during unoccupied mode when unoccupied space temperature setpoint is satisfied), maximum CFM or minimum CFM position based on operator commands. The operator shall also have the capability to adjust the maximum and minimum airflow limits of the air valve through the BAS.

c. Operating Mode: The BAS shall place the box in either the occupied or unoccupied mode based on an operator adjustable time schedule. Separate heating and cooling set-points shall be provided for each mode through the BAS.

d. Occupied Mode: As the space temperature rises above the cooling set-point, the terminal unit shall modulate to its maximum CFM set-point. As the space temperature falls below cooling set-point, the terminal unit shall modulate to its minimum CFM set-point. Upon a further decrease in space temperature, the terminal unit shall modulate to heating CFM and the heating coil (when provided) shall modulate. During heating mode, upon a further space temperature decline, the controller to modulate the electric heat until the discharge air temperature is 85 F (adj) then modulate the air valve to the heating cfm setpoint with the discharge air temperature maintained at 85 F (adj).

e. Unoccupied Mode: During this mode, the air valve on the terminal unit shall be closed if the unoccupied space temperature set-point is satisfied. When required by the unoccupied set-point, the heat shall cycle to maintain a reduced space temperature. Unit shall be at minimum heating CFM when heat is energized.

f. Morning warm-up Mode: The air valve on the terminal unit shall modulate to their maximum heating CFM and the heating shall cycle to maintain the occupied heating set-point.

g. The building automation system shall provide the ability to automatically commission and calibrate the terminal Air System. The following tests shall be performed, at a minimum: Calibration of the air valve/damper, Verification of air flow through the terminal box, Verification of local reheat performance.

h. The building automation system (BAS) shall provide the ability to initiate the auto-commissioning/auto-calibration command directly from the user interface. Special service tools shall not be required. The terminal boxes shall allow the operator to perform on an individual or group basis auto-commissioning report for the terminal Air System which contains the results of the auto-commissioning/auto-calibration tests which is printable and

i. remain in memory until the next auto-commissioning test is initiated. This report shall contain, at a minimum, the following information for each terminal box in the system. Name of terminal box. Date and time the terminal box was tested. Presence of any alarms. Space temperature and set-point. Active airflow (in CFM). Air valve/damper position at every 5% increment. Discharge air temperature of the terminal box when the box heat is active.

C. Zone Thermostats:

1. The zone thermostats shall be accurate to within 1.0 degrees F. The thermostats shall be provided by the controls contractor and shall be as noted in section 230900.
2. The zone thermostat shall be installed to avoid relaying false temperatures (i.e. not close to heating/cooling sources).
3.

Air Terminal Unit	Hardware Points				Software Points						
Point Name	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
Airflow	x								x		x
Discharge Air Temp	x								x		x
Zone Temp	x								x		x
Zone Setpoint Adjustment (where required)	x								x		x

Zone Override (where required)			x						x		x
Electric Reheat (SCR Control)		x							x		x
Zone Damper		x							x		x
Airflow Setpoint					x				x		x
Cooling Setpoint					x				x		x
DAT Heating Limit					x						
Heating Setpoint					x				x		x
Percent of Time Satisfied					x				x		
Heating Mode						x			x		
Schedule								x			

1.7 SPACE CO2 SENSORS FOR SPACESSERVED BY AIR TERMINAL UNITS

A. In areas served by Air Terminal Units, a CO2 sensor shall be installed in all densely occupied spaces as indicated on the drawings. A CO2 sensor shall also be installed outdoors. The CO2 differential between the space levels and outside levels shall be monitored.

1.8 TOILET EXHAUST RISERS

A. EF shall energize on time of day schedule from BAS. Monitor status of fans on BAS. Open the isolation damper when fan is energized.

B.

Toilet Exhaust Riser	Hardware Points				Software Points						
Point Name	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
Fan Status			x						x		x
Exhaust Air Damper				x					x		x
Fan Start/Stop				x					x		x
Schedule								x			
Fan Failure										x	

1.9 DUCTLESS SPLIT SYSTEMS

A. Where rooms are provided with both ductless split systems and VAV boxes, this sequence shall be utilized.
   1. During occupied times, VAV box shall serve as the first stage of cooling, with an occupied setpoint of 70°. During unoccupied times, the VAV box shall serve as the second stage of cooling with a setpoint of 75°.
   2. Ductless split systems shall perform the second stage of cooling during occupied times with a setpoint of 75°. During unoccupied times, the ductless split system shall serve as the first stage of cooling with a setpoint of 70°. If space temperature rises above 78° in either the occupied or unoccupied mode, an alarm shall be sent to the central BAS.

3. Ductless split system indoor unit fans shall be started and stopped with thermostat call for cooling. Upon a rise in space temperature above thermostat setpoint, unit compressor shall activate to satisfy space conditions

Ductless Split Systems (Rooms VAV boxes)

	Hardware Points				Software Points						
Point Name	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
Space Temperature	x									x	
Start/Stop				x		x			x		x
Schedule								x			

B. Rooms provided with only a ductless split system shall utilize this sequence.

1. Ductless split systems indoor unit fan shall be started and stopped with thermostat call for cooling. Upon a rise in space temperature above thermostat setpoint, unit compressor shall activate to satisfy space conditions. If space temperature rises above 78°, an alarm shall be sent to the central BAS. No occupied or unoccupied settings shall be used.

Ductless Split Systems (Rooms with only ductless split systems)

	Hardware Points				Software Points						
Point Name	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
Space Temperature	x									x	

1.10 UNIT HEATERS

A. Unit heaters shall be controlled only by local thermostats.

B. Upon the space temperature falling below the setpoint (60 deg (adj.)), the unit heater shall be energized and remain so until the space temperature has risen above the setpoint.

1.11 SMOKE DETECTOR OPERATION

A. When particles of combustion are detected by the duct mounted smoke detector, stop the HVACU supply fan, close the outside damper and stop the fans in all air terminal units associated with the HVACU.

B. Refer to Division 26 Fire Alarm Section for duct mounted smoke detectors.

C. Smoke detectors and sampling tubes shall be furnished by the electrical contractor for installation by the mechanical contractor. Sampling tubes shall be connected under electrical and installed under the mechanical section of this specification.

D.

Smoke Detector Operation	Hardware Points	Software Points

Point Name	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
Smoke Detector Status*			x						x	x	x
Smoke shutdown command						x			x	x	x

*Monitor Smoke detector status on detectors on each HVACU.

1.12 FIRE ALARM INTERFACE

A. The BAS shall shut-down all air handling equipment as required by code upon contact closure by a remote fire alarm relay located adjacent to the BAS control panel. The HVAC equipment shall de-energize based on whether the dedicated smoke detector or the general alarm contact for that floor is in alarm. The equipment shall include, but not be limited to the following:
1. Central Air Handling Units, Rooftop Units
2. Air terminal units.
3. Toilets riser exhaust fans.

B.

Fire Alarm Interface	Hardware Points				Software Points						
Point Name	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
FA Remote Relay Status*			x						x	x	x
FA Remote Relay shutdown command**						x			x	x	x

*Monitor FA Remote Relay status on relays next to each HVACU control panel.

**Remote shutdown command shall shutdown equipment by floor or area based on local relay status. HVACU, terminal units and fans included.

1.13 MISCELLANEOUS

A. Gas Meter
1. The controller shall monitor the gas meter for current gas consumption on a continual basis. These values shall be made available to the system at all time.
2. Alarm shall be generated as follows:
   a. Meter Failure: Sensor reading indicates a loss of pulse output from the Gas Meter.
3. Peak Demand History:
   a. The controller shall monitor and record the peak (high and low) demand readings from the gas meter. These readings shall be recorded on a daily, month-to-date, and year-to-date basis.
4. Usage History:
   a. The controller shall monitor and record gas meter readings to provide a gas consumption history. KCF usage readings shall be recorded on a daily, month-to-date, and year-to-date basis.

Gas Meter	Hardware Points	Software Points

Point Name	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
Gas Flow Rate	x										
Demand									x		x
Peak Month-to-Date									x		x
Peak Today									x		x
Peak Year-to-Date									x		x
Usage Month-to-Date									x		x
Usage Today									x		x
Usage Year-to-Date									x		x
Meter Failure										x	

1.14 ELECTRICAL POWER

A. Electric Meter:
1. The controller shall monitor the electric meter for current power consumption on a continual basis as described in Division 26. These values shall be made available to the system at all time.
2. Alarm shall be generated as follows:
   a. Meter Failure: Sensor reading indicates a loss of pulse output from the Electric Meter.
   b. Peak Demand History:
3. The controller shall monitor and record the peak (high and low) demand readings from the electric meter. These readings shall be recorded on a daily, month-to-date, and year-to-date basis.
4. Usage History:
   a. The controller shall monitor and record electric meter readings so as to provide a power consumption history. KWH usage readings shall be recorded on a daily, month-to-date, and year-to-date basis.

Electric Meter	Hardware Points				Software Points						
Point Name	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
kW Pulse	x										x
Current Demand Level					x				x		x
kW Demand									x		x
kW Peak Month-to-Date									x		x
kW Peak Today									x		x
kW Peak Year-to-Date									x		x
kWh Today									x		x
MWh Month-to-Date									x		x
MWh Year-to-Date									x		x
Meter Failure										x	

Power Monitoring Interface

(BACnet interface)	Hardware Points				Software Points						
Point Name	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
Apparent Power - kVA					x				x		x
Current Neutral					x				x		x
Current Phase A					x				x		x
Current Phase B					x				x		x
Current Phase C					x				x		x
Frequency					x				x		x
Power Factor					x				x		x
Real Energy - kWh					x				x		x
Real Power - kW					x				x		x
Voltage A-B					x				x		x
Voltage A-N					x				x		x
Voltage B-C					x				x		x
Voltage B-N					x				x		x
Voltage C-A					x				x		x
Voltage C-N					x				x		x

B. The BAS shall monitor and control all variable frequency drives (VFD) via BACnet interface in the drives.

Variable Frequency Drive Interface

	Hardware Points				Software Points						
Point Name	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
Start / Stop*				x					x		x
Speed*		x							x		x
Motor Current Amps					x				x		x
Motor Frequency Hertz					x				x		x
Motor Runtime					x						x
Motor Speed RPM					x				x		x
In Fault Condition						x			x	x	x
VFD Status						x			x		x

*Note: All VFDs shall have Start/Stop, Status and Speed as hardwired direct contact points. Other listed points shall be provided via a BACnet interface.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230993