

MicroNet LONMARK® 200 Series Controllers

The I/A Series MicroNet LONMARK 200 Series Controllers MN 200 is an interoperable, LONMARK-certified controllers. Controllers are loaded with a pre-engineered application, that provides control for Magic Aire unit ventilators. Controllers feature Sensor Link (S-Link) support, LED indication, screw terminal blocks and are panel mounted in the left end compartment. These controllers can function in either standalone mode or as part of a LONWORKS® FTT-10 Free Topology communications network that must be field provided.



Applications

Designed for new or existing system installations, the MN controller provides control for:

- Unit Ventilators

Connectivity

Features —

- Field programmable using WorkPlace Tech Tool.
- Uses LONMARK HVAC profiles for interoperability.
- Capability to function in standalone mode or as part of a LONWORKS FTT-10 Free Topology communications network.
- Multiple controllers on a LonWorks FTT network creates a complex network of controllers for virtually any building control needs.
- Proportional (P) damper control and Proportional Plus Integral (PI) for heating and cooling control., and Proportional Plus Integral and Derivative (PID) control for cooling and heating.
- Onboard LED indication without cover removal.
- Plenum-rated enclosure allows direct mounting in plenum.
- Protective hinged covers provide access to field wiring terminals.

Hardware Specifications

Dimensions 4 5/16" high x 4 3/8" wide x 2" deep (109 mm x 111 mm x 51 mm).

Enclosure Conforms to NEMA-1 requirements. Meets UL94-5V flammability for plenum application use.

Power Supply Input 20.4 to 30 Vac, 50/60 Hz.

Maximum Power Consumption 15 VA @ 24 Vac, 50/60 Hz, excluding relay output power.

Controllers offer the advantages of standalone and networked control. Using an I/A Series MicroNet Sensor (MN-SX series), the operator can monitor controller performance and edit operational values.

The WorkPlace Tech Tool software is used to program the controllers.

Surge Immunity Compliance

ANSI C62.41 (IEEE-587, Category A & B).

Agency Listings

FCC, Class B.

UL Listed

UL-916 (File # E71385 Category PAZX).

UL Listed to Canadian Safety Standards (CAN/CSA C22.2).

European Community – EMC Directive

Emissions EN50081-1.

Immunity EN50082-1.

Mounting 35 mm DIN rail or panel.

Ambient Limits Operating Temperature -40 to 140 °F (-40 to 60 °C).

Shipping and Storage Temperature -40 to 160 °F (-40 to 71 °C).

Humidity 5 to 95% RH, non-condensing.

Wiring Terminals Screw terminals.

AWG #16 to #24 (1.5 mm² maximum) wire.

Inputs (from I/A Series MicroNet Sensors)

Space Temperature 32 to 122 °F (0 to 50 °C).

Adjustable Setpoints 40 to 95 °F (4.4 to 35 °C).

Override Pushbutton For standalone occupancy control or remote status monitoring of local status condition.

Digital Inputs Dry Contact.

Detection of closed switch requires less than 300 ohms.

Detection of open switch requires more than 100K ohms.

Digital Outputs

Current Ratings 24 VA at 24 Vac, pilot duty.

Universal Inputs

10KW Thermistor w/ 11KW Shunt Resistor -40 to 250 °F (-40 to 121 °C) range. TS-5700-850 or equivalent.

Voltage 0 to 5 Vdc.

Current 0 to 20 mA requires an external 500 ohm shunt resistor.

Digital Input Dry Contact. Detection of closed switch requires less than 300 ohm. Detection of open switch requires more than 1.5K ohm.

Analog Outputs

Current 0 to 20 mA. (Output load from 80 to 550 ohms).

Software Capabilities

- LONMARK-compatible.
- HVAC interoperability achieved through use of LONMARK HVAC profiles.
- Pre-packaged factory installed software customized for optimum unit operation.

Communications

LONWORKS Networks A LONWORKS communications network uses an FTT-10 Free Topology configuration. Controllers on a LONWORKS network can communicate with each other in a peer-to-peer fashion, and connect to the WorkPlace Tech Tool software platforms via the LON Jack on any LonMark controller or on any MN-Sx sensor. The wall sensor must be connected to the LON network. A LONWORKS network has a communications speed of 78k baud, using unshielded, twisted-pair cabling.

S-Link A Sensor Link (S-Link) communications wiring provides power and communication interface to the I/A Series MicroNet sensor (MN-SX series). It uses two-wire, unshielded cable and is not polarity sensitive. From some sensor models, the user can view and adjust application parameters. Maximum wire length allowed between a controller and the I/A Series MicroNet Sensor is 200 ft. (61 m).

In a continuing effort toward product improvement the following

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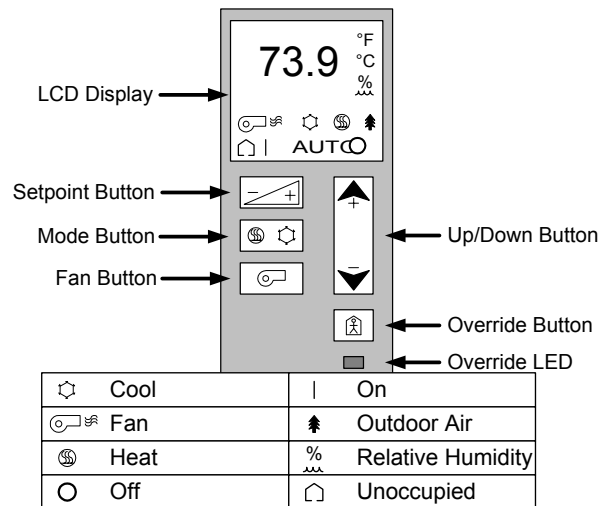
1) Dual-Mount Thermostat (Wall Thermostat)

A) Use

The dual-mount thermostat or "wall 'stat" is factory mounted in the unit for setpoint adjustment and diagnostics. As factory wired, this thermostat is NOT used to sense temperature. This thermostat may be removed from the unit and remotely mounted. In the remote location, the thermostat may be used for setpoint adjustment and diagnostics, but it can also be used to sense the space temperature. See Section 1-E for mounting details and instructions on using this thermostat to sense space temperature.

B) Keypad Layout and Display Icons

Figure 1 - Buttons & Icons



C) Adjusting Setpoints

The Mode Button and Fan Button are not used.

The setpoint button is used in conjunction with the up/down button to set one of four setpoints. Press the setpoint button once to get the first setpoint, twice for the second setpoint, etc. Use the up/down button to increase/decrease the setpoint value. The setpoints are:

Setpoint #	Point	Range	Default	Icons Displayed
1	Space Setpoint	65 - 85 °F	74 °F	°F
2	Unoccupied Offset	0 - 15 °F	5 °F	°F, Unoccupied
3	Minimum Position	0 - 100 %	10 %	%, Cool
4	Deadband	1.5-3 °F	2 °F	°F

- (1) Space Setpoint - Used to calculate the heating and cooling setpoints.
- (2) Unoccupied Offset - Used to calculate the unoccupied heating and cooling setpoints. This value is added to the cooling setpoint and subtracted from the heating setpoint.
- (3) Minimum Position - sets the minimum position of the outdoor air damper in terms of damper actuator position. Value is used only in occupied mode.
- (4) Deadband - offset value used calculate the heating and cooling setpoints.

Occupancy Offset = 0°F in occupied mode and Unoccupied Offset in unoccupied mode.

Heating setpoint = Space Setpoint - Deadband - Occupancy Offset. Cooling setpoint = Space Setpoint + Deadband + Occupancy Offset.

D) Unoccupied Override

A single press of the override button is used to provide a 2 hour unoccupied override. The override LED is lit during override. The occupancy override may be canceled by pressing the override button for more than 4 seconds, but less than 8 seconds.

E) Remote Mounting (Wall Mounting)

The dual-mount thermostat is factory mounted on the control panel. This thermostat may be mounted in the space for setpoint control and to sense the space temperature. This thermostat may be mounted directly to a wall, a 2x4 electrical box, a 1/4 DIN electrical box, or a surface mount electrical box.

The sensor link (S-LK) wiring requires at least 24 gauge, twisted pair, voice grade telephone wire. Shielded wire is not required; however, this cable type is recommended. The maximum wire length is 200 ft. The capacitance between conductors cannot be more than 32 pF per foot. If shielded cable is used, the capacitance between any one of the conductors and the other conductors (connected to the shield) cannot exceed 60 pF per foot.

The sensor link wiring and any LON network wiring, must have dedicated wire pairs. These wire pairs must not be part of an active, bundled telephone trunk. The sensor link wiring and LON wiring should not be routed with any Class 1 power wiring. The sensor link wiring may be routed with any of the low voltage controller wiring, including LON. LON wiring must not be routed with any of the low voltage controller wiring, except the sensor link wires.

The thermostat subbase provides terminals for the sensor link wiring and LON network wiring. These terminals are used connect the LON jack on the subbase to the LON network. The thermostat does not connect to the LON network. If these optional terminals are used with shielded wire, the shield should be connected to the shield of the network conductors at the controller. The LON network shield must be connected to earth ground through a 470-ohm resistor at only one end of the network.

To remotely mount the thermostat:

- (1) Disconnect Unit power.
- (2) Unsnap the thermostat faceplate from the subbase. Remove the thermostat faceplate by placing the thumb in the center of the thermostat and pulling on the top edge of the plate.
- (3) Unscrew the two small screws that secure the thermostat to the subbase.
- (4) Disconnect the yellow S-LK wires from the S-LK terminals of the unit controller and from terminals 1 and 2 of the subbase.
- (5) Remove the two screws that hold the subbase to the controller mounting plate.
- (6) Move the subbase to the mounting location and feed the sensor link (S-LK) and LON wires (if used) through the back of the subbase.
- (7) Mount the subbase. The wiring terminals should be at the top end of the subbase. For direct wall-mount, 2x4 box mount, and surface mount boxes, use mounting holes 1 and 3. For 1/4 DIN boxes, uses mounting holes 1 and 2. See Figure 2. Use the appropriate flathead screws, such as 6-32 x 5/8", to attach the subbase to the box or wall. When attaching to directly to drywall, use anchors as necessary.
- (8) The sensor link wires (S-LK or U-link) connect to subbase terminals 1 and 2; these wires are not polarity sensitive. If used, the LON wires connect subbase terminals 3 and 4; these wires are not polarity sensitive. Connect the S-LK wires to the S-LK terminals of the controller. If used, connect the LON wires to the LON terminals of the controller.
- (9) Push the excess wire back through the subbase and insulate the opening to minimize air drafts from an unconditioned space.
- (10) Hold the t'stat with the display out and oriented towards the top of the t'stat. Set the t'stat circuit board so that the bottom edge is captured by the mounting hooks near the bottom of the subbase.
- (11) Secure the t'stat to the subbase by tightening the two small screws near the top, outer edge of the t'stat.
- (12) Snap the faceplate back onto the t'stat. Snap in the bottom edge first and then the top edge.
- (13) If using the t'stat to detect space temperature, disconnect the unit mounted room air temperature sensor (RAT) from the controller (terminals UI1 and COM).
- (14) Apply unit power and verify t'stat operation.

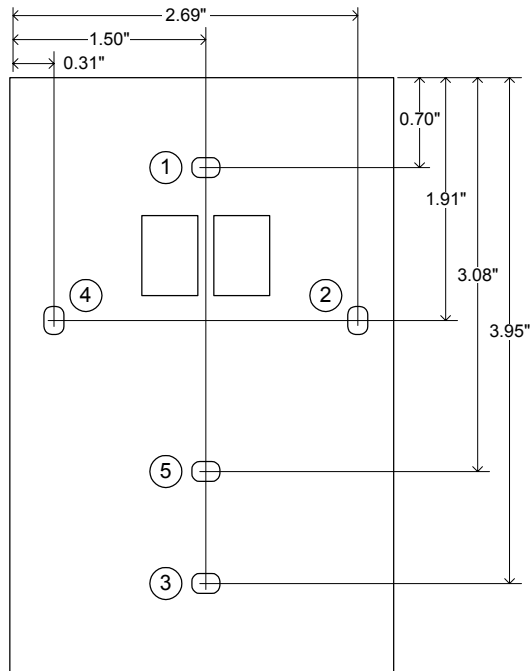


Figure 2 - Subbase Mounting Holes & Dimensions

F) Thermostat Accessories

The following accessories are not offered from the factory, but can be purchased from Invensys Building Systems.

- (1) Thermostat Locking Cover - When a locking cover is required for a dual-mount thermostat that is mounted in the space, Invensys part AT-1155 may be used.
- (2) Thermostat Guard - When a thermostat guard (non-locking) is required for a dual-mount thermostat, Invensys parts AT-1104 (Cast Aluminum) and AT-1163 (Wire Guard) may be used.
- (3) Remote Space Temperature Sensor - This sensor may be field wired in place of the factory mounted room air sensor (RAT). Unlike the dual-mount thermostat (which remains in the unit), this sensor does not allow setpoint adjustments nor does it provide a display. This is Invensys part TSMN-57011-850.

2) Discharge Air, Outdoor Air, and Room Air Sensors

A) Description

The discharge air, outdoor air, and room air sensors use a 2-wire, 10K-thermistor element with an 11K shunt. These sensors have a maximum error rate of +/- 0.36°F over 32° to 158°F. These sensors have a maximum drift of 0.045°F per year, over the 32° to 158°F temperature range.

B) Sensor Location

The discharge air temperature (DAT) sensor is located in the discharge air stream. On some units, this sensor is mounted in the discharge of the left most blower scroll. On later model units, this sensor is mounted behind the "front" access panel, with the sensor located between the coil and a fan inlet.

The outdoor air temperature (OAT) sensor is located on the left-end of the unit. This sensor projects into the outdoor air stream, immediately upstream of the outdoor air damper.

The room air temperature sensor (RAT) is located behind the decorative room air grille in "front" access panel. This sensor is mounted near the room air intake hole on the blower section. It is important that this sensor remain outside the blower compartment.

C) Measurement & Scale

At least one of the sensor wires must be disconnected from the controller before resistance measurements are taken. A digital multimeter or other low voltage ohmmeter may be used to measure the sensor resistance.

Important: Units with water/steam coils are equipped with a low limit thermostat. This thermostat is wired in parallel with the outdoor air temperature sensor, such that the sensor is shorted when the thermostat closes for low limit conditions.

Nominal Temperature vs. Resistance

°C	°F	Ohms
-40	-40	10517
-30	-22	10172
-20	-4	9654
-10	14	8933
0	32	8044
10	50	6938
20	68	5798
25	77	5238
30	86	4696
40	104	3707
50	122	2875
60	140	2206
70	158	1685
80	176	1287
90	194	986
100	212	760
110	230	590
120	248	462

D) Sensor Calibration

Out of range sensors must be replaced, as these sensors cannot be calibrated.

E) Sensing Room Temperature - Wall Thermostat vs. Room Air Temp. Sensor

These units are factory configured to use the room air temperature sensor (RAT) as the space temperature control point. The controller will use one of three inputs as the space temperature value. The first valid input, ordered as shown below, will be used as the space temperature input.

- (1) LON network (nviSpaceTemp) - If the controller is connected to a LON network and this point is bound to a valid temperature, then this temperature shall be used as the space temperature input.
- (2) Room Air Temperature Sensor (RAT) - shall be used as the space temperature input if there is no network input.
- (3) Dual-Mount Thermostat (Wall t'stat) shall be used as the space temperature input, if the room air sensor input is not valid. The RAT sensor MUST be disconnected to allow the wall t'stat to sense room temperature.

3) System Diagnostics

A) Sensor Diagnostics with Display Points - Preferred Method

The display on the dual mount thermostat can be used to verify the unit controller is receiving an accurate temperature signal. This is the preferred method for verifying the operation of the temperature sensors, since the actual sensor values are displayed. A damaged sensor may provide an input that is within the allowable range of temperatures, but may be far from the true temperature.

The up and down keys of the thermostat can be used to view four controller points. The four points are (1) Space Temperature, (2) Discharge Air Temperature, (3) Outdoor Air Temperature, and (4) Outdoor Air damper position. A display value of "ABn" indicates that the sensor input is out of the allowed range (ABnormal). See Section 1 for details on the thermostat.

- (1) Space Temperature is the default display value. This value is obtained from one of three sources: LON Network, Room Air Temperature Sensor, and the dual mount thermostat.
- (2) The discharge air temperature is the value returned from the discharge air temperature sensor.
- (3) The outdoor air temperature is the value returned from the outdoor air temperature sensor.

- (4) The outdoor air damper position returns the percentage of full-scale output (20mA) being sent through the proportionally controlled actuator. Unlike the other display points, this is not a sensed value. This represents the percentage output of the control algorithm.

B) Display of Controller Diagnostics with dual-mount thermostat

This method will detect sensors that are out of the allowable scale, but it cannot detect a sensor that is out of calibration. This method requires inputs from the dual mount thermostat; see Section 1 for thermostat details, such as keypad layout. These diagnostics provide the following data: (1) Subnet Address; (2) Node Address; (3) Errors; (4) Alarms; (5) Temperature Offset; and (6) Relative Humidity Offset. Instructions on how to get to the diagnostic screen follow the explanation of diagnostic values.

- (1) Subnet Address - display indicates "Add" then displays the numerical value of the subnet address.
- (2) Node Address - display indicates "nod" then displays the numerical value of the node address.
- (3) Errors - The error displays the value of any current errors detected by the controller. The display indicates "Err" then displays a numerical code representing all the current errors. If the controller detects no errors, "---" is displayed instead of a numerical code. A single error code is used to display all errors. When the controller detects multiple errors, the error code is the sum of all current error codes. For example, if the controller detects errors 2, 4, and 8, error code 14 is displayed. The following table provides a list of the single error codes and suggested actions for each.

Code	Condition	Resolution Path
---	No Errors.	
1	EEPROM error	Test Controller
2	RAT sensor out of Range★	Test RAT sensor - See Section 2★
4	DAT sensor out of Range	Test DAT sensor - See Section 2
8	OAT sensor out of Range	Test OAT sensor - See Section 2
16	Analog Output Error	Test Controller
32	Calibration Error	Test Controller

★This error condition is normal when the dual-mount thermostat is used to detect room temperature.

When an EEPROM error, Analog Output Error, or Calibration Error is detected, reset the controller by removing power for 15 seconds. If the error condition remains when power is re-applied to the controller, the controller is internally damaged and must be replaced.

- (4) Alarms - This code shows the error codes for the last four alarms reported by the controller. This feature is not supported.
- (5) Temperature Offset - This value adds an offset of -99 to 99°F to temperature value reported by the dual-mount thermostat. This value has no effect on the temperature reported by the room air sensor (RAT) sensor or a network space temperature value.
- (6) Humidity Offset - This value is NOT USED.

C) Initiating Controller Self-Diagnostics.

- (1) To initiate the diagnostics display, press both ends of the up/down key for 4 seconds. When diagnostics are initiated, the thermostat will display the address codes.
- (2) Press the UP/Down Key to scroll through the Address, Errors, and Alarms in this mode.
- (3) Press the Override key to display the Temperature Offset value. Use the Up/Down Key to adjust this value.
- (4) Press the Override key again to display to Humidity Offset value.
- (5) Press the Override key again to return to the Address, Errors, and Alarms display.
- (6) Press both ends of the up/down key to return to the normal display screen. The sensor will automatically return to the normal display screen if the keypad is idle for 30 seconds.

D) Controller Lights (LEDs)

The controller is equipped with 3 LEDs that are green (closest to edge of controller), yellow, and red (closest to center of controller).

- (1) Green - Power and Data Transmission LED. If this light is off, check controller power. Under operation conditions, this light should flicker or be ON. This light will flicker when data is being transmitted onto the communications network.
- (2) Yellow - Data Reception LED. This light will flicker when data is being received from the communications network.
- (3) Red - Service LED. This light will flicker when a controller is being programmed over the network.

If the light steadily blinks at the rate of once per second, the controller is not programmed. Contact the factory for a replacement controller.

If this light remains ON, the controller has detected an internal error and requires service. Remove controller power for 15 seconds, and then restore power. If the LED remains ON, check the controller power supply (nominal 24 VAC across terminals 24H and 24G). If the LED remains ON, turn off the unit and replace the controller.

4) Standard Inputs

The following inputs are the digital (binary) inputs used with the controller. Some items are optional and others are used only with specific control packages. Please see Section 6 for details on the unit sequence of operation.

A) Water Coil Low Limit

This input is attached to the coil used on all units with steam or water. A low limit switch is connected in parallel with the outdoor air temperature sensor (OAT). When the low limit switch closes, it short circuits the OAT sensor input, thus initiating low limit mode.

B) Occupancy Input

If the unit is connected to a LON network and the network occupancy input is bound to an occupancy controller, the network initiates occupied/unoccupied modes, regardless of the status of the physical occupancy input. Without a network, all units use controller digital input 1 (DI1, terminal #26) for the occupancy status input. When terminal DI1 is connected (input switch closed) to a common terminal (COM, #22), the controller switches to unoccupied mode, unless the unoccupied override button on the dual-mount thermostat is pressed. When terminal DI1 is disconnected from COM, the unit enters occupied mode.

This input may be factory connected to an optional day/night relay, where the relay coil must be field wired to an occupancy controller. This relay is factory wired so that the relay is energized for unoccupied mode and de-energized for occupied mode. When ordered, this relay is mounted on the control panel.

This input may be factory connected to an optional 7-day timeclock. This timeclock has an override switch (holiday switch) built into the clock face that can be used to force the unit into occupied or unoccupied modes. When ordered, this timeclock is mounted on the control panel.

C) Change-over Input

This input is used only on 2-pipe, systems with chilled water. A changeover switch (aquastat) is connected between controller terminals DI2 (#24) and COM (#25). The switch contacts close when the switch senses that the water temperature is below 65°F, thus indicating that chilled water is available and initiating cooling mode. The unit enters heating mode when the contacts open at 85°F.

D) Refrigerant Low Limit

This input is used with DX coils on self-contained unit ventilators. A low limit switch is connected between controller terminals DI2 (#24) and COM (#25). The switch contacts close when the DX coil temperature falls below 28°F, thus prompting the controller to disable the compressor.

5) Standard Outputs

Some output items are optional and others are used only with specific control packages. Please see Section 6 for details on the unit sequence of operation.

A) Outdoor Air / Return Air Damper Actuator

This actuator is connected to 24 VAC power and is controlled with a 4-20 mA signal from Analog Output 1 (AO1, #23). The actuator will close the outdoor air damper on a power failure. A 4 mA signal drives the damper fully closed, while a 20 mA signal drives the actuator to full open position.

B) Face and Bypass Damper Actuator

This non-spring return actuator is connected to 24 VAC power and is controlled with a 4-20 mA signal from Analog Output 2 (AO2, #21). A 4 mA signal drives the damper into full bypass position (closed), while a 20 mA signal drives the actuator to the full face position (open).

C) 2-Pipe Valve Controlled Unit

A proportional valve is used on all 2-pipe (steam, chilled water and/or hot water) units. The valve actuator is connected to 24 VAC power and is controlled with a 0-20 mA signal from Analog Output 2 (AO2, #21). The valve will return to the full open position on a loss of power. A 0 mA signal drives the valve fully open, while a 20 mA signal drives the valve fully closed.

D) 4-Pipe Valve Controlled Unit

A proportional valve is used control the heating valve (steam or hot water) as described above.

A floating point (tri-state) valve is used to control the cooling valve (chilled water). The valve actuator is connected to 24 VAC power and will fully close on a loss of power. Binary (Relay) Output 5 (NO5, #13) is energized to drive the chilled water valve open, while Output 6 (NO6, #15) is energized to drive the chilled water valve closed.

E) Binary (Relay) Outputs

- (1) Fan control - the Fan Relay (FR1) is connected to Output 1 (NO1, #5). This output is energized to start the fan and de-energized to stop the fan
- (2) DX cooling Control - On self-contained units and units with DX cooling, the DX control circuit is connected to NO5, #13. This output is energized to start the compressor/condenser and de-energized to disengage the compressor/condenser.
- (3) Electric Heat Control - 1st stage electric heat relay (HR1) is connected to NO2 (#7). 2nd stage electric heat relay (HR2) is connected to NO3 (#9). 3rd stage electric heat relay (HR3) is connected to NO4 (#11). These outputs are energized to engage the electric heat stage and de-energized to disengage the stage.
- (4) Radiant Heat Control - when this option is ordered on units with water/steam heating, a relay (HR1) is added to control radiant heat. The coil of this relay is connected to NO2, #7.

6) Sequences of Operation

The following sequences of operation detail each ASHRAE Cycle II control configuration.

A) 2-Pipe unit (steam/water), Damper Control

Fan Operation

The supply fan shall run continuously in the occupied and tenant (unoccupied) override modes. The fan shall cycle with calls for cooling or heating in the unoccupied mode.

Cooling Operation

The unit enters cooling mode when the optional changeover t'stat contacts close to indicate that chilled water is available. Since there is no changeover t'stat on heating only units, such units will not enter mechanical cooling mode.

When the space temperature exceeds the cooling setpoint, a proportional-integral control loop shall position the face & bypass damper to maintain the space temperature.

The face and bypass damper shall be driven closed (full bypass) if the discharge air temperature falls below 55°F. The damper shall be held closed until the discharge air temperature rises above 57°F.

Heating Operation

The unit enters heating mode when the optional changeover t'stat contacts open to indicate that hot water is available. Heating only units shall not have a changeover t'stat.

When the space temperature falls below the heating setpoint, a proportional-integral control loop shall position the face & bypass damper to maintain the space temperature.

The face and bypass damper shall be driven open (full face) if the low limit thermostat trips (closes) OR the discharge air temperature falls below 55°F. The damper shall remain open until the low limit thermostat is opened AND the discharge air temperature exceeds 57°F.

In heating mode, the face & bypass damper shall be closed when the discharge air temperature exceeds 130°F. This damper shall remain closed until the discharge air temperature falls below 110°F.

End-of-Cycle Valve Operation (Optional)

A normally open, 2-position valve with return on power failure is optionally used as an end-of-cycle (EOC) valve. This valve prevents radiant effects from overcooling/overheating the space when the face & bypass damper is in the full bypass position. The EOC valve shall open when the face & bypass damper is commanded to open. If the outdoor air temperature falls below 40°F, the EOC valve shall be forced open, regardless of the face & bypass damper position.

Outdoor Air Damper Control

The outdoor air damper shall be closed in the unoccupied mode, regardless of the space temperature.

The outdoor air damper shall be closed in low limit conditions (See Safeties).

The outdoor air damper shall be closed if the space temperature falls more than 3°F below the heating setpoint. The damper will not open until the space temperature rises within 2°F of the heating setpoint.

The outdoor air damper shall be closed if the space temperature rises more than 3°F above the cooling setpoint, while chilled water is available (changeover t'stat closed). The damper will not open until the space temperature falls to less than 2°F above the cooling setpoint. If chilled water is not available, the damper continues to operate under normal control.

The outdoor air damper shall close to minimum position when the outdoor air temperature exceeds 68°F, while chilled water is available. If chilled water is unavailable, the damper continues to operate under normal control.

The outdoor air damper shall be controlled with a proportional control loop based upon the deviation from setpoint. The outdoor air damper shall begin to modulate open from minimum position when the space temperature exceeds the (space setpoint - 0.5°F). The outdoor air damper shall be fully open when the space temperature rises 1.5°F above the setpoint. Except as noted in the paragraphs above, the outdoor air damper shall not close beyond minimum position during occupied operation.

Safeties - Low Limit Conditions

If the low limit thermostat trips OR the discharge air temperature falls below 55°F, the unit enters low limit mode. This shall drive the outdoor air damper closed. In heating mode, this shall force the face & bypass damper into full face position and the optional EOC valve shall open. In cooling mode, this shall force the face & bypass damper into full bypass position and the optional EOC valve shall close.

Normal unit operation shall resume when the discharge air temperature exceeds 57°F AND the low limit thermostat opens.

B) 2-Pipe Unit (steam/water), Valve Control

Fan Operation

The supply fan shall run continuously in the occupied and tenant (unoccupied) override modes. The fan shall cycle with calls for cooling or heating in the unoccupied mode.

Cooling Operation

The unit enters cooling mode when the optional changeover t'stat contacts close to indicate that chilled water is available. Since there is no changeover t'stat on heating only units, such units will not enter mechanical cooling mode. Heating only units will use outdoor air, when applicable, for cooling; please see the Outdoor Air Damper Operation section for operational details.

When the space temperature exceeds the cooling setpoint, a proportional-integral control loop shall position the control valve to maintain the space temperature.

If the discharge air temperature falls below 55°F, the control valve shall be closed. The valve shall remain closed until the discharge air temperature rises above 57°F.

Heating Operation

The unit enters heating mode when the optional changeover t'stat contacts open to indicate that hot water is available. Heating only units shall not have a changeover t'stat; such units operate only in heating mode.

When the space temperature falls below the heating setpoint, a proportional-integral control loop shall position the control valve to maintain the space temperature.

The control valve shall be driven open if the low limit thermostat trips (closes) OR the discharge air temperature falls below 55°F. The valve shall remain open until the low limit thermostat is opened AND the discharge air temperature exceeds 57°F.

In heating mode, the control valve shall be closed when the discharge air temperature exceeds 130°F. The valve shall remain closed until the discharge air temperature falls below 110°F.

Outdoor Air Damper Control

The outdoor air damper shall be closed in the unoccupied mode, regardless of the space temperature.

The outdoor air damper shall be closed in low limit conditions (See Safeties).

The outdoor air damper shall be closed if the space temperature falls more than 3°F below the heating setpoint. The damper will not open until the space temperature rises within 2°F of the heating setpoint.

The outdoor air damper shall be closed if the space temperature rises more than 3°F above the cooling setpoint, while chilled water is available (changeover t'stat closed). The damper will not open until the space temperature falls to less than 2°F above the cooling setpoint. If chilled water is not available, the damper continues to operate under normal control.

The outdoor air damper shall close to minimum position when the outdoor air temperature exceeds 68°F, while chilled water is available. If chilled water is unavailable, the damper continues to operate under normal control.

The outdoor air damper shall be controlled with a proportional control loop based upon the deviation from setpoint. The outdoor air damper shall begin to modulate open from minimum position when the space temperature exceeds the (space setpoint - 0.5°F). The outdoor air damper shall be fully open when the space temperature rises 1.5°F above the setpoint. Except as noted in the paragraphs above, the outdoor air damper shall not close beyond minimum position during occupied operation.

Safeties - Low Limit Conditions

If the low limit thermostat trips OR the discharge air temperature falls below 55°F, the unit enters low limit mode. This shall drive the outdoor air damper closed. In heating mode, this shall drive the control valve open. In cooling mode, this shall drive the control valve closed.

Normal unit operation shall resume when the discharge air temperature exceeds 57°F AND the low limit thermostat opens.

C) 4-pipe unit (hot water or steam and chilled water), Damper Control

Fan Operation

The supply fan shall run continuously in the occupied and tenant (unoccupied) override modes. The fan shall cycle with calls for cooling or heating in the unoccupied mode.

Cooling Operation

When the space temperature exceeds the cooling setpoint a proportional-integral control loop shall position the face & bypass damper to maintain the space temperature. When the space temperature falls below the cooling setpoint, the face & bypass damper shall be closed (bypass).

If the discharge air temperature falls below 55°F OR the low limit thermostat closes, the face and bypass damper shall be driven closed (full bypass). This damper shall remain closed until the discharge air temperature rises above 57°F AND the low limit thermostat opens.

Heating Operation

When the space temperature falls below the heating setpoint, a proportional-integral control loop shall position the face & bypass damper to maintain the space temperature. When the space temperature exceeds the heating setpoint, the face & bypass damper shall be closed (bypass).

If the discharge air temperature falls below 55°F OR the low limit thermostat closes, the face and bypass damper shall be driven open (full face). This damper shall remain open until the discharge air temperature rises above 57°F AND the low limit thermostat opens.

If the discharge air temperature exceeds 130°F, the face & bypass damper shall be driven closed. This damper shall remain closed until the discharge air temperature falls below 110°F.

End-of-Cycle Valve Operation

2-position valves with return on power failure are used as end-of-cycle (EOC) valves. These valves prevent radiant effects from overcooling/overheating the space when the face & bypass damper is in the full bypass position.

If the space temperature is at or above the cooling setpoint, the cooling EOC valve shall open. This valve shall close when the when the space temperature falls below the cooling setpoint. If the low limit thermostat trips OR the discharge air temperature falls below 55°F, the cooling EOC valve shall drive closed.

If the discharge air temperature exceeds 130°F, the heating EOC valve shall close and remain closed until the discharge air temperature drops below 110°F, regardless of other conditions. If the outdoor air temperature falls below 40°F OR the low limit thermostat closes, the heating EOC valve shall be opened and shall remain open until the outdoor air temperature exceeds 44°F AND the low limit thermostat opens. If the space temperature falls below the heating setpoint, the heating EOC valve shall open.

Outdoor Air Damper Control

The outdoor air damper shall be closed in the unoccupied mode, regardless of the space temperature.

The outdoor air damper shall be closed in low limit conditions (See Safeties).

The outdoor air damper shall be closed if the space temperature falls more than 3°F below the heating setpoint. The damper will not open until the space temperature rises within 2°F of the heating setpoint.

The outdoor air damper shall be closed if the space temperature rises more than 3°F above the cooling setpoint. The damper will not open until the space temperature falls within 2°F of the cooling setpoint.

The outdoor air damper shall close to minimum position when the outdoor air temperature exceeds 68°F

The outdoor air damper shall be controlled with a proportional control loop based upon the deviation from setpoint. The outdoor air damper shall begin to modulate open from minimum position when the space temperature exceeds the (space setpoint - 0.5°F). The outdoor air damper shall be fully open when the space temperature rises 1.5°F above the setpoint. Except as noted in the paragraphs above, the outdoor air damper shall not close beyond minimum position during occupied operation.

Safeties - Low Limit Conditions

If the low limit thermostat trips OR the discharge air temperature falls below 55°F, the unit enters low limit mode. This shall drive the outdoor air damper closed. In heating mode, this shall force the face & bypass damper into full-face position and the optional heating EOC valve shall open. In cooling mode, this shall force the face & bypass damper into full bypass position and the optional cooling EOC valve shall close.

Normal unit operation shall resume when the discharge air temperature exceeds 57°F and the low limit thermostat opens.

D) 4-pipe unit (hot water or steam and chilled water), Valve Control

Fan Operation

The supply fan shall run continuously in the occupied and tenant (unoccupied) override modes. The fan shall cycle with calls for cooling or heating in the unoccupied mode.

Cooling Operation

When the space temperature exceeds the cooling setpoint, a proportional-integral control loop shall position the cooling valve to maintain the space temperature. When the space temperature falls below the cooling setpoint, the cooling valve shall be closed.

If the discharge air temperature falls below 55°F OR the low limit thermostat closes, the cooling valve shall be driven closed. This valve shall remain closed until the discharge air temperature rises above 57°F AND the low limit thermostat opens.

Heating Operation

When the space temperature falls below the heating setpoint, a proportional-integral control loop shall position the heating valve to maintain the space temperature. When the space temperature exceeds the heating setpoint, the heating valve shall be closed.

If the discharge air temperature exceeds 130°F, the heating valve shall be driven closed, regardless of other conditions. This valve shall remain closed until the discharge air temperature falls below 110°F.

If the discharge air temperature falls below 55°F OR the low limit thermostat closes, the heating valve shall be driven open. This valve shall remain open until the discharge air temperature rises above 57°F AND the low limit thermostat opens.

Outdoor Air Damper Control

The outdoor air damper shall be closed in the unoccupied mode, regardless of the space temperature.

The outdoor air damper shall be closed in low limit conditions (See Safeties).

The outdoor air damper shall be closed if the space temperature falls more than 3°F below the heating setpoint. The damper will not open until the space temperature rises within 2°F of the heating setpoint.

The outdoor air damper shall be closed if the space temperature rises more than 3°F above the cooling setpoint. The damper will not open until the space temperature falls to less than 2°F above the cooling setpoint.

The outdoor air damper shall close to minimum position when the outdoor air temperature exceeds 68°F.

The outdoor air damper shall be controlled with a proportional control loop based upon the deviation from setpoint. The outdoor air damper shall begin to modulate open from minimum position when the space temperature exceeds the (space setpoint - 0.5°F). The outdoor air damper shall be fully open when the space temperature rises 1.5°F above the setpoint. Except as noted in the paragraphs above, the outdoor air damper shall not close beyond minimum position during occupied operation.

Safeties - Low Limit Conditions

If the low limit thermostat trips OR the discharge air temperature falls below 55°F, the unit enters low limit mode. This shall drive both the outdoor air damper and the cooling valve closed. In heating mode, this shall drive the heating valve open.

Normal unit operation shall resume when the discharge air temperature exceeds 57°F AND the low limit thermostat opens.

E) Electric Heat Only

Fan Operation

The supply fan shall run continuously in the occupied and tenant (unoccupied) override modes. The fan shall cycle with calls for cooling or heating in the unoccupied mode.

Cooling Operation

When the space temperature exceeds the cooling setpoint, the supply fan shall start (Unoccupied mode).

Heating Operation

There is a fixed 15-second delay between the engagement of each electric heat stage. Each electric heat stage must be engaged for 1 minute (minimum ON timer) and each stage cannot be re-engaged for 1 minute after being switched OFF (minimum OFF timer). These delays are built into the unit controller.

When the space temperature falls below the heating setpoint, electric heating shall be staged on to maintain the space temperature. A proportional-integral control loop and built-in digital sequencer shall be used to control up to 3 stages of electric heat. When the space temperature exceeds the heating setpoint, all electric heat stages shall be staged OFF.

If the discharge air temperature exceeds 130°F, all electric heat stages shall be immediately disengaged, regardless of the space temperature or the minimum ON timer. Electric heating shall remain disengaged until the discharge air temperature falls below 110°F.

If the discharge air temperature falls below 55°F, all electric heat stages are immediately engaged. All electric heat shall remain ON until the discharge air temperature rises above 57°F.

Outdoor Air Damper Control

The outdoor air damper shall be closed in the unoccupied mode, regardless of the space temperature conditions.

The outdoor air damper shall be closed if the discharge air temperature falls below 55°F and remain closed until the discharge air rises above 57°F.

The outdoor air damper shall be closed if the space temperature falls more than 3°F below the heating setpoint. The damper will not open until the space temperature rises within 2°F of the heating setpoint.

The outdoor air damper shall close to minimum position when the outdoor air temperature exceeds the space cooling setpoint by more than 10°F. The damper shall remain at minimum position until the outdoor air temperature drops to within 9°F of the cooling setpoint.

The outdoor air damper shall be controlled with a proportional control loop based upon the deviation from setpoint. The outdoor air damper shall begin to modulate open from minimum position when the space temperature exceeds the (space setpoint - 0.5°F). The outdoor air damper shall be fully open when the space temperature rises 1.5°F above the setpoint. Except as noted in the paragraphs above, the outdoor air damper shall not close beyond minimum position during occupied operation.

Safeties - Low Limit Conditions

If the discharge air temperature exceeds 130°F, all electric heat stages shall be immediately disengaged, regardless of other conditions. Electric heat shall remain locked out, until the discharge air temperature falls below 110°F.

If the discharge air temperature falls below 55°F, all electric heat stages are immediately engaged. Normal unit operation shall resume when the discharge air temperature exceeds 57°.

F) DX cooling only

Fan Operation

The supply fan shall run continuously in the occupied and tenant (unoccupied) override modes. The fan shall cycle with calls for cooling or heating in the unoccupied mode.

Cooling Operation

When the space temperature exceeds the cooling setpoint, the compressor shall be started. The compressor shall run until the space temperature falls 0.5°F below the cooling setpoint. Compressor operation shall be controlled with an integrated run timer such that once engaged, the compressor shall operate for a minimum of 2 minutes before disengaging. This run timer also provides a 3-minute minimum OFF time delay (anti short-cycle timer).

If the outdoor air temperature falls below 59°F, the compressor shall be disengaged when the minimum run time of 2 minutes is complete. The compressor shall remain disengaged until the outdoor air temperature exceeds 61°F AND the minimum off time of 3 minutes has elapsed.

If the discharge air temperature falls below 50°F OR the optional refrigerant low limit switch trips, the compressor shall be immediately disengaged, regardless of the minimum run timer status. The compressor shall remain disengaged until the low limit switch opens AND the discharge air temperature is above 52°F AND the minimum off time of 3 minutes has elapsed.

Heating Operation

The supply fan shall be engaged when the space temperature falls below the heating setpoint (unoccupied mode).

Outdoor Air Damper Control

The outdoor air damper shall be closed in the unoccupied mode, regardless of the space temperature conditions.

The outdoor air damper shall be closed if the discharge air temperature falls below 53°F and remain closed until the discharge air rises above 55°F.

The outdoor air damper shall be closed if the space temperature falls more than 3°F below the heating setpoint. The damper will not open until the space temperature rises within 2°F of the heating setpoint.

The outdoor air damper shall close to minimum position when the outdoor air temperature exceeds 68°F.

The outdoor air damper shall be controlled with a proportional control loop based upon the discharge air temperature. The outdoor air damper shall begin to modulate open from minimum position when the discharge air temperature exceeds 55°F and shall be fully open at 59°F. Except as noted in the paragraphs above, the outdoor air damper shall not close beyond minimum position during occupied operation.

Safeties - Low Limit Conditions

If the discharge air temperature falls below 53°F, the unit enters ventilation low limit mode. This shall drive the outdoor air damper closed. This damper shall not open until the discharge air temperature exceeds 55°F.

If the discharge air temperature falls below 50°F, the unit enters refrigeration low limit mode. This shall immediately disengage the compressor, regardless of the minimum on timer status. The compressor shall not be allowed to operate until the discharge air temperature exceeds 52°F AND the minimum off time has elapsed.

G) DX Cooling with Electric Heat

Fan Operation

The supply fan shall run continuously in the occupied and tenant (unoccupied) override modes. The fan shall cycle with calls for cooling or heating in the unoccupied mode.

Cooling Operation

When the space temperature exceeds the cooling setpoint, the compressor shall be started. The compressor shall run until the space temperature falls 0.5°F below the cooling setpoint. Compressor operation shall be controlled with an integrated run timer such that once engaged, the compressor shall operate for a minimum of 2 minutes before disengaging. This run timer also provides a 3-minute minimum OFF delay (anti short-cycle timer).

If the outdoor air temperature falls below 59°F, the compressor shall be disengaged when the minimum run time of 2 minutes is complete. The compressor shall remain disengaged until the outdoor air temperature exceeds 62°F AND the minimum off time of 3 minutes has elapsed.

If the discharge air temperature falls below 52°F OR the optional refrigerant low limit switch trips OR electric heat is engaged, the compressor shall be immediately disengaged, regardless of the minimum run timer status. The compressor shall remain disengaged until the discharge air temperature rises above 52°F AND the low limit switch opens AND electric heat is disengaged AND the minimum off time of 3 minutes has elapsed.

Heating Operation

There is a fixed 15-second delay between the engagement of each electric heat stage. Each electric heat stage must be engaged for 1 minute (minimum ON timer) and each stage cannot be re-engaged for 1 minute after being switched OFF (minimum OFF timer). These delays are built into the unit controller. Another built-in timer prevents electric heat operation for 30 seconds after the compressor operation.

When the space temperature falls below the heating setpoint, electric heating shall be staged on to maintain the space temperature. A proportional-integral control loop and built-in digital sequencer shall be used to control up to 3 stages of electric heat. When the space temperature exceeds the heating setpoint, all electric heat stages shall be staged OFF.

If the discharge air temperature exceeds 130°F, all electric heat stages shall be immediately disengaged, regardless of the space temperature or the minimum ON timer. Electric heating shall remain disengaged until the discharge air temperature falls below 110°F.

If the discharge air temperature falls below 52°F, all electric heat stages are immediately engaged, unless the compressor is operating. All electric heat shall remain ON until the discharge air temperature rises above 55°F.

Outdoor Air Damper Control

The outdoor air damper shall be closed in the unoccupied mode, regardless of the space temperature conditions.

The outdoor air damper shall be closed if the discharge air temperature falls below 52°F and remain closed until the discharge air rises above 55°F.

The outdoor air damper shall be closed if the space temperature falls more than 3°F below the heating setpoint. The damper will not open until the space temperature rises within 2°F of the heating setpoint.

The outdoor air damper shall close to minimum position when the outdoor air temperature exceeds 68°F.

The outdoor air damper shall be controlled with a proportional control loop based upon the deviation from setpoint. The outdoor air damper shall begin to modulate open from minimum position when the space temperature exceeds the (space setpoint - 0.5°F). The outdoor air damper shall be fully open when the space temperature rises 1.5°F above the setpoint. Except as noted in the paragraphs above, the outdoor air damper shall not close beyond minimum position during occupied operation.

Safeties - Low Limit Conditions

If the discharge air temperature falls below 52°F, the unit enters low limit mode. This shall drive the outdoor air damper closed and immediately disengage the compressor. All stages of electric heat shall be staged on by the integral timer; however, electric heat staging shall be delayed for 30 seconds if the compressor was in operation. Normal unit operation shall resume when the discharge air temperature exceeds 55°F.

If the optional refrigerant low limit switch closes, the unit enters refrigeration low limit mode. This shall immediately disengage the compressor, regardless of the minimum on timer status. The compressor shall not be allowed to operate until the low limit switch opens AND the minimum off time (3 minutes) has elapsed.

H) DX Cooling with Wet Heat, Damper Control

Fan Operation

The supply fan shall run continuously in the occupied and tenant (unoccupied) override modes. The fan shall cycle with calls for cooling or heating in the unoccupied mode.

Cooling Operation

When the space temperature exceeds the cooling setpoint, the compressor shall be started and the face & bypass damper driven fully open (face position). The compressor shall run until the space temperature falls 0.5°F below the cooling setpoint. Compressor operation shall be controlled with an integrated run timer such that once engaged, the compressor shall operate for a minimum of 2 minutes before disengaging. This run timer also provides a 3-minute minimum OFF time delay (anti short-cycle timer).

If the outdoor air temperature falls below 59°F, the compressor shall be disengaged when the minimum run time of 2 minutes is complete. The compressor shall remain disengaged until the outdoor air temperature exceeds 61°F AND the minimum off time of 3 minutes has elapsed.

If the heating coil low limit switch closes OR the optional refrigerant low limit switch closes, OR the discharge air temperature falls below 50°F, the compressor shall be immediately disengaged, regardless of the minimum run timer status. The compressor shall remain disengaged until the heating coil low limit switch is open AND the optional refrigerant low limit switch is open AND the discharge air temperature is above 52°F AND the minimum off time of 3 minutes has elapsed.

Heating Operation

When the space temperature falls below the heating setpoint, a proportional-integral control loop shall position the face and bypass damper to maintain the space temperature. When the space temperature exceeds the heating setpoint, the face and bypass damper shall close (bypass).

If the discharge air temperature fall below 53°F, OR the heating coil low limit thermostat closes, the face and bypass damper shall drive open (face). This damper shall return to normal control when the discharge air temperature exceeds 55°F AND the low limit thermostat is opened.

Optional End-of-Cycle Valve Operation

A normally open, 2-position valve with return on power failure is optionally used for end-of-cycle (EOC) control.

When the space temperature falls below the heating setpoint, the EOC valve shall open. The EOC valve shall remain open until the space temperature exceeds the heating setpoint by 2°F.

When the outdoor air temperature falls below 40°F or the heating coil low limit switch closes, the EOC valve shall open, regardless of space conditions. This valve shall remain open until the outdoor air temperature rises above 44°F AND the heating coil low limit switch is open.

If the discharge air temperature exceeds 130°F, the EOC valve shall be closed, regardless of other conditions. The EOC valve shall remain closed until the discharge air temperature falls below 110°F.

Outdoor Air Damper Control

The outdoor air damper shall be closed in the unoccupied mode, regardless of the space temperature conditions.

The outdoor air damper shall be closed if the discharge air temperature falls below 53° OR the heating coil low limit thermostat closes. This damper shall remain closed until the discharge air temperature rises above 55°F AND the heating coil low limit thermostat is open.

The outdoor air damper shall be closed if the space temperature falls more than 3°F below the heating setpoint. The damper will not open until the space temperature rises within 2°F of the heating setpoint.

The outdoor air damper shall close to minimum position when the outdoor air temperature exceeds 68°F OR the room temperature falls more than below the heating setpoint.

The outdoor air damper shall be controlled with a proportional control loop based upon the discharge air temperature. The outdoor air damper shall begin to modulate open from minimum position when the discharge air temperature exceeds 55°F and shall be fully open at 59°F. Except as noted in the paragraphs above, the outdoor air damper shall not close beyond minimum position during occupied operation.

Safeties - Low Limit Conditions

If the discharge air temperature falls below 53°F OR the heating coil low limit thermostat closes, the unit enters ventilation low limit mode. This shall drive the outdoor air damper closed and forces the face and bypass damper fully open (face). These dampers shall return to normal control when the discharge air temperature exceeds 55°F AND the heating coil low limit thermostat is open.

If the discharge air temperature falls below 50°F OR the heating coil low limit thermostat closes OR the optional refrigerant low limit switch closes, the unit enters refrigeration low limit mode. This shall immediately disengage the compressor, regardless of the minimum on timer status. The compressor shall not be allowed to operate until the discharge air temperature exceeds 52°F AND the heating coil low limit thermostat is open AND the optional refrigerant low limit switch is open AND the minimum off time has elapsed.

I) DX Cooling with Wet Heat, Valve Control

Fan Operation

The supply fan shall run continuously in the occupied and tenant (unoccupied) override modes. The fan shall cycle with calls for cooling or heating in the unoccupied mode.

Cooling Operation

When the space temperature exceeds the cooling setpoint, the compressor shall be started. The compressor shall run until the space temperature falls 0.5°F below the cooling setpoint. Compressor operation shall be controlled with an integrated run timer such that once engaged, the compressor shall operate for a minimum of 2 minutes before disengaging. This run timer also provides a 3-minute minimum OFF time delay (anti short-cycle timer).

If the outdoor air temperature falls below 59°F, the compressor shall be disengaged when the minimum run time of 2 minutes is complete. The compressor shall remain disengaged until the outdoor air temperature exceeds 61°F AND the minimum off time of 3 minutes has elapsed.

If the heating coil low limit switch closes OR the optional refrigerant low limit switch closes, the compressor shall be immediately disengaged, regardless of the minimum run timer status. The compressor shall remain disengaged until the heating coil low limit switch is open AND the optional refrigerant low limit switch is open AND the minimum off time of 3 minutes has elapsed.

Heating Operation

When the space temperature falls below the heating setpoint, a proportional-integral control loop shall position the heating valve to maintain the space temperature. When the space temperature exceeds the heating setpoint, the heating valve shall be closed.

If the discharge air temperature exceeds 130°F, the heating valve shall be driven closed, regardless of other conditions. This valve shall remain closed until the discharge air temperature falls below 110°F.

In heating mode, if the discharge air temperature falls below 53°F OR the heating coil low limit thermostat closes, the heating valve shall be driven open. This valve shall remain open until the discharge air temperature rises above 55°F AND the low limit thermostat opens.

Outdoor Air Damper Control

The outdoor air damper shall be closed in the unoccupied mode, regardless of the space temperature conditions.

The outdoor air damper shall be closed if the discharge air temperature falls below 53°F AND the space temperature is below the cooling setpoint. This damper shall remain closed until the discharge air temperature rises above 55°F.

The outdoor air damper shall be closed when the heating coil low limit thermostat closes. This damper shall remain closed until the low limit thermostat opens.

The outdoor air damper shall be closed if the space temperature falls more than 3°F below the heating setpoint. The damper will not open until the space temperature rises within 2°F of the heating setpoint.

The outdoor air damper shall close to minimum position when the outdoor air temperature exceeds 68°F.

The outdoor air damper shall be controlled with a proportional control loop based upon the discharge air temperature. The outdoor air damper shall begin to modulate open from minimum position when the discharge air temperature exceeds 55°F and shall be fully open at 59°F. Except as noted in the paragraphs above, the outdoor air damper shall not close beyond minimum position during occupied operation.

Safeties - Low Limit Conditions

If the discharge air temperature falls below 53°F with the space temperature below the cooling setpoint OR the heating coil low limit thermostat closes, the unit enters ventilation low limit mode. This shall drive the outdoor air damper closed. This damper shall not open until the discharge air temperature exceeds 55°F AND the heating coil low limit thermostat is open.

If the discharge air temperature falls below 50°F OR the heating coil low limit thermostat closes, the unit enters refrigeration low limit mode. This shall immediately disengage the compressor, regardless of the minimum on timer status. The compressor shall not be allowed to operate until the discharge air temperature exceeds 52°F AND the heating coil low limit thermostat opens AND the minimum off time has elapsed.

J) Damper Controlled Chilled Water Cooling with Electric Heat

Fan Operation

The supply fan shall run continuously in the occupied and tenant (unoccupied) override modes. The fan shall cycle with calls for cooling or heating in the unoccupied mode.

Cooling Operation

When the space temperature exceeds the cooling setpoint, a proportional-integral control loop shall position the face & bypass damper to maintain the space temperature. When the space temperature falls below the cooling setpoint, the face & bypass damper shall close (bypass).

The face and bypass damper shall be driven closed (full bypass) if the discharge air temperature falls below 55°F OR the low limit thermostat closes. The damper shall remain closed until the discharge air temperature exceeds 57°F AND the low limit thermostat opens.

Heating Operation

There is a fixed 15-second delay between the engagement of each electric heat stage. Each electric heat stage must be engaged for 1 minute (minimum ON timer) and each stage cannot be re-engaged for 1 minute after being switched OFF (minimum OFF timer). These delays are built into the unit controller.

When the space temperature falls below the heating setpoint, electric heating shall be staged on to maintain the space temperature. The face & bypass damper shall fully open (face) when an electric heat stage is engaged. A proportional-integral control loop and built-in digital sequencer shall be used to control up to 3 stages of electric heat. When the space temperature exceeds the heating setpoint, all electric heat stages shall be staged OFF.

If the discharge air temperature falls below 52°F, all electric heat stages are immediately. All electric heat shall remain ON until the discharge air temperature rises above 55°F.

If the discharge air temperature exceeds 130°F, all electric heat stages shall be immediately disengaged, regardless of the space temperature or the minimum ON timer. Electric heating shall remain disengaged until the discharge air temperature falls below 110°F.

End-of-Cycle Valve Operation (Optional)

A normally closed, 2-position valve with return on power failure is optionally used as a cooling end-of-cycle (EOC) valve. This valve prevents radiant effects from overcooling the space when the face & bypass damper is in the full bypass position. The EOC valve shall open when the face & bypass damper is commanded to open.

The EOC valve shall be closed whenever the discharge air temperature falls below 55°F OR the coil low limit thermostat closes. The valve shall remain closed until the discharge air temperature exceeds 57°F AND the low limit thermostat opens.

Outdoor Air Damper Control

The outdoor air damper shall be closed in the unoccupied mode, regardless of the space temperature conditions.

The outdoor air damper shall be closed in low limit conditions (See Safeties).

The outdoor air damper shall be closed if the space temperature falls more than 3°F below the heating setpoint. The damper will not open until the space temperature rises within 2°F of the heating setpoint.

The outdoor air damper shall be closed if the space temperature rises more than 3°F above the cooling setpoint. The damper will not open until the space temperature falls within 2°F of the cooling setpoint.

The outdoor air damper shall close to minimum position when the outdoor air temperature exceeds 68°F

The outdoor air damper shall be controlled with a proportional control loop based upon the deviation from setpoint. The outdoor air damper shall begin to modulate open from minimum position when the space temperature exceeds the (space setpoint - 0.5°F). The outdoor air damper shall be fully open when the space temperature rises 1.5°F above the setpoint. Except as noted in the paragraphs above, the outdoor air damper shall not close beyond minimum position during occupied operation.

Safeties - Low Limit Conditions

If the low limit thermostat trips OR the discharge air temperature falls below 55°F, the unit enters low limit mode. This shall drive the outdoor air damper closed. In cooling mode, this shall force the face & bypass damper into full bypass position and the optional EOC valve shall close. If the discharge air temperature falls below 52°F, the all stages of electric heat shall be engaged.

Electric heat shall return to normal control when the discharge air temperature exceeds 55°F. Normal unit operation shall resume when the discharge air temperature exceeds 57°F and the low limit thermostat opens.

K) Valve Controlled Chilled Water Cooling with Electric Heat

Fan Operation

The supply fan shall run continuously in the occupied and tenant (unoccupied) override modes. The fan shall cycle with calls for cooling or heating in the unoccupied mode.

Cooling Operation

When the space temperature exceeds the cooling setpoint, a proportional-integral control loop shall position the control valve to maintain the space temperature. When the space temperature falls below the cooling setpoint, the control valve shall be closed.

The chilled water valve shall be driven closed when the discharge air temperature falls below 55°F OR the coil low limit thermostat closes. The valve shall remain closed until the discharge air temperature exceeds 57°F AND the coil low limit thermostat opens.

Heating Operation

There is a fixed 15-second delay between the engagement of each electric heat stage. Each electric heat stage must be engaged for 1 minute (minimum ON timer) and each stage cannot be re-engaged for 1 minute after being switched OFF (minimum OFF timer). These delays are built into the unit controller.

When the space temperature falls below the heating setpoint, electric heating shall be staged on to maintain the space temperature. A proportional-integral control loop and built-in digital sequencer shall be used to control up to 3 stages of electric heat. When the space temperature exceeds the heating setpoint, all electric heat stages shall be staged OFF.

All electric heat stages shall be immediately engaged when the discharge air temperature falls below 52°F. Electric heat shall remain engaged until the discharge air temperature rises above 55°F.

If the discharge air temperature exceeds 130°F, all electric heat stages shall be immediately disengaged, regardless of the space temperature or the minimum ON timer. Electric heating shall remain disengaged until the discharge air temperature falls below 110°F.

Outdoor Air Damper Control

The outdoor air damper shall be closed in the unoccupied mode, regardless of the space temperature conditions.

The outdoor air damper shall be closed in low limit conditions (See Safeties).

The outdoor air damper shall be closed if the space temperature falls more than 3°F below the heating setpoint. The damper will not open until the space temperature rises within 2°F of the heating setpoint.

The outdoor air damper shall be closed if the space temperature rises more than 3°F above the cooling setpoint. The damper will not open until the space temperature falls within 2°F of the cooling setpoint.

The outdoor air damper shall close to minimum position when the outdoor air temperature exceeds 68°F

The outdoor air damper shall be controlled with a proportional control loop based upon the deviation from setpoint. The outdoor air damper shall begin to modulate open from minimum position when the space temperature exceeds the (space setpoint - 0.5°F). The outdoor air damper shall be fully open when the space temperature rises 1.5°F above the setpoint. Except as noted in the paragraphs above, the outdoor air damper shall not close beyond minimum position during occupied operation.

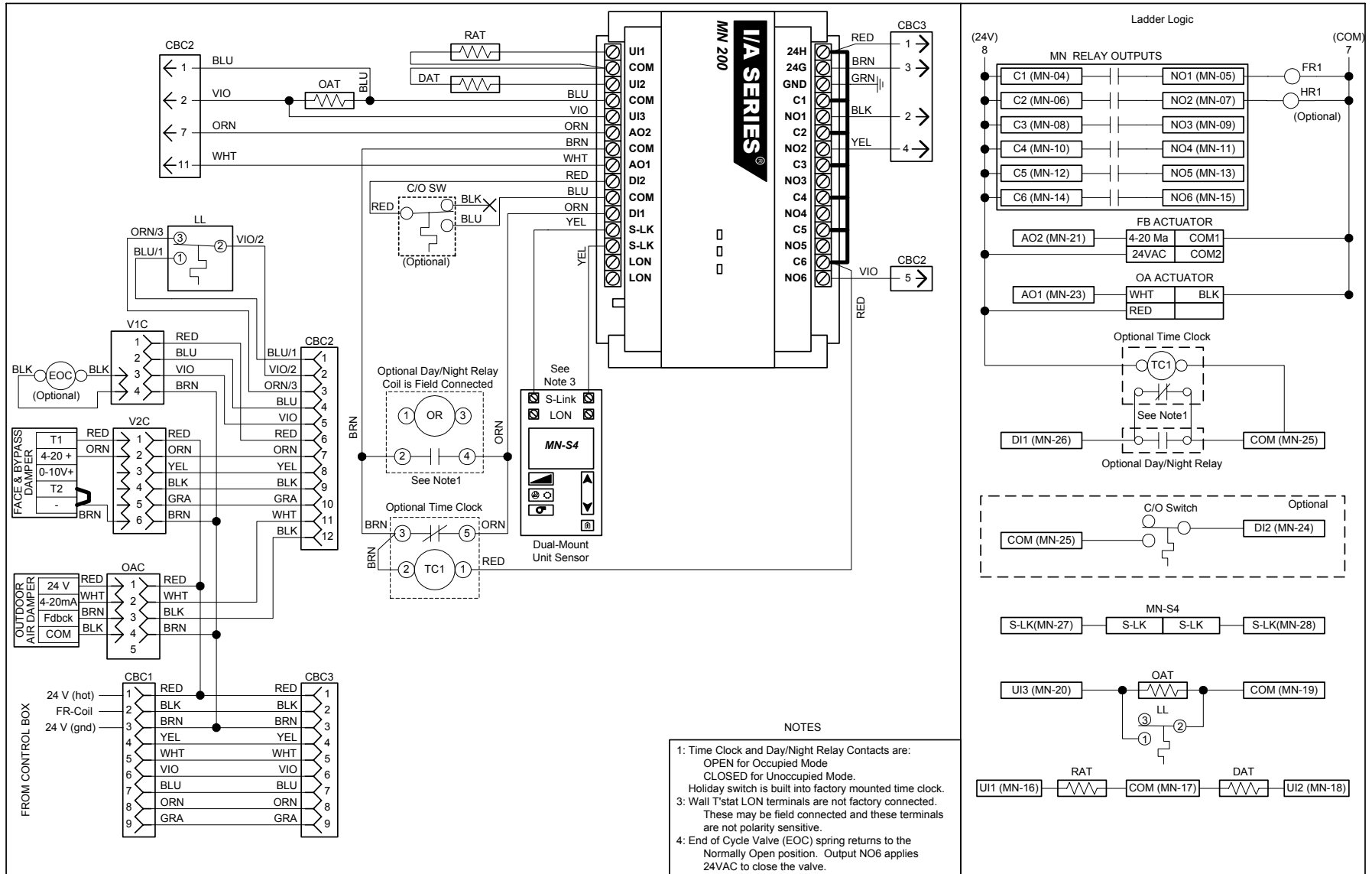
Safeties - Low Limit Conditions

If the low limit thermostat trips OR the discharge air temperature falls below 55°F, the unit enters low limit mode. This shall drive the outdoor air damper closed. In cooling mode, this shall force the cooling valve closed. If the discharge air temperature falls below 52°F, all stages of electric heat shall be engaged.

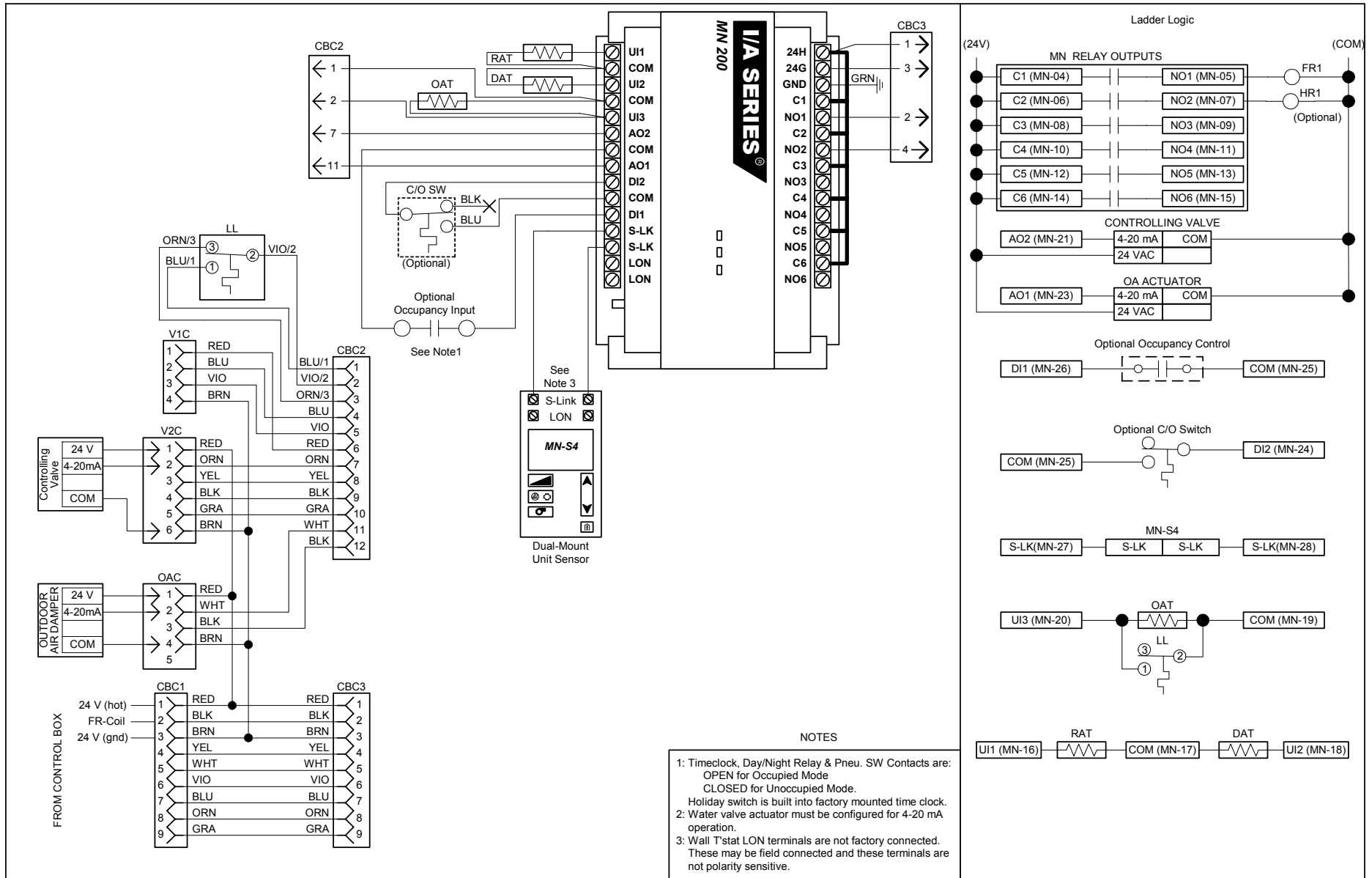
Electric heat shall return to normal control when the discharge air temperature exceeds 55°F. Normal unit operation shall resume when the discharge air temperature exceeds 57°F AND the low limit thermostat opens.

7) Typical Unit Wiring

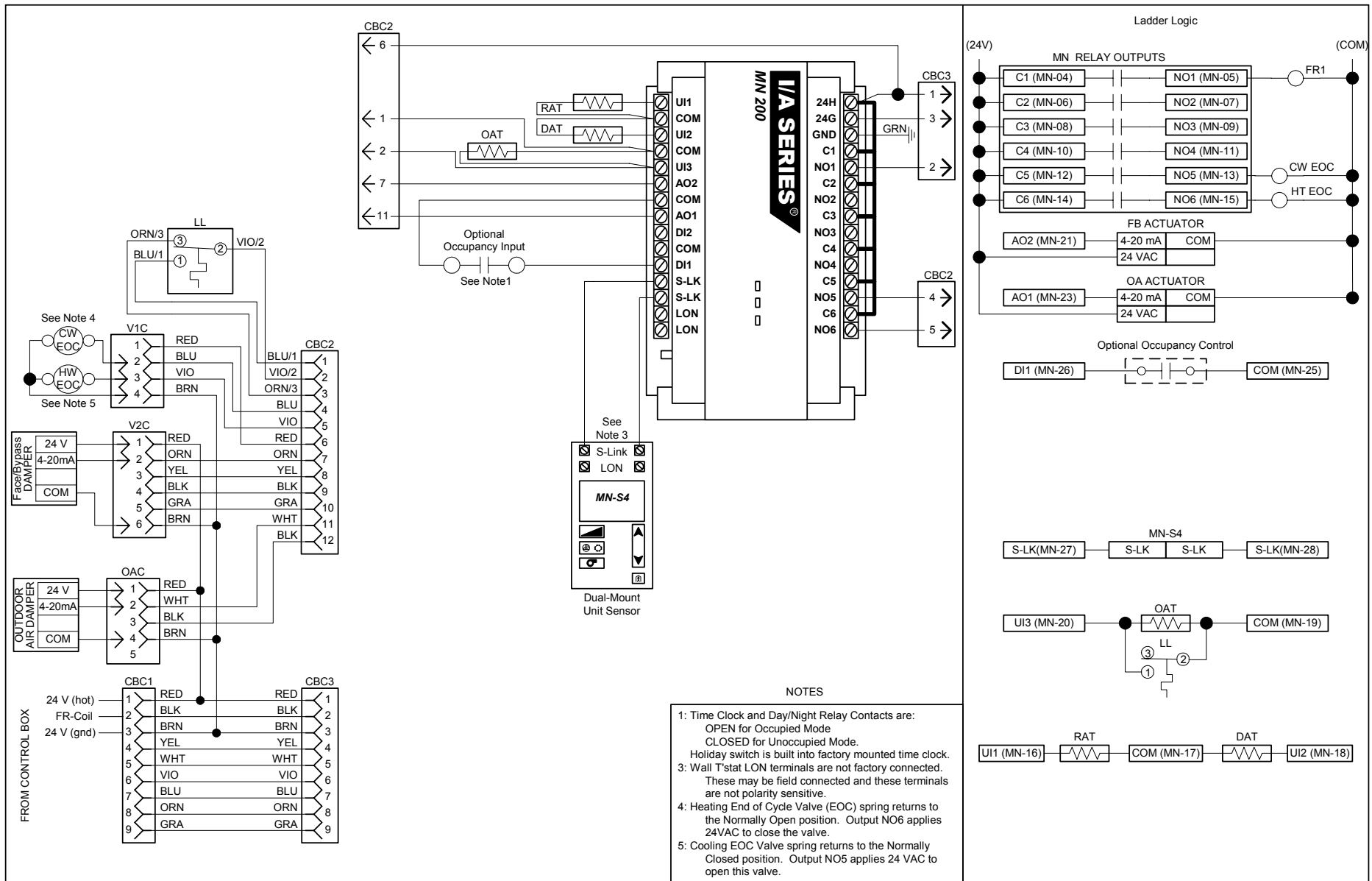
A) Control Diagram, 2-pipe Damper Control



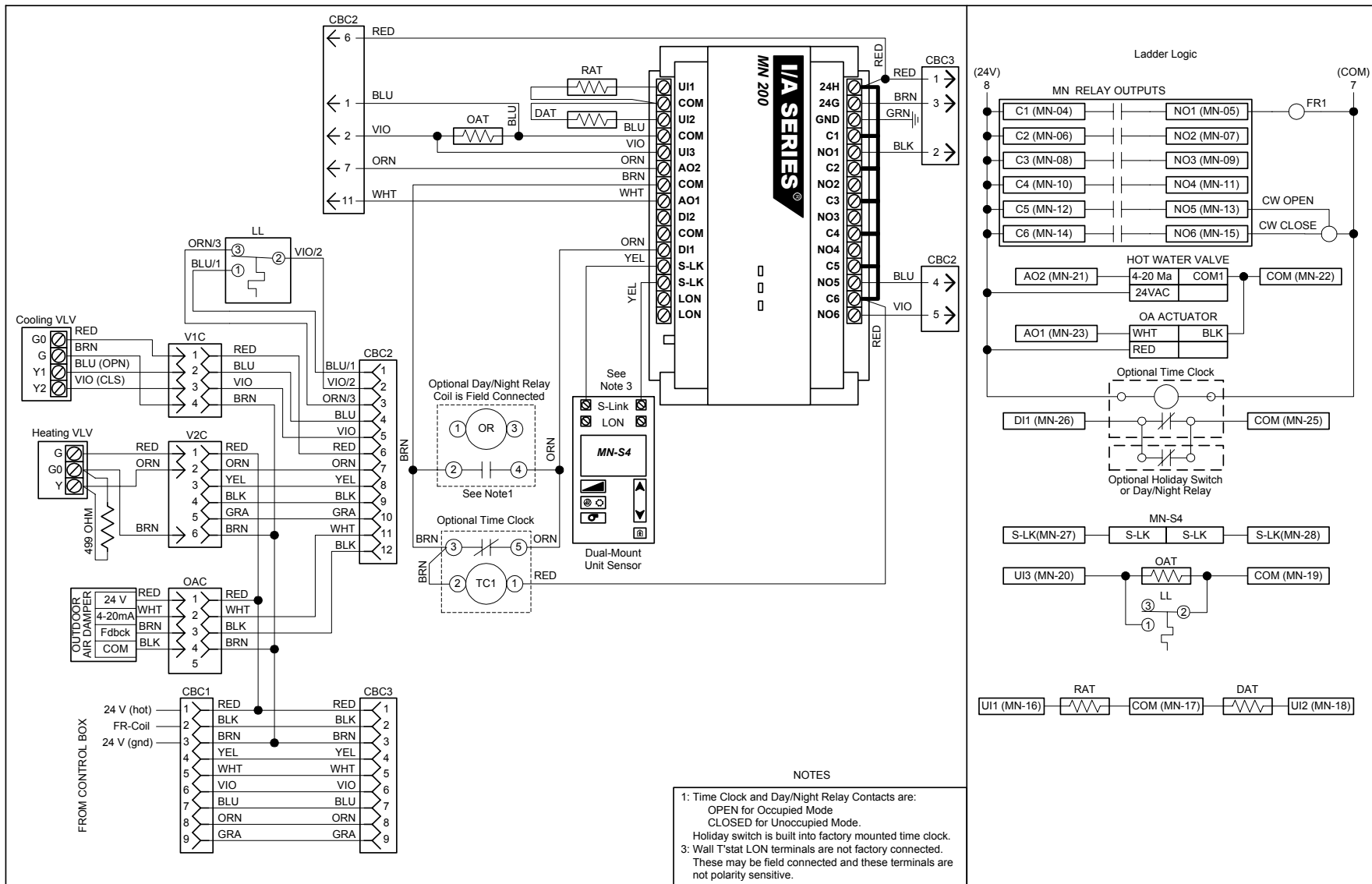
B) Control Diagram, 2-pipe Valve Control



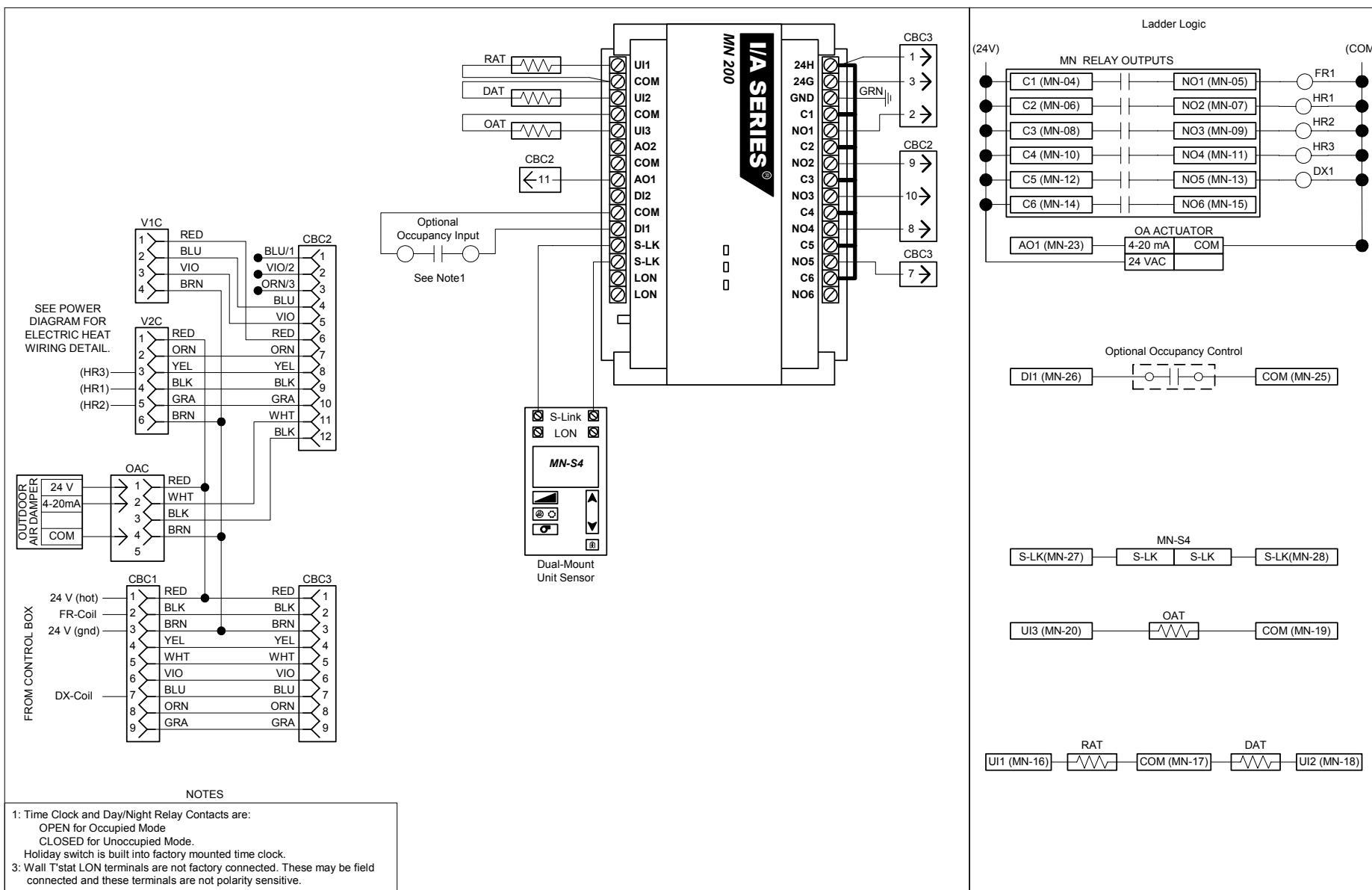
C) Control Diagram, 4-pipe, Damper Control



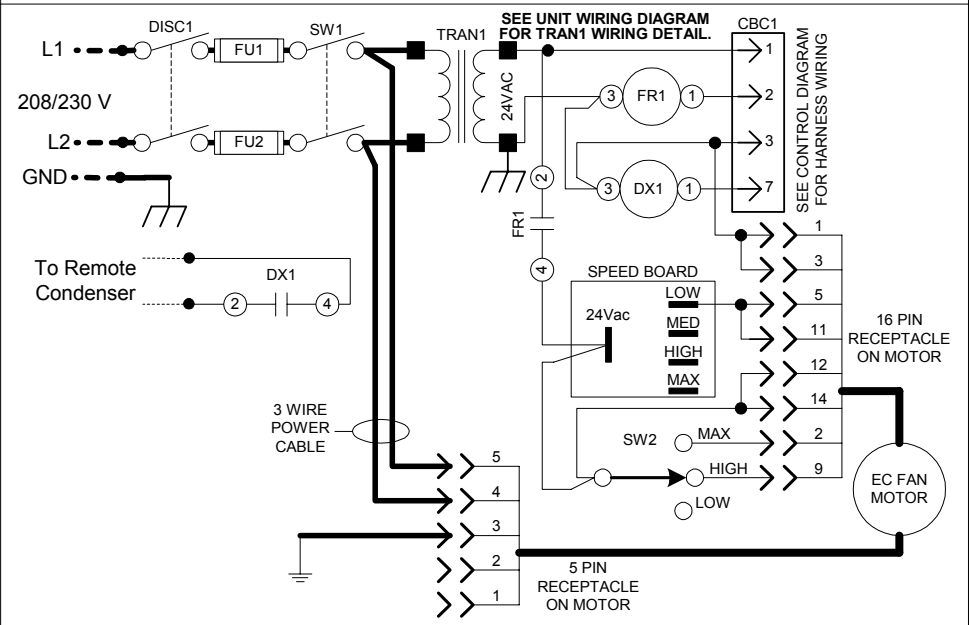
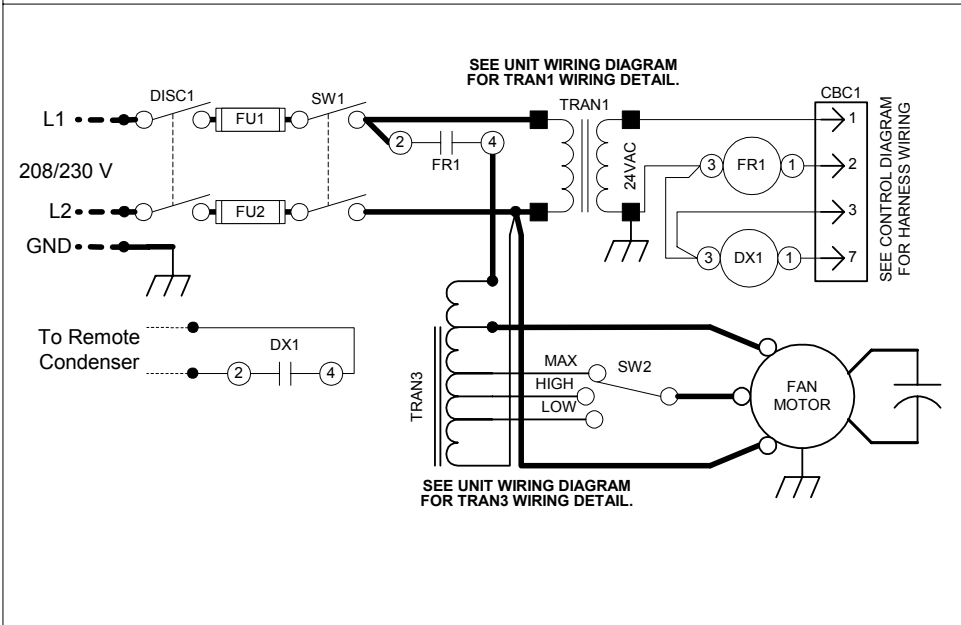
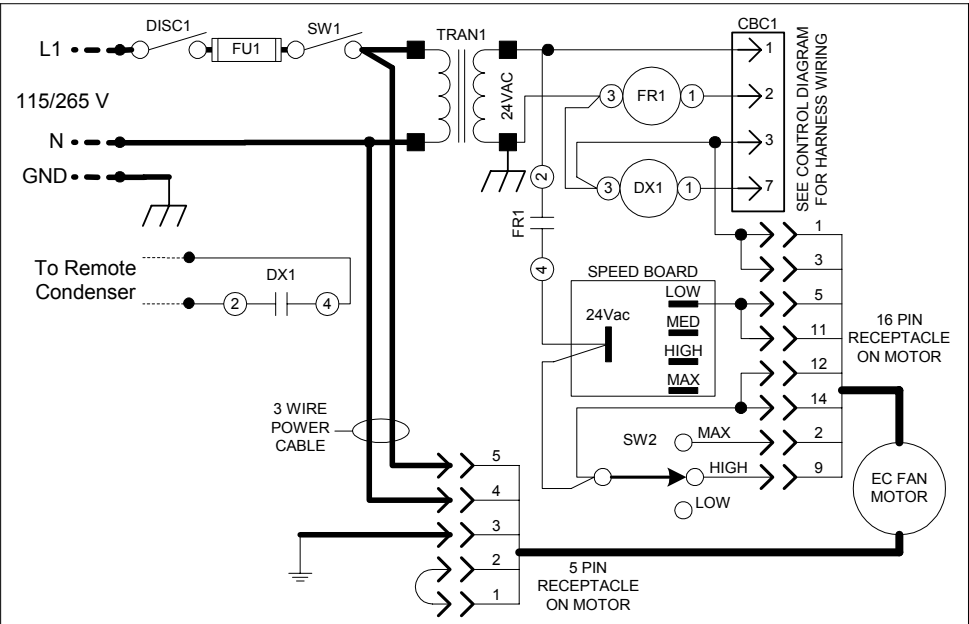
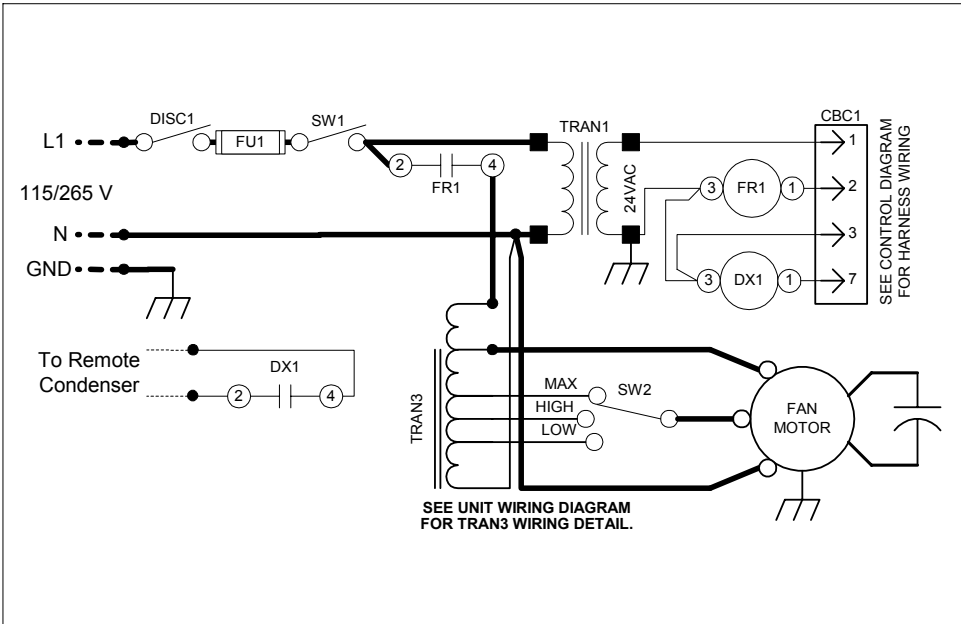
D) Control Diagram, 4-pipe, Valve Control



E) Control Diagram, DX with Electric Heat



F) Typical Power Diagrams



8) Parts List

A) Standard Control Parts

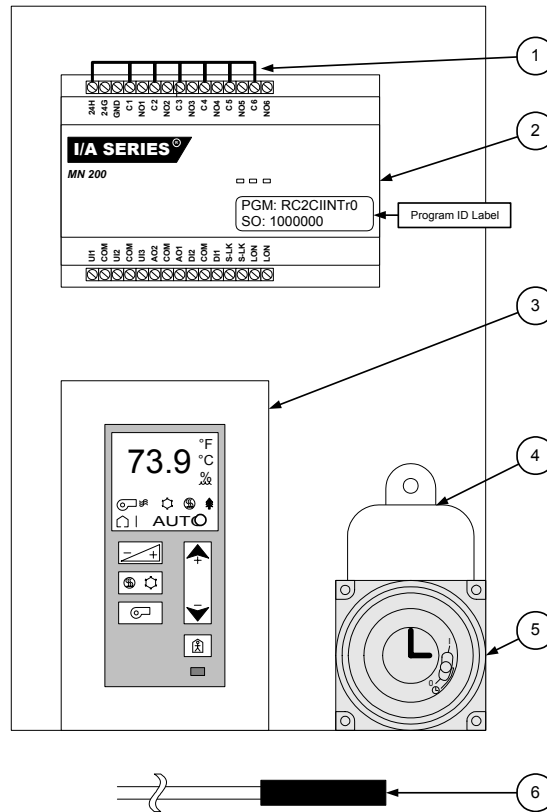


Figure 4

Ref.	Description	P/N
1	Connection Jumper Comb	UV0427
2	MNL200 Unit Controller	UV0391
3	MN-S4 Dual Mount Thermostat	UV0395
4	Day/Night Relay	112000
5	24V, 7Day Timeclock	UV0400
6	Discharge, Room, or Outdoor Air Temperature Sensor	UV0401
Not shown	Fan Relay	112000
Not shown	Outdoor Air Damper Actuator	103209
Not shown	Face & Bypass Damper Actuator	103208

B) Instructions for Ordering Replacement Controllers

When ordering a replacement controller, it is necessary to provide information to determine which control program must be loaded into the controller. The factory can determine which program is needed from the complete unit model number and serial number; however, for quickest service, please provide the control program name (PGM) and original sales order (SO) number listed on the program ID label of the original unit controller. See figure 4 for the location of this label.

9) Troubleshooting Chart

Symptom	Check	Explanation
Fan Runs Continuously	Unit in Occupied Mode?	Fan runs continuously in Occupied and Tenant Override Modes.
	Unit in Unoccupied Mode?	Shut down is delayed 1 minute on transition to unoccupied mode.
	Discharge Air Temp. Input	Fan is forced on when DAT exceeds 130°F or when DAT falls below DAT low limit setpoint. Fan is locked-on until DAT is between the low limit setpoint and 110°F. The fan is also engaged if the DAT sensor fails.
	Space Temp & Setpoints	Fan operates with call for cooling or heating. If a conditioning mode is NOT available, the unit will run the fan. For example, on a heating only unit, the supply fan will be engaged when the space temperature exceeds the unoccupied cooling setpoint.
	Sensor Values & Locations	Verify that the room, outdoor, and discharge air temperature sensors are installed in the correct locations and that they are operating normally.
	Controller NO1 Output	NO1 is energized (24 VAC) with a call for the fan.
	Fan Relay	NO1 energizes the fan relay. Check the wiring and relay contacts.
Fan Won't Run	Unit in Unoccupied Mode?	The fan operates only with calls for heating or cooling.
	Wall 'stat Fan Icon OFF?	If the fan icon is not ON, the controller is not calling for the fan. Check the setpoints, space conditions, and occupancy modes.
	Wall 'stat Fan Icon ON?	If the fan icon is ON, the controller has engaged the fan output.
	Controller NO1 Output	If the fan icon is ON, 24 VAC should be on the NO1 terminal. If no voltage is present, Make sure that there is continuity between the controller NO1 pin and the subbase.
	Fan Relay	Verify that the fan relay coil is connected to NO1 and neutral. When the controller engages the fan, a nominal 24V is applied across the coil of the fan relay. Check the fan motor wiring and relay contacts.
	Fan Motor	Refer to the unit wiring diagram; check the fan motor wiring.
Space Too Warm (Heat Mode)	Discharge Air Temp. Input	When the DAT falls below the DAT low limit setpoint or the DAT sensor fails, heat is engaged. Where applicable: Heating Valve is Opened. Electric Heat is Engaged. Face & Bypass damper driven to full face position. Outdoor air damper is closed.
	Sensor Values & Locations	Verify that the room, outdoor, and discharge air temperature sensors are installed in the correct locations and that they are operating normally.
	Water Coil Low Limit Switch	When the water coil low limit switch trips, it shorts the OAT sensor input to signal the low limit condition. If the switch trips or the OAT sensor fails, heat is engaged as described above.
	Outdoor Air Temp. Input	Check the heating valve operation - HEATING VALVE MUST BE PIPED FOR NORMALLY OPEN OPERATION.
	Heating Valve	Refer to the unit wiring diagram. Check for a stuck contact on the electric heat control relays.
Space Too Warm (Cool Mode)	Discharge Air Temp. Input	When the DAT falls below the DAT low limit setpoint or the DAT sensor fails, cooling is disabled. Where applicable: Cooling Valve is Closed. Face & Bypass damper driven to full bypass position. Compressor is disabled. Outdoor air damper is closed.
	Sensor Values & Locations	Verify that the room, outdoor, and discharge air temperature sensors are installed in the correct locations and that they are operating normally.
	Water Coil Low Limit Switch	When the water coil low limit switch trips, it shorts the OAT sensor input to signal the low limit condition. If the switch trips or the OAT sensor fails, the outdoor air damper is closed.
	Outdoor Air Temp. Input	On 2-pipe cooling and heating units the changeover switch closes when the water supply falls below 63°F. Is this switch installed so that it properly detects the supply water temperature?
	Changeover (Aquastat)	Compressor operation is disabled when the RLL switch closes.
	Refrigerant Low Limit (Optional)	Does the cooling valve open? Is the heating valve closed?
	Cooling/Heating Valve(s)	Is chilled water available at correct temperature and flow rate? Is compressor operation disabled?
Space Too Cool (Cool Mode)	Adequate Cooling Capacity	Is chilled water available at correct temperature and flow rate? Is compressor operation disabled?
	Room Air Sensor	Check the location and operation of the room (return) air temperature (RAT) sensor or the wall 'stat. The RAT must be disconnected when the wall 'stat is mounted in the space and used to detect space temperature.
	Sensor Values & Locations	Verify that the room, outdoor, and discharge air temperature sensors are installed in the correct locations and that they are operating normally.
Space Too Cool (Heat Mode)	Cooling Valve Operation	Verify cooling valve operation.
	Discharge Air Temp Input	Heating is disabled when the DAT input exceeds 130°F or the DAT sensor fails. Heating remains disabled until the DAT falls below 110°F.
	Sensor Values & Locations	Verify that the room, outdoor, and discharge air temperature sensors are installed in the correct locations and that they are operating normally.
	Cooling/Heating Valve(s)	Does the heating valve open? Is the cooling valve closed?
Outdoor Air Damper Won't Close	Adequate Heating Capacity	Is hot water/steam available at correct temperature and flow rate?
	Unit in Occupied Mode?	Outdoor air damper will open to minimum position in occupied mode and tenant override modes.
Outdoor Air Damper Won't Open	Damper Actuator	Measure the control signal to the actuator. The actuator will drive fully closed with a signal of 4 mA or less. The actuator will drive fully open with a signal of 20 mA. Verify that the outdoor air/ return air dampers can turn without binding.
	Unit in Occupied Mode?	The outdoor air damper is closed during unoccupied mode.
	Discharge Air Temp. Input	When the DAT falls below the DAT low limit setpoint or the DAT sensor fails, the Outdoor air damper is closed.
	Water Coil Low Limit Switch	When the water coil low limit switch trips, it shorts the OAT sensor input to signal the low limit condition. If the switch trips or the OAT sensor fails, the damper closes.
Outdoor Air Temp. Input	If the space temperature falls more than 3°F below the heating setpoint, the outdoor air damper closes. The damper shall remain closed until the space temperature is within 2° of the heating setpoint.	
Space Temperature Input	On chilled water units, if the space temperature rises more than 3°F above the cooling setpoint the outdoor air damper will close. The damper shall remain closed until the space temperature is within 2° of the cooling setpoint.	