

## SECTION 23 0993

### SEQUENCE OF OPERATIONS FOR HVAC 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. Air terminal units.
  - 2. Cabinet heaters.
  - 3. Central refrigeration systems.
  - 4. Central fan systems.
  - 5. Combustion air unit heaters.
  - 6. Electrical rooms and telephone rooms.
  - 7. Elevator machine rooms.
  - 8. Emergency generators.
  - 9. Excess pressure controls.
  - 10. Fan coil units.
  - 11. Heating coils.
  - 12. Heating water zone control.
  - 13. Humidifiers.
  - 14. Induction units.
  - 15. Parking garage ventilation systems.
  - 16. Radiant panels.
  - 17. Radiation and convectors.
  - 18. Refrigeration systems.
  - 19. Unit heaters.

##### 1.02 RELATED REQUIREMENTS

- A. Section 01 9113 - General Commissioning Requirements: Commissioning requirements that apply to all types of work.
- B. Section 23 0913 - Instrumentation and Control Devices for HVAC.
- C. Section 23 0923 - Direct-Digital Control System for HVAC.
- D. Section 26 2817 - Enclosed Circuit Breakers.

##### 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.
  - 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. 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. 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 specified in elsewhere.
  - 6. Include a key to all abbreviations.
- D. Points List: Submit list of all control points indicating at least the following for each point.
  - 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.

#### **1.04 QUALITY ASSURANCE**

- A. Design system under direct supervision of a Professional Engineer experienced in design of this Work and licensed at Michigan.

### **PART 2 PRODUCTS - NOT USED**

### **PART 3 EXECUTION**

#### **3.01 AIR TERMINAL UNITS**

- A. Single-duct Variable Volume:
  - 1. Cooling Only:
    - a. On a rise in space temperature, the damper will modulate to provide maximum airflow.

- b. As space temperature decreases, the damper will modulate down to its minimum airflow.
  - 2. Cooling with Reheat:
    - a. On a rise in space temperature above the cooling set-point, the unit modulates to its maximum airflow.
    - b. As the space temperature falls below the cooling set-point, the unit modulates to its minimum airflow.
    - c. As the space temperature continues to fall to the heating set-point, the terminal modulates to its heating minimum airflow. At this point, the heat will be staged on as follows:
- B. Fan-powered:
  - 1. Series Units:
    - a. Series-fan runs continuously via control interlock with the AHU supply fan.
    - b. The air valve modulates the primary airflow in response to space temperature with the reheat de-energized.
    - c. Reheat is activated to increase discharge temperature when further decrease in primary airflow will not maintain space temperature.

### 3.02 CABINET HEATERS

- A. Single temperature thermostat on return heating water line from floor mounted cabinet heaters de-energizes unit on temperatures below 95 degrees F.
- B. Single temperature room thermostat set at 68 degrees F maintains constant space temperature by cycling unit fan motor and electric heating elements.

### 3.03 CENTRAL REFRIGERATION SYSTEMS

- A. Time Schedule: Start and stop condensing water pump.
- B. Condensing Water Pump: Allow start on proof of water in cooling tower sump and on outdoor temperature above 50 degrees F. Start on demand from ventilation system.
- C. Energize chilled water pump to start and allow cooling tower fans to start when condensing water pump started.
- D. When chilled water pump starts, open chiller control valve.
- E. Modulate chiller control valve to maintain constant flow through chiller.
- F. When chilled water flow and condensing water flow are proven by flow switches, allow refrigeration machine to start.
- G. Maintain minimum condenser water temperature of 55 degrees F by modulating tower bypass valve.
- H. Maintain temperature in cooling tower sump of 40 degrees F by modulating heater control valve. Outdoor thermostat set at 35 degrees F shall open valve to activate electric heat tracing.
- I. Thermostat in cooling tower sump, set at 35 degrees F, opens drain lines, closes make-up valve, and deactivates sump heaters and piping electric heat tapes.
- J. Display:
  - 1. System graphic.
  - 2. Condensing water pump on/off indication.
  - 3. Chilled water pump on/off switch.
  - 4. Chiller on/off indication.
  - 5. Chiller condensing water supply and return temperature.
  - 6. Chiller chilled water supply and return temperature.
  - 7. Chiller condensing water control point adjustment.
  - 8. Common chilled water control point adjustment.
  - 9. Low level cooling tower sump alarm.
  - 10. Expansion tank low level alarm.
  - 11. Cooling tower fan on/off indication.

12. Cooling tower sump heater on/off indication.
13. Cooling tower dump indication.
14. Chilled water control point adjustment.
15. Condensing water pump on/off switch.
16. Chilled water pump on/off/auto switch.
17. Chiller on/off switch.

### 3.04 CENTRAL FAN SYSTEMS

- A. Time Schedule: Start and stop supply and return fans. Determine fan status through auxiliary contactors in motor starter. If fan fails to start as commanded, signal alarm.
- B. Safety Devices:
  1. Freeze Protection: Stop fans and close outside air dampers if temperature before supply fan is below 37 degrees F; signal alarm.
  2. High Temperature Protection: Stop fans and close outside dampers if temperature in return air is above 300 degrees F; signal alarm.
  3. Smoke Detector: Stop fans, close outside dampers, and close smoke dampers if smoke is detected; signal alarm.
- C. Preheat Coil:
  1. When fan is not running, and outside air temperature is below 40 degrees F, fully open preheat coil valve to heating.
  2. When fan is running, maintain constant mixed air temperature of 55 degrees F by modulating preheat coil valve.
- D. Outside Air Damper: When supply fan is running, open outside air damper to minimum position. Prevent supply fan starting until outside air damper is open and position is verified.
- E. Humidifier: When supply fan is running, allow humidifier to operate.
- F. Humidifier: When supply fan is running and there is water in humidifier sump, humidistat located in return air, reset from outdoors modulates normally closed humidifier valve. Set outdoor reset to 50 percent relative humidity at 70 degrees F and 15 percent relative humidity at minus 30 degrees F.
- G. Outside, Return, and Relief Dampers:
  1. When supply fan is not running, outside and relief dampers are closed and return damper is open.
  2. When supply fan is running, dampers are controlled and operate with outside and relief dampers opening, and return damper closing.
  3. For cooling and outside air temperatures below 55 degrees F, modulate dampers to maintain mixed air temperature of 55 degrees F or higher.
  4. For cooling and outside air temperatures above 55 degrees F compare return and outside air temperatures. If return air temperature is lower, drive outside damper to minimum, close relief damper, and open return damper.
  5. For outside air temperatures above 79 degrees F, drive outside damper to minimum, close relief damper, and open return damper.
  6. For heating, drive outside damper to minimum, close relief damper, and open return damper.
- H. Modulate mixed air dampers in sequence to maintain constant mixed air temperature.
- I. Maintain constant supply static pressure of 3.0 inches wg by modulating supply and return fan VFDs in sequence. Locate sensor minimum 50 ft downstream of supply fan in supply air duct.
- J. Display:
  1. System graphic.
  2. System on/off indication.
  3. System day/night mode.
  4. System fan on/off indication.
  5. Return fan on/off indication.

6. Preheat coil pump on/off indication.
7. Outside air temperature indication.
8. Mixed air temperature indication.
9. Fan discharge air temperature indication.
10. Reheat zone air temperature indication.
11. Return humidity indication.
12. Fan discharge temperature control point adjustment.
13. Return humidity control point adjustment.
14. Reheat zone control point adjustment.
15. Supply static pressure indication.
16. Supply static pressure control point adjustment.
17. System on/off auto switch.
18. Supply fan on/off switch.
19. Return fan on/off/auto switch.
20. Preheat coil pump on/off switch.

### **3.05 COMBUSTION AIR UNIT HEATERS**

- A. Single temperature room thermostat set at 68 degrees F maintains constant room temperature by modulating two-way heating control valve.

### **3.06 ELECTRICAL ROOMS AND TELEPHONE ROOMS**

- A. On room temperatures above 85 degrees F open intake damper and start exhaust fan.

### **3.07 ELEVATOR MACHINE ROOMS**

- A. On room temperature above 85 degrees F, open intake dampers and start exhaust fans.
- B. On room temperatures above 90 degrees F, signal alarm.

### **3.08 EMERGENCY GENERATORS**

- A. When the generator is not running, outside and exhaust dampers are closed and recirculation damper is open.
- B. When generator is running, dampers are controlled and operate with outside and exhaust dampers opening, and recirculating dampers closing, to maintain room temperature of 85 degrees F.
- C. On room temperatures above 95 degrees F open intake damper and start exhaust fan.

### **3.09 EXCESS PRESSURE CONTROLS**

- A. Maintain constant pressure differential between supply and return lines by varying pump speed through variable speed drive control.

### **3.10 FAN COIL UNITS**

### **3.11 HEATING COILS**

- A. Single temperature thermostat set at 72 degrees F maintains constant space temperature during the day and 15 degrees F cooler at night by modulating two-way control heating valve with spring range of 3 to 7 psig.

### **3.12 HEATING WATER ZONE CONTROL**

- A. Flow switch in heating pump discharge provides on/off indication.
- B. Control heating water at maximum 195 degrees F at outdoor temperature of minus 30 degrees F, and minimum 130 degrees F at outdoor temperature of 75 degrees F, with straight line relationship between.
- C. Display:
  1. System graphic.
  2. System supply temperature.
  3. System supply control point adjustment.
  4. System return temperature.

5. Pump on/off indication.
6. Pump on/off switch.
7. Boiler lead lag switch.

### **3.13 HUMIDIFIERS**

- A. When fan is running and air flow switch proves air flow, line voltage room humidistat reset from outdoors maintains humidity level of 30 percent by cycling unit fan two-way steam valve.

### **3.14 INDUCTION UNITS**

### **3.15 PARKING GARAGE VENTILATION SYSTEMS**

- A. Carbon Monoxide (CO) detector maintains maximum CO level of 50 ppm by cycling exhaust fan. When CO level exceeds 100 ppm, signal alarm.

### **3.16 RADIANT PANELS**

- A. Single temperature thermostat set at 72 degrees F shall maintain constant space temperature by modulating two-way control valve.
  1. During heating cycle, modulate hot water supply to coil.

### **3.17 RADIATION AND CONVECTORS**

- A. Single temperature thermostat set at 72 degrees F maintains constant space temperature by modulating two-way control heating valve with spring range of 3 to 7 psig.

### **3.18 REFRIGERATION SYSTEMS**

- A. Maintain constant supply air duct temperature of 55 degrees F by cycling refrigeration system and signalling VFD capacity\_\_\_\_\_.

### **3.19 UNIT HEATERS**

- A. Single temperature electric room thermostat maintains constant space temperature of 68 degrees F by cycling unit fan motor.
- B. 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 23 0993**