SECTION 230993

SEQUENCE OF OPERATION

PART 1 GENERAL

1.1 RELATED SECTIONS

A. Section 23 09 23 - Digital Control Equipment.

B. Section 26 05 05 - Equipment Wiring Systems: Electrical characteristics and wiring connections.

1.2 SYSTEM DESCRIPTION

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.

1.3 SUBMITTALS FOR REVIEW

A. Submit under the provisions of Division 01.

B. Shop Drawings: Indicate mechanical system controlled and control system components.
1. Label with settings, adjustable range of control and limits. Include written description of control sequence.
2. Include flow diagrams for each control system, graphically depicting control logic.
3. Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.

1.4 SUBMITTALS AT PROJECT CLOSEOUT

A. Submit under the provisions of Division 01.

B. Project Record Documents: Record actual locations of components and setpoints of controls, including changes to sequences made after submission of shop drawings.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.1 PACKAGED REFRIGERATION SYSTEMS

A. The D.D.C. system shall determine the need for mechanical refrigeration by evaluation of building cooling requirements.

B. The chilled water pump and chiller controls shall be activated by the D.D.C. system. When hydronic flow of chilled water is proven, the chiller shall be energized, and chiller controls shall maintain chilled water temperature. D.D.C. system shall provide signal to chiller controllers to reset chilled water temperature.

3.2 CENTRAL REFRIGERATION SYSTEMS

A. Mechanical Refrigeration:
   1. The D.D.C. system shall determine the need for mechanical refrigeration by evaluation of building cooling requirements and measuring outside wet bulb conditions.
   2. The primary chilled water pump, primary condenser water pump and chiller controls shall be activated by the D.D.C. system. When hydronic flow of chilled water and condenser is proven, the respective chiller is energized, and chiller controls shall maintain chilled water temperature. D.D.C. system shall provide signal to chiller controllers to reset chilled water temperature.
   3. When primary chilled water temperature is maintained, secondary chilled water pumps shall be energized. Secondary chilled water pumps shall have variable speed drives and flow in secondary chilled water system shall be maintained based on differential pressure controller varying pump speeds.

B. Economizer Operation:
   1. When outside air wet bulb is low enough to provide free cooling, the system shall be changed over in the following sequence:
      a) Primary and secondary chilled water pumps shall be de-energized.
      b) Changeover valves shall be indexed to divert condenser water flow through the heat exchanger.
      c) Condenser water set point shall be changed from 85^{o} F to 40^{o} F.
      d) After approximately two (2) minute delay, the economizer pump, condenser water pumps and secondary chilled water pumps shall be energized.
      e) Chilled water temperature shall be maintained by varying cooling towers fan speeds. The low limit of condenser water shall be 40^{o} F.
   2. Secondary chilled water pumps shall be operated as described for mechanical refrigeration.
   3. When outside air temperature rises, and economizer system can no longer provide proper cooling the following sequence shall occur:
      a) Cooling tower fans shall be de-energized and condenser water control reset to 85^{o} F.
      b) System shall operate until condenser water temperature rises to 55^{o} F.
      c) When condenser water temperature reaches 55^{o} F, economizer pump, condenser water pumps; and secondary chilled water pumps shall be de-energized.
      d) Changeover valves shall be indexed to normal position - condenser water flow through chiller condensers.
      e) After a delay of two (2) minutes the mechanical refrigeration system shall be started as described above.

3.3 HOT WATER HEATING SYSTEM

A. The D.D.C. system shall determine the need for building heating based on outside air temperatures and building temperatures.

B. The hot water pump shall be started, and boiler controls shall be energized.

C. The hot water supplied to building systems shall be reset as determined by outside temperature and inside building temperatures.

3.4 HOT WATER HEATING SYSTEM

A. The D.D.C. system shall determine the need for building heating based on outside air temperatures, building temperatures, and inside humidity levels.

B. The hot water pump(s) shall be started, and combustion air flow confirmed by air flow switch in boiler room make-up air unit. Boiler controls shall be energized, and boiler water temperature maintained at 180° F.

C. The hot water supplied to building systems shall be reset as determined by outside temperature and inside building temperatures. D.D.C. system shall module a pneumatic three-way mixing valve to maintain system temperature.

D. The building hot water pumps shall maintain flow to the heating system by varying speed of hot water pumps as determined by differential pressure transmitter.

3.5 AIR HANDLING UNIT (CONSTANT VOLUME)

A. The air handling unit supply fan shall run continuously during occupied hours and intermittently during unoccupied hours to satisfy space temperature. D.D.C. system shall, with input from space sensor modulate the three (3) way heating or cooling valve in sequence to maintain space set point. During the occupied mode the outside air damper shall open to the minimum position.

B. As outside air conditions permit, the unit shall enter an economizer mode by modulating the outside air and return air damper to maintain space set point. Reference relief air fan sequence.

C. Smoke detectors as indicated on the drawings shall signal fire alarm. Actuation of fire alarm shall de-energize supply fan.

D. A low limit controller with sensor located downstream of cooling coil shall de-energize supply fan and send alarm if temperature falls below 40° F.

3.6 AIR HANDLING UNIT (VARIABLE AIR VOLUME)

A. The air handling unit supply fan shall run continuously during occupied hours and be de-energized during unoccupied hours. D.D.C. system shall with input from space sensor maintain supply air temperature by modulating three (3) way cooling valve. Supply air temperature shall be reset as space loads permit. During the occupied mode the outside air damper shall modulate to provide the minimum required ventilation air flow.

B. As outside air conditions permit, the unit shall enter an economizer mode by modulating the outside air and return air damper to maintain space set point. Reference relief air fan sequence.

C. As supply duct static pressure increases or decreases the air handling unit inlet vanes will modulate to maintain a constant discharge pressure.

D. Smoke detectors as indicated on the drawings shall signal fire alarm. Actuation of fire alarm shall de-energize supply fan.

E. A low limit controller with sensor located downstream of cooling coil shall de-energize supply fan and send alarm if temperature falls below 40° F.

3.7 TERMINAL UNITS

A. Variable Air Volume:
   1. V.A.V. boxes shall be energized during occupied mode to modulate air valve open to maximum air flow when space thermostat calls for cooling and modulate closed to provide minimum air flow as space becomes satisfied. As temperature falls below set point, the hot water coil valve shall modulate to provide heating to the hot water coil (V.A.V. box at minimum position).

B. Fan Powered (Parallel):
   1. Cooling: Air valve shall modulate open to provide maximum air flow when space thermostat calls for cooling and modulate closed to provide minimum air flow as space becomes satisfied.
   2. Heating: Air valve shall close to minimum position and fan shall operate intermittently during occupied and unoccupied mode as space calls for heating.

3.8 FAN COIL UNITS

A. The fan shall run constantly during occupied hours and intermittently during unoccupied hours to satisfy set point conditions.

B. Dual temperature unit mounted thermostat maintains constant space temperature by modulating three-way control valves.

3.9 FAN COIL UNITS

A. Fan coil units shall run continuously during occupied periods and cycle during unoccupied periods to maintain space conditions - Occupied - 75^{o} F - Unoccupied - min. 60^{o} F, max. 85^{o} F.

B. During occupied periods space temperature shall be maintained by modulating two (2) way hot and chilled water valves in sequence.

C. Smoke detectors as indicated on the drawings shall signal fire alarm. Actuation of fire alarm shall de-energize supply fan.

3.16 PACKAGED AIR CONDITIONING UNITS

A. When in occupied mode the rooftop unit supply air fans shall run continuously, and outside air damper shall open to provide minimum air as scheduled on drawings. Thermostat shall cycle two stages of heating in sequence to maintain occupied set point during the heating season, and two stages of cooling in sequence to maintain occupied set point during the cooling season.

B. When in unoccupied mode the rooftop unit supply air fans shall cycle to maintain space conditions and the outside air damper shall close. Thermostat shall cycle two stages of heating in sequence to maintain unoccupied set point during the heating season, and two stages of cooling in sequence to maintain unoccupied set point during the cooling season.

C. Humidistat shall sequence evaporator coil and hot gas reheat coil simultaneously to maintain set point (recommended 60% R.H.).

D. Unit economizer controls shall modulate outside air in sequence with return and relief air to provide cooling when outside air enthalpy permits operation.

E. Smoke detectors as indicated on the drawings shall signal fire alarm. Actuation of fire alarm shall de-energize supply fan.

3.17 SPLIT SYSTEM AIR CONDITIONING UNITS WITH HOT WATER HEAT

A. During the occupied mode the air handling unit fan shall run continuously, and outside air damper shall open to provide minimum air as scheduled on drawings. During the occupied mode the air handling unit fan shall cycle to maintain set point conditions and the outside air damper shall close.

B. Two- or three-way hot water valve shall modulate to maintain set point during the heating season.

C. Condensing unit shall cycle stage(s) of cooling to maintain set point during the cooling season.

D. Smoke detectors as indicated on the drawings shall signal fire alarm. Actuation of fire alarm shall de-energize supply fan.

3.18 SPLIT SYSTEM HEAT PUMPS

A. Each split system heat pump is to be controlled by one low voltage thermostat located as shown on the drawings.
   1. When in normal operating mode the air handling unit fan shall run continuously, and outside air damper shall open to provide minimum air as scheduled on drawings.
   2. Thermostat shall cycle one stage of "heat pump" heating and auxiliary electric heat to maintain 70^{o}F during the heating season.
   3. Thermostat shall cycle one stage of cooling to maintain 75^{o}F during the cooling season.

B. Smoke detectors as indicated on the drawings shall signal fire alarm. Actuation of fire alarm shall de-energize supply fan.

3.19 EXHAUST FANS

A. The exhaust fans serving the kitchen hood shall be turned on by a wall switch located on the hood by the hood manufacturer.
   1. Operating note: the hood/fan above the rotisserie cooker should only be operated when the cooker doors are open. When this hood/fan is operating the hood above the broiler should be manually turned off to prevent severe negative pressure in the building.

B. The exhaust fan serving the dishwasher shall be interlocked with the dishwasher.

C. The exhaust fan serving the restrooms shall be switched with the lights.

D. Exhaust fans shall run continuously. Each exhaust fan shall be interlocked with the air handling unit serving the same zone.

E. Exhaust fans shall run during the occupied mode as determined by the D.D.C. control system.

3.20 SMOKE DAMPERS

A. The duct smoke detector located at each smoke damper shall signal the fire alarm system.

B. The fire alarm system shall then shut down the HVAC unit serving the air distribution system with the subject smoke damper.

C. The normally closed smoke damper, (being powered open by the HVAC unit), shall then close.

3.21 MAKE-UP AIR UNITS

A. The make-up air system is made up of two units - primary and secondary. The primary unit is untempered and serves the main kitchen hood. The secondary unit is tempered and provides air directly to the space.

B. The primary and secondary make-up air units shall be interlocked with the exhaust fan serving the main kitchen hood.

C. The secondary make up air unit's heating section shall be controlled by a thermostat located in the kitchen area.

D. Each make-up air unit will have a fire alarm contact to provide unit shutdown upon activation.

3.22 UNIT HEATERS

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

END OF SECTION