TruVu™ MPC Controller for 39MN,MW Indoor and Weathertight Outdoor Air Handlers

Application Data

CONTENTS

INTRODUCTION

This book describes the TruVu™ MPC control system and the control and sensor options available for the 39M air handlers. It details the features, benefits, selection procedures and provides specific guidelines to ensure an effective system design for the Aero® 39M air-handling units (AHU).

Carrier's Aero 39M central station air handlers provide heating, cooling and ventilation in constant volume (CV) and variable air volume (VAV) applications. The TruVu MPC control system provides easy-to-set, centralized management of all air-handling components. The TruVu MPC control system is available for all 39M units.

Aero 39M units can operate stand-alone or interface with the BACnet[1] communication option. If a control is installed as part of a network, it is connected to the BACnet communication bus with a field-installed cable (communication link).

All factory-installed sensors, actuators and wiring are internal to the unit. As shown in Fig. 1 and 2, the TruVu MPC control system presents an uncluttered outer surface with no factory-installed wires or controls extending outside the unit.

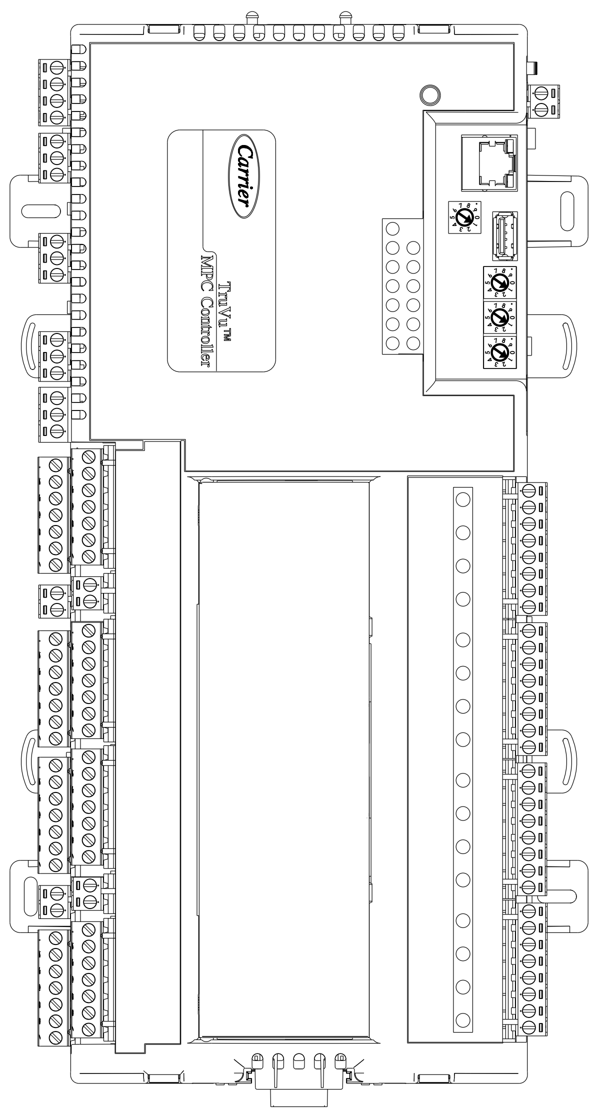

Fig. 1 — TruVu MPC Controller Module

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Benefits

RELIABLE

Inherent safeties and diagnostics within the control software properly protect equipment and quickly alert the operator to operation problems or potential problems.

FLEXIBLE

Various options meet a variety of application requirements such as variable or constant volume, energy recovery, smoke control, and timed override. The TruVu MPC control system is designed to function on a network with other system elements to optimize and coordinate the operation of the mechanical equipment.

COMPLIANT

When used with demand controlled ventilation (DCV), the TruVu MPC control system conforms to ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) 62 Indoor Air Quality Standards.

Product Overview

The TruVu MPC control system is factory-installed in its own control plenum section of Carrier's Aero 39M air handler. In addition, this programmable direct-digital controller (DDC) can be field installed in a variety of other heating, ventilating, and air-conditioning applications.

The user configures the TruVu MPC control system to contain a database of algorithms, points, schedules, alarms, and system functions that are necessary to control and monitor the air-handling unit. The controller data can be configured using many interface devices including the following:

- i-Vu® Application Builder software.
- SNAP graphical programming.

In addition to factory-wired control devices, an optional input/output module can be easily added to the enclosure, giving the TruVu MPC control system the capability to control and/or monitor a total of up to 48 points.

The TruVu MPC control system provides auxiliary building control to interface with other equipment including chillers, hot water systems, lighting and other HVAC equipment.

Applications

The TruVu MPC control system supports a wide range of building control applications, including:

- Air handlers (CV and VAV), heating, cooling and ventilating control.
- Mechanical room equipment control, including cooling towers, pumps (lead/lag), boilers, unit heaters and heat exchangers.
- Scheduling
- Custom programming
- Practically any other control process needed in commercial buildings.

Facility management applications include:

- Night Time Free Cooling (NTFC).
- Adaptive Optimal Start/Stop.
- Power fail restart.

The control box provides a centralized location for the TruVu MPC control module, which can store hundreds of configuration settings and set points. The TruVu MPC module also performs self-diagnostic tests at start-up, monitors unit operation, and provides alarms.

Physical Characteristics

The TruVu MPC control system with enclosure consists of the controller assembly mounted in an enclosure compliant with National Electrical Manufacturers Association (NEMA) type-1 standards. The controller will run off of the AHU systems power with transformers to adjust the incoming voltage to 24 vac ± 10%. The incoming power supply may be 50 or 60 Hz and capable of providing a minimum of 3 amps (but not greater than 20 amps) to the control board.

All factory-installed electronic control devices are terminated inside the control box, which is mounted in a control plenum. See Fig. 2.

The control box enclosure includes the TruVu MPC control system, circuit breaker, transformers, and terminal blocks. A field-supplied on/off switch allows power shut off to the control box. The control box environmental limitations are as follows:

CONTROL BOX CONDITIONS	TEMPERATURE RANGE °F (°C)	HUMIDITY RANGE (%) (NON-CONDENSING)
Shipping	–40-158 (–40-70)	10-95
Operating	–40-158 (–40-70)	10-95
Storage	–40-158 (–40-70)	10-95

All electrical components are UL (Underwriters Laboratories) listed. The electronic control module is approved under UL HVAC (Heating, Ventilation and Air Conditioning) Equipment Standard 916 for energy management equipment. Complete air-handling unit with factory-installed controls are listed and labeled by UL to comply with UL Standard 60335-2-40 for heating and cooling equipment, and comply with NFPA (National Fire Protection Association) Standard 90A.

All listings are for all factory-supplied controls options. Use of other accessory components are not covered under these listings.

Service Area Requirements

Article 110-16 of the NEC (National Electrical Code) describes electrical installation. All TruVu MPC control system installations must comply with the minimum clearances required for electrical installation as listed in Table 110-16(a) of the code. Make sure to provide the necessary clearance from the TruVu MPC control system and unit to any adjoining wall. Refer to the 39M Application Data catalog for detailed dimensions for each air-handling component section.

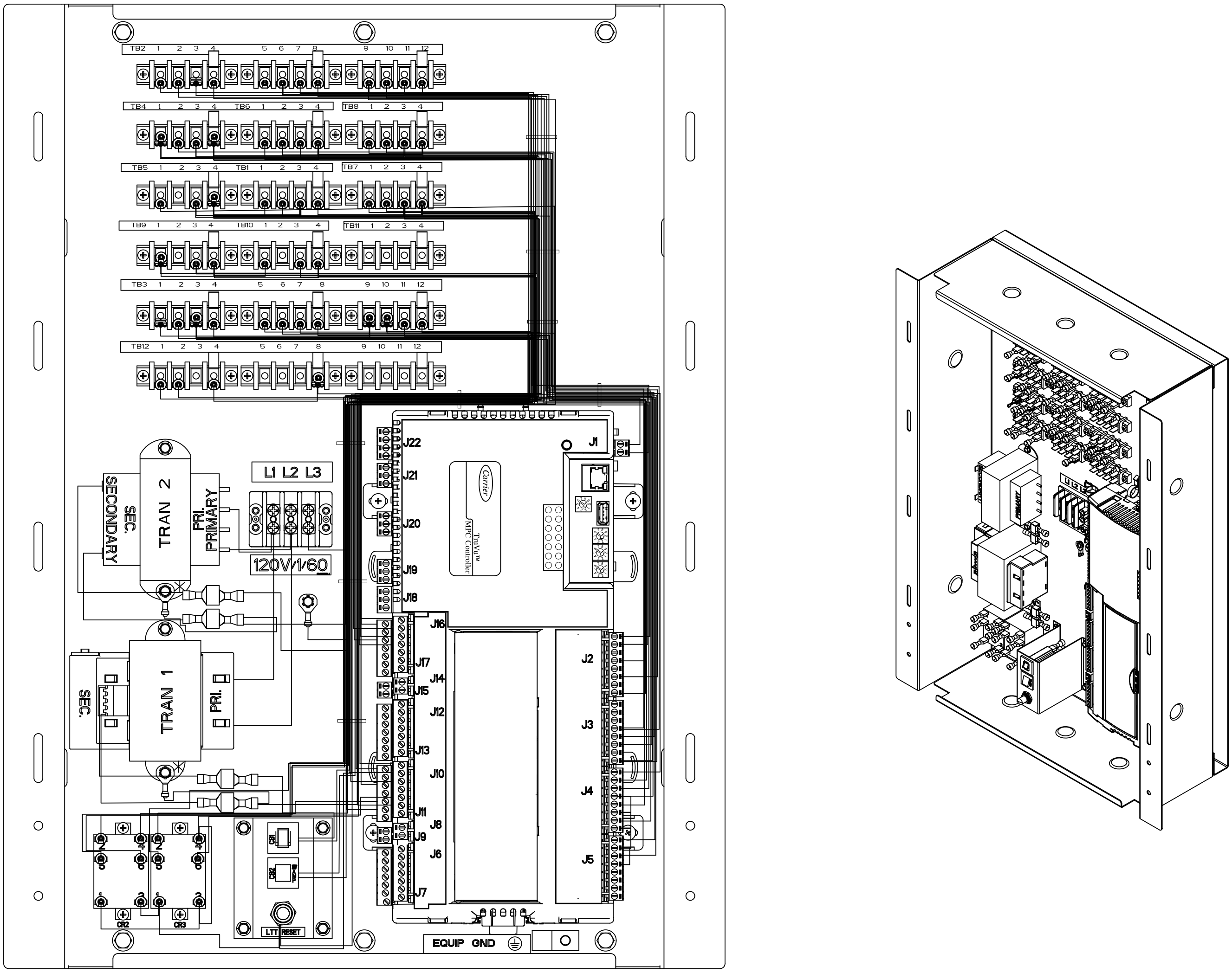


Fig. 2 — TruVu MPC Factory-Wired Controller

CONTROL SYSTEM

The TruVu MPC control system consists of the TruVu MPC control module, sensors and other controlled devices.

Control Module

The TruVu MPC control module, when factory installed, is mounted in its own dedicated control plenum. Inside the module is a control board, which contains a microprocessor that controls the operation of the unit. The controls software is not factory loaded onto the TruVu MPC control module as this software is selected and loaded in the field via a software development platform (e.g., Application Builder or SNAP). Dependent upon the controls selected, the control module will continuously monitor inputs and will control outputs such as the supply fan, cooling and heating coil valves, electric heat, DX (direct expansion) cooling, and air quality sensor.

A connection terminal to additional expander modules can be connected to the TruVu MPC depending on the power type provided to the controller. Refer to Fig. 3 and 4.

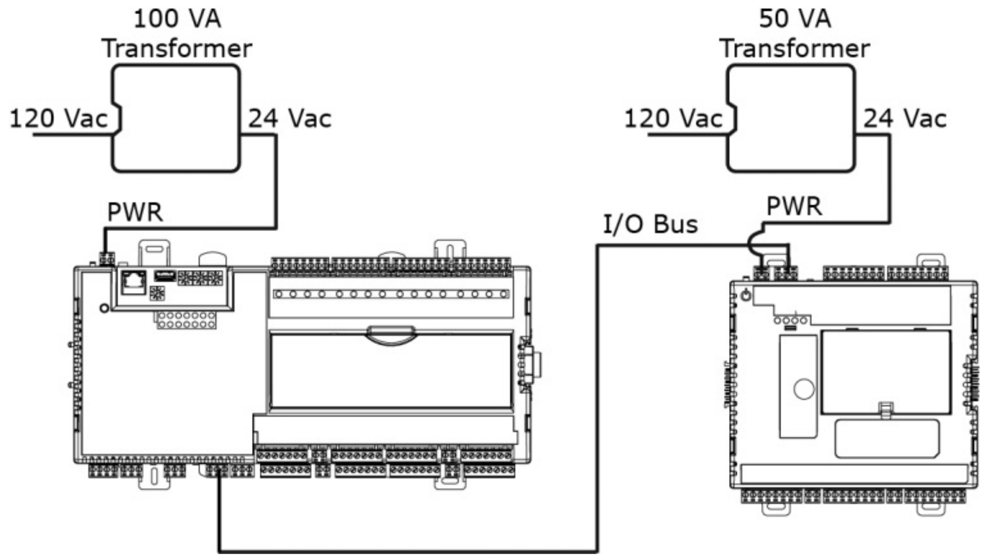
Daisy-chain the module to additional modules within the BACnet or other building management systems on the front of TruVu MPC control module. Refer to Fig. 3 and 4.

The TruVu MPC control module monitors multiple inputs from sensors and other devices within the system, and sends multiple output signals. Device inputs and outputs are wired to the TruVu MPC via multiple terminals. Refer to Fig. 5 and 6 and Table 1 for detailed wiring information.

The TruVu MPC control module communicates with either of the following:

- BACnet on an MS/TP network segment communication at 9600 to 115200 bps in Port S1.
- Modbus serial network at 9600 to 115200 bps in Port S1.
- Modbus serial network at 9600 to 115200 bps in Port S2.
- 10/100/1000 Base T, full duplex, ethernet port for BACnet/IP and/or BACnet/Ethernet, or Modbus TCP/IP communication in Gig-E port.

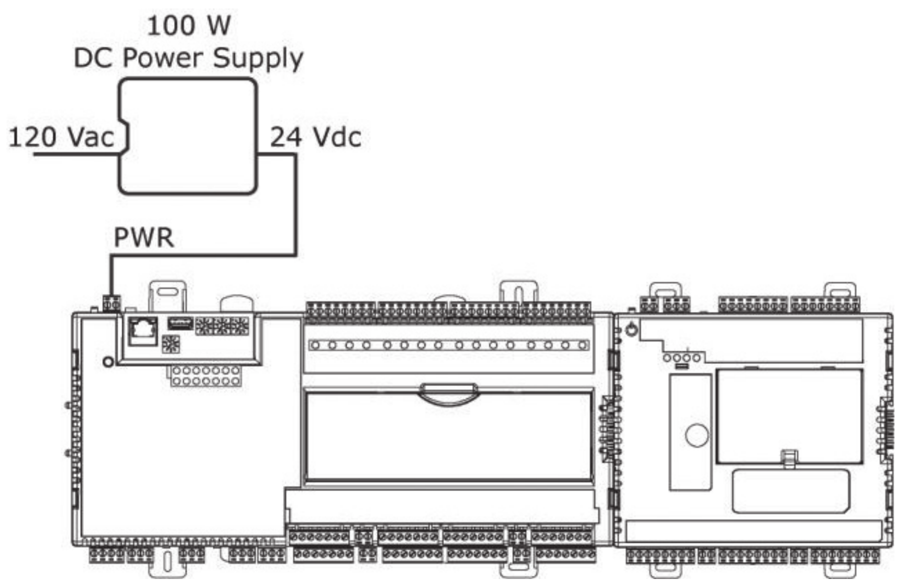
AC or **DC** - Wired to the **I/O Bus** port for communication and also wired to an external transformer for power



WARNING
Do not apply line voltage (mains voltage) to the controller's ports and terminals.

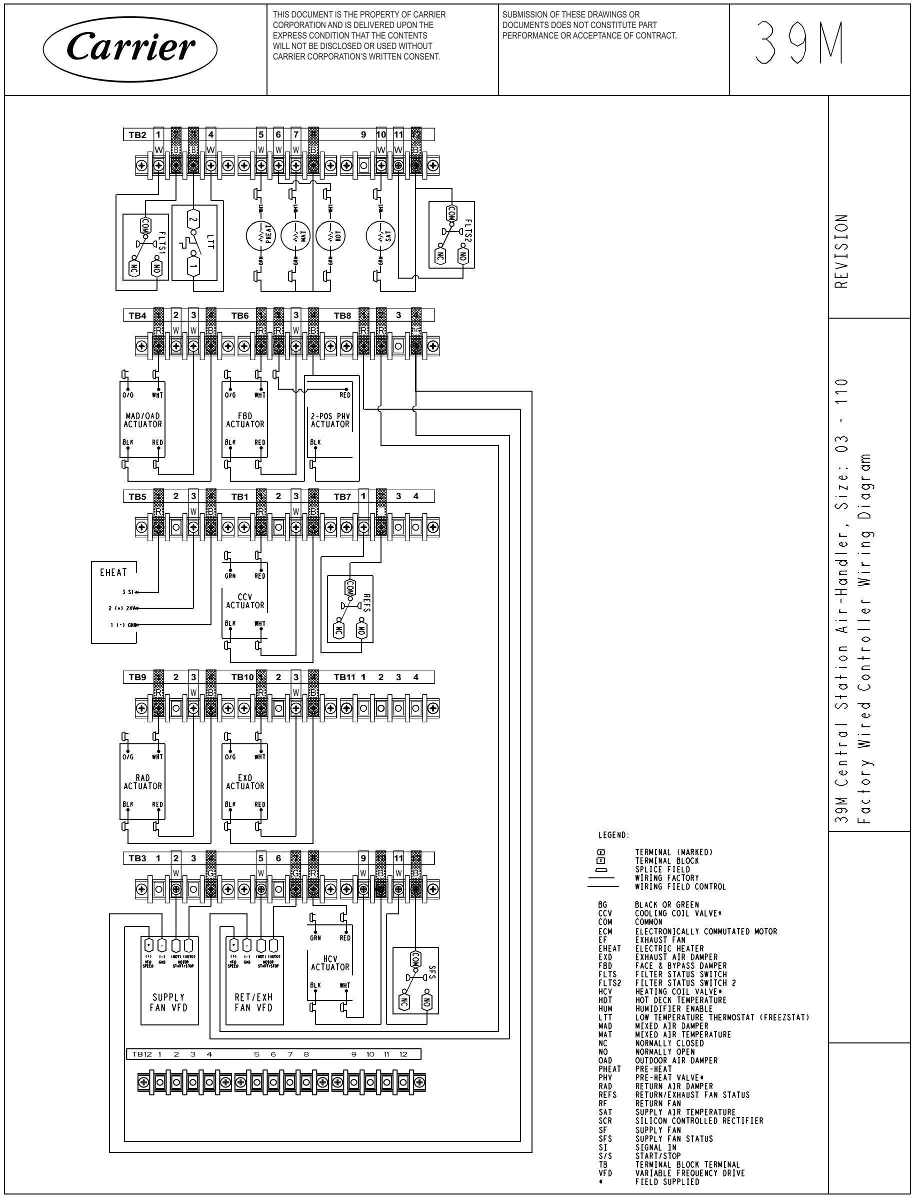
Fig. 3 — TruVu MPC Control Expander Module Connection — AC or DC

DC only - Directly-connected to the I/O bus edge connector that provides power and communication



WARNING
Do not apply line voltage (mains voltage) to the controller's ports and terminals.

Fig. 4 — TruVu MPC Control Expander Module Connection — DC Only



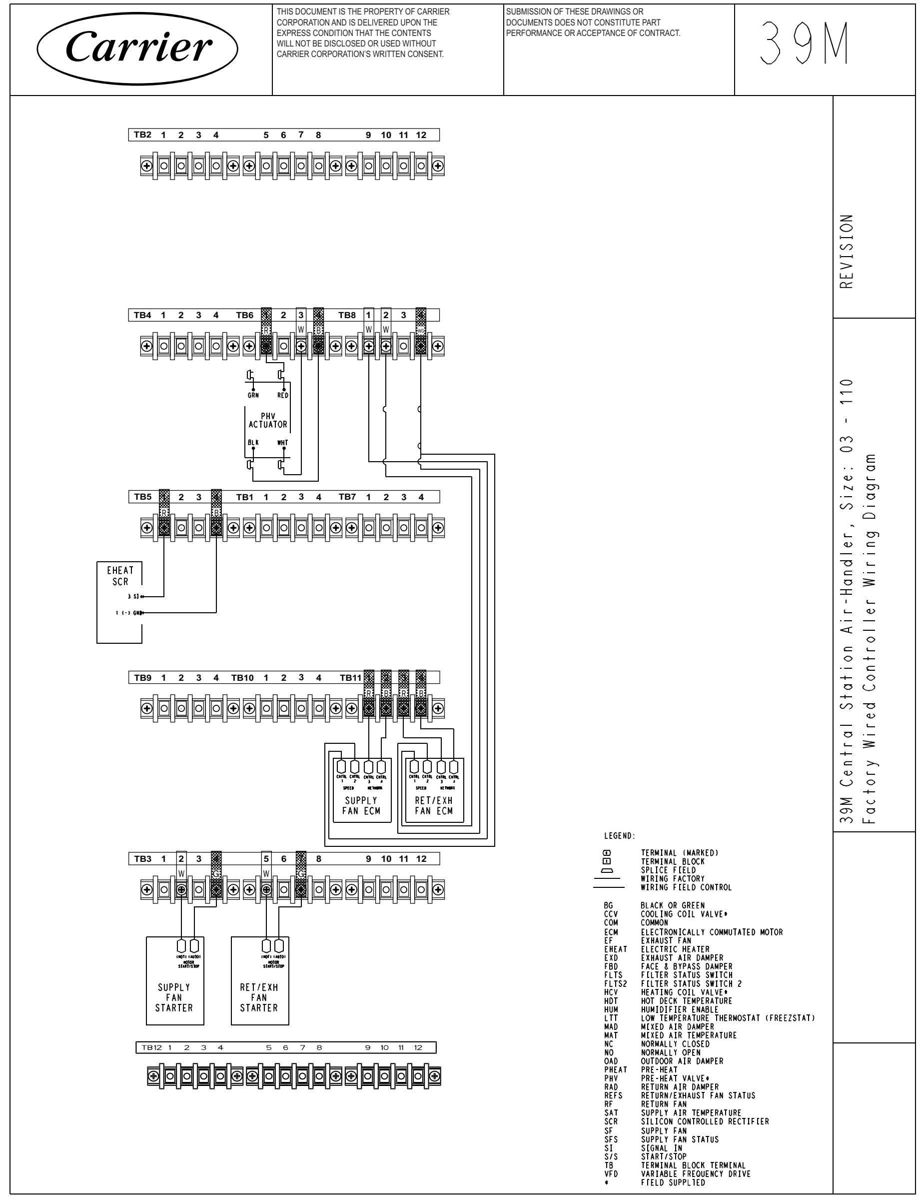


Fig. 5 — Sensor Wiring Schematic

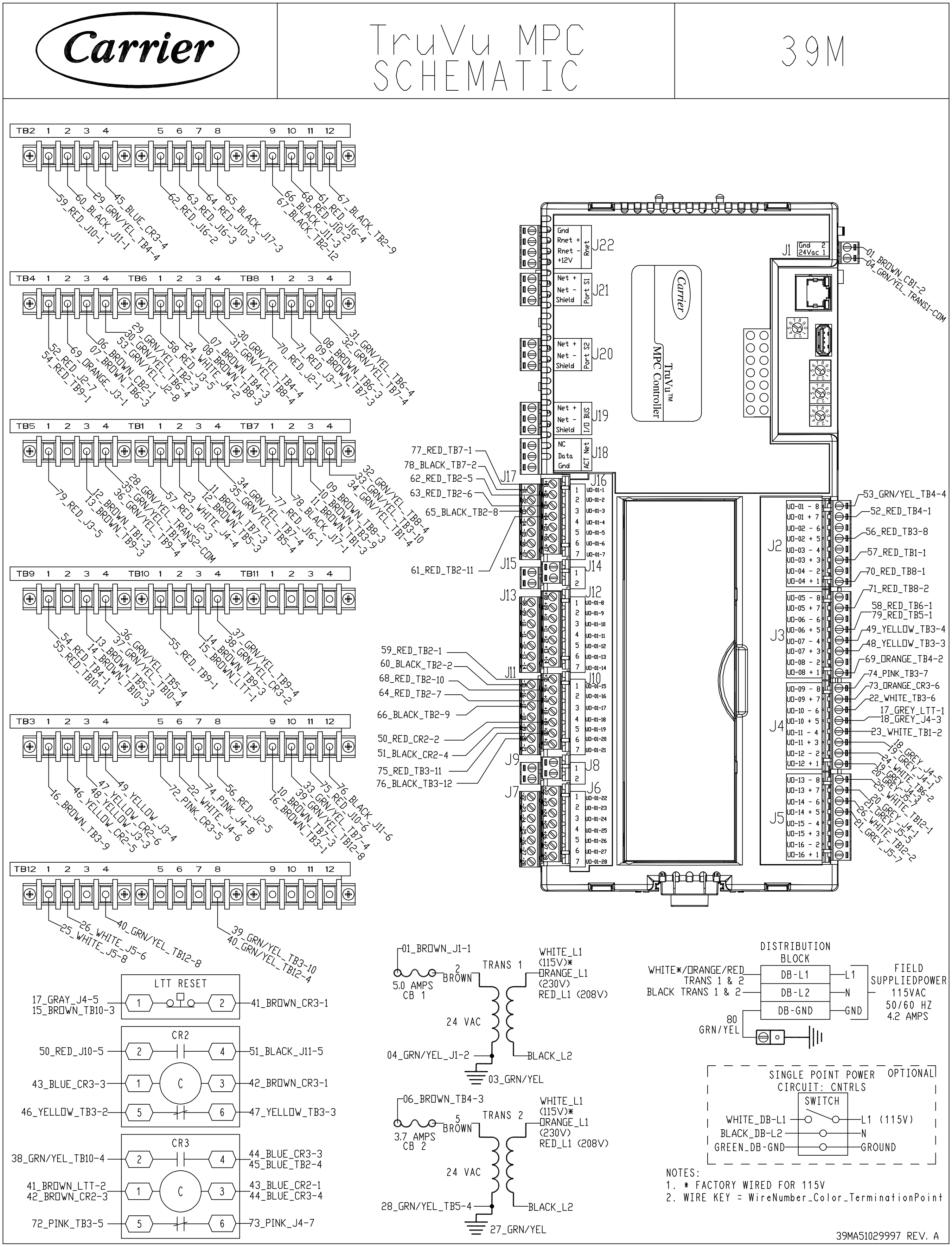


Fig. 6 — Controller Wiring Schematic

Table 1 — TruVu MPC I/O Applications

CHANNEL NO.	DEVICE (CABLE NO.)	WIRE COLOR	TERMINAL	SIGNAL
UNIVERSAL INPUT				
UI-26	BUILDING PRESSURE (FIELD SUPPLIED/INSTALLED)	FIELD INST.	J6-5	4-20 MA (+)
		FIELD INST.	J14-1	+24 VDC POWER
		FIELD INST.	J7-5	SIGNAL GROUND
UI-25	OUTDOOR AIR QUALITY (CO_2) (FIELD SUPPLIED/INSTALLED)	FIELD INST.	J6-4	4-20MA (+)
		FIELD INST.	J9-2	+24 VDC POWER
		FIELD INST.	J7-4	SIGNAL GROUND
UI-24	SPACE INDOOR AIR QUALITY (CO_2) (FIELD SUPPLIED/INSTALLED)	FIELD INST.	J6-3	4-20MA (+)
		FIELD INST.	J9-1	+24 VDC POWER
		FIELD INST.	J7-3	SIGNAL GROUND
UI-23	DUCT STATIC PRESSURE (FIELD SUPPLIED/INSTALLED)	FIELD INST.	J6-2	4-20 MA (+)
		FIELD INST.	J8-2	+24 VDC POWER
		FIELD INST.	J7-2	SIGNAL GROUND
UI-22	SPACE RH (FIELD SUPPLIED/INSTALLED)	FIELD INST.	J6-1	4-20 MA (+)
		FIELD INST.	J8-1	+24 VDC POWER
		FIELD INST.	J7-1	SIGNAL GROUND
UI-21	RETURN AIR TEMPERATURE (FIELD SUPPLIED/INSTALLED)	FIELD INST.	J10-7	10K THERMISTOR AI
		FIELD INST.	J11-7	SIGNAL GROUND
UI-20	SUPPLY FAN STATUS (CABLE NO. 21)	WHITE	TB3-11	DRY CONTACT DI
		BLACK	TB3-12	SIGNAL GROUND
UI-19	LOW TEMPERATURE THERMOSTAT (FREEZSTAT) (CABLE NO. 2)	WHITE	TB2-4	DRY CONTACT DI
		BLACK	TB2-3	SIGNAL GROUND
UI-18	OUTDOOR AIR TEMPERATURE (FIELD SUPPLIED/INSTALLED)	FIELD INST.	J10-4	10K THERMISTOR AI
		FIELD INST.	J11-4	SIGNAL GROUND
UI-17	MIXED AIR TEMPERATURE (CABLE NO. 4)	WHITE	TB2-7	10K THERMISTOR AI
		BLACK	TB2-8	SIGNAL GROUND
UI-16	SUPPLY AIR TEMPERATURE (CABLE NO. 1)	WHITE	TB2-10	10K THERMISTOR AI
		BLACK	TB2-12	SIGNAL GROUND
UI-15	FILTER STATUS SWITCH (CABLE NO. 3)	WHITE	TB2-1	DRY CONTACT DI
		BLACK	TB2-2	SIGNAL GROUND
UI-14	NOT USED	N/A	N/A	N/A
UI-13	NOT USED	N/A	N/A	N/A
UNIVERSAL INPUT (cont)				
UI-12	NOT USED	N/A	N/A	N/A
UI-11	NOT USED	N/A	N/A	N/A
UI-10	ENTHALPY SWITCH	FIELD INST.	J12-3	DRY CONTACT DI
		FIELD INST.	J13-3	SIGNAL GROUND
UI-09	SMOKE MODE PURGE INPUT	FIELD INST.	J12-2	DRY CONTACT DI
		FIELD INST.	J13-2	SIGNAL GROUND
UI-08	SMOKE MODE PRESSURIZATION INPUT	FIELD INST.	J12-1	DRY CONTACT DI
		FIELD INST.	J13-1	SIGNAL GROUND
UI-07	SMOKE MODE EVACUATION INPUT	FIELD INST.	J16-7	DRY CONTACT DI
		FIELD INST.	J17-7	SIGNAL GROUND
UI-06	FIRE/SMOKE SHUTDOWN CONTACT	FIELD INST.	J16-6	DRY CONTACT DI
		FIELD INST.	J17-6	SIGNAL GROUND
UI-05	HIGH SUPPLY DUCT RH	FIELD INST.	J16-5	DRY CONTACT DI
		FIELD INST.	J17-5	SIGNAL GROUND
UI-04	FILTER STATUS-2 (CABLE NO. 17)	WHITE	TB2-11	DRY CONTACT DI
		BLACK	TB2-12	SIGNAL GROUND
UI-03	HOT DECK TEMPERATURE (CABLE NO.18)	WHITE	TB2-6	10K THERMISTOR AI
		BLACK	TB2-8	SIGNAL GROUND
UI-02	PRE-HEAT TEMPERATURE (CABLE NO. 7)	WHITE	TB2-5	10K THERMISTOR AI
		BLACK	TB2-8	SIGNAL GROUND
UI-01	RETURN/EXHAUST FAN STATUS (CABLE NO. 19)	WHITE	TB7-1	DRY CONTACT DI
		BLACK	TB7-2	SIGNAL GROUND
UNIVERSAL OUTPUT				
COMMON	COMMON	**FIELD INST.**	**TB1-4**	**GROUND**
UO-16	DX STAGE 2 (FIELD SUPPLIED/FIELD INSTALLED)	FIELD INST.	J5-1	DX STAGE 2 (24VAC)
UO-15	DX STAGE 1 (FIELD SUPPLIED/FIELD INSTALLED)	FIELD INST.	J5-3	DX STAGE 1 (24VAC)
UO-14	NOT USED	N/A	N/A	N/A
UO-13	NOT USED	N/A	N/A	N/A

Table 1 — TruVu MPC I/O Applications (cont)

CHANNEL NO.	DEVICE (CABLE NO.)	WIRE COLOR	TERMINAL	SIGNAL
UNIVERSAL OUTPUT (cont)				
UO-12	2-POSITION PRE-HEAT VALVE (CABLE NO. 20)	RED	TB6-2	+24 VAC DO
		WHITE	N/C	—
		BLACK	TB6-4	POWER GROUND
		GREEN	N/C	—
U0-11	F/B 2-POSITION CW VALVE (CABLE NO. 8)	RED	TB1-2	+24 VAC DO
		WHITE	N/C	—
		BLACK	TB1-4	GROUND
		GREEN	N/C	—
UO-10	F/B 2-POSITION CW VALVE (CABLE NO. 9)	RED	TB3-6	+24 VAC DO
		WHITE	N/C	—
		BLACK	TB3-10	GROUND
		GREEN	N/C	—
UO-09	RETURN/EXHAUST FAN START/STOP (CABLE NO.11)	RED	N/C	—
		WHITE	TB3-5	MOTOR S/S
		BLACK	N/C	—
		GREEN	TB3-7	MOTOR S/S
UO-08	HUMIDIFIER ENABLE (CABLE NO.16)	RED	N/C	—
		WHITE	TB4-2	24 VAC SIGNAL DO
		BLACK	TB6-4	GROUND
		GREEN	N/C	—
UO-07	SUPPLY FAN START/STOP (CABLE NO.10)	RED	N/C	—
		WHITE	TB3-2	MOTOR S/S
		BLACK	N/C	—
		GREEN	TB3-4	MOTOR S/S
UO-06	ELECTRIC HEAT (CABLE NO. 12)	RED	TB5-1	0-10 VDC AO
		WHITE	TB5-3	+24 VAC
		BLACK	TB5-4	GROUND
		GREEN	N/C	—
UO-06	ELECTRIC HEAT WITH SCR (CABLE NO. 12)	RED	TB5-1	0-10 VDC AO
		WHITE	N/C	—
		BLACK	TB5-4	GROUND
		GREEN	N/C	—
UO-06	F/B DAMPER (CABLE NO. 23)	RED	TB6-1	0-10 VDC AO
		WHITE	TB6-3	+ 24 VAC
		BLACK	TB6-4	GROUND
		GREEN	N/C	—
UO-06	PRE HEAT VALVE (CABLE NO. 20)	RED	TB6-1	0-10 VDC AO
		WHITE	TB6-3	+24 VAC
		BLACK	TB6-4	GROUND
		N/C	N/C	—
UO-05	RETURN FAN/EXHAUST FAN VARIABLE FREQUENCY SPEED (CABLE NO. 11)	RED	TB8-2	2-10 VDC AO
		BLACK	TB8-4	GROUND
UO-05	RETURN FAN/EXHAUST FAN ELECTRONICALLY COMMUTATED MOTOR SPEED (CABLE NO. 25)	WHITE	TB8-2	2-10 VDC AO
		GREEN	TB8-4	GROUND
UO-04	SUPPLY FAN ELECTRONICALLY COMMUTATED MOTOR SPEED (CABLE NO. 10)	WHITE	TB8-1	2-10 VDC AO
		GREEN	TB8-4	GROUND
UO-04	SUPPLY FAN ELECTRONICALLY COMMUTATED MOTOR SPEED (CABLE NO. 24)	WHITE	TB8-1	2-10 VDC AO
		GREEN	TB8-4	GROUND
UO-03	COOLING COIL VALVE (CABLE NO. 8) CW-Modulating, External F/B, Internal F/B	RED	TB1-1	0-10 VDC AO
		WHITE	TB1-3	+ 24 VAC
		BLACK	TB1-4	GROUND
		GREEN	N/C	—
UO-02	HEATING COIL VALVE (CABLE NO. 9)	RED	TB3-8	0-10 VDC AO
		WHITE	TB3-9	+ 24 VAC
		BLACK	TB3-10	GROUND
		GREEN	N/C	—
UO-01	MODULATING EXHAUST AIR DAMPER (CABLE NO. 6)	RED	TB10-1	0-10 VDC AO
		WHITE	TB10-3	+ 24 VAC
		BLACK	TB 10-4	GROUND
		GREEN	N/C	—
UO-01	MODULATING RETURN AIR DAMPER (CABLE NO. 22)	RED	TB9-1	0-10 VDC AO
		WHITE	TB9-3	+ 24 VAC
		BLACK	TB9-4	GROUND
		GREEN	N/C	—

Table 1 — TruVu MPC I/O Applications (cont)

CHANNEL NO.	DEVICE (CABLE NO.)	WIRE COLOR	TERMINAL	SIGNAL
UNIVERSAL OUTPUT (cont)				
UO-01	MIXED AIR/ MODULATING OUTSIDE AIR DAMPER (CABLE NO. 5)	RED	TB4-1	0-10 VDC AO
		WHITE	TB4-3	+ 24 VAC
		BLACK	TB4-4	POWER GROUND
		GREEN	N/C	
TERMINAL BLOCK ONLY				
—	SUPPPLY FAN ELECTRONICALLY COMMUTATED MOTOR NETWORK (CABLE NO. 24)	RED	TB11-1	MODBUS/BACNET +
		BLACK	TB11-2	MODBUS/BACNET -
—	RETURN FAN/EXHAUST FAN ELECTRONICALLY COMMUTATED MOTOR NETWORK (CABLE NO. 25)	RED	TB11-3	MODBUS/BACNET +
		BLACK	TB11-4	MODBUS/BACNET -

LEGEND

AI	—	Analog In
AO	—	Analog Out
BO	—	Binary Out
CW	—	Chilled Water
DI	—	Direct Input
DO	—	Direct Output
DX	—	Direct Expansion
F/B	—	Face and Bypass
N/A	—	Not Applicable
RH	—	Relative Humidity
SCR	—	Silicon Controller Rectifier
S/S	—	Start/Stop
UI	—	Universal Input
UO	—	Universal Output

CONTROL HARDWARE

The TruVu MPC control module works in conjunction with the following equipment by receiving inputs and sending outputs to the sensors, switches, dampers and other devices in the system. Figure 7 shows the air handler with typical sensors and actuators installed.

All factory-installed sensors will be wired to one of 2 locations based on the controls option selected in *AHU*Builder® program as outlined below:

Wiring

NO PRODUCT INTEGRATED CONTROLS

No sensors are installed nor wired in the AHU.

FACTORY WIRED, NO CONTROLLER

All factory-installed sensors are wired to a terminal strip normally located in either a control plenum or the supply fan section.

FACTORY WIRED, UNPROGRAMMED CONTROLLER IN CONTROL PLENUM

All factory-installed sensors are wired to a terminal strip inside the control plenum. The TruVu MPC control system is then wired to the terminal strip and mounted inside the control plenum.

NOTE: If shipping splits exist, wiring will be terminated at each split with a Molex-type quick connect at each end of the wiring.

Sensors

Various factory-installed and field-installed sensors are available to provide varying amounts of control within the air-handling system. Following are the factory available sensors that work in conjunction with the TruVu MPC control system.

Table 2 lists the standard and optional factory-installed sensors provided with each controls option in *AHU*Builder® program.

SUPPLY-AIR TEMPERATURE (SAT) SENSOR (P/N 33ZCSENSAT)

The sensor consists of a thermistor encased within a stainless steel probe and is mounted to a junction box. The sensor's thermistor has a range of –40° to 245°F (–40° to 118°C) with a nominal resistance of 10,000 ohms at 77°F (25°C) and an accuracy of ±0.36°F (0.2°C) from 32°F to 158°F (0° to 70°C). See Table 2 for SAT sensor details. See Fig. 7 for typical SAT sensor location.

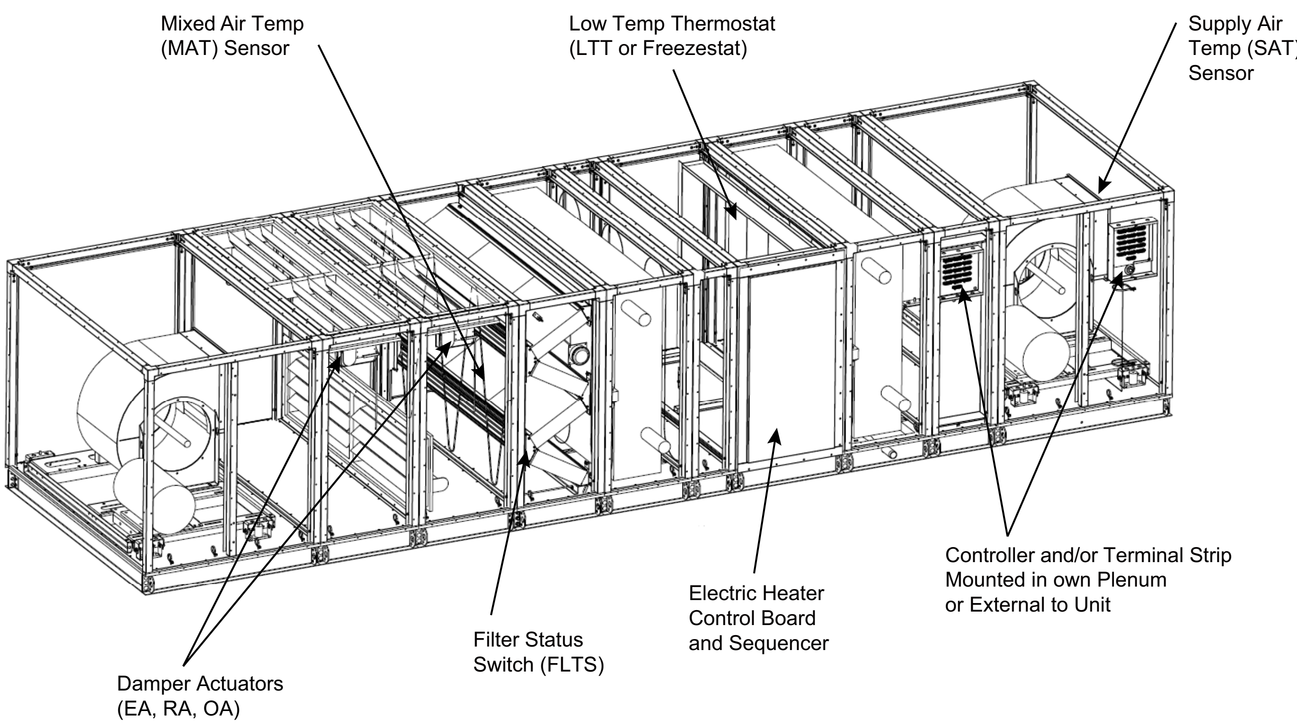


Fig. 7 — 39M Typical Actuator and Sensor Installation Locations

Table 2 — Standard and Optional Factory-Installed Sensors in A*HU*Builder® Program

*AHU*BUILDER® CONTROLS OPTION	TruVu™ MPC CONTROLLER INSTALLED?	TYPE	INSTALLED WHEN	LOCATION
STANDARD SENSORS INSTALLED (39M)				
No Product Integrated Controls	No	None	N/A	N/A
Factory Wired - No Controller	No	Mixed Air Temp (MAT)	Mixing Box or Filter Mixing Box is Present	Leaving Air Side of MXB/FMB
		Low Temp Thermostat (LTT)	Steam, HW or CW Coil is Present	If HW or Steam Coil Present and Upstream of any CW Coil, LTT Installed on Leaving Air Side of Steam or HW coil. Otherwise, Installed on Entering Air Side of CW Coil.
		Supply Air Temp Sensor (SAT)	Always Present	Draw Thru Fan (AF/FC Fan) – Probe type sensor located in the discharge of fan
				Draw Thru Fan (Belt/Direct Drive Plenum Fan) – Probe type sensor located on the fan leaving side of the fan sled in airflow path
				Draw Thru Fan, Horizontal (ECM DD Plenum Fan) – Averaging type sensor located at the discharge of the ECM fan section
				Draw Thru Fan, Vertical (ECM DD Plenum Fan) – Probe type sensor for field installation in field cut or factory supplied discharge opening
				Blow Thru Fan (AF/FC Fan) - NO downstream coils-Probe type sensor located in the discharge of fan - Downstream coils-Averaging type sensor located at the end of the last blow thru coil section.
				Blow Thru Fan (Belt/Direct Drive/ECM Plenum Fan) - NO downstream coils – Averaging type sensor located at the discharge of the plenum fan section - Downstream coils – Averaging type sensor located at the end of the last blow thru coil section
		Fan Status Switch	Supplied with each Supply, Return, or Exhaust Fan	In the Bottom Section of the VFD or Inside of the Starter, Disconnect or ECM FAN POWER BOX Otherwise, Factory Supplied in Fan Section for Field Installation.
		Preheat Temp Sensor (PHEAT)	Electric Heat Section is at Least 18 Inches in Length and Upstream of a Cooling Coil	Installed After the Electric Heater in the Electric Heater Section
Factory Wired - Unprogrammed Controller in Control Plenum	Yes	Same Offering as "Factory Wired - No Controller" Option		
OPTIONAL SENSORS AND CONTROLS (39M)				
No Product Integrated Controls	No	None	N/A	N/A
Factory Wired - No Controller	No	Damper Actuators (with or without linkage)	All Sections with Dampers	Mounted on Damper Actuating Shaft
		Filter Status Switch	All Filter Sections	Sensor Mounted Upstream and Downstream of Filter
		Humidifier Terminal Box for Field Supplied Control Valve	Humidifier Section	Mounted on Outside of the Humidifier Section
		Cooling/Heating Terminal Box for Field Supplied Control Valve	All CW, DX, HW and Steam Sections	Mounted on Outside of the Cooling or Heating Section
		6-stage Electric Heat Sequencer	Electric Heat Section	Mounted Inside Electric Heat Section
		SCR Controller	Electric Heat Section (low kW heaters)	Mounted Inside Electric Heat Section
		Vernier Controller	Electric Heat Section (high kW heaters)	Mounted Inside Electric Heat Section
		VFD	Fan Section	External to Fan Section or Inside VFD Plenum
		Motor Starter with or without Disconnect	Fan Section	External to Fan Section
Factory Wired - Unprogrammed Controller in Control Plenum	Yes	Same Offering as "Factory Wired - No Controller" Option		

LEGEND for Table 2

AF	—	Airfoil
BT	—	Blow Thru
CW	—	Chilled Water
DT	—	Draw Thru
DX	—	Direct Expansion
ECM	—	Electronically Commutated Motor
FC	—	Forward Curve
FMB	—	Filter Mixing Box
HW	—	Hot Water
LTT	—	Low Temperature Thermostat
MAT	—	Mixed Air Temperature
MXB	—	Mixing Box
PF	—	Plenum Fan
PHEAT	—	Preheat Temperature Sensor
SAT	—	Supply Air Temperature Sensor
SCR	—	Silicon Control Rectifier
VFD	—	Variable Frequency Drive

RETURN-AIR TEMPERATURE (RAT) SENSOR

The return-air temperature sensor (33ZCSENPAT) is ordered separately as an accessory for field installation in the return air duct. The sensor consists of a thermistor encased within a stainless steel probe. See Fig. 8.

The sensor's thermistor has a temperature range of –40° to 245°F (–40° to 118°C) with a nominal resistance of 10,000 ohms at 77°F (25°C) and an accuracy of ±0.36°F (0.2°C) from 32°F to 158°F (0° to 70°C).

CO_2 SENSOR

The CO_2 sensor (Fig. 9) monitors carbon dioxide levels and is a field-installed accessory. As CO_2 levels increase, the controller adjusts the outside-air dampers to increase ventilation and improve indoor-air quality. The sensor can be wall mounted or duct mounted, however an Aspirator Box (P/N 33ZCASPCO2) is required to house the CO_2 sensor for duct installation. CO_2 sensor part numbers are in Table 3.

The CO_2 sensor uses a Dual Beam Absorption Infrared™ method to detect levels of CO_2 present in the air. All CO_2 sensors are set to the factory default measurement range of 0 to 2000 ppm and are adjustable to up to 10,000 ppm. The digital display will show concentrations in the range of 0 to 10,000 ppm with a sensitivity of ± 10 ppm and resolution of ± 1 ppm. Under typical conditions of 60°F to 90°F, the sensor accuracy is ±50 ppm or ± 3% of reading in the 0 to 2000 ppm range and ±5% of reading in the 2000 to 10,000 ppm range. The sensor will operate in conditions of 32°F to 122°F (0°C to 50°C) and 0 to 95% RH, non-condensing.

Also available are CO_2/space temperature sensors that house the two sensors in a single unit. These sensors use a Single Beam Absorption Infrared™ diffusion technology to monitor CO_2 levels and have a 10,000 thermistor to measure space temperature. This sensor has the same measurement range as the CO_2 sensors, with an accuracy of ± 110 ppm in the 0 to 2000 ppm range under typical conditions of 60°F to 90°F (15°C to 32°C).

Figure 10 shows ventilation rates for various CO_2 set points when outside air with a typical CO_2 level of 350 ppm is used to dilute the air.

The CO_2 sensor has a 4 to 20 mA output that is converted to 0 to 5 vdc by a 250 ohm, 1/4 watt, 2% tolerance resistor connected across the zone controller's CO_2 input terminals.

Table 3 — CO_2 Sensor Part Numbers

PART NUMBER	DESCRIPTION
33ZCSPTCO2LCD-01	CO_2 sensor with display
33ZCSPTCO2-01	CO_2 sensor without display
33ZCT55CO2	Space temperature and CO_2 sensor with override
33ZCT56CO2	Space temperature and CO_2 sensor with override and set point adjustment
33ZCASPCO2	Aspirator box for duct mount CO_2 sensors

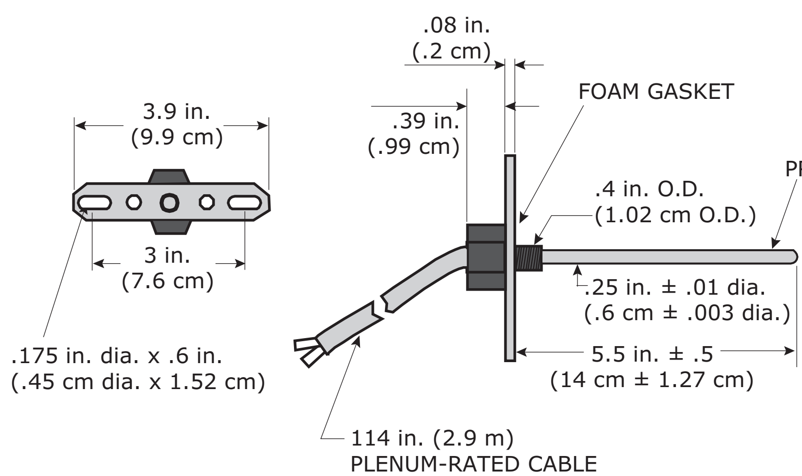


Fig. 8 — Supply-Air/Return-Air Temperature Sensor (33ZCSENSAT)

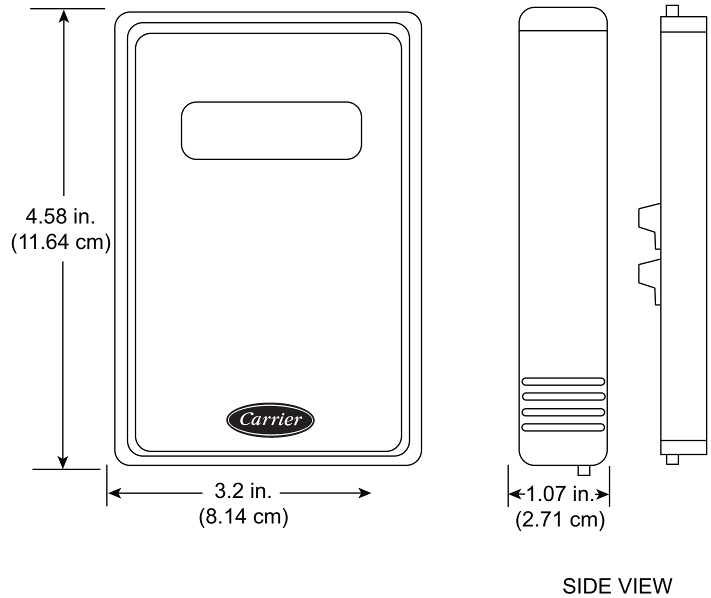


Fig. 9 — Air Quality (CO_2) Sensor (Wall Mount Version Shown)

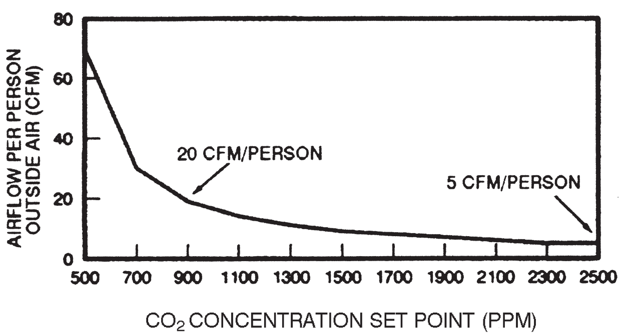


Fig. 10 — Ventilation Air Based on CO_2 Set Point

OUTDOOR-AIR TEMPERATURE SENSOR (OAT)
(P/N 33ZCSENOAT)

The OAT sensor is ordered separately for field installation and consists of a thermistor encased within a probe. See Fig. 11.

The OAT Sensor has an operating range of –40° to 245°F (–40° to 118°C) with a nominal resistance of 10,000 ohms at 77°F (25°C) and an accuracy of ±0.36°F (0.2°C) from 32°F to 158°F (0° to 70°C).

SPACE TEMPERATURE (SPT) SENSOR
(CV UNITS ONLY)

The space temperature sensor has a low profile enclosure in a neutral color and is available in 4 different offerings. See Table 4. The SPT Pro (Fig. 12) has a large, easy-to-read LCD and displays space temperature, outside-air temperature, heating set point, cooling set point, time and a local override for after hours occupancy.

The SPT sensor provides a hidden communication port allowing a laptop computer or a BACview[1] keypad to commission and maintain the connected equipment easily. Multiple SPT sensors can be daisy-chained to one controller for temperature averaging or high/low select control (one SPT Pro+ with up to four SPT Standard sensors). See Table 5.

The SPT sensor contains a precise 10,000 ohm thermistor with a standard accuracy of ±0.45°F (0.25°C) and less than 0.18°F (0.1°C) drift over a ten-year period. The sensor has a range of 50°F to 95°F (10°C to 35°C).

Table 4 — Space Temperature Sensors

PART NUMBER	DESCRIPTION
SPS	SPT Standard
SPPL	SPT Plus
SPP	SPT Pro
SPPF	SPT Pro+

Table 5 — TruVu MPC Communications Bus to System Element Color Code System

SIGNAL TYPE	CCN BUS CONDUCTOR INSULATION COLOR
+12V	RED
RNET-	BLACK
RNET+	WHITE
GND	GREEN

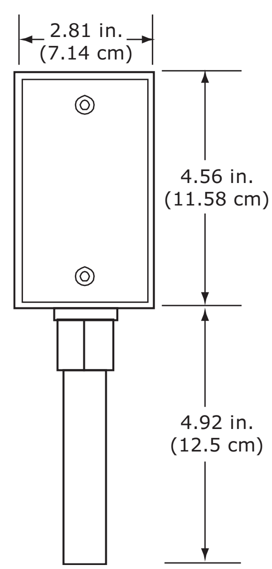


Fig. 11 — Outdoor-Air Temperature (OAT) Sensor

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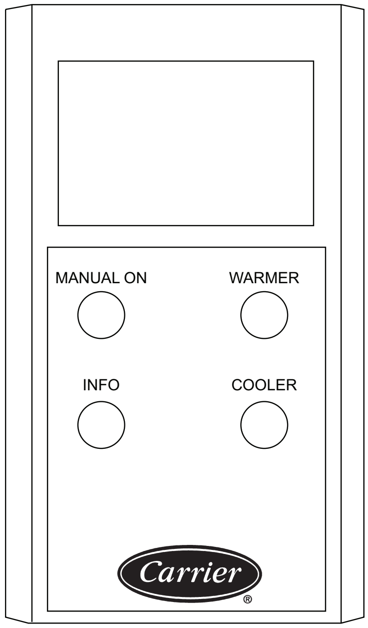


Fig. 12 — SPT Pro Sensor

MIXED-AIR TEMPERATURE (MAT) SENSOR

The mixed-air temperature sensor measures the temperature of the air leaving the mixing box. The MAT sensor is factory supplied and installed when either of the factory-wired control options is selected in the *AHU*Builder® program and a mixing box or filter mixing box is present. The sensor is located inside the last mixing box in the airflow.

The MAT sensor consists of multiple thermistors evenly spaced and encased within a flexible copper tube, which provides average temperature sensing. The sensor tubing is installed on the downstream side of the mixing box and is serpentined so it can sense average temperature. The MAT has a range of –40° to 185°F (–40° to 85°C) with a nominal resistance of 10,000 ohms at 77°F (25°C) and an accuracy of ±0.36°F (0.2°C) from 32°F to 158°F (0° to 70°C).

PREHEAT TEMPERATURE SENSOR (PHEAT)

The preheat temperature sensor measures the temperature of the air leaving the preheat coil. The sensor is factory supplied and installed when there is an extended length electric heating coil in its own section before a cooling coil and either of the factory-wired control options is selected in the *AHU*Builder® program. The PHEAT sensor is normally on the downstream side of the heating coil in the heating coil section.

The sensor consists of multiple thermistors evenly spaced and encased within a flexible copper tube, which provides average temperature sensing. The sensor tubing is installed on the downstream side of the preheat coil and is serpentined so it can sense average temperature. The preheat sensor has a range of –40° to 185°F (–40° to 85°C) with a nominal resistance of 10,000 ohms at 77°F (25°C) and an accuracy of ±0.36°F (0.2°C) from 32°F to 158°F (0° to 70°C).

LOW-TEMPERATURE THERMOSTAT (LTT)

The low-temperature thermostat (often referred to as a freeze-stat) protects the chilled water from freezing when abnormally cold air passes through the coil. (See Fig. 13.) The sensor is factory supplied and installed when there is a factory supplied and installed steam or water heating and/or cooling coil and either of the factory-wired control options is selected in the *AHU*Builder® program. The LTT is a factory-installed 20-ft long capillary tube mounted in the airstream on the entering side of the chilled water coil or the leaving air side of the first hot water coil if no cooling is supplied in the equipment. The thermostat reset mechanism is provided inside the control box.

The low-temperature thermostat has a range of 35°F to 60°F (1.7°C to 15.5°C) and is factory-set to switch at 35°F (1.7°C). It can be field-adjusted to meet the specific job requirements.

The thermostat is wired to the control box. If any one-foot section of the capillary senses air cooler than the thermostat set point, it causes the fan to shut down and an alarm is generated. A manual reset inside the control box can restart the fan after the problem is corrected and the coil temperature has risen by at least 5°F (3°C). The location of the reset eliminates the need to open the air handler.

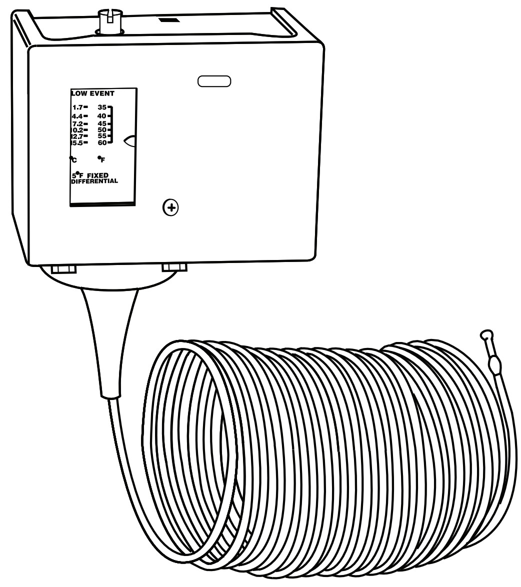


Fig. 13 — Low-Temperature Thermostat

RELATIVE HUMIDITY SENSORS

The relative humidity sensor can either be wall mounted (Fig. 14), duct mounted or outdoor mounted. Relative humidity sensors can be used for dehumidification control, for monitoring the relative humidity in the occupied space or for monitoring the relative humidity in the outdoor air. These sensors use bulk polymer resistance technology, which eliminates the effect of surface contamination and helps maintain the sensor accuracy over a long period of time.

The wall-mounted relative humidity sensor is normally installed on an interior wall where the relative humidity is representative of the entire zone to be serviced. The duct mounted relative humidity sensor is normally mounted in the zone's return air duct, and the outdoor relative humidity sensor is normally mounted where the sensor is protected from the elements and direct sunlight, such as under an eave.

The relative humidity sensors have a range of 0 to 99% RH< non-condensing and operate at temperatures from 40°F to 130°F (4°C to 54°C). Their accuracy at 77°F (25°C) is ± 2% RH from 10 to 80% and ± 3% RH from 80 to 99%. The wall-mounted sensor has an output of 4 to 20mA, the duct-mounted sensor has a 0 to 5 vdc output and the outside sensor has a 0 to 10 vdc output. Part numbers for each are shown in Table 6.

Table 6 — Sensor Part Numbers

PART NUMBER	SENSOR DESCRIPTION
33ZCSENSRH-02	Space (wall mounted) Relative Humidity Sensor
33ZCSENDRH-02	Duct Relative Humidity Sensor
33ZCSENORH-02	Outdoor Relative Humidity Sensor

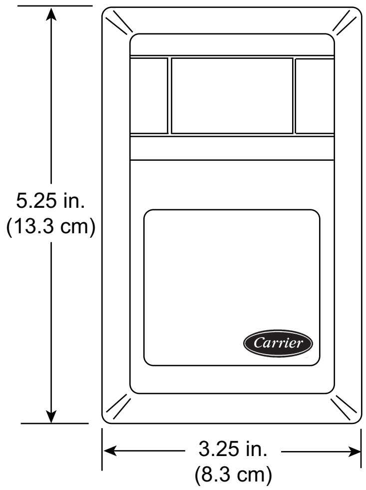


Fig. 14 — Wall-Mounted Relative Humidity Sensor (33ZCSENSRH-02)

Switches

FAN STATUS SWITCH

The fan status switch monitors any change in AC current that is indicative of a motor failure, belt loss or slippage or mechanical failure of the fan. The fan status switch is factory supplied with each supply, return and exhaust fan when either of the factory-wired control options are selected. The switch is factory-installed and wired when a VFD, starter, disconnect or ECM fan power box is factory-installed and sufficient room exists. Otherwise, the switch is factory supplied for field installation.

The fan status switch includes two status LED indicators that will indicate one of three states: tripped on, current present but below trip point, and current off or below the low end of the adjustable trip point range.

The fan status switch has an amperage rating of 0.32 to 150 amps continuous and a maximum sensing current voltage of 600 vac.

DIFFERENTIAL ENTHALPY CONTROL

The enthalpy switch/receiver (P/N 33CSENTHSW) and the enthalpy sensor (P/N 33CSENTSEN) are available for differential enthalpy control (Fig. 15). The enthalpy switch/receiver, mounted in the outdoor air intake, calculates the outdoor air enthalpy. The enthalpy sensor, mounted in the return airstream, calculates the indoor air enthalpy. The enthalpy switch/receiver energizes the HI enthalpy relay output when the outdoor enthalpy is greater than the indoor enthalpy, and the LOW enthalpy terminal when the outdoor enthalpy is lower than the indoor enthalpy.

The switch and sensor have an operating range of –40°F to 140°F (–40°C to 60°C) and a 0 to 100% (non condensing) operating relative humidity. The switch/receiver has a sourced 24 vac through 10 amp form 1C relay output, and the sensor has a 2-wire, 4 to 20 mA loop powered output. Both are accurate to ±1 Btu/lb at 77°F (25°C).

FILTER STATUS SWITCH (P/N 33AMSENFLT000)

The filter status switch is factory-installed in a filter or filter mixing box section if ordered via a drop down menu in the *AHU*Builder® program when either of the factory-wired control options is selected. The FLTS is a snap-acting SPDT switch. When dirty filter elements cause the pressure drop across the filter media to exceed the switch setting, the switch closes and causes an alarm signal to be generated at the control box.

The FLTS has an operating range of 0.05 to 2.0 in. wg and can be adjusted for field-installed filter elements. The switch is factory set to trip at 0.5 in. wg. See the recommended settings for all filter types in Table 7.

Table 7 — Recommended Pressure Settings per Filter Type

FILTER TYPE (EFFICIENCY)	RECOMMENDED MAXIMUM PRESSURE SETTING (in. wg)
2-in. Flat (< 35%)	0.5
2 to 4-in. Flat (35-65%)	1.0
Bag/Cartridge (65-85%)	1.2
Final (85-98%)	1.5

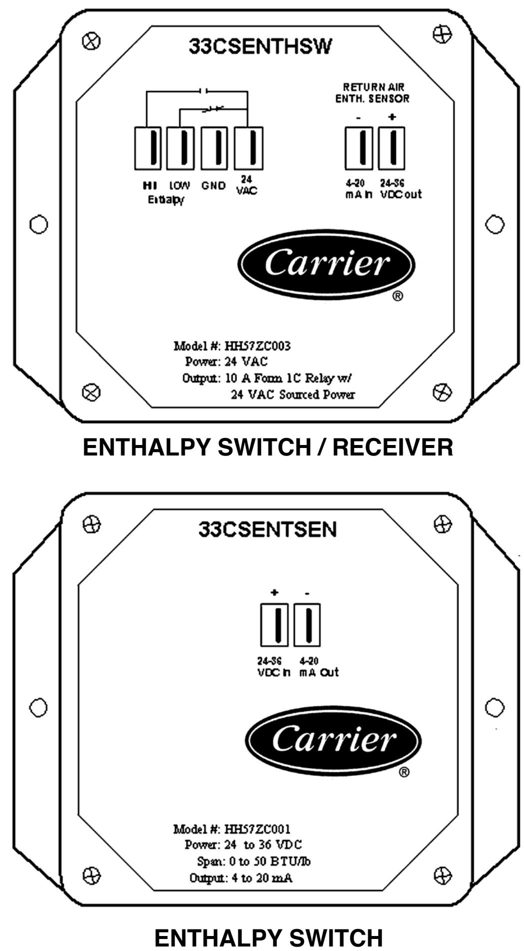


Fig. 15 — Differential Enthalpy Control, Sensor, and Mounting Plate (33AMKITENT000)

Relays

MODULATING MIXED-AIR DAMPER ACTUATORS

The mixed-air damper actuators are factory supplied and installed when ordered via a drop down menu in the *AHU*Builder® program. When installed, the actuators are done so directly on the damper jackshaft. If more than one damper is located inside of the mixing box, either separate actuators on each damper or one actuator with damper linkage can be ordered.

The actuators consist of an electronically controlled reversible motor equipped with a microprocessor drive. This drive provides constant speed regardless of load, which maintains proper position for all dampers.

All actuators are capable of holding their position at any point in the stroke and moving the dampers in either direction.

All actuators have a spring return feature that automatically closes the damper to outside air whenever there is a loss of power. Spring return means reliable fail-safe operation and positive close-off on airtight dampers.

The actuators provide 95 degrees of rotation and include a graduated position indicator showing –5 to 90 degrees. The actuator has a unique manual positioning mechanism that allows the setting of any damper position within its rotation.

Actuators are shipped in the zero position (5 degrees from fully closed) to provide automatic compression against damper gaskets for tight shutoff. When power is applied, the manual mechanism is released and the actuator drives toward the fully closed position. The actuator will memorize the angle where it stops rotating and use this point for its zero position during normal control operations. The manual override can also be released physically by using the crank supplied with the actuator.

The actuators are 24 V with a 2 to 10 VDC output signal and a 4 to 20 mA control signal.

FACE AND BYPASS DAMPERS ACTUATORS

Face and bypass damper actuators are factory supplied and installed when ordered via a dropdown menu in the *AHU*Builder® program. These actuators are of the same make and type as the mixed-air damper actuators.

Electric Heat Control

Electric heaters can be controlled via an electric heat sequencer, SCR controller or Vernier controller as described below.

ELECTRIC HEAT SEQUENCER

The UCS-621E is a solid-state device used for multi-stage electric heater control. This transducer can be factory supplied and wired if ordered via the *AHU*Builder® program and will be installed inside the electric heat control compartment. The UCS-621E provides six stages of relay control with adjustable relay setpoints and differentials, requires 24 vac/vdc power and provides a LED indication of relay status. The electric heat transducer accepts a 0 to 20 mA or 0 to 15 vdc input signal and has an operating temperature range of 32°F to 158°F (0°C to 70°C) with a humidity limit of 5% to 95% relative, non-condensing.

SCR CONTROLLER

The silicon controlled rectifier (SCR) is available via a drop down in *AHU*Builder® program for low kW electric heaters on un-sheathed wire elements only. The SCR controller is a solid-state device that provides 0 to 100% power control. With no moving parts, the SCR controller is both stepless and noiseless and provides a much longer operational life for an electric heater.

The SCR controller is a semiconductor rectifier that can conduct and block current flow in the forward direction, depending on the control or gate signal given, while also blocking current flow in the reverse direction (operating as a diode). See Fig. 16. The SCR has 2 states: ON and OFF. During the ON stage, a control signal is applied between the gate and cathode. It allows current to flow through the SCR to the heater (SCR is now a conductor). During the OFF stage, the control signal is removed and since no voltage is applied across the gate and cathode, no current will flow through the SCR to the heater (SCR is now an insulator).

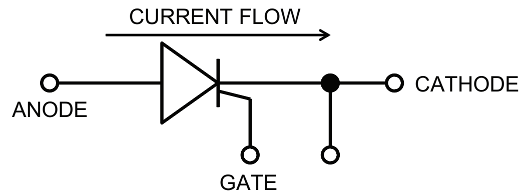


Fig. 16 — SCR Diagram

Since the SCR, as described above, allows current to flow in only one direction, it will only allow half of the AC current waveform to be conducted. As a result, a second SCR is used and is connected in parallel but in the opposite direction to the first SCR. This configuration, known as the "back-to-back" configuration, conducts both halves of the AC waveform delivering maximum power. See Fig. 17.

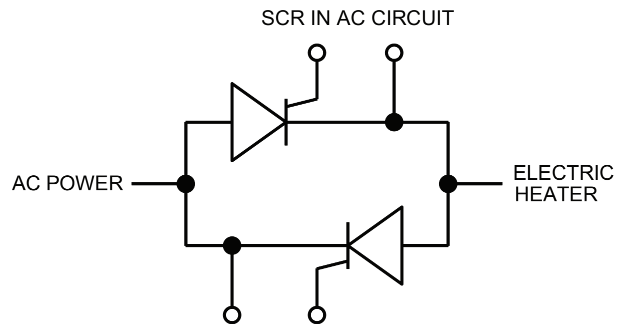


Fig. 17 — SCR Back-to-Back Configuration

The SCR uses time proportioning control to produce a near infinite power control resolution. In time proportioning control, the SCR will provide a pulse proportioned over a 1-second period to achieve the desired percentage of heater control or ON time. For example, if the heater is to operate at 50% load, then the SCR controller will be ON for 500 milliseconds transferring current to the heater and OFF for the following 500 milliseconds where no current is transferred, and the process then repeats (please see Fig. 18). If the heater were to operate at full load, then the SCR will be ON and provide current for the entire 1-second period and then repeat (continuous power). See Fig. 18.

The SCR controller is designed to receive a 0 to 10 vdc, 4 to 20 mA or 0 to 135 ohm control signal. The controller operates between 32°F and 176°F (0°C to 80°C) from 0% to 95% relative humidity, non-condensing. The SCR provides an auto shut-off feature when the SCR ambient temperature is above 180°F (82°C) and requires a 24 vac (+10%, –15%) power supply.

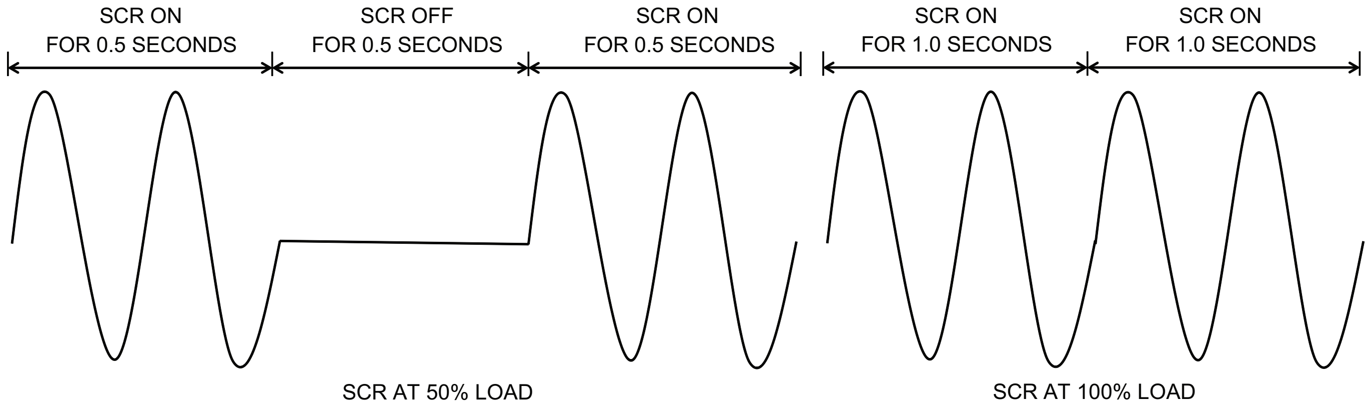


Fig. 18 — SCR Current Draw at 50% and 100% Loading

VERNIER CONTROLLER

The Vernier controller is available via a drop down in *AHU*Builder® program for high kW electric heaters on unsheathed wire elements only. The Vernier controller is a combination of a standard multi-stage controller and an SCR controller and provides 0 to 100% power control for an electric heater. The Vernier controller is an economical means of power control at high kW loads as it modulates the SCR portion of the controller between each operating stage of the standard stage controller. For example, when the electric heater requires power between the set points of any 2 stages, the lower stage is energized and then the SCR controller is energized to provide the precise level of power required.

The Vernier controller is designed to receive a 0 to 10 vdc, 4 to 20 mA or 0 to 135 ohm control signal. The controller operates between 32°F and 176°F (0°C to 80°C) from 0% to 95% relative humidity, non-condensing. The SCR provides an auto shut-off feature when the SCR ambient temperature is above 180°F (82°C) and requires a 24 vac (+10%, –15%) power supply.

Select a valve where the pressure drop is equal to 50% of the total system pressure drop or 5 psig, whichever is greater. The examples below use this method. An alternate selection procedure is described at the end of this section.

VALVE SELECTION

Two-Position Control of Hot and Cold Water

Two psi is typically the maximum pressure loss allowed. Ten to 20% of the supply-to-return differential pressure is also used as a rule of thumb. Figure 19 shows the common applications for 2-way valves in a 2-position control.

Standard full port and reduced port ball valves and butterfly valves used in 2-position applications can be full line size. They may be reduced if the calculations are performed and show a low enough pressure drop. Cv is the capacity of water in GPM which flows through a valve with a 1 psi pressure loss.

The formula for calculating the Cv needed is:

$Cv = GPM / \sqrt{\Delta P/g}$

($g = 1$ for water and therefore $Cv = GPM / \sqrt{\Delta P}$)

It is typical to select a 2-position valve with a Cv = GPM required. Examinations of the sizing tables shows that line size valves are usually selected.

Table 8 shows the valve flow rates in water applications.

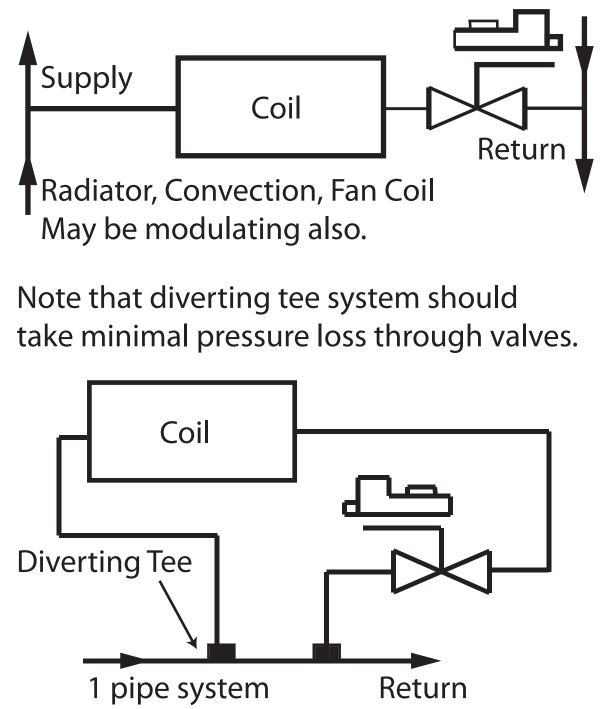


Fig. 19 — Applications for Two-Way Valves in Two-Position Control

Table 8 — Valve Flow Rates for Water Applications (Gallons per Minute - GPM)[a,b]

Cv MAXIMUM RATING	VALVE in.	VALVE mm	TWO-WAY BALL VALVE	THREE-WAY BALL VALVE	PRESSURE DROP ACROSS THE VALVE 1 psi	2 psi	3 psi	4 psi	5 psi	6 psi	7 psi	8 psi	9 psi	10 psi
0.8	1/2	15	B209	B309	0.8	1.1	1.4	1.6	1.8	2.0	2.1	2.3	2.4	2.5
1.2	1/2	15	B210	B310	1.2	1.7	2.1	2.4	2.7	2.9	3.2	3.4	3.6	3.8
1.9	1/2	15	B211	B311	1.9	2.7	3.3	3.8	4.2	4.7	5.0	5.4	5.7	6.0
3.0	1/2	15	B212	B312	3.0	4.2	6.2	6.0	6.7	7.3	7.9	8.5	9.0	9.5
4.7	1/2	15	B213	B313	4.7	6.6	8.1	9.4	11	12	12	13	14	15
7.4	1/2	15	B214	—	7.4	10	13	15	17	18	20	21	22	23
10	1/2	15	B215[c]	B315	10	14	17	20	22	24	26	28	30	32
4.7	3/4	20	B217	B317	4.7	6.6	8.1	9.4	11	12	12	13	14	15
7.4	3/4	20	B218	B318	7.4	10	13	15	17	18	20	21	22	23
10	3/4	20	B219	—	10	14	17	20	22	21	26	28	30	32
24	3/4	20	B220[c]	B320	24	34	42	48	54	59	63	68	72	76
7.4	1	25	B222	B322	7.4	10	13	15	17	18	20	21	22	23
10	1	25	B223	B323	10	14	17	20	22	24	26	28	30	32
19	1	25	B224	—	19	27	33	38	42	47	50	54	57	60
30	1	25	B225[c]	B325	30	42	52	60	67	73	79	85	90	95
10	1-1/4	32	B229	B329	10	14	17	20	22	24	26	28	30	32
19	1-1/4	32	B230[c]	B330	19	27	33	38	42	47	50	54	57	60
25	1-1/4	32	B231	B331	25	35	43	50	56	61	66	71	75	79
37	1-1/4	32	B232[c]	B332	37	52	64	74	83	91	98	105	111	117
19	1-1/2	40	B238	B338	19	27	33	38	42	47	50	54	57	60
29	1-1/2	40	B239	B339	29	41	50	58	65	71	77	82	87	92
37	1-1/2	40	B240[c]	B340	37	52	64	74	83	91	98	105	111	117
29	2	50	B248	B348	29	41	50	58	65	71	77	82	87	92
46	2	50	B249	B349	46	65	80	92	103	113	122	130	138	145
57	2	50	B250[c]	B350	57	81	99	114	127	140	151	161	171	180

NOTE(S):

a. GPM = Cv $\sqrt{\Delta P}$
b. The influence of the pipe geometry, due to reduced flow, is negligible for all valves with characterizing discs.
c. Models with no characterizing disc.

Two-Way Modulating Control of Hot and Cold Water

Two-way valves should be sized for Cv, based on the supply-to-return differential, not the coil loss. Equal percent valves are necessary. As much pressure loss as possible should be taken across the valve to achieve the deep equal percentage curve. (See Fig. 20.) Since differentials are typically unknown, the 5 psi rule of thumb has evolved. Size the valve to 4 to 9 psi drop at design flow. Cooling coils are more sensitive to under-sizing than heated coils. Size appropriately.

One quick method is to size the valve for 3 to 5 psi or nominally 4 psi pressure drop when fully open. Cv = GPM / 2 or GPM = 2 Cv (since $\sqrt{4} = 2$).

This formula is very easy to use and is as accurate as any other method. Size the valve for a Cv=1/2 the GPM it must pass in modulating applications. When the valves fall between Cv required, size for the smaller valve in heating applications. Note that a 9 psi drop gives GPM = 3 Cv, which would be an upper limit for heating pressure drops. When the valves fall between the Cv required for cooling valves, select for the larger.

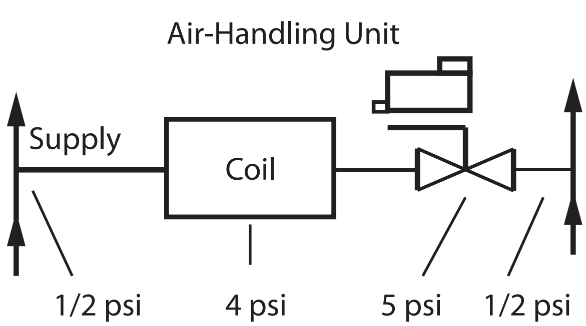


Fig. 20 — Pressure Loss for Modulating Control

Three-Way Control of Hot and Cold Water Flow

When controlling flow, the valve is sized to take a high pressure drop. Normally, the higher of 3 to 5 psi or the coil pressure drop is the goal. Thus, 4 psi drop is the nominal goal.

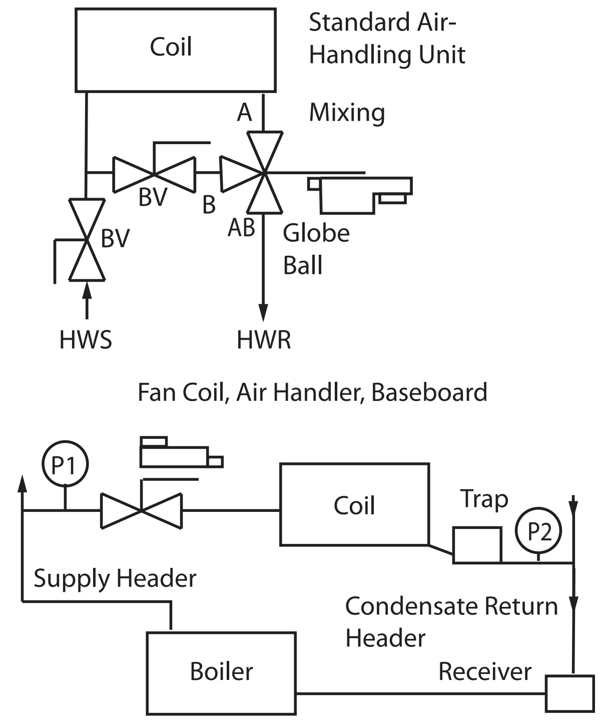
The formula used for sizing is: GPM = Cv $\sqrt{\Delta P}$

This is the same as for 2-way valves. Since ΔP = about 4, $\sqrt{\Delta P} = 2$ and the required Cv = GPM/ 2. This valve is normally sized to be the same pressure loss as the coil. These valves should have equal percentage characteristics.

Sizing methods are similar to those for two-way valves. The A port, control, should be equal percent. The B port, bypass, is best linear to maintain constant flow in the primary system, but can be equal percentage. The valve should take a high percentage of the supply to return pressure difference. No less than the coil or 4 to 9 psi is used as the rule of thumb when the actual pressures are unknown.

Two-Position Control

For two-position control, the steam valve is sized for as low a pressure drop as possible. (See Fig. 21.) A line-sized valve is used in most cases. A maximum of 10% of P1 is also a valid method for both high and low pressure systems. P1=Inlet Pressure. This is assumed to be equal to the boiler pressure. P2=Outlet Pressure. This is the return header pressure after the trap. It is assumed to be at atmospheric or zero gauge pressure. There are some systems with vacuum in the return which require slightly different calculations. P1 – P2 is the differential pressure across the valve, coil, and trap. “h” = P1 – P2 It is the valve pressure drop and is used to size the valve.



LEGEND

BV — Ball Valve
HWS — Hot Water Supply
HWR — Hot Water Return

Fig. 21 — Steam Systems and Two-Position Control/ Modulating Control of Steam

Low pressure systems, less than 15 psi, are sized using gauge pressure or psig - pounds per square inch gauge. High pressure systems are sized using absolute pressure or psia - sometimes called atmospheric pressure. (See Table 9.) Inside the pipes, the gauge pressure is less than it would be is exposed to atmosphere. Absolute pressure adds the pressure of the atmosphere to the gauge pressure. Use the formula: psia = psig + 14.7 psi. High pressure systems require valves with stainless steel trim. Low pressure valves should use stainless steel trim. Erosion of the seat and disc, due to high velocity steam when the valve is near closed, is always a possibility. It is important to distinguish between low and high pressure applications in order to size correctly. This formula is used to size valves: $Cv = (W * \sqrt{V}) / (63.3 * \sqrt{h}) * Y$ W = #/hr. Sometimes it is written as Q V = specific volume using psig h = pressure drop. This is P1, inlet pressure – P2 outlet pressure. Y = expansion factor. It is typically 0.75 for steam valves.

SUPERHEAT

For correction with superheated steam, increase the required Cv by (1 + superheat x 0.0007) for each degree F of superheat.

Therefore, the new Cv required = Cv calculated x (1 + 0.0007 x °F superheat).

Table 9 — Specific Volume

PSIG	PSIA	V^.5
0	14.7	5.2
10	25.0	4.0
20	35.0	3.4
30	45.0	3.1
40	55.0	2.8
50	65.0	2.6
60	75.0	2.4
70	85.0	2.3
80	95.0	2.1
100	115.0	2.0
120	135.0	1.8
140	155.0	1.7
160	175.0	1.6
200	215.0	1.5
300	315.0	1.2
400	415.0	1.1

LOW PRESSURE (< 15 PSI)

For modulation, 80% of the difference between the inlet and outlet pressures is used as the valve pressure drops. Assuming atmospheric pressure at the outlet, this means that 80% of the inlet pressure can be used as the drop. (Some vacuum systems may use more than this drop.) Use h = 80% (P1-P2) to size the valve.

HIGH PRESSURE (> 15 PSI)

The maximum flow through a valve occurs when the drop is about 42% of the absolute inlet pressure. After this, there is no increase in flow. Use the formula: psia = psig + 14.7, or pounds per square inch absolute = pounds per square inch gauge + 14.7 psi, which is the weight of the atmosphere. Use h = 0.42 psia to size valves. Note that the outlet pressure is not used in the calculation. After deciding what pressure drop, h, to use, it is then necessary to find the correct Cv by using a table. Use of the formula is possible, but difficult. In all the aforementioned situations, if using ball or butterfly valves, after finding Cv the Cvc (flow coefficient) must then be found for the final selection. Belimo Characterized Control Valves[1] may not be used for steam.

Alternate Valve Selection Procedure

The following procedure may also be used to select a valve. With this method the valve is selected to meet a specific pressure drop.

1. Determine valve requirements.

   Given:

   Valve Pressure Drop . . . . 4 psig

   Chilled Water Flow . . . . 60 gpm
2. Select a 2-way normally open valve.

   Using the following formula, calculate the flow coefficient (C_v) based on the required flow and pressure drop.

$$C_v = \frac{\text{flow in gpm}}{\sqrt{\text{valve pressure drop}}}$$

$$C_v = \frac{60}{\sqrt{4}}$$

$$C_v = 30$$

   Using the Carrier Belimo Valve Catalog (811-10112), find the valve assembly C_v that most closely matches but is NOT less than the calculated C_v. For this example, a B225B valve is recommended.

1. Third-party trademarks and logos are the property of their respective owners.

When selecting valves, refer to the equations and guidelines below in addition to the examples given.

Water Application

Equations: $C_v = \dfrac{Q\sqrt{G}}{\sqrt{\Delta P}}$

Where Q = Flow in gallons per minute (GPM) required to pass through the valve
G = Specific Gravity of Fluid
ΔP = Pressure drop across the valve in PSI
C_v = Flow Coefficient

Alternate Forms:

$$Q = \frac{C_v\sqrt{\Delta P}}{\sqrt{G}} \qquad \Delta P = \left(\frac{(Q\sqrt{G})}{C_v}\right)^2$$

$$K_{vs} = \frac{C_v}{1.16}$$

Using Metric Measurements, the equation is:

$$K_{vs} = \frac{V_{100}}{\sqrt{\dfrac{\Delta P_{V100}}{100}}}$$

K_{vs} = Flow Coefficient in m^3/h
V_{100} = Flow in m^3/h
ΔP_{V100} = Pressure differential in kPa
$\dfrac{\Delta P_{V100}}{100}$ = Pressure differential in bar

Guidelines

Two-Way Valve, Water Application

Two-position applications: Valve should be line size.

Proportional applications:

Flow Characteristic:	Equal Percentage
Sizing:	ΔP should match ΔP of coil or 3 to 5 psi drop or use ASHRAE authority method

NOTE: Valve and actuator must meet conditions of service.

Always verify:

- Maximum pressure of body
- Close off pressure rating
- Ambient temperature limits are within valve/actuator limits
- Actuator control circuit matches analog or digital output

Three-Way Valve, Water Application

Two-position applications: Valve should be line size.

Proportional applications:

Flow Characteristic:	Linear
Constant flow:	Valve should be line size or ΔP equal to coil drop
Variable flow:	Size valve for 3 to 5 psi pressure drop or use ASHRAE authority method
Cooling tower bypass:	Size valve according to required pressure drop and flow requirement
System bypass:	Size valve according to required pressure drop and flow requirement

Two-Way Valve, Steam Application

Two-position applications: Valve could be line size, Use h, pressure drop, equal to 10% of inlet pressure.

Proportional applications:

Flow Characteristic:	Equal Percentage
Low pressure <15 psi:	Use h = 80% P1 where P1 is inlet pressure
Medium/high pressure <15 psi and <100 psi:	Use h = 42% P1 (in psia) where psia = psig + 14.7

$$Cv = \frac{Q}{3\sqrt{h \times Po}}$$

Where:

Cv = Valve coefficient of flow
Q = Pounds per hour of steam = #/hr
h = Pressure drop across open valve
Po = Outlet pressure in Psia = P_1-h
P_1 = Absolute Inlet Pressure = Gauge Pressure (PSIG) + 14.7

DIRECT EXPANSION (DX) COOLING

General

Direct expansion (DX) cooling applications are not directly controlled via the TruVu MPC control system. DX cooling applications are controlled only by the applicable condensers controller by controlling the staging of the compressors. Most condensers offer a factory-installed digital compressor option composed of one digital scroll compressor and the rest of the compressors being the standard type scroll compressors. Below is information regarding digital compressor control. For further information regarding compressor control, the applicable condenser control guide should be used.

Digital Compressor

The digital compressor has the ability to load and unload rapidly, and the load/unload timing can be varied to achieve unit capacity and closely match the load. The digital scroll option provides better capacity control by digitally modulating capacity, effectively increasing the number of compression stages. The digital scroll compressor modulates the capacity output using a digital unloader solenoid (DUS) which is activated by a signal from the controller to allow the scroll sets to rapidly separate (stop compressing) and reengage (resume compressing) during operation. The supply air (SAT) and return air (RAT) sensors are the necessary inputs to stage unloading for all digital compressors, and are used to determine the temperature drop across the evaporator coils to determine the optimum capacity of the digital compressor.

The digital scroll compressor operates in two stages: loaded - when the solenoid valve is normally closed; and unloaded - when the solenoid valve is energized. These two stages rapidly alternate between full capacity and zero capacity where during the loaded state the compressor operates like a standard scroll and delivers full capacity and mass flow, and during the unloaded state, the compressor does not flow refrigerant.

The capacity of the system is varied by varying the time the compressor operates in an unloaded and loaded state during a set period of time, normally 15 seconds. For example, if the DUS is energized for 7.5 seconds, the compressor will be operating at 50% capacity. If the DUS is energized for 11 seconds, the compressor will be operating at approximately 25% of its capacity. Capacity is the time averaged summation of loaded and unloaded states, and its range is nearly continuous from 10% to 100%.

The digital compressor is always installed in the first on, last off compressor position. For example, when installed in a 38RC condensing unit, the digital compressor is always installed in circuit A, and an example of the resulting sequence of compressor operation can be seen in Table 10. The remaining compressors are normally standard scroll compressors and are controlled via compressor staging (on/off depending on needed capacity).

NOTE: For controlling more than 2 stages of condenser compressors, a sequencer must be installed to provide additional compressor stagging. Contact customer representative to ask for this feature on the required unit.

VARIABLE AIR VOLUME (VAV) SYSTEMS WITH DX COOLING

VAV systems with DX cooling modulate the condenser compressors based on maintaining the supply air temperature (SAT) set point. The SAT and return-air temperature (RAT) sensor inputs are needed for controlling the operation of the compressors. These inputs can be obtained by the condenser's controller either directly from the SAT and RAT, or indirectly from the TruVu MPC control system and the PIC6 BACnet communication option on the 38RC condensing unit.

When designing a VAV system, it is recommended to use only row-split DX coils. This prevents the possibility of freezing condensate to the coil during part load operation at low loads.

CONSTANT VOLUME (CV) SYSTEMS WITH DX COOLING

CV systems with DX cooling modulate the condenser compressors based on maintaining the space temperature set point as can be determined from space temperature thermostats. The inputs from the space temperature thermostats can be obtained by the condenser controller either directly or via the PIC6 BACnet communication option on the 38RC condensing unit.

WIRING GUIDELINES

Component Wiring

Each field-installed control device will come with installation instructions, including the appropriate wiring guidelines.

System Wiring

Since air-handling systems are normally made up of multiple component sections, Carrier has designed the control system wiring using quick connect Molex[1] type connectors on wires that run between sections.

There may be multiple devices mounted within the various sections, which all must connect back to the TruVu MPC control system mounted on the supply fan section or the control plenum section.

1. Third-party trademarks and logos are the property of their respective owners.

Table 10 — Compressor Stages and Circuit Cycling Example[a]

STAGE	TOTAL UNIT CAPACITY[b]	CIRCUIT A					CIRCUIT B			
		CIRCUIT CAPACITY[c]	MLC[d]	A1	A2	A3	CIRCUIT CAPACITY[c]	B1	B2	B3
0	0	0	—	—	—	—	0	—	—	—
Last	12	24	X[d]	—	—	X	0	—	—	—
1	17	33	—	—	—	X	0	—	—	—
2	33	66	—	—	X	X	0	—	—	—
3	49	100	—	X	X	X	0	—	—	—
4	66	100	—	X	X	X	33	—	X	—
5	83	100	—	X	X	X	66	—	X	X
6	100	100	—	X	X	X	100	X	X	X

NOTE(S):

a. Example is to determine minimum load control, equal circuit loading, and Circuit A leads select.
b. Total Unit Capacity values are approximate percentage values.
c. Circuit Capacity values are approximate percentage values.
d. Minimum Load Control (MLC) is only available as last stage of capacity during de-staging, MLC is bypassed during condensing unit start.

OPERATING SEQUENCES

NOTE: The TruVu MPC control system can be configured using many different software applications. The following outline of the operating sequence is based on selections from i-Vu® Application Builder software.

Constant Volume and Variable Air Volume Units

TWO-POSITION DAMPER CONTROL

Two-position damper control opens or closes field-supplied and field-installed two-position outdoor-air dampers to provide minimum outdoor air ventilation.

If the supply fan is OFF, the damper is closed. If the supply fan is ON, the TruVu MPC control system determines if the unit is in the Occupied mode. If unit is in the Occupied mode, the dampers open and will maintain a minimum adjustable position. If unit is in the Unoccupied mode, the dampers remain closed.

FILTER STATUS

This control monitors the differential pressure between the upstream and downstream side of a filter.

When the filter becomes dirty or needs to be replaced, the airflow switches send a discrete signal to the TruVu MPC control system. This, in turn, generates an alarm locally or at customer user interface.

FAN CONTROL

The supply fan is started or stopped based on an occupancy schedule, unit optimal (temperature compensated) start, nighttime (unoccupied) free cooling, unoccupied heating, unoccupied cooling, timed override, or the remote contact input.

The start of an occupied period is determined by either the occupancy schedule, unit optimal start, or the remote contact input. If unit optimal start is not used, the supply fan starts at the occupied time entered in the occupancy schedule or when the remote contact input is closed. If unit optimal start is selected, the fan starts at the calculated start time (this algorithm will minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of the scheduled occupied period). The fan stops at the unoccupied time entered in the occupancy schedule. (Timed override may be used to provide an occupied period to a user adjustable timeframe.)

During the unoccupied period, whenever the space temperature falls below the unoccupied heating set point or rises above the unoccupied cooling set point, the supply fan energizes and runs until the space temperature returns to within the required limits.

The supply fan can also run during the unoccupied period when the unit is in the Nighttime Free Cooling mode to pre-cool the space prior to the occupied period.

NIGHTTIME FREE COOLING MODE

Nighttime (unoccupied) free cooling is used to start the supply fan to precool the building's interior using outside air. This delays the need for mechanical cooling when the system enters the Occupied mode.

The system determines if the outside conditions (temperature and enthalpy) are suitable for cooling. If conditions are suitable and cooling is necessary, the supply fan is energized and the dampers modulate open. Once the space has been sufficiently cooled, the fan stops.

If the outside air conditions are not suitable, the fan remains OFF.

The unit must be equipped with mixed-air dampers to provide nighttime free cooling.

Nighttime free cooling can be provided whenever the unit is in the unoccupied mode, conditions are suitable, and the nighttime free cooling feature has been selected.

INDOOR-AIR QUALITY (IAQ)

This function maintains the correct occupied ventilation rate using CO_2 as an indicator of occupancy level or controls the levels of volatile organic compounds (VOCs) or other indoor air pollutants by modulating the outside air dampers. Varying quantities of outdoor air are admitted during the Occupied period to maintain the ventilation rate at a set point which ensures the pollutant level does not exceed the configured set point of the air-quality (AQ) sensor.

The sensor can be either duct-mounted in the return-air duct or mounted within the conditioned space. The sensor will be used to continuously monitor the pollutant level during occupied periods.

During the unoccupied period, the damper position is not affected by the IAQ control. During the occupied period, the TruVu MPC control system reads the AQ sensor input and compares it to the configured set point. The TruVu MPC control system then calculates the minimum damper position to maintain the set point. If no other control is attempting to adjust the dampers to a more fully open position than the IAQ control, the damper is adjusted to the position determined by the IAQ control. Otherwise, the damper is positioned by the superseding control routine or at its configured minimum position.

UNIT OPTIMAL START

Unit Optimal (temperature compensated) Start is used to heat up or cool down the space prior to occupancy so the space temperature will reach the occupied set point at time of occupancy. The TruVu MPC control system uses space temperature and an occupied set point to determine the time in minutes that the system should be started in advance of the occupied time.

FIRE/SMOKE SHUTDOWN

Fire/Smoke Shutdown is used to stop the unit supply and return fan whenever a field-supplied and installed fire/smoke sensor connected to the input is energized. The status of the input is continuously monitored by the TruVu MPC control system. If the fan is operating, it is immediately stopped by the TruVu MPC control system upon receiving a fire shutdown status. The alarm can be annunciated locally at the alarm output as well as repeated through the network to a Building Supervisor.

SMOKE PRESSURIZATION/PURGE

Upon receiving a smoke pressurization status signal, the unit will start the supply fan, stop the return fan, open the outside air dampers and close the return and exhaust air dampers. Upon receiving a smoke purge signal, the unit will start both the supply and return fans while opening the outdoor and exhaust air dampers and closing the return air damper.

Constant Volume Units Only

HEATING COIL CONTROL

The heating coil control adjusts the steam or hot water valve. The valve is modulated to prevent the space temperature from falling below the desired heating set point.

If the supply fan is OFF, the heating valve is modulated to maintain a desired minimum duct temperature.

If the fan is ON, the TruVu MPC control system reads the space sensor and computes the supply-air temperature required to satisfy conditions.

Once the required supply-air temperature has been calculated, it is compared to the actual supply-air temperature and the heating coil valve modulates to the required position.

For those systems where the heating coil is located downstream from the cooling coil, if dehumidification is being provided by the cooling coil control and Reheat has been selected, the valve is modulated in order to maintain the supply-air temperature above a user-configured temperature set point.

FACE AND BYPASS HEATING COIL CONTROL

The heating coil control is used to position a set of face and bypass dampers immediately upstream of a steam or hot water heating coil. The damper set is modulated to prevent the space temperature from falling below the desired heating set point.

If the fan is off, the dampers are positioned to the full bypass position and the heating control valve is closed. To maintain the minimum desired duct temperature while the fan is OFF, the heating valve is opened as necessary.

If the fan is on, the TruVu MPC control system reads the space temperature sensor and computes the supply-air temperature required to satisfy the desired set point.

Once the required supply-air temperature has been calculated, it is compared to the actual supply-air temperature and the face and bypass damper set is modulated to the required position. The heating valve is opened whenever the damper set moves away from the full bypass position.

For those systems where the heating coil is located downstream from the cooling coil, if dehumidification is being provided by the cooling coil control and Reheat has been selected, the damper set is modulated in order to maintain the supply-air temperature above a user-configured leaving air temperature.

CHILLED WATER COIL COOLING CONTROL

The cooling coil control adjusts the chilled water valve. The valve is modulated to prevent space temperature from exceeding the desired cooling set point. The valve remains closed if the space temperature is below the set point, or the supply fan is OFF or the economizer (if present) is operational or not fully open.

If the fan is ON, the TruVu MPC control system reads the humidity sensor (optional) and compares the value to the high humidity limit.

If the humidity is higher than the high humidity limit, the chilled water valve opens.

If the humidity is below the high humidity limit, the TruVu MPC control system reads the space temperature sensor and computes the supply-air temperature required to satisfy conditions.

Once the required supply-air temperature has been calculated, it is compared to the actual supply-air temperature and the chilled water valve modulates to the position required to maintain desired conditions.

FACE AND BYPASS COOLING COIL CONTROL

The cooling coil control is used to position a set of face and bypass dampers immediately upstream of a chilled water cooling coil. The damper set is modulated to prevent the space temperature from exceeding the desired cooling set point.

If the fan is off, the dampers are positioned to the full bypass position and the chilled water control valve is closed.

If the fan is on, the TruVu MPC control system reads the humidity sensor (optional) and compares the value to the high-humidity limit. If the humidity value exceeds the set point, the damper set modulates to the full face position and the chilled water valve is opened. If the humidity is below the high humidity limit, the TruVu MPC control system reads the space temperature and calculates the supply-air temperature required to satisfy the desired set point.

Once the required supply-air temperature has been calculated, it is compared to the actual supply-air temperature (read from the sensor) and the face and bypass damper set is modulated to the required position. The cooling valve is open whenever the damper set moves away from the full bypass position.

DIRECT EXPANSION COOLING CONTROL

The direct expansion (DX) cooling control regulates the DX cooling system. The DX cooling system is controlled via the compressors in the condensing units which are controlled directly by the condenser's controller. In a VAV system, the compressors are modulated to maintain the supply air temperature set point and outputs from the RAT and SAT sensors are read directly by the condenser controller, or indirectly via the TruVu MPC control system via the PIC6 BACnet communication option. In a CV system, the compressors are modulated to maintain the space temperature set point, and the outputs from the space temperature thermostats can be read directly by the condenser controller or indirectly via the PIC6 BACnet communication option.

MIXED-AIR DAMPER CONTROL

The mixed-air damper control adjusts modulating outside-air, return-air, and exhaust air dampers. When outside air conditions are unsuitable for atmospheric cooling, the dampers are held to an adjustable minimum outside air percentage. When outside air conditions are suitable for atmospheric cooling, the mixed-air dampers are modulated in an effort to minimize the need for heating or mechanical cooling. The damper set point is automatically calculated from the desired set points.

If the supply fan is OFF or operating for unoccupied heating, the mixed-air dampers are kept closed to outside air and open to return air.

If the fan is ON and the control is in the Occupied mode, the TruVu MPC control system checks to see if the system is in the HEAT mode.

If the system is in the HEAT mode, the mixed-air dampers are positioned to provide only the user-configured minimum percentage of outdoor air. If the system is not in the HEAT mode, the TruVu MPC control system determines if the outside conditions are suitable for atmospheric cooling and then compares the outdoor-air temperature to the space temperature. If the outdoor-air temperature is less than the space temperature, the system does either an enthalpy check (using an outside-air enthalpy switch) or a differential enthalpy check (return-air enthalpy is compared to outside-air enthalpy).

If outside conditions are suitable, the TruVu MPC control system compares the space temperature to the damper set point and computes the mixed-air temperature required to satisfy conditions.

Once the required mixed-air temperature has been calculated, it is compared to the mixed-air temperature sensor value. The damper is adjusted as required to maintain the mixed air temperature set point. The damper adjustment rate is automatically limited to prevent nuisance low temperature thermostat tripping.

ELECTRIC HEATER CONTROL

Electric heater control operates the electric heater stages as required. The heater is staged to prevent the space temperature from falling below the desired set point.

If the supply fan is OFF, all stages of electric heat are turned off.

If the fan is ON, the cooling (if present) is not active and the outside air temperature is less than a user defined setpoint the TruVu MPC control system reads the space temperature sensor and calculates the supply-air temperature required to satisfy conditions.

Once the required supply-air temperature has been calculated, it is compared to the actual supply-air temperature to determine the number of heat stages required to satisfy conditions. If more than one stage is required, the stages are energized one at a time, with a delay between stages, and each stage will have a user definable minimum runtime.

Variable Air Volume Units Only

HEATING COIL CONTROL

The heating coil control adjusts the steam or hot water valve. Heat is primarily used for Unit Optimal Start (morning warm-up) or Occupied Heating with the valve modulated to maintain desired return-air temperature.

If the supply fan is OFF, the heating valve is modulated to maintain a desired minimum supply-air temperature.

If the fan is ON, the cooling (if present) is not active and the outside air temperature is below a user-adjustable set point, the system determines if it is in the unit optimal start mode. If it is, the return-air sensor is read and compared to the Occupied Heating set point. If heating is required, the TruVu MPC control system calculates the supply-air temperature required to satisfy conditions.

Once the required supply-air temperature has been calculated, it is compared to the actual supply-air temperature and the heating coil valve modulates to the required position.

Once the unit optimal start is completed, heat is not activated again unless the supply air setpoint falls below the occupied heating set point.

During cooling or fan-only operation, heat can also be provided to maintain the supply-air temperature when the amount of cold outside air admitted by the IAQ control causes the temperature to fall below the minimum supply-air duct temperature.

If dehumidification is being provided by the chilled water coil cooling control the valve is modulated to maintain the minimum supply air duct temperature.

FACE AND BYPASS HEATING CONTROL

The heating coil control is used to position a set of face and bypass dampers immediately upstream from a steam or hot water heating coil. Heat is primarily used for unit optimal start (morning warm-up) or Occupied Heating with the dampers modulated to maintain the desired return-air temperature.

If the fan is off, the dampers are positioned to the full bypass position, and the heating control valve is closed. If the supply-air temperature drops below the minimum desired supply air temperature, the heating control valve is opened as required to maintain the desired set point.

If the fan is on, the TruVu MPC control system determines if it is in the Unit Optimal Start (morning warm-up) or Occupied Heating mode. If true, the value of the supply air temperature is read by the TruVu MPC control system and is compared to the occupied heating set point. If heating is needed, the control calculates the supply-air temperature required to satisfy the desired set point.

Once the control has calculated the required supply-air temperature, it compares the actual supply-air temperature to the calculated value and modulates the face and bypass damper set as required to achieve this value.

Once the Unit Optimal Start is completed, heat is not activated again unless the supply-air temperature falls below the occupied heating set point.

During cooling or fan-only operation, heating is also used to maintain the supply-air temperature when the amount of cold outdoor air admitted by the IAQ control causes the supply-air temperature to drop below the minimum supply-air temperature set point.

CHILLED WATER COIL COOLING CONTROL

The cooling coil control adjusts the chilled water valve. The valve is modulated to maintain desired leaving-air temperature set point. The valve is closed whenever the system is in Nighttime (unoccupied) Free Cooling or whenever the supply fan is OFF.

If the fan is ON, the economizer (if present) is disabled or fully open, outside air temperature is greater than a user adjustable setpoint and the heating (if present) is not active, the TruVu MPC control system reads the humidity sensor (optional) and compares the value to the high humidity limit.

If the humidity is higher than the humidity limit, the chilled water valve opens.

If the humidity is below the high humidity limit, or if no humidity sensor is supplied, the TruVu MPC control system reads the supply-air sensor, and compares this value to the desired supply air temperature set point. The chilled water valve is then modulated as necessary to maintain the cooling set point.

FACE AND BYPASS COOLING CONTROL

The cooling coil control is used to position a set of face and bypass dampers immediately upstream from a chilled water cooling coil. The cooling coil control adjusts the position of the dampers to maintain the desired leaving-air temperature set point.

If the fan is off or nighttime (unoccupied) free cooling is active, the damper set is modulated to the full bypass position and the chilled water valve is closed.

If the fan is on, the TruVu MPC control system reads the humidity sensor (optional) and compares the value to the high humidity limit. If the humidity exceeds the limit, the damper set is modulated to the full face position and the chilled water valve is opened.

If the humidity is below the high humidity limit, or if no humidity sensor is supplied, the TruVu MPC control system reads the supply air sensor, provided that the return-air temperature has risen above the Occupied Heating Set Point. The control then calculates the desired supply-air temperature set point.

Once the required supply air set point has been calculated, it is compared to the current supply-air temperature and the dampers are modulated to the required position.

STATIC PRESSURE CONTROL

The static pressure control adjusts the supply-fan variable frequency drive (optional) in a variable air volume system in order to maintain the duct static pressure set point.

If the supply fan is OFF, the minimum speed signal is sent to the variable frequency drive.

If the fan is ON, the control reads the duct static pressure sensor. The system compares the duct static pressure to the set point and calculates the required signal that is output to the variable frequency drive.

ELECTRIC HEATER CONTROL

The electric heater control operates the electric heater stages as required. The heater is primarily used for Unit Optimal Start (morning warm-up) or Occupied Heating, with the heater staged to maintain the desired return-air temperature.

If the supply fan is OFF, all stages of electric heat are turned off.

If the fan is ON, outside air temperature is below an adjustable set point and the cooling (if present) is not active then the TruVu MPC control system determines if the stem is in Unit Optimal Start. If it is, the supply air sensor is read and compared to the occupied heating set point. If heat is required, the TruVu MPC control system calculates the supply-air temperature required to satisfy conditions.

Once the required supply-air temperature has been calculated, it is compared to the supply-air temperature sensor reading to determine the number of heat stages required to satisfy conditions. The required stages are energized sequentially.

Once the unit optimal start is completed, heat is not activated again unless the supply-air temperature drops below the occupied heating set point.

SUPPLY-AIR TEMPERATURE RESET

The supply-air temperature reset is used to reset the supply-air temperature set point upward as the space air temperature falls below the Occupied Cooling set point, but not less than the occupied heating set point. For every degree that the space temperature falls below the occupied cooling set point, the supply air temperature set point will be reset upwards at the adjustable amount (nominally 1°F) up to an adjustable maximum (nominally 75°F). When enabled, the supply air cooling set point will be reset upwards every two minutes.

When the fan is ON, and the system is in the Occupied mode, the TruVu MPC control system reads the space temperature sensor and computes the reset value. If the reset value is greater than the reset limit, the TruVu MPC control system uses the reset limit as the reset value. The modified supply-air temperature set point is determined by adding the reset value to the configured supply-air temperature set point. This value is then used by the cooling coil and mixed-air damper control algorithm.

MIXED-AIR DAMPER CONTROL

The mixed-air damper control modulates the outside-air, return-air, and exhaust-air dampers. When outdoor-air conditions are unsuitable for atmospheric cooling, the dampers are positioned to provide only the minimum percentage of outside air (adjustable) whenever in the occupied mode. At all other times the mixed-air dampers are modulated to maintain a mixed-air temperature equal to the calculated supply-air temperature set point minus 2°F (1°C).

If the supply fan is OFF, the mixed-air temperature falls below an adjustable set point or the freezestat (if present) is on, the mixed-air dampers are held closed to outside air and held open to return air. If the supply fan is ON, the control is in occupied mode and the system is in the HEAT mode, the mixed-air dampers are positioned to provide only the user-configured minimum percentage of outdoor air. At all other times the system determines if outside-air conditions are suitable for atmospheric cooling. The outside-air temperature is compared to the space temperature and if the outside-air temperature is less than the space temperature, the system performs either an enthalpy check or a differential enthalpy check.

If the outside conditions are suitable, the TruVu MPC control system modulates the damper to maintain the damper set point. The mixed-air damper opening rate is limited to protect against nuisance low temperature thermostat tripping.

COOLING MODE WITH ECONOMIZING

If the OA (outdoor air) temperature is less than the economizing set point, the OA temperature is less than the RA (return air) temperature and the OA enthalpy is less than the enthalpy switch set point:

- The OA (outdoor air) and Recirc dampers will modulate to maintain discharge air temperature at the discharge air temperature set point.
- EA (exhaust air) and OA bypass dampers will remain 100% open.
- Unit cooling and heating coil valves will remain closed.
- The ERV exhaust fan will be enabled and run continuously.

Demand Controlled Ventilation (DCV)

The energy recovery system sequence of operations is unchanged by the incorporation of DCV. The CO_2 sensors may override the normal thermal controls and airflow measuring system (if used) in some situations. The sequences included below discuss the ventilation functions only and must be added to the designer's description of thermal controls to create complete operating sequences.

CONSTANT VOLUME — PURGE CYCLE

At air handler start-up, the outdoor-air damper shall open, initiating a timed purge cycle. The outdoor-air damper shall modulate to maintain a predetermined percentage of outdoor air. The purge cycle shall be adjustable and set for a predetermined period of time.

The air handler controller shall modulate its preheat coil to maintain the discharge-air temperature set point if the mixed air temperature falls below the discharge-air temperature set point. At the conclusion of the timed purge cycle, the outdoor-air damper shall modulate closed to maintain a predetermined base ventilation rate and the DCV control algorithm shall be enabled.

CONSTANT VOLUME — SINGLE AND MULTI-ZONE APPLICATIONS

All zones served by the air-handling unit shall be polled and the highest CO_2 sensor reading will be taken by the air handler controller and used to control the outdoor-air damper. The worse case CO_2 reading shall be compared to the CO_2 set point at the unit controller. If the reading is below an adjustable set point (nominally 550 ppm above outside air CO_2 levels), the air handler shall maintain the predetermined minimum outdoor-air damper position. If the reading is above the set point, the air handler controller shall modulate the outdoor-air damper open to increase the amount of ventilation to the space and reduce the CO_2 concentration. Once the CO_2 levels drop below the set point, the outside-air dampers shall modulate to maintain the base ventilation rate.

The economizer function is enabled when the air handler controller determines that it is beneficial to use outside air for cooling the space. Once the economizer function is enabled, as commanded by the air handler controller, the outdoor-air damper will modulate between minimum position and fully open to maintain the discharge-air temperature at the economizing set point.

VARIABLE-AIR-VOLUME SYSTEMS

Each zone controller shall include the inherent ability to override the temperature control loop and modulate the VAV box's damper based on a CO_2 sensor and its associated set point schedule. The zone controller shall be capable of maintaining a ventilation set point through a DCV algorithm in conjunction with the air-handling unit to fulfill the requirements of ASHRAE standard, 62-1989 "Ventilation for Acceptable Indoor Air Quality" (including Addendum 62a-1990).

The DCV control function shall determine the zone ventilation airflow based on the CO_2 zone sensor input value. When the DCV function is enabled, the zone controller shall override (increase) the primary airflow in order to provide additional ventilation as required to maintain the CO_2 set point if the base ventilation airflow is insufficient to meet the zone ventilation requirements. A control algorithm shall be used to determine the required airflow in order to maintain the required ventilation rate in the space (maintain the CO_2 sensor reading at the desired zone set point).

Whenever the air-handling system is in the occupied mode, the air handler controller shall maintain the base ventilation rate (minimum outdoor air damper position) until overridden by the system DCV function.

All zone controllers working with a given air-handling unit shall be polled and the highest CO_2 sensor reading will be taken by the air handler controller and used to control the outdoor-air damper. The worse case CO_2 reading shall be compared to the CO_2 adjustable set point (nominally 750 ppm CO_2) at the unit controller. If the reading is below the set point, the air handler shall continue to maintain the base ventilation. If the reading is above the set point, the air handler controller shall modulate the outdoor-air damper open to increase the amount of outdoor air ventilation. Once the CO_2 levels drop below the set point, the outside-air dampers shall modulate to maintain the base ventilation rate.

The economizer function is enabled when the air handler controller determines that it is beneficial to use outside air for cooling the space. Once the economizer function is enabled, as commanded by the air handler controller, the outdoor-air damper will modulate between minimum position and fully open to maintain the discharge-air temperature at the economizing set point.

Component specific control sequences help to maximize the amount of energy recovered by the total energy recovery wheel section.

GUIDE SPECIFICATIONS

Central Station Air-Handling Control Guide Specifications

NOTE: The following guide specification is provided to assist in specifying central station air-handling unit controls. There are several options that may be applied, depending on the application requirements. These specifications have been written such that the equipment supplier is also the temperature control vendor.

Part 1 — General

1.01 SYSTEM DESCRIPTION

A. Aero® 39M central station air-handling unit controls are designed to provide air to a conditioned space as required to meet specified performance requirements for ventilation, heating, cooling, filtration and distribution on both constant volume (CV) and variable air volume (VAV) systems.

B. The control box shall be mounted in the control plenum in a NEMA-type enclosure.

1.02 MICROPROCESSOR CONTROLLER

The integrated controls shall include a factory-installed solid-state microprocessor controller using direct digital controls. The microprocessor controller shall be factory installed and wired within the control box for the central station air-handling device. The system software shall be field installed as the TruVu MPC control system does not contain factory-installed software.

1.03 BUILDING CONTROL SYSTEM NETWORK INTERFACE

The control shall have the ability to interface and communicate directly to the building control system without the use of additional field-installed hardware or software. Other manufacturers' building control systems may be used to interface to the equipment control. This functionality shall be provided through the additional hardware inputs and outputs of the control. Functions such as equipment start/stop, supply-air temperature set point adjustments (VAV), and alarm condition identification must be provided.

Part 2 — Products

2.01 TruVu MPC CONTROL SYSTEM

Central Station Air Handler:

The controller shall be a solid-state microprocessor-based controller used to control each function of the applicable HVAC equipment using Direct Digital Controls (DDC) and specifically designed software. The controls shall be capable of providing stand-alone operation. All application software actually performing the required control functions shall be configured and supplied by a field service technician separate from the controller. The control shall accept analog and digital signals from sensors, switches, relays, etc. and shall multiplex the various signals into digital format. All closed-loop DDC routines shall utilize controller based software algorithms that shall be resident in the controller memory.

The controller shall be shipped in a NEMA (National Electrical Manufacturers Association) rated-enclosure and will be mounted inside the control plenum when the factory wired option is selected. An on/off switch shall be field installed and wired next to each control panel. The factory shall mount all panel mounted electrical components inside the factory-supplied control plenum when the factory-wired option is selected. Control transformers for the controlled devices shall also be factory supplied and wired.

The controller shall include and maintain an internal time clock function and shall receive time scheduling information from a network occupancy schedule or Linkage thermostat time schedule. The time clock function shall also be capable of interfacing to a dry contact to perform occupancy override. Timed override requests shall be performed by each control without any network requirement.

The controller shall not require a battery. All configuration data is to be stored in non-volatile memory. Systems that require a battery to store data are not acceptable.

Alarm/Alert Processing — The controller shall contain a routine to process alarms and alerts. Alarm/alert processing shall consist of a scan of all input points. Certain analog alarms/alerts shall only be monitored when the controller is in the occupied mode (i.e., static pressure, CO_2, relative humidity, etc.). Time delays shall be provided with the software to prevent nuisance alarms/alerts during a transition period or if a set point change occurs. The controller shall also be capable of providing local alarm/alert indication for out of limit conditions, status, thermistor or sensor failure. All alarms/alerts shall be displayed at a portable PC and via the network to a remote operator's station or alarm printer as applicable.

A. VAV and CV standard control hardware:

The controller can include the following standard control hardware when ordered for both VAV and CV applications:

1. Supply-Air Sensor:

   The factory-supplied sensor shall be a thermistor type (RTDs [Resistive Temperature Device] shall also be acceptable), and shall be factory installed in the fan scroll. The sensor shall be factory wired to the controller inside the factory-provided control box.

2. Outside-Air Sensor:

   The sensor shall be a thermistor type (RTDs shall also be acceptable), factory or field supplied for each air handler for field mounting and wiring. The sensor shall be installed upstream from the outside-air damper where it shall accurately sense the temperature of the outside air entering mixing box. Each air handler shall include its own outside-air sensor unless all units are being served by a common outside air plenum.

3. Return Air Sensor (VAV only):

   The sensor shall be a field-supplied 6-in. probe as a minimum. The sensor shall be a thermistor type (RTDs shall also be acceptable), encased in a stainless steel probe to resist corrosion, supplied for each air handler for field mounting and wiring.

4. Space Temperature Sensor (CV only):

   The sensor shall be field supplied for field installation as shown on the plans. The sensor shall consist of a thermistor (RTDs shall also be acceptable), terminal block with screw terminals mounted on a printed circuit board, push button for remote occupant override, and a remote communication port. Space sensors shall include a space temperature adjustment slide for occupant adjustment. The range of adjustment shall be configurable from 0° to 20°F and may be disabled. The sensor shall be mounted approximately 60 in. from the floor and shall be capable of mounting directly to a wall or to a wall-mounted standard American electrical box.

5. Fan Relay:

   The relay shall be factory installed and wired in the control box. The relay shall be a SPDT type and shall interface to the fan motor starter circuit through field wiring to the starter.

6. Fan Status Switch:

   The switch shall be factory installed and wired in the control box. The switch shall be a SPDT snap-acting switch with an amperage rating of 0.32 to 150 amps continuous.

B. Variable Air Volume (VAV):

The controller can include the variable and constant volume control hardware when ordered for each variable air volume central station in addition to the above.

C. Variable and Constant Volume Control Options:

The following control hardware shall be provided for each central air handler device if the control hardware or associated control function is listed in the I/O summary and/or the sequence of operation:

1. Mixed Air Temperature Sensor:

   The factory-supplied sensor shall consist of multiple thermistor sensors evenly spaced and encased in a flexible copper tube. The sensor shall provide both mechanical and electrical averaging to achieve the average temperature measurement over the entire element length. The sensor shall be factory installed in the mixing box on the downstream side of the filters for combination filter/mixing boxes, and shall also be serpentined to sense the average temperature. The factory shall provide the wiring from the sensor to the factory-installed control box mounted on the unit. The sensor shall be provided in two different sizes; 12 ft or 24 ft based on the mixed-air chambers size/configuration and the manufacturers recommendations.

2. Low Temperature Thermostat:

   The low temperature thermostat (LTT) shall include a 20-ft long, factory installed, capillary strung out in the airstream to protect the coil. Multiple LTTs shall be supplied if required. The sensor is factory wired to the control box. The contacts shall be wired to the control circuit to stop the supply fan and shall also be wired to the controller for alarm monitoring. The LTT shall be manually reset from the control panel.

3. Outdoor/Return/Space Relative Humidity Sensors:

   The humidity sensors shall be factory or field supplied and field mounted and wired. The sensors shall use bulk polymer resistance technology to eliminate the effects of surface contamination. The wall-mounted RH sensor shall be enclosed within a decorative case. The sensors shall have a measuring range of 0 to 95% with an accuracy of ± 3% at 25°C.

4. Filter Status Switch:

   The filter maintenance switch shall be factory installed in the first filter section of the unit. The filter switches shall measure the differential pressure across the filter. The switch shall have an adjustable set point range of 0.05 to 2.0 in. wg. The controller shall be capable of monitoring more than one filter bank, each bank with its own filter maintenance switch. All filter switches (as applicable) shall be field wired to the control panel.

D. Actuators:

1. Valve Actuators:

   All valve actuators, shipped from the factory, mounted on complete valve assemblies, shall be equipped with spring return capability unless the valve services a non-critical application. The actuators shall use electric motors. Each actuator (heating and cooling) shall be independently powered by a Class II transformer, protected by a resettable circuit breaker, located in the control box. Each actuator shall be capable of interfacing to a modulating output control signal and shall include the capability to hold its position anywhere in its stroke. The valve actuators shall be factory mounted with the appropriate linkage connection on the selected valve assembly for field installation.

2. Damper Actuators:

   The damper actuators shall be factory supplied and installed when ordered. The actuators shall include an electronically controlled reversible motor equipped with a microprocessor drive. The drive shall provide a constant speed regardless of load. Actuators shall be capable of holding their position at any point in the stroke in either direction. Each actuator shall be capable of interfacing to a modulating output control signal. The manufacturer shall guarantee to meet the torque requirements of the dampers.

   Two-position minimum outdoor-air damper actuators shall be field supplied with a field-powered actuator guaranteed to interface to the factory provided output relay. All wiring shall be field installed.

E. Valves:

All new control valves shall be supplied by the manufacturer. All valves shall be sized by the building control contractor and shall be guaranteed to be of sufficient size and to meet the capacities shown. Two-way and three-way valves shall be equal percentage type globe valves with a brass body, seat and plug, stainless steel stem, composition disc and spring loaded Teflon[1]-coated V-ring packing. The valve body shall be brass, globe, screwed, FNPT type and shall be rated at 40 to 281 F at 250 psig.

F. Control Algorithms:

1. Fan Control:

   The supply fan shall be started and stopped based on an occupancy schedule, Nighttime (unoccupied) Free Cooling, smoke control (when applicable), unoccupied heating or cooling, demand limiting, network command, and timed override. (Starting and stopping of motor for demand limiting shall pertain only when tied into a network.)

   The start of an occupied period shall be determined by either the occupancy schedule, remote timed override, the unit optimal start routine, or if the remote start contact opens (see I/O summary and/or sequence of operation for requirements). If unit optimal start is not selected the supply fan shall start at the occupied time entered in the occupancy schedule. If unit optimal start is selected, the fan shall be started at the calculated start time. The fan shall stop at the unoccupied time entered in the occupancy schedule. Timed override shall also be used to extend the occupied schedule for up to a user defined limit). Timed override shall be initiated by the operator or by an occupant pushing the override button on the space sensor, if enabled by the operator.

   During unoccupied period whenever the space temperature falls below the unoccupied heating set point (VAV systems shall use return-air temperature) or rises above the unoccupied cooling set point the supply fan shall run until the space temperature has returned to the required unoccupied space temperature limits.

   The supply fan shall also run during the unoccupied period when the unit is in the Nighttime Free Cooling mode to pre-cool the space prior to occupancy.

2. Nighttime (Unoccupied) Free Cooling (UFC):

   The nighttime free cooling mode will operate only during unoccupied hours. When enabled, the con-

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troller will measure the space temperature and modulate the economizer to maintain the space occupied cooling setpoint. This mode will be enabled via a user selectable switch.

Nighttime free cooling shall not operate if the outside air temperature is below a user-selectable value or if the algorithm determines that the enthalpy of the outside air is unsuitable.

3. Unit Optimal Start:

   The Unit Optimal Start shall include the capabilities necessary to minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of the scheduled occupied period.

   High and low space temperature alarms shall be provided with the Unit Optimal Start algorithm. Both alarms are based on deviations from the zone temperature by a user definable amount.

4. Heating Coil Control:

   a. The heating coil routine shall modulate the heating valve to maintain the conditioned space's heating set point based on the supply air temperature. The heating coil routine shall also modulate the heating coil valve when the freezestat (if present) is on to maintain a minimum duct temperature to help protect against freezing. The dual loop PID control algorithm shall utilize the space temperature sensor as the master sensor and the discharge sensor as the submaster sensor. During VAV only, the heating coil valve will open whenever the supply-air temperature drops from 40°F to a user-adjustable level, normally set at 35°F.

   b. Electric Heater Control (CV) — If the fan is on, cooling (if present) is not active and the outside-air temperature is less than a user-defined set point, then the control shall read the space temperature and calculate the required supply air temperature to satisfy conditions. Once the required supply-air temperature has been calculated, it shall be compared to the actual supply-air temperature to determine the number of heat stages required to satisfy conditions. The electric heat control shall also provide for unoccupied heating whenever the space temperature drops below the heating unoccupied set point. If more than one stage is required, the stages shall be enabled one at a time with a time delay between stages.

   c. Electric heater Control (VAV) — When the supply fan is on, cooling (if present) is active and the outside-air temperature is less than the user-defined set point, the controller shall determine based on the space and supply-air temperature if heating is required. If it is, the controller compares the return-air temperature to the occupied heating set point or unoccupied heating set point. If heat is required, the controller shall calculate the supply-air temperature required to satisfy conditions. Once the supply-air temperature is calculated it shall be compared to the supply-air temperature sensor reading to determine the number of stages required to satisfy conditions.

   d. Heating — Face and Bypass (CV) — This routine shall modulate a face and bypass damper to prevent the space temperature from falling below the occupied/unoccupied heating set point. When the supply fan is on, outside-air temperature is less than a user-definable set point and cooling (if present) is not active, the controller shall measure the space temperature and open the heating coil valve in sequence with the face and bypass dampers to maintain its heating set point. The heating coil valve will open whenever the freezestat (if present) is on.

      When the fan is off, the damper shall be positioned to the full bypass position and the heating valve shall be closed.

   e. Heating — Face and Bypass (VAV) — This routine shall modulate a face and bypass damper to prevent the supply-air temperature from falling below the occupied/unoccupied heating set point. When the supply fan is on, outside-air temperature is less than a user-definable set point and cooling (if present) is not active, the controller open the heating valve in sequence with the face and bypass dampers to maintain its heating setpoint. The heating coil valve will open whenever the freezestat (if present) is on.

      When the fan is off, the damper shall be positioned to the full bypass position and the heating valve shall be closed.

5. Cooling Coil Control:

   a. The cooling coil (CV) routine shall modulate the cooling coil valve to maintain the conditioned space's cooling set point. The valve shall be closed whenever the space temperature is below the cooling set point. When the supply fan is on, the outside-air temperature is greater than a user-defined set point, and the economizer (if present) is disabled or fully open, the controller will modulate the cooling coil valve to maintain the space temperature below its cooling set point. The cooling coil valve will open to a user-definable percentage whenever the freezestat (if present) is on.

      For those units that require dehumidification control (see I/O summary and/or the sequence of operation) the control valve shall open whenever the humidity sensor exceeds its (adjustable) humidity set point and calls for dehumidification.

   b. The cooling coil (VAV) routine shall modulate the cooling coil valve to maintain the desired supply-air temperature set point. When the supply fan is on, the outside-air temperature is above a user-definable set point, heating (if present) is not active and the economizer (if present) is disabled or fully open, the controller will modulate the cooling coil valve to maintain the supply air temperature below its cooling set point. The cooling coil valve will open to a user-definable percentage when the freezestat (if present) is on.

      For those units that require dehumidification control (see I/O summary and/or the sequence of operation) the cooling coil control valve shall open whenever the humidity sensor exceeds it user adjustable humidity set point.

   c. Cooling — Face and Bypass (CV) — When the supply fan is on, the outside-air temperature is greater than a user-definable level, the economizer (if present) is disabled or fully open, heating (if present) is not active and the space temperature is above the cooling set point, then the face and bypass dampers will modulate open to face position (closed to bypass position) to maintain the supply air temperature set point by modulating the air passing over the cooling coil. When the space temperature is less than the cooling set point, the face and bypass dampers will close to the face position (open to bypass position).

When the fan is off the dampers shall be positioned to the full bypass position and the chilled water valve shall be closed.

For those systems that require a dehumidification cycle (see I/O summary and/or sequence of operation) the damper and valve shall be opened fully.

d. Cooling — Face and Bypass (VAV) — When the supply fan is on, the outside-air temperature is greater than a user definable level, the economizer (if present) is disabled or fully open, heating (if present) is not active and the supply-air temperature is above the user defined cooling set point, then the controller will open the cooling coil valve and modulate the face and bypass dampers open to face position (closed to bypass position). When the supply-air temperature is less than the cooling set point, the face and bypass dampers will close to face position (open to bypass position). The cooling coil valve will open whenever the freezestat (if present) is on.

For those systems that require a dehumidification routine (see I/O summary and/or sequence of operation) when the space humidity sensor exceeds its high limit set point, the dampers shall be positioned to the full face position with the chilled water valve open.

6. Direct Expansion Cooling Control:

The direct expansion (DX) cooling control regulates the DX cooling system. The DX cooling system is controlled via the compressors in the condensing units and are controlled directly by the condenser's controller. In a VAV system, the compressors are modulated to maintain the supply air temperature set point and outputs from the RAT and SAT sensors are read directly by the condenser controller, or indirectly via the TruVu MPC control system via the PIC6 BACnet communication option. In a CV system, the compressors are modulated to maintain the space temperature set point, and the outputs from the space temperature thermostats can be read directly by the condenser controller or indirectly via the PIC6 BACnet communication option.

7. Mixed Air Damper Control:

a. The mixed air damper routine (CV) shall modulate the outside, return and exhaust air dampers, as applicable. When an enthalpy comparison by the routine determines that the outside-air conditions are unsuitable for atmospheric cooling, the dampers shall be positioned to admit an adjustable, minimum outside air percentage when in the occupied mode.

When the enthalpy comparison determines that outside-air conditions are suitable for atmospheric cooling, the mixed-air dampers shall be modulated to maintain a space temperature that is between the heating and cooling set points in an effort to minimize the need for mechanical cooling or heating (the controller shall automatically provide this value based on the set points entered). The damper adjustment rate shall be automatically limited to prevent nuisance low temperature thermostat tripping.

During the unoccupied cycle and unit optimal start, the mixed-air dampers shall be kept closed to outside and exhaust air and open to return air unless the system has been indexed to nighttime free cooling.

The minimum damper position shall be the greatest of the supplied configured minimum percentage position(s), as applicable, from the Indoor Air Quality routine or this routine, whichever is greatest.

If the supply fan is off, the mixed-air dampers shall be kept closed to outside and exhaust air and open to return air.

b. The mixed air damper (VAV) routine shall modulate the outside, return, and exhaust air dampers as applicable. When an enthalpy comparison by the routine determines that outside air conditions are unsuitable for atmospheric cooling the dampers shall be held at an adjustable minimum position or modulated to a minimum position determined by the IAQ routine, as applicable when in the occupied mode. When the enthalpy comparison determines that outside-air conditions are suitable for atmospheric cooling, the mixed-air dampers shall be modulated to maintain a mixed-air temperature equal to the supply air temperature set point (plus any reset value) minus 2°F.

For those systems with mechanical cooling, this routine shall ensure that outside air is always fully used as the first stage of cooling (when available) and that the mechanical cooling is always disabled first as the load decreases.

During the unoccupied cycle and unit optimal start the mixed-air dampers shall be kept closed to outside and exhaust air and open to return air unless the system has been indexed to nighttime free cooling. If the supply fan is off, the mixed-air dampers shall be kept closed to outside and exhaust air and open to return air.

The dampers shall also be capable of being modulated to maintain a desired temperature set point set by the operator.

The controller shall be capable of providing a protection feature that shall automatically limit the amount of outside air to prevent the mixed-air temperature from falling below an adjustable set point (nominally 45°F).

c. Two-Position Damper Control — Two-position damper control shall be used to control two-position outside dampers to provide minimum outside-air ventilation.

If the supply fan is off, the damper shall be closed. If the supply fan is on, the control shall determine if the unit is in the Occupied mode. If the unit is in the Occupied mode the dampers shall open. If the unit is in the Unoccupied mode the dampers shall remain closed, however, the dampers shall open when the unit is indexed to Nighttime Free Cooling.

8. Supply Air Duct Static Pressure Control:

The controller shall modulate the supply-fan VFD speed to maintain the duct static pressure set point. When the supply fan is off, the drive shall be reset to an adjustable minimum speed value. When the supply fan is on, the controller shall read the duct static pressure and the PID control algorithm shall compute the drive output required. The controller shall compare the actual duct static pressure to the desired set point value and re-calculate the required signal output to the drive.

9. Indoor Air Quality (IAQ):

   The controller shall be capable of monitoring and alarming an IAQ sensor or may be used to maintain a IAQ set point by overriding the current minimum mixed-air damper position when the IAQ sensor exceeds its operator adjustable set point of CO_2 concentration. This routine shall also be subject to a field selectable low temperature override based on the mixed-air or supply-air temperature.

   The IAQ routine shall be capable of suspending its damper override position based on space temperature and humidity.

10. Filter Status Control:

    The controller shall monitor an airflow switch or switches, as applicable, measuring the differential pressure between the upstream and downstream side of the filter(s) for all units that list filter status within the I/O summary. When the filter becomes dirty or needs to be replaced, the airflow switch shall input a discrete signal to the controller, that will in turn, generate an alarm at the portable PC or EMS operator's station, if tied into a network.

G. Portable PC Local Interface:

Each controller shall include the inherent ability to be added to a network or to be modified without the addition of any external devices. If connected to a EMS network and/or if a portable PC with EMS software is plugged into the controller the operator shall have access to input set point and configuration data, display conditions, alarms, etc.

H. Network Compatible:

The factory-installed Product Integrated Control shall have the resident capacity of connecting onto a communication network with other like controllers and communicating with other compatible microprocessor-based controllers and PCs. Controllers that do not include this resident capability without adding additional hardware are not acceptable.

Network features. The controller shall support the following network features:

1. Data collection and transfer
2. Interface to a local and/or remote EMS operator's station
3. Interface to portable PC or alarm printer
4. Demand Limiting and Maintenance Management
5. Dynamic Linkage to Air Terminals
6. Interface to Field Installed Controllers (FICs) to provide custom programming access
7. Interface to a linkage thermostat (CV only)

Demand Controlled Ventilation (DCV) Guide Specifications

1.01 SENSORS

A. Wall-Mounted Combination Sensors:

1. Wall-mounted combination sensors shall contain a space temperature sensor and carbon dioxide (CO_2) sensors in a single, decorative housing.

   The CO_2 sensor shall use Single-Beam Absorption Infrared™ diffusion technology (non-dispersive infrared), and shall have integral programming to perform automatic baseline calibration without user interface. The recommended manual recalibration period shall not be less than five years.

   Other features of wall-mounted combination sensors shall include:

   a. Operating conditions: 60°F to 90°F (15°C to 32°C), and 0 to 95% RH, non-condensing.
   b. Power supply: 18 to 30 vac, 50/60 Hz (18 to 42 vdc polarity protected).
   c. CO_2 sampling method: diffusion.
   d. CO_2 sensor output: 4 to 20 mA or 0 to 10 volt signal.
   e. CO_2 measurement range: 0 to 2,000 ppm.
   f. Sensitivity: ±20 ppm.
   g. Accuracy: ±100 ppm at 60°F to 90°F (15°C to 32°C); and 760 mm Hg.
   h. CO_2 sensor calibration: single point calibration via push button and LED.
   i. Space temperature sensor: 10,000 ohm ±2% at 77°F (25°C) thermistor with push button override (and a temperature set point adjustment potentiometer).

2. Combination sensors shall be provided with the manufacturer's recommended carbon dioxide calibration kit. The quantity shall be suitable to initially calibrate each sensor provided for the project.

B. Wall-Mounted Carbon Dioxide Sensors:

1. Carbon dioxide (CO_2) sensors shall be manufactured in a decorative, wall-mounted housing.

   The CO_2 sensor shall use single-beam or dual-beam absorption infrared diffusion technology (non-dispersive infrared), and shall have integral programming to perform automatic baseline calibration without user interface. The recommended manual recalibration period shall not be less than five years. Sensors shall be equipped with an LED display.

   Other features of wall-mounted carbon dioxide sensors shall include:

   a. Operating conditions: 60°F to 90°F (15°C to 32°C), and 0 to 95% RH, non-condensing.
   b. Power supply: 18 to 30 vac, 50/60 Hz half wave rectified (18 to 42 vdc polarity protected).
   c. CO_2 sampling method: diffusion or flow through.
   d. CO_2 sensor output: 4 to 20 mA or 0 to 10 volt signal.
   e. CO_2 measurement range: 0 to 10,000 ppm.
   f. Set point: adjustable.
   g. Sensitivity: ±10 ppm.

h. Accuracy: ±50 ppm (0 to 2000 ppm), ±5% of reading (2000 to 10,000 ppm).

i. CO_2 sensor calibration: single point calibration via push button and LED.

j. Relay contacts: normally open or normally closed, 2 amps at 24 vac.

2. Carbon dioxide sensors shall be provided with the manufacturer's recommended calibration kit. The quantity shall be suitable to initially calibrate each sensor provided for the project.

C. Duct-Mounted Carbon Dioxide Sensors:

1. Carbon dioxide (CO_2) sensors for duct-mounted applications shall be identical to the wall-mounted sensors specified above except as described below.

2. The CO_2 sensor shall be mounted in an enclosed aspirator box that mounts directly to the duct. The aspirator box shall be equipped with an induction tube to direct a side-stream of air from the duct through the CO_2 sensor. A hinged, clear access door shall be installed on the front of the aspirator box to permit access to the sensor and to permit viewing the sensor without opening the door.

3. CO_2 sensors for duct-mounted applications shall be designed for flow-through sampling.

1.02 CONTROLLERS

The following paragraphs describing DCV requirements for solid-state, microprocessor (direct digital) controllers, and should be inserted as supplements to the project controller specifications. They are not intended to describe the complete requirements for controllers.

A. Zone Controllers:

1. Each single-duct (fan-powered) zone controller shall be specifically designed to provide demand controlled ventilation (DCV) operation using a proportional-integral (PI) control loop. The zone controller shall be capable of stand-alone operation and shall execute the DCV control functions without being dependent on a network system, additional hardware, or intermediate controllers.

2. Zone controllers shall be capable of being added to a system network without additional hardware. They shall be designed for connection to other zone controllers and to a common system controller to perform DCV control functions as part of an integral ventilation system.

3. Zone controllers shall be designed to interface directly with the specified CO_2 sensors.

4. Zone controllers shall be capable of maintaining a ventilation set point through a DCV algorithm in conjunction with system controller to fulfill the requirements of ASHRAE standard, 62-1989 "Ventilation For Acceptable Indoor Air Quality" (including Addendum 62a-1990). The algorithm shall also be capable of modulating the terminal unit heating to maintain the space temperature between the heating and cooling set points. For terminal units without supplementary heating, the zone controller DCV algorithm shall have a primary airflow limit to protect the zone from overcooling.

5. DCV control sequences shall be as specified herein (or as indicated on the drawings).

B. System Controllers:

1. System controllers shall be specifically designed to provide demand controlled ventilation (DCV) operation using a proportional-integral (PI) control loop. All DCV application software shall be resident in the system controller's memory and shall be factory-tested and factory-configured. The system controller shall be capable of stand-alone operation and shall execute the DCV control functions without being dependent on a network system, additional hardware, or intermediate controllers.

2. The system controller shall be designed for connection to zone controllers to perform DCV control functions as part of an integral ventilation system.

3. The system controller shall be designed to interface directly with the specified CO_2 sensors.

4. The system controller shall be capable of maintaining a ventilation set point through a DCV algorithm in conjunction with zone controllers to fulfill the requirements of ASHRAE standard, 62-1989 "Ventilation For Acceptable Indoor Air Quality" (including Addendum 62a-1990).

5. DCV control sequences shall be as specified herein (or as indicated on the drawings). Unit (Product Integrated) Controllers:

a. The unit controller shall be a solid-state microprocessor controller using direct digital control and software specifically designed to provide demand controlled ventilation (DCV) functions.

The controller shall be factory-installed and wired within the unit, and shall be furnished complete with all application software to perform DCV functions. The unit controller shall be preconfigured and pre-tested for DCV operation.

b. The controller shall maintain an adjustable CO_2 set point by control of the mixed-air damper position. The unit controller shall also have the ability to limit the maximum amount of outdoor air during DCV operation, and modulate heating to maintain a minimum supply air temperature.

c. The unit controller shall be designed to interface directly with the specified CO_2 sensors.

d. DCV control sequences shall be as specified herein (or as indicated on the drawings).