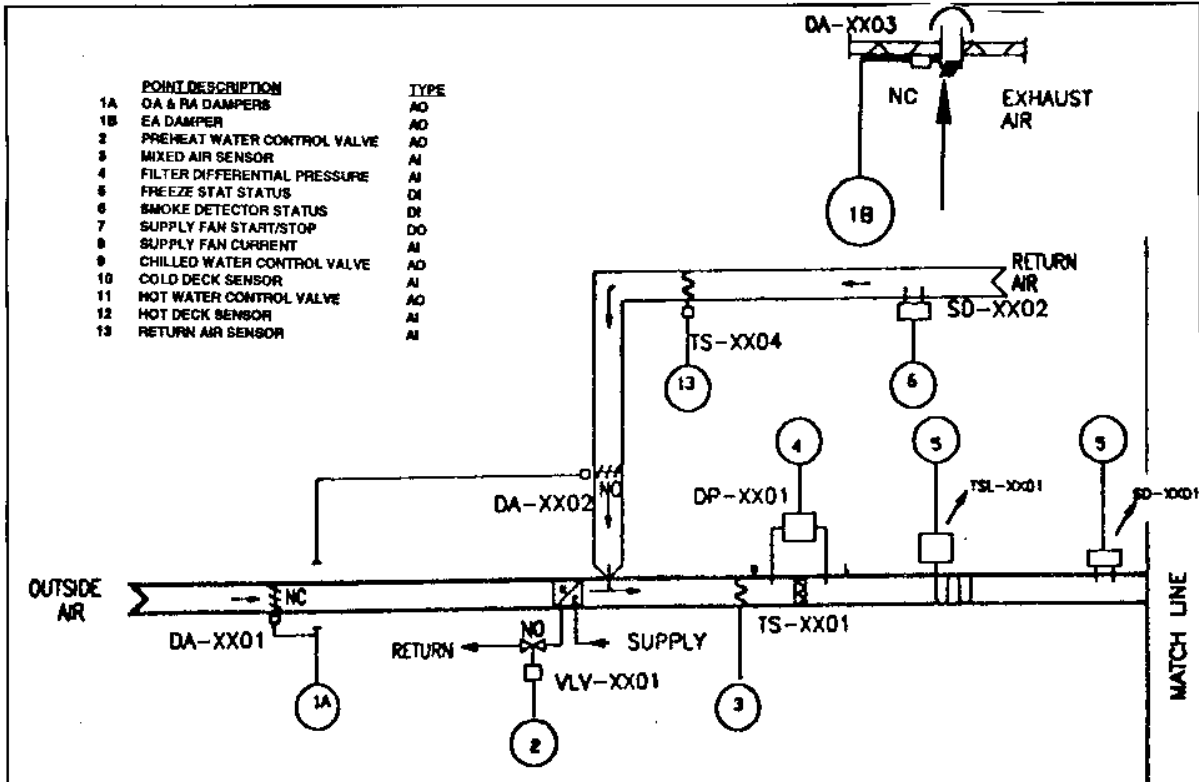


Table 15  
Equipment for Single Zone HVAC Control System XX

| LOOP CONTROL FUNCTION | DEVICE NUMBER   | DEVICE FUNCTION                        | SETPOINT                      | RANGE        | ADDITIONAL PARAMETERS                      |
|-----------------------|-----------------|--|-------------------------------|--------------|--|
| ROOM ZONE TEMPERATURE | DA-XX01, 02, 03 | DAMPER ACTUATOR                        | --                            | 4-20 ma      | MIN.O.A. XXXX CFM                          |
|                       | --              | OUTDOOR AIR DB HI LIMIT                | 65° F                         | --           | SOFTWARE POINT                             |
|                       | TS-XX01         | MIXED AIR LOW LIMIT TEMPERATURE SENSOR | 55° F                         | 30-130° F    | --   |
|                       | VLV-XX01        | PREHEAT COIL VALVE                     | --                            | 4-20 ma      | CV-10 CLOSE AGAINST 16 PSIG                |
|                       | TS-XX02         | SUPPLY AIR                             | 55° F                         | 40-140° F    | --   |
|                       | VLV-XX02        | HEATING COIL VALVE                     | --                            | 4-20 ma      | CV-12 CLOSE AGAINST 16 PSIG                |
|                       | VLV-XX03        | COOLING COIL VALVE                     | --                            | 4-20 ma      | CV-20 CLOSE AGAINST 20 PSIG                |
|                       | TS-XX03         | ROOM ZONE TEMPERATURE SENSOR           | H-70° F<br>C-76° F<br>N-55° F | 50-100° F    | WITH SETPOINT ADJUSTMENT & OVERRIDE SWITCH |
| SAFETY & MAINTENANCE  | TSL-XX01        | LOW TEMPERATURE PROTECTION THERMOSTAT  | 35° F                         | --           | --   |
|                       | SD-XX01         | SUPPLY AIR SMOKE DETECTOR              | --                            | --           | --   |
|                       | SD-XX02         | RETURN AIR SMOKE DETECTOR              | --                            | --           | --   |
|                       | DP-XX01         | FILTER STATUS DIFFERENTIAL PRESSURE    | 0.5 IN. W.G.                  | 0-2 IN. W.G. | --   |

Table 15 (Continued)  
 Equipment for Single Zone HVAC Control System XX

| LOOP CONTROL<br>FUNCTION                          | DEVICE<br>NUMBER | DEVICE<br>FUNCTION                  | SETPOINT | RANGE     | ADDITIONAL<br>PARAMETERS |
|---|------------------|-------------------------------------|----------|-----------|--------------------------|
| SAFETY &<br>MAINTENANCE<br>(CONT'D)<br>SUPPLY FAN | TS-XX04          | RETURN AIR<br>TEMPERATURE<br>SENSOR | --       | 50-100° F | --                       |
|   | R-XX01           | SUPPLY FAN<br>START RELAY           | --       | --        | --                       |
|   | CS-XX01          | SUPPLY FAN<br>CURRENT SENSOR        | --       | --        | --                       |



- | POINT DESCRIPTION | TYPE |
|-------------------|------|
| 1A                | AO   |
| 1B                | AO   |
| 2                 | AO   |
| 3                 | AI   |
| 4                 | AI   |
| 5                 | DI   |
| 6                 | DI   |
| 7                 | DO   |
| 8                 | AI   |
| 9                 | AO   |
| 10                | AI   |
| 11                | AO   |
| 12                | AI   |
| 13                | AI   |

Equipment for Multizone HVAC Control System XX

| LOOP CONTROL FUNCTION     | DEVICE NUMBER   | DEVICE FUNCTION                        | SETPOINT             | RANGE           | ADDITIONAL PARAMETERS                         |
|---------------------------|-----------------|--|----------------------|-----------------|---|
| COLD DECK TEMPERATURE     | DA-XX01, 02, 03 | DAMPER ACTUATOR                        | -                    | 0-20 ms         | MIN. O.A. XXXX CFM                            |
|                           | -               | OUTDOOR AIR DE FE LIMIT                | 88° F                | -               | SOFTWARE POINT                                |
|                           | TS-XX01         | MIXED AIR LOW LIMIT TEMPERATURE SENSOR | 88° F                | 88° to 158° F   | -   |
|                           | VLV-XX01        | PREHEAT COIL VALVE                     | -                    | 0-98 ms         | CV-10 CLOSE AGAINST 18 PSIG                   |
|                           | TS-XX02         | COLD DECK TEMPERATURE SENSOR           | 88° F                | 40° to 140° F   | -   |
| HOT DECK TEMPERATURE      | VLV-XX02        | COOLING COIL VALVE                     | -                    | 0-20 ms         | CV-20 CLOSE AGAINST 30 PSIG                   |
|                           | TS-XX03         | HOT DECK TEMPERATURE SENSOR            | 160° F               | 40° to 240° F   | -   |
| ROOM SENSORS (RAK TYP. R) | TS-XX04         | ROOM TEMPERATURE SENSORS               | 70° F C/W, 94° F W/W | 88° to 108° F   | WITH SET POINT ADJUSTMENT AND OVERRIDE SWITCH |
|                           | DA-XX04         | ZONE DAMPER ACTUATORS                  | -                    | 0-20 ms         | ONE PER ZONE                                  |
| SAFETY AND MAINTENANCE    | TSL-XX01        | LOW TEMPERATURE PROTECTION THERMOSTAT  | 38° F                | -               | -   |
|                           | SD-XX01         | SUPPLY AIR SMOKE DETECTOR              | -                    | -               | -   |
|                           | SD-XX02         | RETURN AIR SMOKE DETECTOR              | -                    | -               | -   |
|                           | DP-XX01         | FILTER STATUS DIFFERENTIAL PRESSURE    | 0.3 INCH W.G.        | 0.2 INCHES W.G. | -   |
| SUPPLY FAN                | R-XX01          | SUPPLY FAN START RELAY                 | -                    | -               | -   |
|                           | CS-XX01         | SUPPLY FAN CURRENT SENSOR              | -                    | -               | -   |

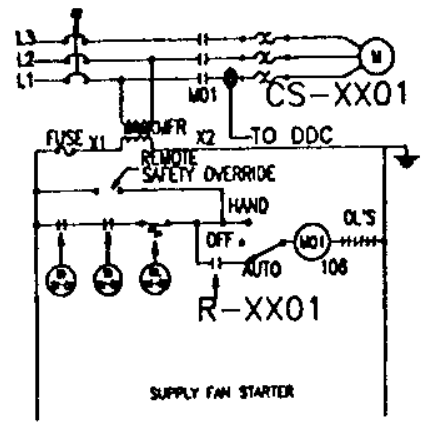


Figure 34 Control System Schematic for Multizone HVAC System XX

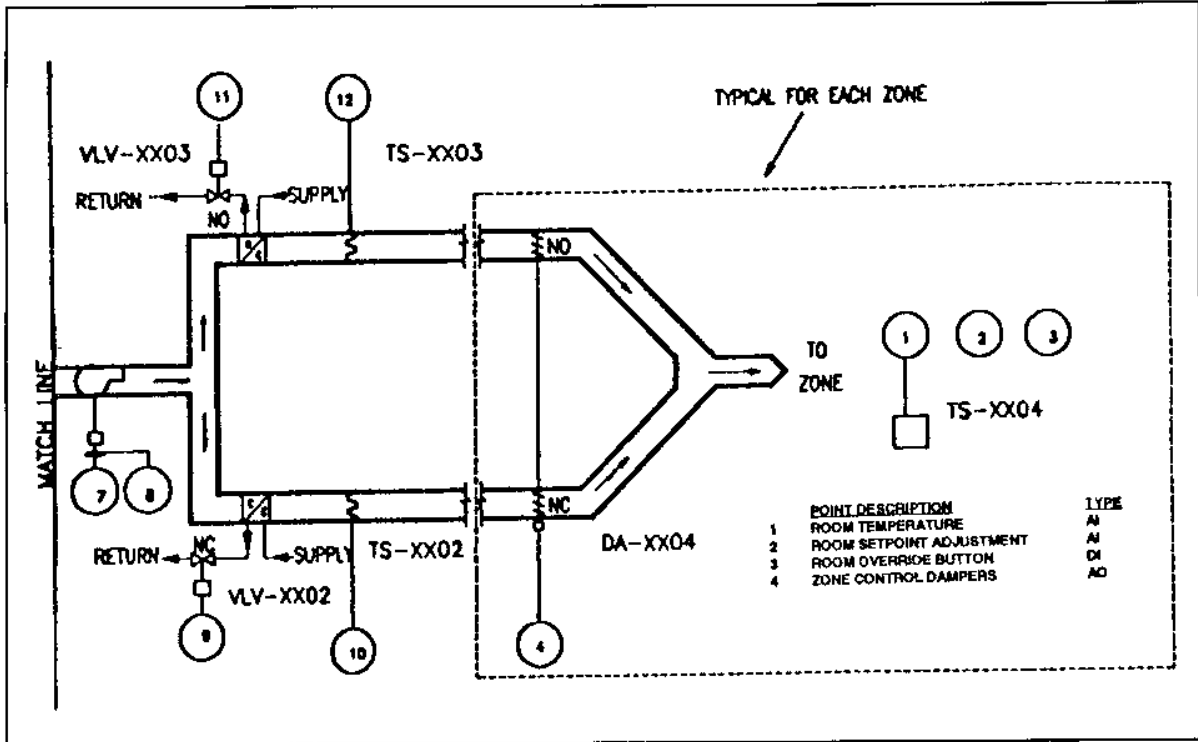


Figure 34 (Continued)  
Control System Schematic for Multizone HVAC System XX

Table 16  
Equipment for Multizone HVAC Control System XX

| LOOP CONTROL FUNCTION | DEVICE NUMBER   | DEVICE FUNCTION                        | SETPOINT | RANGE        | ADDITIONAL PARAMETERS |
|-----------------------|-----------------|--|----------|--------------|-----------------------|
| COLD DECK TEMPERATURE | DA-XX01, 02, 03 | DAMPER ACTUATOR                        | --       | 4-20 ma      | MIN.O.A.<br>XXXX CFM  |
|                       | --              | OUTDOOR AIR DB HI LIMIT                | 65 deg F | --           | SOFTWARE POINT        |
|                       | TS-XX01         | MIXED AIR LOW LIMIT TEMPERATURE SENSOR | 55 deg F | 30-130 deg F | --                    |

Table 16 (Continued)  
Equipment for Multizone HVAC Control System XX

| LOOP CONTROL FUNCTION          | DEVICE NUMBER | DEVICE FUNCTION                       | SETPOINT                      | RANGE        | ADDITIONAL PARAMETERS                                       |
|--------------------------------|---------------|---------------------------------------|-------------------------------|--------------|---|
| COLD DECK TEMPERATURE (CONT'D) | VLV-XX01      | PREHEAT COIL VALVE                    | --                            | 4-20 ma      | CV-10<br>CLOSE<br>AGAINST<br>16 PSIG                        |
|                                | TS-XX02       | COLD DECK TEMPERATURE SENSOR          | 55° F                         | 40-140° F    | --  |
|                                | VLV-XX02      | COOLING COIL VALVE                    | --                            | 4-20 ma      | CV-20<br>CLOSE<br>AGAINST<br>20 PSIG                        |
| HOT DECK TEMPERATURE           | TS-XX03       | HOT DECK TEMPERATURE SENSOR           | 180° F                        | 40-240° F    |   |
|                                | VLV-XX03      | HEATING COIL VALVE                    | --                            | 4-20 ma      | CV-12<br>CLOSE<br>AGAINST<br>16 PSIG                        |
| ROOM SENSORS (MULTIPLE)        | TS-XX04       | ROOM TEMPERATURE SENSORS              | H-70° F<br>C-76° F<br>N-55° F | 50-100° F    | WITH<br>SETPOINT<br>ADJUST-<br>MENT &<br>OVERRIDE<br>SWITCH |
|                                | DA-XX04       | ZONE DAMPER ACTUATORS                 | --                            | 4-20 ma      | ONE PER<br>ZONE   |
| SAFETY & MAINTENANCE           | TSL-XX01      | LOW TEMPERATURE PROTECTION THERMOSTAT | 35° F                         | --           | --  |
|                                | SD-XX01       | SUPPLY AIR SMOKE DETECTOR             | --                            | --           | --  |
|                                | SD-XX02       | RETURN AIR SMOKE DETECTOR             | --                            | --           | --  |
|                                | DP-XX01       | FILTER STATUS DIFFERENTIAL PRESSURE   | 0.5 IN. W.G.                  | 0-2 IN. W.G. | --  |
|                                | TS-XX04       | RETURN AIR TEMPERATURE SENSOR         | --                            | 50-100° F    | --  |

Table 16 (Continued)  
Equipment for Multizone HVAC Control System XX

| LOOP CONTROL FUNCTION                       | DEVICE NUMBER | DEVICE FUNCTION               | SETPOINT | RANGE     | ADDITIONAL PARAMETERS |
|---|---------------|-------------------------------|----------|-----------|-----------------------|
| SAFETY & MAINTENANCE (CONT'D)<br>SUPPLY FAN | TS-XX04       | RETURN AIR TEMPERATURE SENSOR | --       | 50-100° F | --                    |
|   | R-XX01        | SUPPLY FAN START RELAY        | --       | --        | --                    |
|   | CS-XX01       | SUPPLY FAN CURRENT SENSOR     | --       | --        | --                    |

b) Optimized Start Mode: Energize equipment at maximum capacity at the latest time required for heating up (or cooling down) the space to normal occupied temperature conditions. Outside air and exhaust air dampers are closed and return air dampers are opened.

c) Occupied Mode: Maintain occupied conditions under all load variations while providing required ventilation. Supply fan operates continuously. Outside air dampers are opened to the minimum ventilation air position. If an economizer outside air cycle is provided, the outside air, return air, and exhaust air dampers are automatically controlled. An outdoor air dry bulb sensor disables the economizer cycle and maintains minimum ventilation air when outside air dry bulb temperature exceeds the changeover point.

d) Unoccupied Mode: Cycle the equipment to maintain minimum heating temperature (or maximum cooling temperature) in the space while providing no ventilation. Outside air and exhaust air dampers are closed and return air dampers are opened.

e) Maintenance and Safety Mode: A differential pressure sensor measuring static pressure drop across the filter, shall initiate an alarm when the pressure drop exceeds the recommended value.

A freezestat with extended surface sensing element located ahead of the chilled water coil shall stop the supply fan, return system components to their fail-safe position, and initiate a low-temperature alarm if the temperature at any point

of the sensing element falls below the setpoint. Normal operation will occur only after the freezing condition is corrected and the freezestat is manually reset.

f) Chilled Water Coil Discharge Air Mode: A dry bulb temperature sensor located in the chilled water coil discharge air shall, on a rise in temperature, first gradually close the preheat coil valve, next gradually open the outside air damper from its minimum ventilation air position while simultaneously gradually close the return air damper (ensure thorough mixing) and gradually open the exhaust air damper, and then gradually open the chilled water coil valve. A dry bulb temperature low limit sensor located in the mixed air (ensure thorough mixing) shall, on a fall in temperature, gradually open the preheat coil valve. An outdoor air dry bulb sensor disables the economizer cycle and maintains minimum ventilation air when outside air dry bulb temperature exceeds the changeover point.

g) Heating Coil Discharge Air Mode: A dry bulb temperature sensor located in the heating coil discharge air shall, on a rise in dry bulb air temperature, gradually close the heating coil valve.

h) Room Control Mode: A room type dry bulb temperature sensor located in the most critical spot shall, on a rise in dry bulb temperature in the space, gradually open the cold deck damper while simultaneously gradually close the hot deck damper.

#### 8.5 Variable Air Volume (VAV) Unit Sequence of Operation (Sample). See Figure 35 and Table 17.

a) General: Sequences describe actions of the control system in one direction of change in the HVAC process analog variable, such as temperature, humidity, or pressure. Reverse sequence shall occur when direction of change is reversed unless specifically modified.

b) Optimized Start Mode: Energize equipment at maximum capacity at the latest time required for heating up (or cooling down) the space to normal occupied temperature conditions. Outside air and exhaust air dampers are closed and return air dampers are opened. Fans of series type VAV terminal units shall start.

c) Occupied Mode: Maintain occupied conditions under all load variations while providing required ventilation. Supply fan operates continuously. Outside air dampers are opened to the minimum ventilation airflow by the air monitoring unit for all

values of supply fan flow. If an economizer outside air cycle is provided, the outside air, return air, and exhaust air dampers are automatically controlled. An outdoor air dry bulb sensor disables the economizer cycle and maintains minimum ventilation air when the outside air dry bulb temperature exceeds the changeover point. Fans of series type VAV terminal units shall run continuously.

d) Unoccupied Mode: Cycle the VAV terminal units at maximum heating capacity to maintain minimum heating temperature in the space while providing no ventilation. Outside air and exhaust air dampers are closed and return air dampers are opened.

e) Maintenance and Safety Mode: A differential pressure sensor measuring static pressure drop across the filter shall initiate an alarm when the pressure drop exceeds the recommended value.

A freezestat with extended surface sensing element located ahead of the chilled water coil shall stop the supply fan, return system components to their fail-safe position, and initiate a low-temperature alarm if the temperature at any point of the sensing element falls below the setpoint. Normal operation will occur only after the freezing condition is corrected and the freezestat is manually reset.

f) Supply Fan Discharge Air Mode: A dry bulb temperature sensor located in the supply air fan discharge air shall, on a rise in temperature, first gradually close the preheat coil valve, next gradually open the outside air damper from its minimum ventilation air position while simultaneously gradually close the return air damper (ensure thorough mixing) and gradually open the exhaust air damper, and then gradually open the chilled water coil valve. A dry bulb temperature low limit sensor located in the mixed air (ensure thorough mixing) shall, on a fall in temperature, gradually open the preheat coil valve. An outdoor air dry bulb sensor disables the economizer cycle and maintains minimum ventilation air when the outside air dry bulb temperature exceeds the changeover point.

g) Supply Duct Static Pressure Mode: A supply duct static pressure sensor located two-thirds the distance from the fan of the length of the longest supply duct run shall, on a rise in static pressure, gradually reduce the speed of the electric motor variable speed drive and close the fan vortex damper. A high-limit duct static pressure sensor located at the fan discharge shall override the supply duct static pressure sensor to limit pressures to design values.

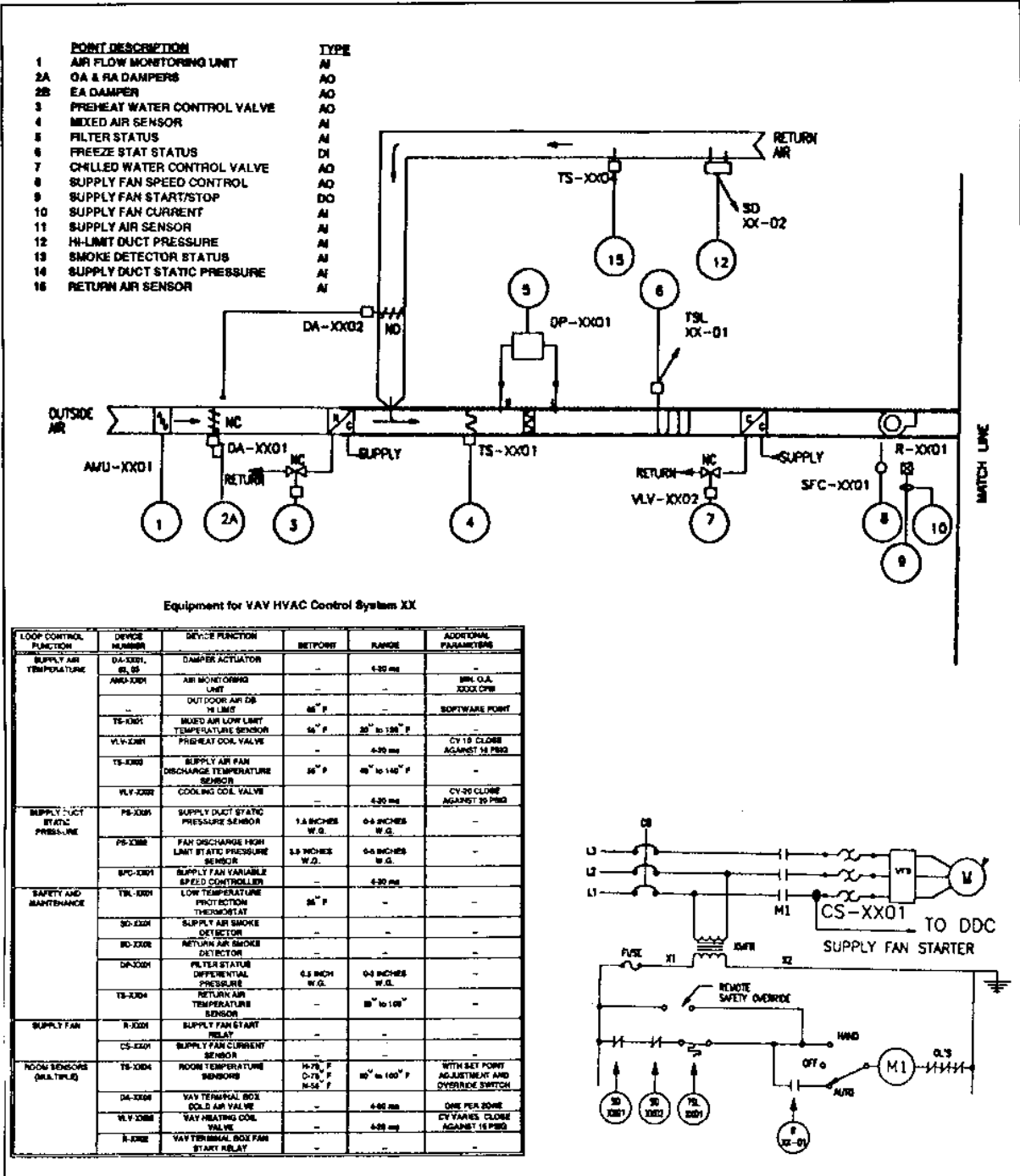


Figure 35  
Control System Schematic for VAV HVAC System XX



Table 17  
Equipment for VAV HVAC Control System XX

| LOOP CONTROL FUNCTION       | DEVICE NUMBER   | DEVICE FUNCTION                                 | SETPOINT     | RANGE        | ADDITIONAL PARAMETERS       |
|-----------------------------|-----------------|---|--------------|--------------|-----------------------------|
| SUPPLY AIR TEMPERATURE      | DA-XX01, 02, 03 | DAMPER ACTUATOR                                 | --           | 4-20 ma      | --                          |
|                             | AMU-XX01        | AIR MONITORING UNIT                             | --           | --           | MIN. O.A. XXXX CFM          |
|                             | --              | OUTDOOR AIR DB HI LIMIT                         | 65° F        | --           | SOFTWARE POINT              |
|                             | TS-XX01         | MIXED AIR LOW LIMIT TEMPERATURE SENSOR          | 55° F        | 30-130° F    | --                          |
|                             | VLV-XX01        | PREHEAT COIL VALVE                              | --           | 4-20 ma      | CV-10 CLOSE AGAINST 16 PSIG |
|                             | TS-XX02         | SUPPLY AIR FAN DISCHARGE TEMPERATURE SENSOR     | 55° F        | 40-140° F    | --                          |
|                             | VLV-XX02        | COOLING COIL VALVE                              | --           | 4-20 ma      | CV-20 CLOSE AGAINST 20 PSIG |
| SUPPLY DUCT STATIC PRESSURE | PS-XX01         | SUPPLY DUCT STATIC PRESSURE SENSOR              | 1.5 IN. W.G. | 0-5 IN. W.G. | --                          |
|                             | PS-XX02         | FAN DISCHARGE HIGH LIMIT STATIC PRESSURE SENSOR | 3.5 IN. W.G. | 0-5 IN. W.G. | --                          |
|                             | SFC-XX01        | SUPPLY FAN VARIABLE SPEED CONTROLLER            | --           | 4-20 ma      |                             |
| SAFETY & MAINTENANCE        | TSL-XX01        | LOW TEMPERATURE PROTECTION THERMOSTAT           | 35° F        | --           | --                          |

Table 17 (Continued)  
Equipment for VAV HVAC Control System XX

| LOOP CONTROL FUNCTION         | DEVICE NUMBER | DEVICE FUNCTION                     | SETPOINT                      | RANGE        | ADDITIONAL PARAMETERS                      |
|-------------------------------|---------------|-------------------------------------|-------------------------------|--------------|--|
| SAFETY & MAINTENANCE (CONT'D) | SD-XX01       | SUPPLY AIR SMOKE DETECTOR           | --                            | --           | --   |
|                               | SD-XX02       | RETURN AIR SMOKE DETECTOR           | --                            | --           | --   |
|                               | DP-XX01       | FILTER STATUS DIFFERENTIAL PRESSURE | 0.5 IN. W.G.                  | 0-2 IN. W.G. | --   |
|                               | TS-XX04       | RETURN AIR TEMPERATURE SENSOR       | --                            | 50-100° F    | --   |
| SUPPLY FAN                    | R-XX01        | SUPPLY FAN START RELAY              | --                            | --           | --   |
|                               | CS-XX01       | SUPPLY FAN CURRENT SENSOR           | --                            | --           | --   |
| ROOM SENSORS (MULTIPLE)       | TS-XX04       | ROOM TEMPERATURE SENSORS            | H-70° F<br>C-76° F<br>N-55° F | 50-100° F    | WITH SETPOINT ADJUSTMENT & OVERRIDE SWITCH |
|                               | DA-XX04       | VAV TERMINAL BOX COLD AIR VALVE     | --                            | 4-20 ma      | ONE PER ZONE                               |
|                               | VLV-XX03      | VAV HEATING COIL VALVE              | --                            | 4-20 ma      | CV VARIES CLOSE AGAINST 16 PSIG            |
|                               | R-XX02        | VAV TERMINAL BOX FAN START RELAY    | --                            | --           | --   |

h) Room Control Mode: A room type dry bulb temperature sensor located in the most critical spot shall, on a rise in dry bulb temperature in the space, gradually open the VAV terminal box cold air valve.

## 8.6 Commissioning Procedures

8.6.1 Functional Performance Test. Participate in the functional performance test as described in ASHRAE Guideline 1.

Verify and document the performance of the control system as required by the Commissioning Plan prepared by the Commissioning Authority. Final positions of manual balancing dampers and valves shall be marked on the device. Permanently record, on system equipment schedule, the final setting of controller proportional, integral, and derivative constant settings in units and terminology specific to the controller. This will become part of the O&M manual.

8.6.2 Preparation for Acceptance Testing. Execute a detailed static and functional checkout procedure to ensure that systems are ready for functional performance testing.

8.6.3 System Static Checkout

8.6.3.1 Observation. Provide a detailed inspection to assure that all equipment is properly mounted, sensors are properly installed and connected, control devices are properly installed, and controllers and control devices are properly connected.

8.6.3.2 Calibration. Check, verify, and calibrate all sensors including those sensors that are "factory calibrated." Perform a two-point accuracy check of the calibration of each HVAC control system sensing element by comparing the HVAC controller readout to the actual value of the variable measured at the sensing element or airflow measurement station location. Use digital indicating test instruments, such as digital thermometers, motor-driven psychrometers, and tachometers. Test instruments shall be at least twice as accurate as the specified sensing element-to-controller readout accuracy. Calibration of test instruments shall be traceable to National Institute of Standards and Technology (NIST) standards. In the shutdown condition, calibration checks shall verify that the sensing element-to-controller readout accuracies at two points are within the specified product accuracy tolerances. If not, re-calibrate or replace the inaccurate device and repeat the calibration check.

a) Check insertion temperature and immersion temperature sensing element and transmitter-to-controller readout calibration accuracy at one physical location along the axis of the sensing element.

b) Check averaging temperature sensing element and transmitter-to-controller readout calibration accuracy every 2 feet along the axis of the sensing element in the proximity of the sensing element, for a maximum of 10 readings. Then average these readings.

c) Verify space type sensors by placing the test instrument as close as possible to the sensor to measure identical conditions. Maintain the test for a sufficient length to ensure achieving stable conditions.

#### 8.6.3.3 Operation

a) Each controller shall be configured for its specified service. Verify each sequence of operation for each HVAC system and subsystem. Verify that each controlled device responds to the proper controller, in the proper manner, and at the proper time. Verify the fail-safe position for each component of the system.

b) Set the time schedule of controllers in accordance with the sequence of operation and the established time schedule.

8.6.4 System Dynamic Checkout. Perform weather-dependent test procedures that cannot be performed by simulation in the appropriate climatic season. When simulation is used, verify the actual results in the appropriate season.

a) Use the controllers' manual-automatic switches as the means of manipulating control devices such as dampers and valves to check operation and to effect stable conditions, prior to making measurement checks.

b) Perform a controller tuning procedure, which shall consist of setting the initial proportional, integral, and derivative (PID) mode constants, controller setpoints, and logging the settings. Tuning shall be self-tuning operation by the controller unless manual tuning is necessary.

8.6.4.1 Controller Manual-Tuning Procedure. A controller manual tuning procedure is described in three steps using a constant temperature setpoint controller as an example.

a) Step 1. This step shall consist of the following:

(1) Index the controller manual-automatic switch to the automatic position, and set the integral and derivative mode constants to zero.

(2) Set the proportional mode constant to an initial setting of 8 percent. This corresponds to a 2.0 ma per degree F or a 1.5 psig per degree F proportional controller output change for a 100-degree F span. This causes the controller output signal to vary from zero output to full output for an input signal change representing an 8-degree F change.

(3) Controllers for other variables, such as relative humidity and static pressure, shall have their proportional mode constants set initially in a similar manner for an achievable output range proportional to the transmitter span.

b) Step 2. This step shall consist of the following:

(1) Set the controller temperature setpoint at any achievable temperature. Observe the controller output and transmitter input.

(2) If the transmitter input continuously oscillates above and below the setpoint without settling at a fixed value, or if such oscillation increases, the proportional mode constant is too small.

(3) If the proportional mode constant is too small, increase it in steps until the transmitter input indicates stable control at any temperature, if the controller output is not at either extreme of the output range.

(4) If the temperature control point slowly drifts toward or away from the controller setpoint, the proportional mode constant is too large. Decrease its setting in steps until oscillations occur as described in the preceding paragraphs, and then increase the setting until stable control occurs.

(5) Introduce a step change in controller setpoint. This should cause the controller to overshoot the setpoint slightly, with each subsequent overshoot peak value decreasing by a factor of two-thirds until stable control is achieved at, above, or below the setpoint.

(6) Increase the integral mode constant setting in small steps, and introduce setpoint changes until control point and controller setpoint coincide at stable control. This should happen consistently after a setpoint change within a short time, such as 5 to 10 minutes.

c) Step 3. This step shall consist of the following:

(1) Unless the HVAC process variable changes rapidly, the derivative mode constant setting can remain at zero. This is usually the case for most HVAC applications.

(2) If derivative control is needed, gradually increase the derivative mode constant.

(3) Introduce step changes in controller setpoint, and adjust the derivative mode constant setting until stable control is achieved.

d) Step 4. After the controller manual tuning procedure is complete, set the controller at the predetermined setpoint in the design drawings.

#### 8.6.5 Procedures for Single Zone Control System (Sample)

a) System Inspection. Observe the HVAC system in its shutdown condition. Check to see that power (and main air) is (are) available for the HVAC system control devices. Check to see that the outside air damper, relief air damper, heating coil valve, and cooling coil valve are closed, and that the return air damper is open. Check to see that the preheat coil valve is being controlled by the mixed air low limit controller.

b) Calibration Accuracy Check. Check with HVAC system in the shutdown condition. Take readings with a digital thermometer at each temperature sensing element location. Read each controller display, and log the thermometer and controller display readings. Check the calibration accuracy of the sensing element to controller readouts for outside air, return air, mixed air, and supply air temperatures.

c) Actuator Range Adjustments. Apply a signal to each actuator, by placing the controller manual-automatic switch in the manual position. Verify visually the proper operation of the actuators for dampers and valves. Vary the signal from 4 ma (or 3 psig) to 20 ma (or 15 psig), and verify that the actuators travel from zero stroke to full stroke within the signal range. Observe that sequenced and parallel operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other. Example: Normally closed actuators are closed at 4 ma (or 3 psig) and are open at 20 ma (or 15 psig). Log the signal levels that move the controlled device to its extreme positions.

#### d) Control System Startup

(1) With the fan ready to start, apply the optimized start mode command, and observe that the designated supply fan starts. Observe that the outside air and relief air dampers are closed, the return air damper is open, and the heating coil valve and preheat coil valve (cooling coil valve) are in the warm up (cool down) position. Change the command to occupied mode and observe that the outside air damper, return air

damper, relief air damper, heating coil valve, preheat coil valve, and chilled water valve are in control, by changing the controller output.

(2) Apply the minimum outside air mode signal. Observe that the outside air damper opens to the minimum position.

(3) Index the mixed air low limit temperature controller manual-automatic switch to the manual position. Perform the two-point calibration accuracy check of sensing element-to-controller readout. Index the mixed air low limit temperature controller manual-automatic switch to the automatic position. Change the controller output to open the preheat coil valve slightly. Perform the controller tuning procedure. Set the controller at the predetermined temperature setpoint. Apply the economizer mode input signal, and observe that the outside air, return air, and relief air dampers are under control. Index the supply air low limit temperature controller manual-automatic switch to the manual position. Perform the two-point calibration accuracy check of sensing element-to-controller readout. Index the supply air low limit temperature controller manual-automatic switch to the automatic position. Change the controller output to open the heating coil valve slightly. Perform the controller tuning procedure. Set the controller at the predetermined temperature setpoint. Index the room temperature controller manual-automatic switch to the manual position, and perform the two-point calibration accuracy check of sensing element-to-controller readout. Index the controller manual-automatic switch to the automatic position, and perform the controller tuning procedure. Set the controller at the temperature setpoint as shown.

(4) Apply an unoccupied mode signal, and observe that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. Raise the night thermostat temperature setting and observe that the HVAC system starts. Lower the setting and observe that the HVAC system stops. Set the night thermostat at the predetermined setting.

(5) With the HVAC system running, simulate a filter differential pressure switch input signal at the device. Observe that the filter alarm is activated. Set the differential pressure switch at the predetermined setpoint.

(6) With the HVAC system running, simulate a low temperature condition at the freezestat. Observe HVAC system shutdown and that the low temperature alarm is activated. Set

the thermostat at the predetermined setpoint. Restart the HVAC system by manual reset, and observe that the alarm is deactivated.

(7) With the HVAC system running, simulate a smoke detector trip input signal at each detector, and observe and verify operation as described in the sequence of operation. Perform simulation without false-alarms any life safety systems. Observe that the HVAC system shuts down and the alarm is activated. Reset the detectors. Restart the HVAC system by manual reset, and observe that the alarm is deactivated.

#### 8.6.6 Procedures for Multizone Control System (Sample)

a) System Inspection. Observe the HVAC system in its shutdown condition. Check to see that power (and main air) is (are) available for the HVAC system control devices. Check to see that the outside air damper, relief air damper, heating coil valve, and cooling coil valve are closed, and that the return air damper is open. Check to see that the preheat coil valve is being controlled by the mixed air low limit controller.

b) Calibration Accuracy Check. Check with the HVAC system in the shutdown condition: take readings with a digital thermometer at each temperature sensing element location; read each controller display, and log the thermometer and controller display readings; and check the calibration accuracy of the sensing element to controller readouts for outside air, return air, mixed air, cold deck air, and hot deck air temperatures.

c) Actuator Range Adjustments. Apply a signal to each actuator by placing the controller manual-automatic switch in the manual position. Verify visually the proper operation of the actuators for dampers and valves. Vary the signal from 4 ma (or 3 psig) to 20 ma (or 15 psig), and verify that the actuators travel from zero stroke to full stroke within the signal range. Observe that sequenced and parallel operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other. Example: Normally closed actuators are closed at 4 ma (or 3 psig) and are open at 20 ma (or 15 psig). Log the signal levels that move the controlled device to its extreme positions.

#### d) Control System Startup

(1) With the fan ready to start, apply the optimized start mode command, and observe that the designated supply fan starts. Observe that outside air and relief air

dampers are closed, the return air damper is open, and the heating coil valve and preheat coil valve (cooling coil valve) are in the warm-up (cool down) position. Change the command to occupied mode and observe that the outside air damper, return air damper, relief air damper, heating coil valve, preheat coil valve, and chilled water valve are in control, by changing the controller output.

(2) Apply the minimum outside air mode signal. Observe that the outside air damper opens to the minimum position.

(3) Index the cold deck coil temperature controller manual-automatic switch to the manual position, and perform the two-point calibration accuracy check of sensing element-to-controller readout. Index the controller manual-automatic switch to the automatic position, and perform the controller tuning procedure. Set the controller at the temperature setpoint as shown. Index the mixed air low limit temperature controller manual-automatic switch to the manual position. Change the controller output to open the preheat coil valve slightly. Perform the two-point calibration accuracy check of sensing element-to-controller readout for outside air, return air, and mixed air temperatures. Index the mixed air low limit temperature controller manual-automatic switch to the automatic position. Apply the economizer mode input signal, and observe that the outside air, return air, and relief air dampers are under control. Perform the controller tuning procedure. Set the controller at the predetermined temperature setpoint.

(4) Apply an unoccupied mode signal, and observe that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. Raise the night thermostat temperature setting and observe that the HVAC system starts. Lower the setting and observe that the HVAC system stops. Set the night thermostat at the predetermined setting.

(5) With the HVAC system running, simulate a filter differential pressure switch input signal at the device. Observe that the filter alarm is activated. Set the differential pressure switch at the predetermined setpoint.

(6) With the HVAC system running, simulate a low temperature condition at the freezestat. Observe HVAC system shutdown and that the low temperature alarm is activated. Set the thermostat at the predetermined setpoint. Restart the HVAC system by manual reset, and observe that the alarm is deactivated.

(7) With the HVAC system running, simulate a smoke detector trip input signal at each detector, and observe and verify operation as described in the sequence of operation. Perform simulation without false-alarmed any life safety systems. Observe that the HVAC system shuts down and the alarm is activated. Reset the detectors. Restart the HVAC system by manual reset, and observe that the alarm is deactivated.

(8) Raise the temperature setpoint of each room thermostat and observe that the zone damper closes to the cold deck and opens to the hot deck. Calibrate the room thermostat of each zone. Set each room thermostat at its predetermined setpoint.

#### 8.6.7 Variable Air Volume Control System (Sample)

a) System Inspection. Observe the HVAC system in its shutdown condition. Check to see that power (and main air) is (are) available for the HVAC system control devices. Check to see that the outside air, relief air dampers, heating coil valve, and cooling coil valve are closed, and the return air damper is open. Check to see that the preheat coil valve is being controlled by the mixed air low limit controller.

b) Calibration Accuracy Check With HVAC System in Shutdown Condition. Take readings with a digital thermometer at each temperature sensing element location. Read each controller display, and log the thermometer and controller display readings. Check the calibration accuracy of the sensing element-to-controller readout for outside air, return air, mixed air, and cooling coil discharge air temperatures.

c) Actuator Range Adjustments. Apply a signal to each actuator by placing the controller manual-automatic switch in the manual position. Verify visually the proper operation of the actuators for dampers and valves. Vary the signal from 4 ma (or 3 psig) to 20 ma (or 15 psig), and verify that the actuators travel from zero stroke to full stroke within the signal range. Observe that sequenced and parallel operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other. Example: Normally closed actuators are closed at 4 ma (or 3 psig) and are open at 20 ma (or 15 psig). Log the signal levels that move the controlled device to its extreme positions.

d) Control System Startup

(1) With the fan ready to start, apply the optimized start mode command, and observe that the designated supply fan starts. Observe that the outside air damper and relief air damper are closed, the return air damper is open, and the heating coil valve and preheat coil valve (cooling coil valve) are in the warm-up (cool down) position. Change the command to occupied mode and observe that the outside air damper, return air damper, relief air damper, heating coil valve, preheat coil valve, and chilled water valve are in control, by changing the controller output.

(2) Apply the minimum outside air mode signal. Observe that the outside air damper opens to its minimum position.

(3) With the supply fan running, simulate a high static pressure input signal at the device by pressure input to the sensing device. Observe HVAC system shutdown and that the high pressure alarm is activated. Restart the HVAC system by manual reset, and observe that the high static pressure alarm is deactivated.

(4) Index the supply fan static pressure controller manual-automatic switch to the manual position and perform a two-point accuracy check of sensing element-to-controller readout. Place the controller in the local setpoint mode. Index the controller manual-automatic switch to the automatic position, and perform the controller tuning procedure. Set the controller at the specified static pressure setpoint, and log the mode constant setpoints.

(5) Index the supply air temperature controller manual-automatic switch to the manual position, and perform the two-point calibration accuracy check of sensing element-to-controller readout. Index the controller manual-automatic switch to the automatic position, and perform the controller tuning procedure. Set the controller at the temperature setpoint as shown. Index the mixed air low limit temperature controller manual-automatic switch to the manual position. Change the controller output to open the preheat coil valve slightly. Perform the two-point calibration accuracy check of sensing element-to-controller readout for outside air, return air, and mixed air temperatures. Index the mixed air low limit temperature controller manual-automatic switch to the automatic position. Apply the economizer mode input signal, and observe that the outside air, return air, and relief air dampers are under control. Perform the controller tuning procedure. Set the controller at the predetermined temperature setpoint.