



UNDERFLOOR AIRWAY™ SYSTEMS

ENGINEERING GUIDE



Meets ASHRAE 90.1 - 2001
Efficiency Requirements



TABLE OF CONTENTS

FOREWORD	3
INTRODUCTION	4
DEVELOPING INNOVATIVE PRODUCTS AND IDEAS	4
FROM PLENUM TO AIRWAY SPACE	4
WHAT IS A FLEXXSYS UNDERFLOOR AIRWAY SYSTEM?	4
ABOUT THIS MANUAL	4
NOMENCLATURE	5
AIRWAY COMPONENTS	6
BASIC AIRWAY SYSTEM COMPONENTS	6
COMPONENT NOMENCLATURE	6
VARIABLE-AIR-VOLUME DIFFUSERS	6
MIT2-C	6
MIT2-G	6
CONSTANT-VOLUME DIFFUSERS	6
MIT2-A	7
MIT2-H	7
PCD	7
FAN-POWERED TERMINAL UNITS	8
UFE	8
UFW	9
HCE	10
HCW	10
ACCESSORIES	10
CX-FlexFloor	10
TCD-C	11
TCD-S	11
IBOX	12
PM	12
QBX-C	12
QBX-H	12
PAP Cables	13
TERMINALS	18
TERMINAL SIZING FUNDAMENTALS	18
VAV Systems	18
CV Systems	18
SUPPLY DIFFUSERS FOR HEATING SERVICE	19
DIFFUSERS USED FOR RETURN SERVICE IN HEATING SYSTEMS	19
LOCATING SUPPLY DIFFUSERS	19
LOCATING RETURN AIR INLETS	19
PERIMETER HEATING SYSTEMS	20
RECOMMENDED PERIMETER HEATING SYSTEM	20
LOCATING FAN-POWERED TERMINAL UNITS IN PERIMETER HEATING APPLICATIONS	20
UFE AND UFW HEATING PERFORMANCE	21
GUIDE SPECIFICATIONS	23

Foreword

YORK developed the FlexSys™ Underfloor Air Systems using the best features of traditional overhead VAV air supply and underfloor displacement ventilation systems. The result was “Convection Enhanced Ventilation,” which has a proven track record as an extremely flexible and reliable technology that is capable of providing the highest level of occupant comfort. YORK’s Modular Integrated Terminal (MIT), designed to provide constant velocity air supply in both constant-volume and variable-air-volume applications, has been the mainstay of the FlexSys system.

Underfloor air distribution systems provide excellent occupant comfort and reduced energy usage, and provide a sustainable and flexible HVAC system.

In 2004, YORK introduced the AirFixture® Airway™ System of above ceiling, ductless air distribution using the pioneering concept of *pulse-modulated* air delivery. Pulse modulation enables true variable-air-volume supply while maintaining air movement and diffuser throw characteristics over the full range of foreseeable loads in the conditioned space.

Introduction of MIT², the second generation of modular integrated terminals for underfloor systems, is the next logical step. MIT² combines the best of FlexSys Underfloor Air Systems with the innovative approach of pulse-modulated air delivery.

This document, the *FlexSys Underfloor Airway™ Systems Engineering Guide* is designed for both novice and experienced designers. It presents helpful, hands-on information to assist the HVAC engineer in the design and layout of underfloor Airway™ systems. The *FlexSys Underfloor Airway™ System Application Guide* is a companion document that examines the fundamentals of underfloor air distribution and pulse-modulated airflow control.

If you have a question about any of the information provided, or just want to send us a comment, please write us at es.commercial@york.com or call (800) 861-1001, and we will be happy to respond.

Introduction

DEVELOPING INNOVATIVE PRODUCTS AND IDEAS

YORK developed the Modular Integrated Terminal (MIT), also known as the FlexSys underfloor air distribution system, using the concept of Convection Enhanced Ventilation (CEV). CEV is a hybrid that offers the advantages of both *displacement effect* ventilation and traditional *well-mixed* ventilation, and at the same time overcomes their disadvantages. CEV supplies air at floor level similar to displacement effect ventilation, but at a constant velocity. Supply air enters the conditioned space with enough velocity to provide mixing in the *breathing zone*, which is the occupied space up to about 6 feet (1.8 meters) above the floor. Warm air stratification occurs naturally above this level.

The **AirFixture** Dual Airway System is a pioneering concept in above-ceiling ductless air distribution. By creating separate supply and return Airway spaces above the ceiling, efficient air distribution can be accomplished without ductwork and at very low static pressures. (See *Applying AirFixture® Technology*, Form 130.30-AG1.)

Now, YORK is combining MIT–FlexSys and the **AirFixture** Airway System in **MIT²**, a new generation of products that provide more air-conditioning options and better comfort control.

FROM PLENUM TO AIRWAY SPACE

The interstitial space beneath a raised floor (and above a structural floor) has traditionally been called a *plenum*. When adapting the ductless distribution concept to an above-ceiling system, the name plenum creates problems. A plenum can be many things: a chamber, a room, or a sheet metal component of an air-handling unit. A code official reading the word *plenum*, may apply inappropriate code provisions leading to an incorrect interpretation. To reduce confusion in the context of ductless air distribution, YORK literature uses the term *Airway space* to describe the air distribution spaces (supply and return) above ceilings and below raised access floors.

WHAT IS A FLEXSYS UNDERFLOOR AIRWAY SYSTEM?

A FlexSys underfloor Airway space is an interstitial volume created between a structural floor and a raised

access floor. Underfloor Airway spaces are *not* specifically designed to only deliver conditioned air; they perform several functions, of which only one is air distribution. Constructed from architectural building components, Airway spaces can be used for convenient distribution of electricity, communications and data cabling, small piping systems, and air distribution. An underfloor Airway space may also make limited use of sheet metal ducts to achieve certain performance characteristics. When conveying air, an underfloor Airway space operates at slow velocities and at a very low static pressure.

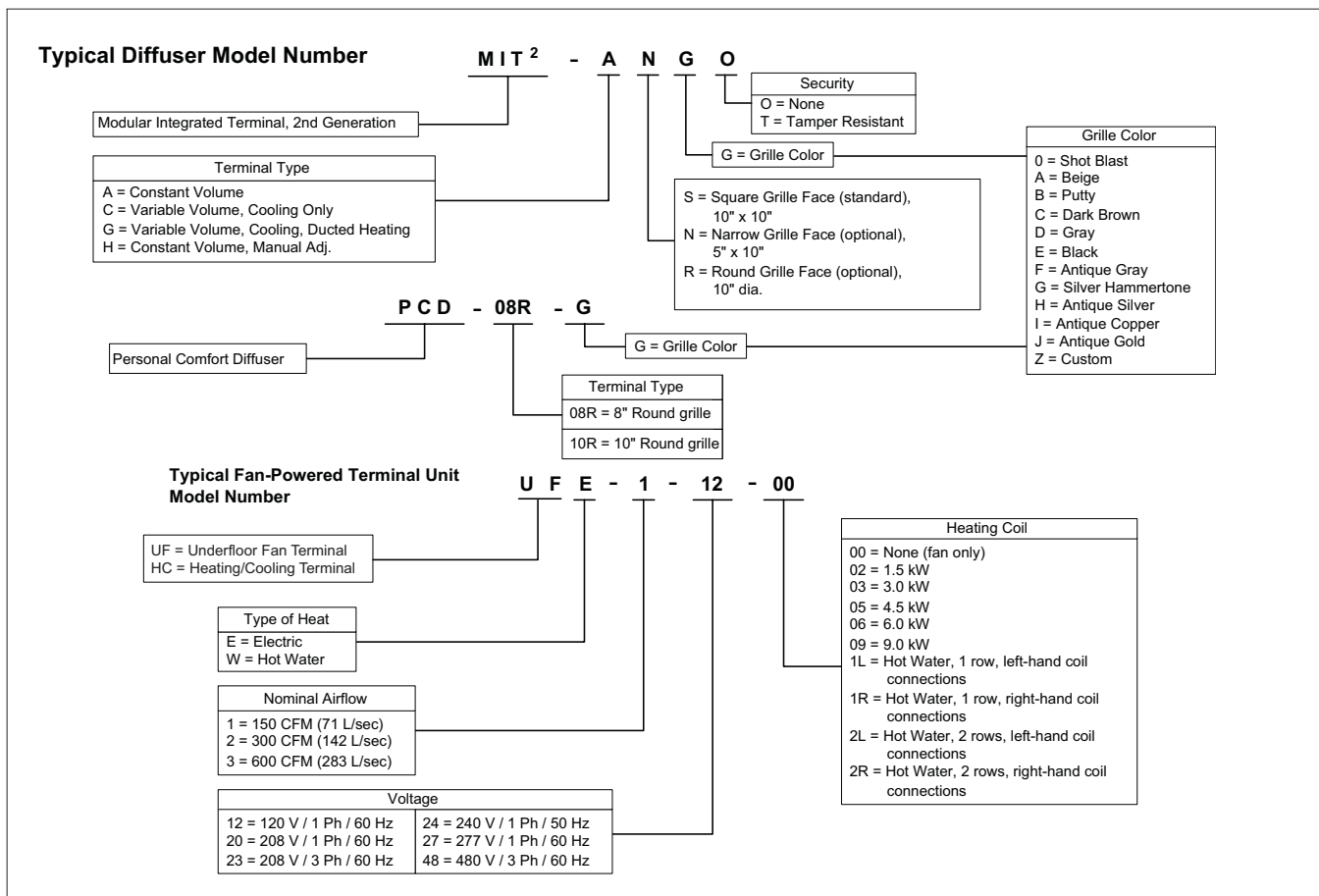
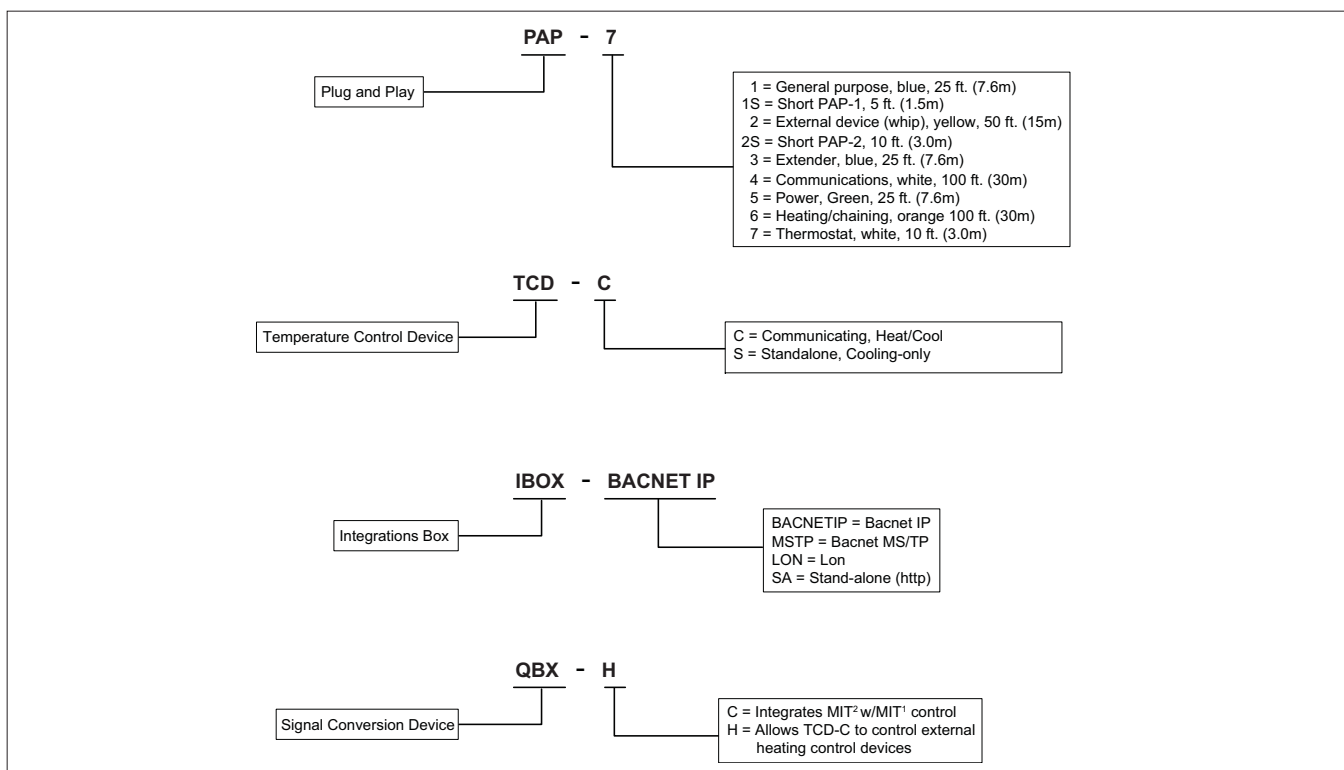
PERSONAL COMFORT DIFFUSERS

As mentioned throughout this guide, the primary building block of the FlexSys system is the Modular Integrated Terminal—MIT. The MIT is generally used as a Variable-Air-Volume (VAV) device that automatically adjusts the delivered airflow in response to a thermostat setting and space conditions. While an all-VAV underfloor system is superior to a system with constant-volume, manually adjustable diffusers in terms of occupant comfort and building automation, we recognize that some applications will require the use of personal comfort diffusers—PCDs. For this reason, YORK has expanded the product line to include PCDs that offer advantages over any other manually adjustable floor diffuser on the market. The PCDs have been designed to operate in systems with 100% manual adjustable diffusers or in a blended system with VAV MITs.

ABOUT THIS MANUAL

This manual provides technical descriptions of FlexSys underfloor air distribution systems with pulse-modulated variable-air-volume controls. It also provides practical guidelines and recommendations for using a new generation of YORK products. The various discussions identify differences between the technology of this air delivery system and the traditional overhead ducted systems. The combination of FlexSys and **AirFixture** is cost effective and provides flexibility beyond any ducted system. It must be emphasized that this manual is only an introduction to the many issues involved in applying this technology. Experienced engineers familiar with this technology should carefully review final design parameters and equipment selection.

Nomenclature

TABLE A - FLEXSYS DIFFUSER AND FAN TERMINAL NOMENCLATURE

TABLE B - FLEXSYS CONTROLS AND ACCESSORIES NOMENCLATURE


Airway Components

BASIC AIRWAY SYSTEM COMPONENTS

YORK has assembled a variety of FlexSys air distribution components to meet most commercial applications. FlexSys components are specifically designed for underfloor Airway system air distribution and are available in both constant-volume (CV) and variable-air-volume (VAV) styles. VAV terminals are specially designed for operation with pulse-modulated airflow controls.

COMPONENT NOMENCLATURE

Table A shows the model numbers and nominal performance ratings for the newest **FlexSys MIT²** components. Please refer to the original “Convection Enhanced Ventilation Technical Manual” (Form 130.15-EG2) for the nomenclature and description of first generation MIT terminals and other underfloor air distribution components.

VARIABLE-AIR-VOLUME DIFFUSERS

FlexSys VAV terminals are designed to operate in an underfloor Airway distribution system pressurized at 0.05 inches w.g. (12.4 Pa). The internal automatic control damper, called an *air valve*, uses pulse modulation to vary the total air delivered to the space. Pulse-modulated air delivery supplies air to a space using short-duration, on-off cycles (pulses). When the air valve is open, air passes at the rated capacity; when the air valve is closed, airflow stops. If the thermostat calls for less air the duration and frequency of ON periods decrease and the OFF periods increase. If more air is necessary, the opposite is true: the duration and frequency of ON periods increase and the OFF periods decrease. This is referred to as the *duty cycle*. Because the air valve is either fully open or fully closed, discharge air velocity is constant any time the air valve is open.

MIT²-C

Shown in Figure 1, the MIT²-C is a variable-air-volume, constant-velocity air terminal for use in cooling-only service. It features galvanized steel construction and a powder-coated (painted), cast aluminum top grille. The standard 10-inch (254-mm) square aluminum grille, with a nominal 150-cfm (71-L/sec) airflow rating, has two adjustable halves that can provide up to 16 different airflow patterns. Optional grilles include a 10-inch (254-

mm) round version with a nominal 150-cfm (71-L/sec) airflow rating, and a narrow rectangular grille (5" x 10", 127 mm x 254 mm) with a nominal 100-cfm (47-L/sec) rating. Grilles may be ordered in many standard colors, and custom colors are available as a special order.

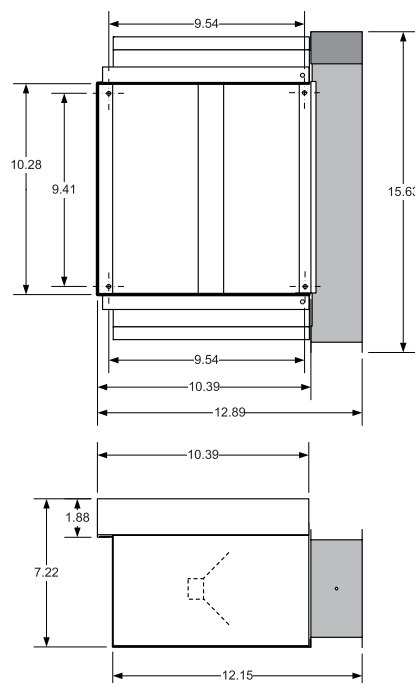


Fig. 1. MIT²-C is a variable-air-volume supply terminal designed for cooling-only applications

MIT²-G

Similar in basic construction and performance to the MIT²-C, the MIT²-G is a constant-velocity air terminal that provides variable-air-volume cooling and constant-volume heating. The unit has a 5-inch (127-mm) duct connection for heating applications, as shown in Figure 2. The unit also has the ability to operate as a return air grille when used in a heating system with a fan-powered terminal unit.

CONSTANT-VOLUME DIFFUSERS

CV air terminals are designed to release air at a constant velocity while operating in an underfloor distribution system pressurized at 0.05 inches w.g. (12.4 Pa). They are manually adjustable to vary both the airflow direction and rate.

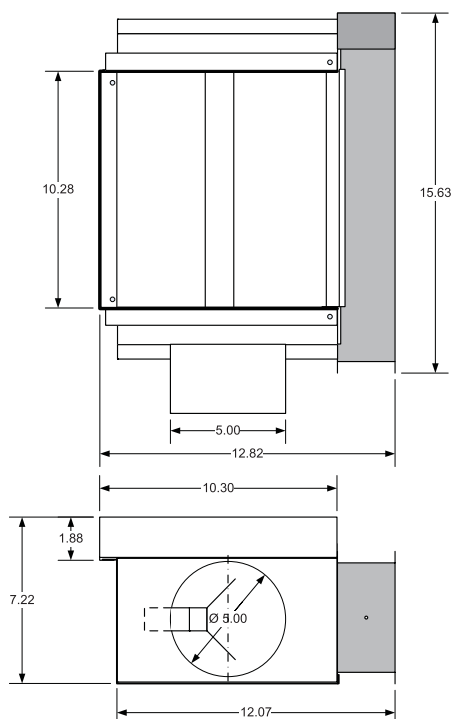


Fig. 2. MIT²-G is a variable-air-volume supply terminal designed for both cooling and heating applications

MIT²-A

The MIT²-A is a constant-volume, constant-velocity air terminal and features galvanized steel construction with a cast aluminum top grille identical to the MIT²-C and

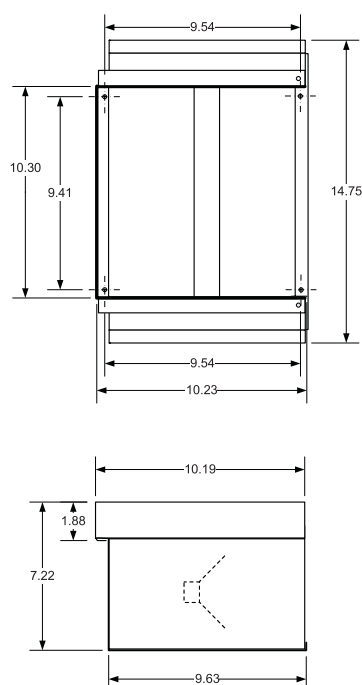


Fig. 3. MIT²-A

JOHNSON CONTROLS

MIT²-G. The primary difference is that the MIT²-A has no internal air valve or controls. The unit is available with either a 10-inch (254-mm) square grille rated at 150 cfm (71 L/sec), or 5-inch by 10-inch (127-mm by 254-mm) narrow model rated at 100 cfm (47 L/sec).

MIT²-H

The MIT²-H is a manually adjustable, constant volume air terminal and features galvanized steel construction with a cast aluminum top grille identical to the other MIT. The MIT²-H has a manual damper inside the terminal unit which can adjust the airflow rate. The unit is available with either a 10 inch (254 mm) square grille rated at 150 cfm (71 L/sec), 5 inch (127 mm) by 10 inch (254 mm) narrow grille rated at 100 CFM, or 10 inch (254 mm) round grille rated at 150 cfm.

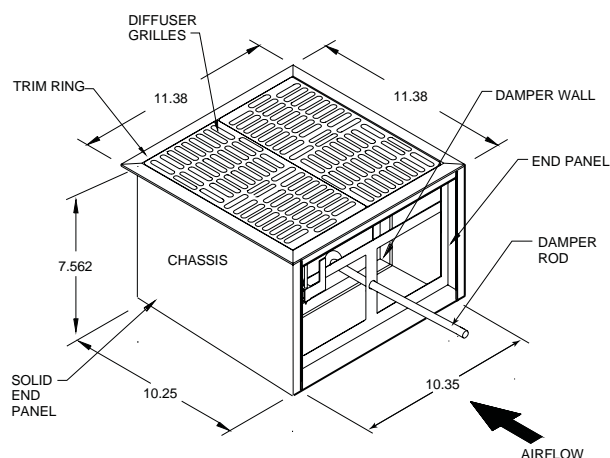


Fig. 4. MIT²-H

PCD

The round-style PCD-08R is a manually adjustable, constant-volume air terminal rated at 60 cfm (28 L/sec). It features galvanized steel construction and a solid, cast-aluminum grille. The unit installs in a floor panel through an 8-1/4 inch (210-mm) round opening, as shown in Figure 5. Airflow direction may be changed by loosening the single mounting screw and rotating the diffuser. The grille is available in many standard colors and a manually adjustable thumbwheel varies the airflow rate.

The PCD-10R is a manually adjustable, constant-volume air terminal rated at 90 cfm (42 L/sec). It is similar in construction to the PCD-08R and installs in a floor panel through a round opening 10-9/16 inches (268-mm) in diameter. A manually adjustable

Airway Components *(continued)*

thumbwheel mounted in the grille varies the airflow rate, and airflow direction may be changed by loosening the single mounting screw and rotating the diffuser. The PCD-10R grille is also available in many standard colors.

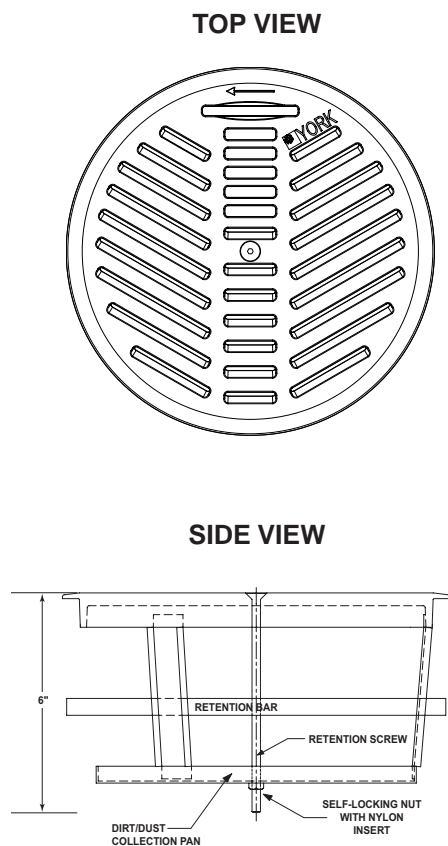


Fig. 5. PCD-08R is an adjustable, constant-volume supply terminal that installs in a 8-1/4" (210 mm) round opening. Construction of the PCD-10R is similar.

FAN-POWERED TERMINAL UNITS

Fan-powered terminal units are designed to be installed in the supply Airway space below the raised floor system. All units have galvanized steel construction with an internal, dual-density, insulating liner. Other features common to all units include:

- Single point power connection
- Centrifugal fan with forward-curved blades
- Permanent split capacitor (PSC) electric motor with overload protection
- Insulating liner meets current indoor air quality testing standards (e.g., ASTM C-665, C-1071, C-

21 and C-22) and fire classification standards including NFPA 90A

- 1-inch (25-mm) replaceable filter
- Removable fan access panel
- ETL listed
- Meets NEC requirements
- NEMA 1 electrical enclosure
- Control transformer

UFE

The model UFE fan-powered terminal is used with MIT²-G terminals for perimeter and other heating applications. UFE terminals are available with nominal airflow ratings of 150, 300, and 600 cfm (71, 142 and 283 L/sec). A 150-cfm (71 L/sec) model UFE-1 is shown in figure 6. A 600-cfm (283 L/sec) model UFE-3 is shown in Figure 7. The unit provides heat using one or two UL-listed finned tubular electric heaters depending on the unit's total heating capacity. In all models, the unit controls first attempt to satisfy the heating requirement using the fan only (1st stage) before energizing the heating elements (2nd stage). UFE fan-powered terminals may be ordered with one of several heating capacity options (no heat, 1.5 kW, 3.0 kW, 4.5 kW, 6.0 kW and 9.0 kW), and all units are manufactured with a single-point electrical connection. Electrical disconnects are standard with all FlexSys fan terminals, and thermal disconnects are standard with all terminals with electric heating coils. Table A (on page 5) lists optional power supply characteristics, and Table E (on page 21) defines the available heating capacity for each unit size and power option.

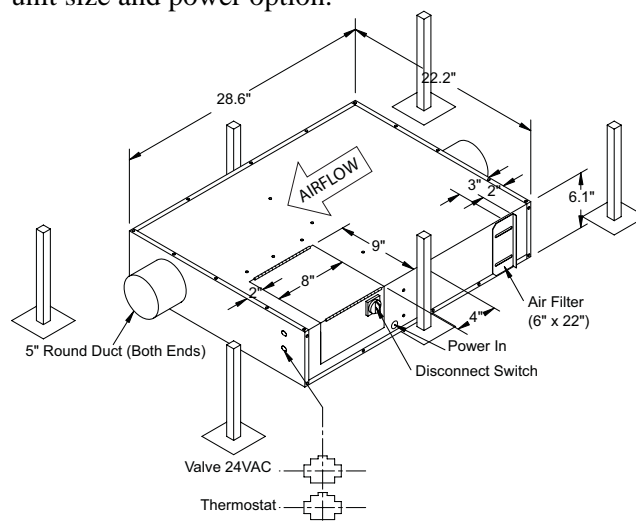


Fig. 6. Casing for UFE-1.

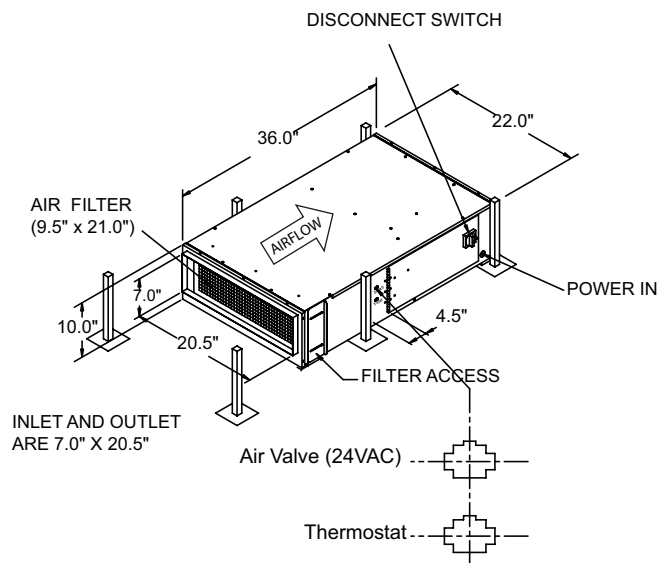


Fig. 7. Casing for UFE-2 or UFE-3.

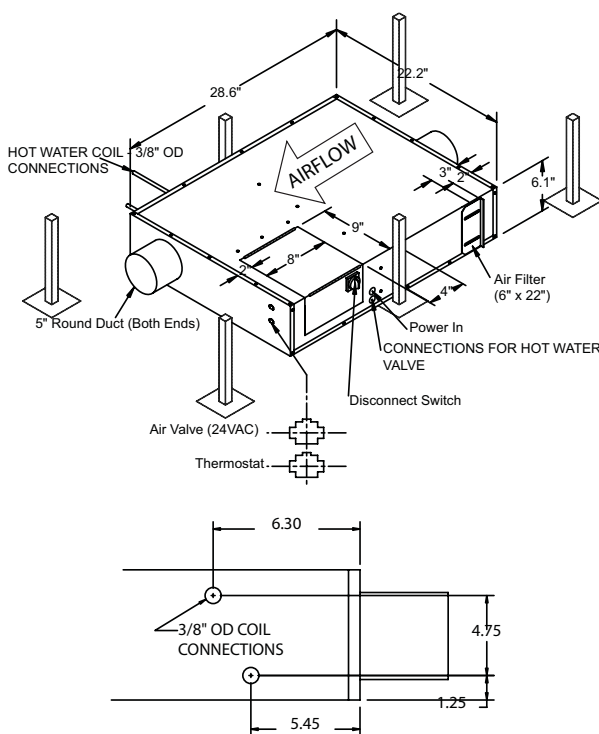


Fig. 8. Casing for a UFW-1. All UFW-1 models come with 2-row hot water coil with right-hand coil connections.

UFW

The model UFW fan-powered terminal is used with MIT²-G terminals for perimeter and other heating applications. UFW terminals are available with nominal airflow ratings of 150, 300, and 600 cfm (71, 142 and 283 L/sec). The unit provides heat using one-

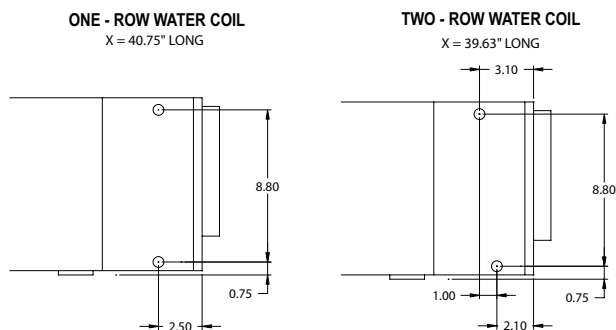
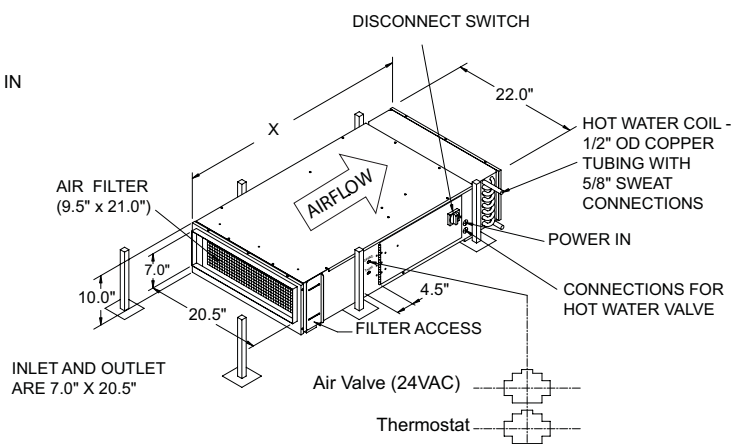


Fig. 9. Casing for a UFW-2 or UFW-3. For sizes -2 and -3, hot water coils are available with 1 or 2 rows; left or right hand coil connections (right-hand coil connections shown).

or two-row hot water coils. Figure 9 shows a 600-cfm (283-L/sec) model UFW-3.

Heating coils are made from seamless copper tubing with, brazed return bends and aluminum fins. The first heating stage is fan only, and the second heating stage is fan plus 100% of the heating coil capacity. Table F (on page 22) lists coil heating and pressure drop characteristics for each available model. All units are manufactured with a single-point electrical connection. The UFW is available with either 120/1/60, 240/1/50 or 277/1/60 (volts/Phase/Hz) incoming power.

Airway Components *(continued)*

HCE

The model HCE heating/cooling terminal with electric heat incorporates the functionality of 2 MIT²-G and a UFE-1 into a single piece construction. It is suspended from the raised access floor through the use of 2 square trim rings. The same trim rings and grilles are used with the HCE as a square MIT2 terminal.

The HCE provides a nominal 300 CFM through 2 air valves during cooling mode—fan is off during cooling mode. During heating mode, the air valves close and the fan provides a nominal 150 CFM—drawing air from one grille and supplying air through the other. Figure 10 shows a model HCE. The HCE is available with either 120/1/60, 208/1/60, 240/1/50, 277/1/60 (volts/phase/Hz) incoming power, and is provided with 1.5kw of electric heating capacity (1.1 kw for 240 volt).

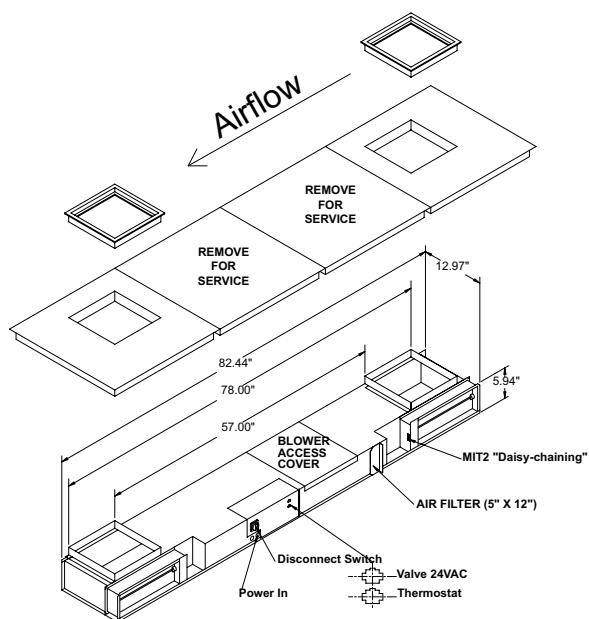


Fig. 10. HCE.

HCW

The model HCW heating/cooling terminal with hydronic heat is very similar to the HCE, but uses the same heating coil as the UFW-1. Table F (on page 22) lists coil heating and pressure drop characteristics for the HCW. The HCW is available with either 120/1/60, 240/1/50 or 277/1/60 (volts/phase/Hz) incoming power.

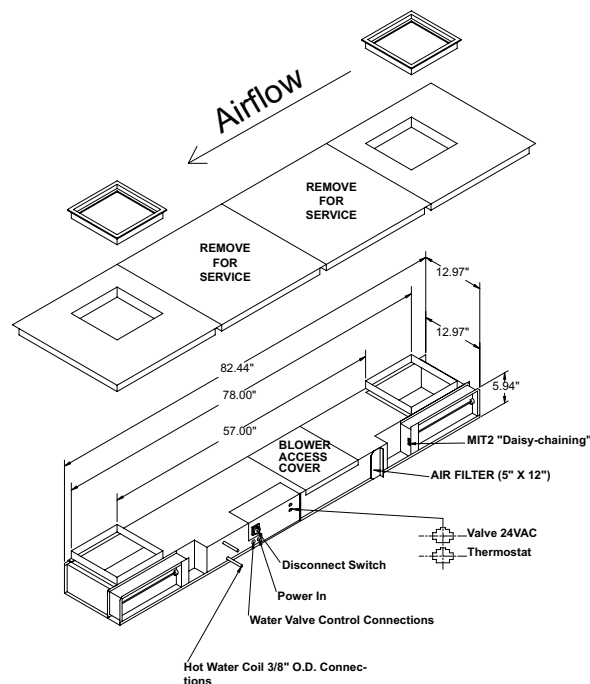


Fig. 11. HCW.

ACCESSORIES

YORK offers a complete line of accessory products to enable single-source supply for FlexSys underfloor Airway systems.

CX-FlexFloor

The CX-FlexFloor monitors the air pressure and temperature of the FlexSys underfloor supply Airway space. Preassembled in a galvanized steel housing with prewired sensors and controller, the CX-FlexFloor installs into an MIT²-size opening in the raised access floor.

The CX-FlexFloor can control the underfloor Airway space pressure by regulating the VFD fan speed or the damper between the supply air duct and the underfloor Airway space. The controller maintains the supply air temperature by controlling the return air bypass damper.

Operation can be as a stand-alone device, or as part of a Building Automation System (BAS) using BACnet MSTP. For non-BACnet systems, analog outputs are available from the CX-FlexFloor for input to any BAS or AHU. These signals provide the necessary data for

a BAS to monitor underfloor air conditions and coordinate air handler control.

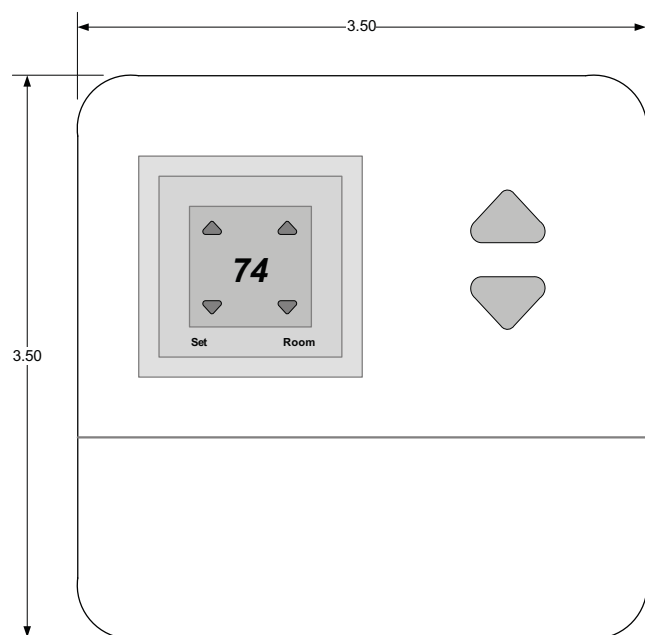
TCD-C

Temperature Control Device, or *AirSwitch*[™], is a wall-mounted, heating and cooling thermostatic device designed for pulse-modulated control of YORK FlexSys MIT² fan-powered terminal units and diffusers. The unit is wall-mounted with a front appearance as shown in Figure 12. A small LCD screen on the front displays set point and room temperature in either Fahrenheit or Centigrade. An internal DIP switch

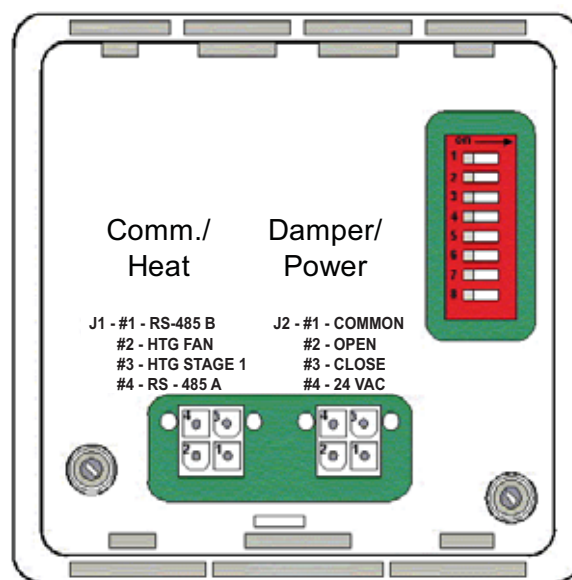
provides up to 62 network addresses, address 0 and 43 cannot be used. Communication with an IBOX occurs through PAP-4 cabling. Set points are permanently held in non-volatile memory and retained during power outages. When operating with fan-powered terminal units, the TCD-C AirSwitch controls up to three stages of heating.

TCD-S

The TCD-S is similar in appearance and function to the TCD-C, but does not have communication or heating control capability.



Front View



Back View

Fig. 12. TCD-C.

Airway Components *(continued)*

IBOX

The IBOX is a communication device that integrates TCD-C *AirSwitch*™ thermostats with a third party building automation system. The IBOX interrogates the thermostat network, gathering read and write data for the building automation system using either the BACnet or LonWorks protocols. BACnet setup can be: BACnet/IP, BACnet MS/TP, BACnet Ethernet, or Stand-alone (HTTP only). The Stand-alone version allows integration of the TCD-C Airswitch thermostats with an internet-style (HTTP) browser.

The IBOX integration platform requires no proprietary software to connect to the device. Internet Explorer or an equivalent software package is the only software required to connect to the IBOX. Each IBOX can support up to 32 AirSwitch thermostats.

It is possible to communicate with an IBOX with nothing more than a common World Wide Web connection in the absence of a building automation system.

PM

A Power Module PM is a power supply module designed specifically for use with the FlexSys system. It provides power for all MIT, TCD and QBX devices in the system. It has a single control transformer mounted on a 4 inch by 4 inch (102 mm by 102 mm) steel junction box with standard knockouts for conduit. The control transformer is rated at 90VA with an output of 24 volts ac. This is adequate to power a total of 14 MIT² and TCD devices. All PM can be wired for 120, 240 or 277 volts ac; 50 or 60 Hertz.

QBX-C

The QBX-C is a cooling control signal conversion device. It is designed for plug-and-play installation and permits YORK controls designed for first generation MIT equipment to function with second generation MIT² devices. See QBX-C data sheet (Form 130.00-S3) for more details.

QBX-H

The QBX-H is a control interface device that enables a TCD thermostat to operate with third-party heating devices, such as, on-off solenoid valves, or modulating control valves (0-10 vdc).

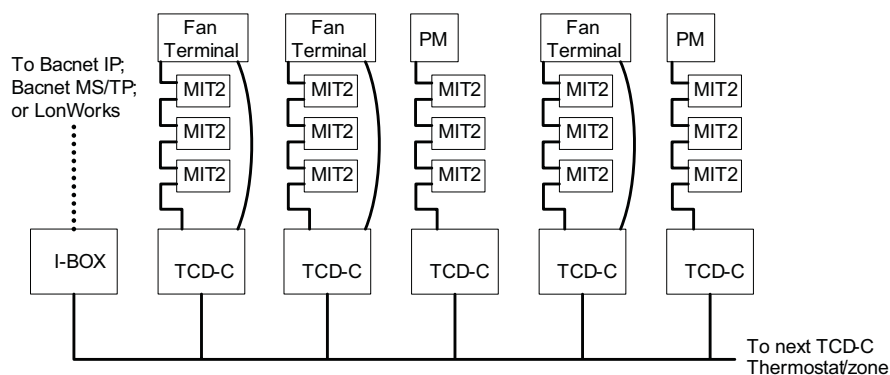


Fig. 13. Simplistic FlexSys System Cabling Diagram.

PAP CABLES

Plug and Play (PAP) cable wiring is used to connect the controllable FlexSys components. Available PAP Cables are shown in Figure 14 on page 14.

The PAP-1 cable ships with each MIT²-C, MIT²-G, HCE and HCW. It's most common use is between two air valves which are part of the MIT²-C, MIT²-G, HCE, and HCW assemblies.

PAP-2 (or PAP-2S) may be necessary when applying the QBX-C.

The PAP-3 exterior cable can lengthen any of the other PAP cables.

The PAP-4 communications-only cable daisy chains the TCD-C AirSwitch thermostats to the IBOX. Each TCD-C is shipped with a PAP-4.

The PAP-5 power-only cable is used to bring only 24Vac power between Flexsys components. The most common use is from a PM or fan terminal (which acts as 24 Vac power sources to a chain of up to 14 devices (i.e. 13 air valves and a TCD). Extending the distance between the PM and the furthest FlexSys device beyond 400' of PAP cabling can create enough voltage loss for the Flexsys components not to operate properly or become damaged. The voltage loss can be minimized by wiring the power source into the middle of a chain of air valves.

The PAP-6 heating cable is most commonly used to carry the signal from the TCD-C to the fan terminal for heating outputs. Another use for the PAP-6 is for continuing the air valve/cooling signal from the TCD-C to additional chain(s) of air valves and power sources. 1 power course (PM or fan terminal) with 13 air valves.

If a zone needs more than 13 air valves (typically 1,950 CFM), then additional power source(s) must be used. Each PAP-6 can continue the air valve/cooling signal to an additional 14 air valves while isolating the power between the chain of air valves. Note: when using the PAP-6 in this manner, tie the grounding for each power source (serving a common TCD) together for proper operation of all of the chains of air valves. See the right side of Figure 16 for an example.

The PAP-7 thermostat cable is shipping with each TCD-C. It connects TCD-C to other PAP cables under the raised access floor. See Table C for a listing of cables provided with the various Flexsys Models.

TABLE C - PAP Cables Provided with FlexSys Equipment

FlexSys Model	PAP cables provided
MIT2-C & MIT2-G	PAP-1
PM	PAP-5
TCD-C	PAP-4 & PAP-7
UFE & UFW	PAP-5 & PAP-6
HCE & HCW	PAP-1, PAP-5 & PAP-6
QBX-H	PAP-5S & PAP-6S

ZONE CABLING DIAGRAMS

Typical zone cabling diagrams are shown in Figures 15 through 19 as follows:

- Small Cooling Only Zone – Figure 15
- Cooling Only / BAS Interface – Figure 16
- UFE / UFW / BAS Interface – Figure 17
- HCE / HCW / BAS Interface – Figure 18
- QBX-H / BAS Interface – Figure 19

Airway Components *(continued)*

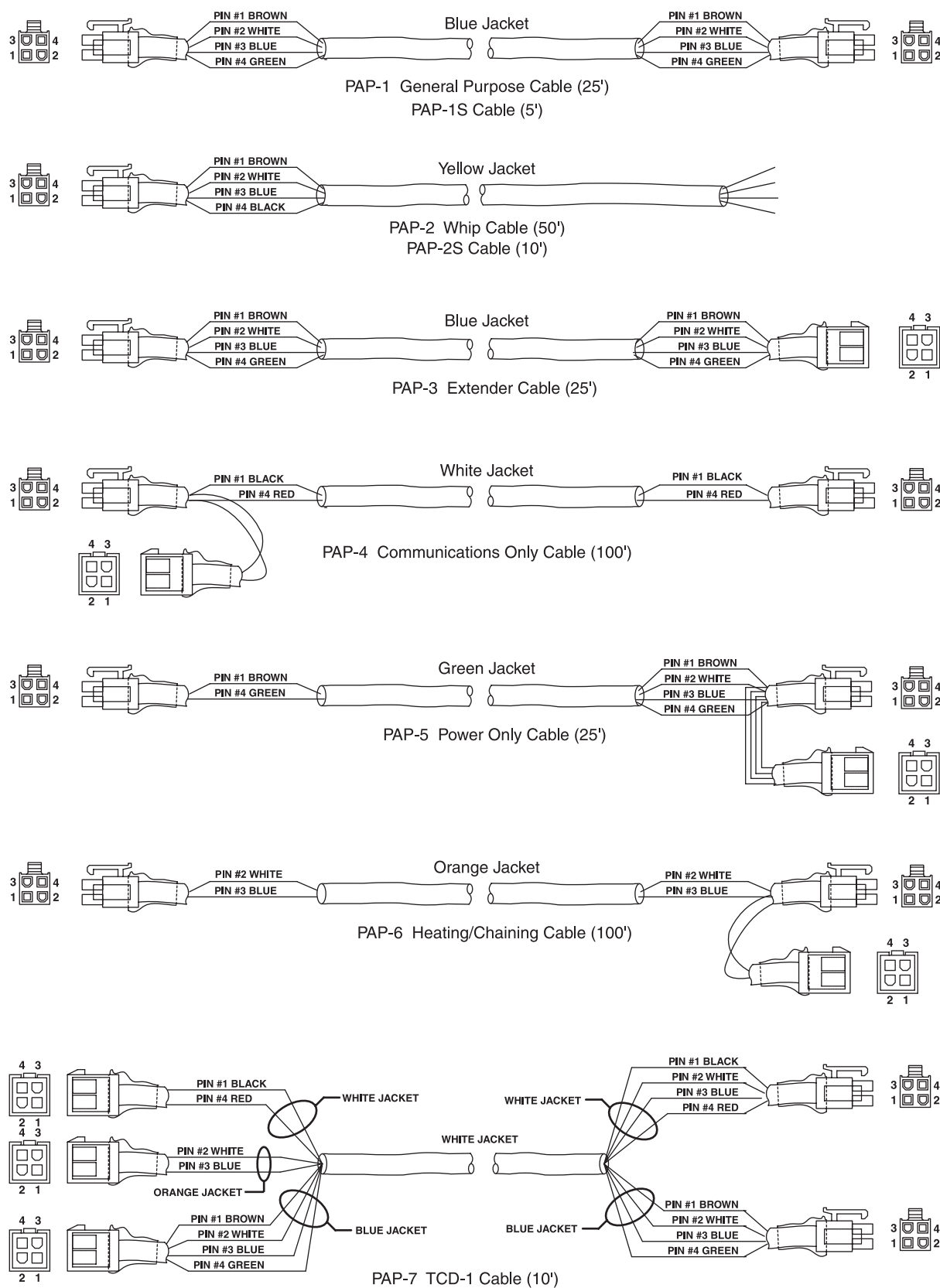


Fig. 14. PAP-Cables

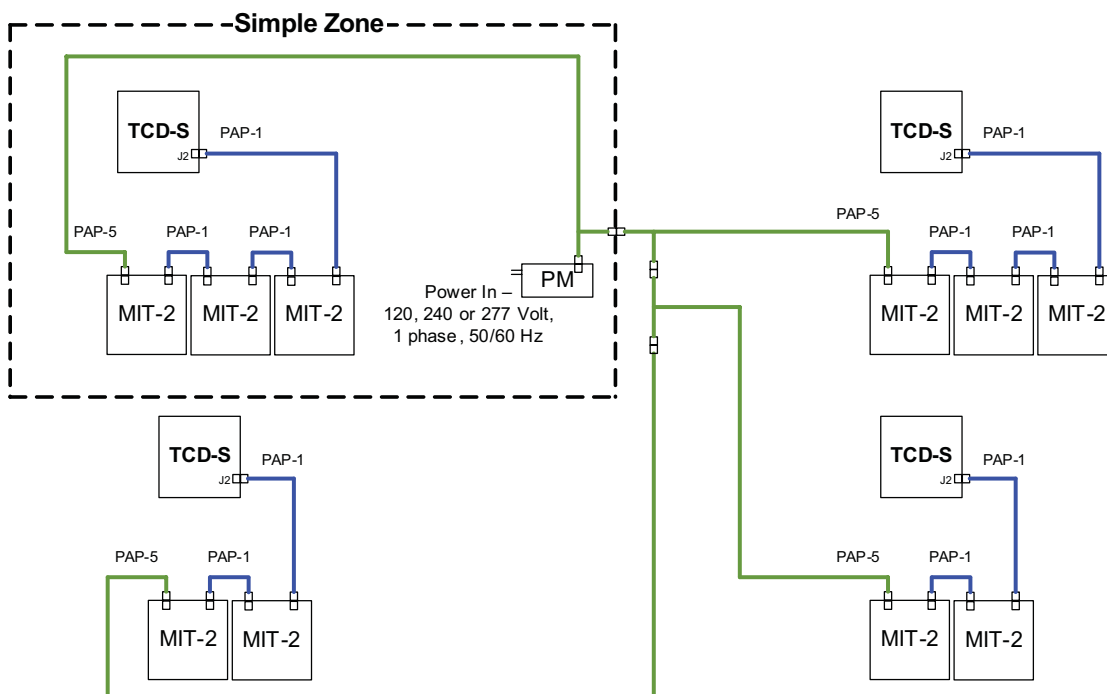


Fig. 15. Small Cooling Only Zone

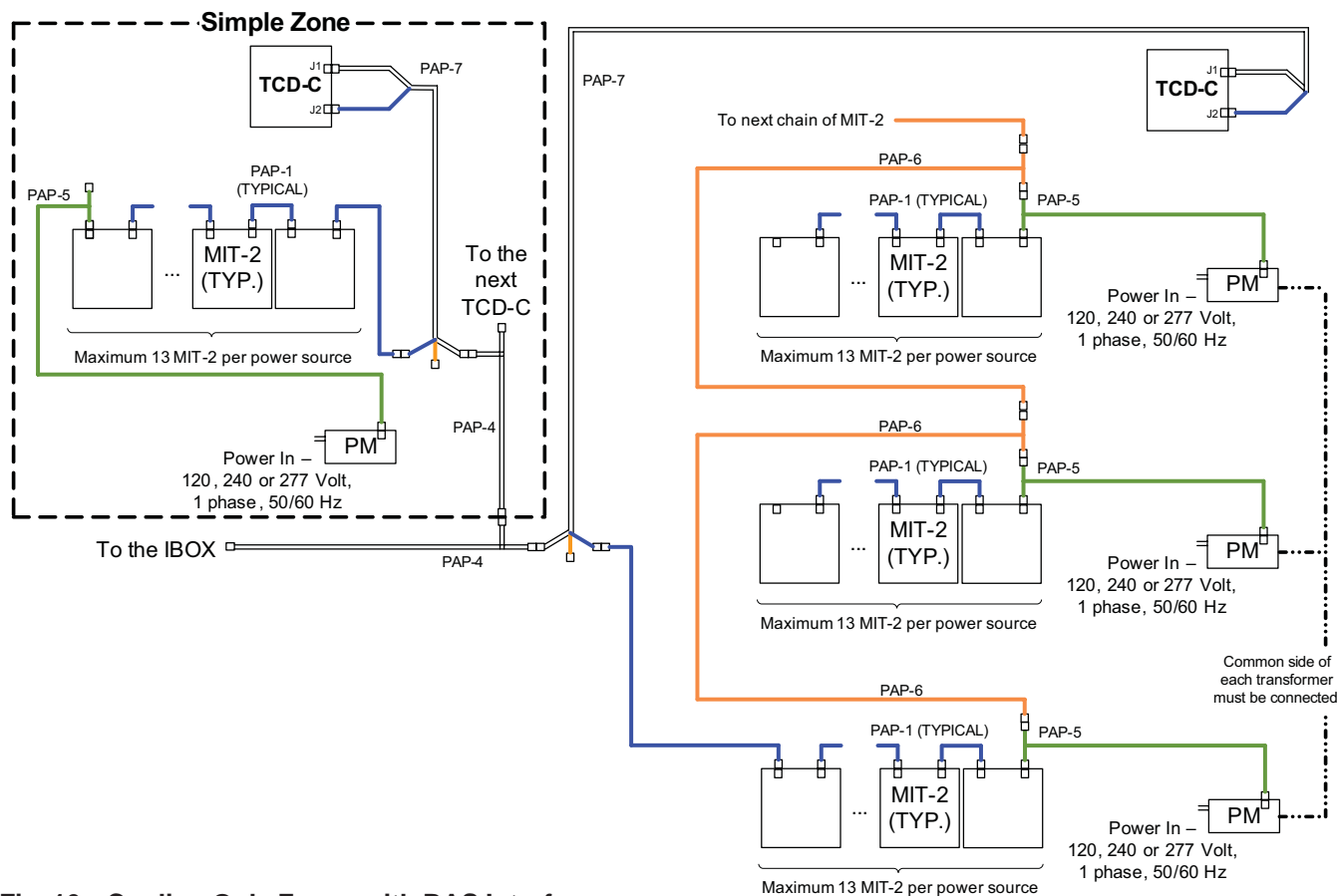


Fig. 16. Cooling Only Zones with BAS Interface

Airway Components *(continued)*

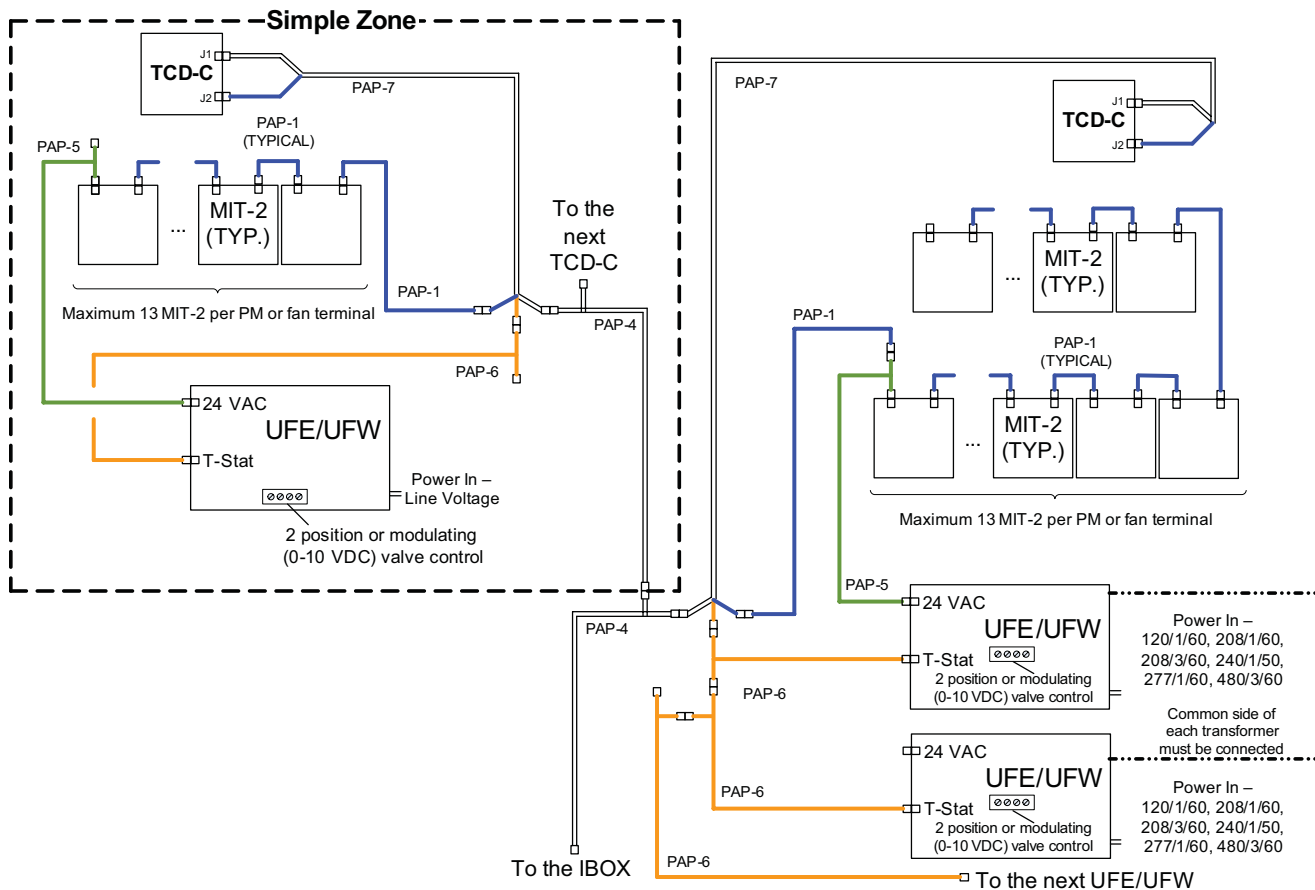


Fig. 17. UFE/UFW Zones with BAS Interface

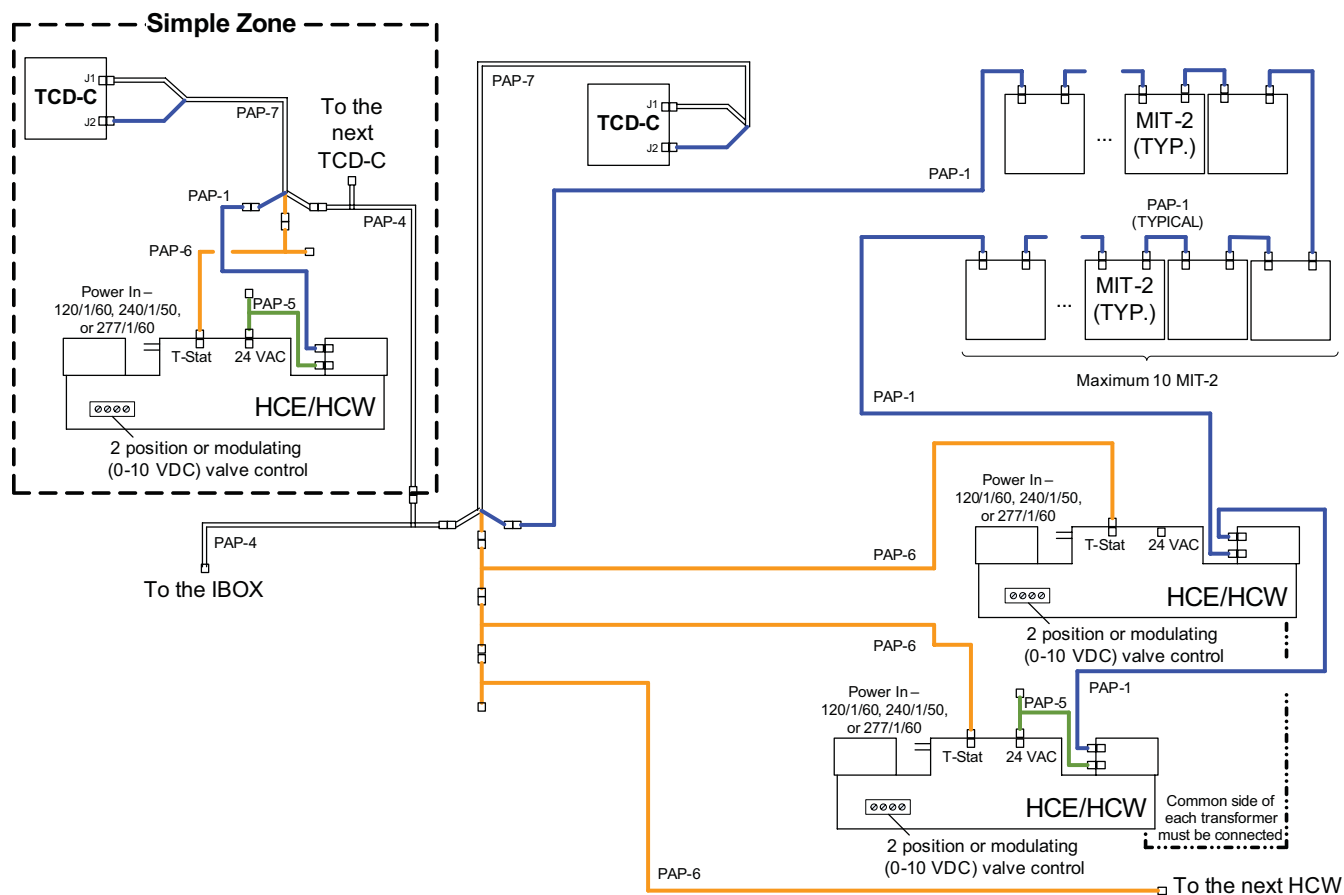


Fig. 18. HCE/HCW Zones with BAS Interface

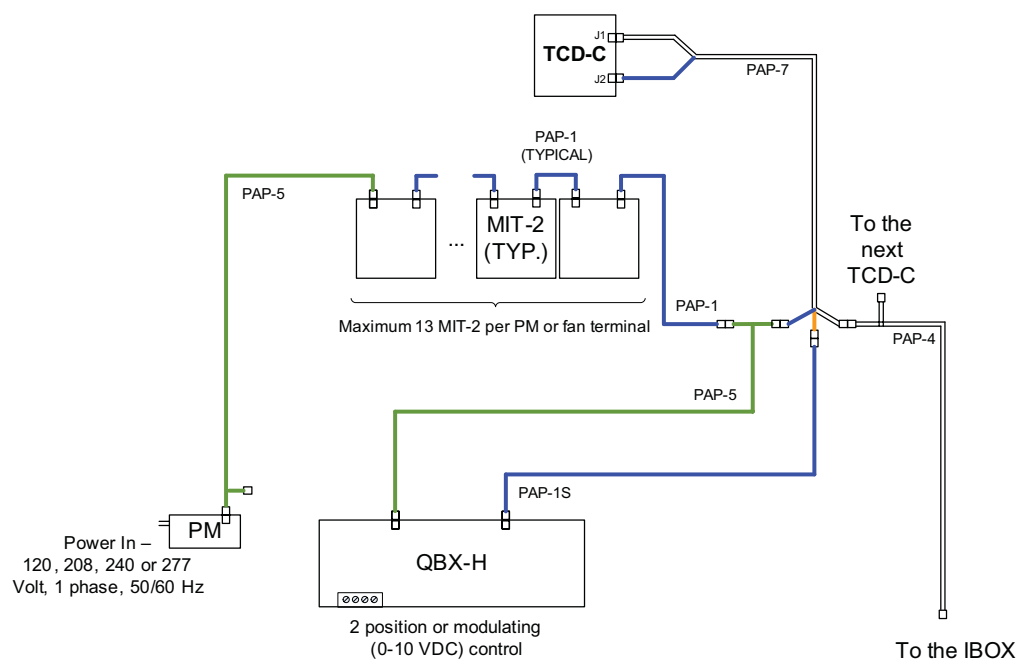


Fig. 19. QBX-H Zone with BAS Interface

Terminals

TERMINAL SIZING FUNDAMENTALS

The nature of FlexSys underfloor air distribution systems ideally suits them to using an array of relatively small supply air diffusers. In a large open area, traditional overhead systems may use a small number of relatively large diffusers in an effort to control ductwork costs. This provides a generalized level of comfort averaged over all occupants, which infers that there will be no individual comfort control. In contrast, underfloor systems seek to provide a greater degree of individual control, which then implies using more, smaller diffusers that function on a personalized level. Without ductwork, a FlexSys underfloor Airway system has almost no cost penalty for using an array of smaller diffusers as compared to one or more large overhead diffusers.

FlexSys supply diffuser sizes are standardized to simplify design and improve flexibility. The practical limit for low-pressure Airway technology in underfloor applications is about 150 cfm (71 L/sec) per diffuser. If more than 150 cfm (71 L/sec) is necessary, use several terminals arranged in an array to distribute air uniformly. In the end, this is much simpler than selecting a different size diffuser or register for each zone, and the flexibility of the systems means that building owners aren't locked into a specific configuration by the high cost of a change, as would be the case in traditional overhead VAV systems.

VAV Systems

In traditional overhead air distribution systems, designers must be cautious to avoid selecting oversized terminals. When airflow is less than design conditions, the exit velocity and throw characteristics of conventional diffusers decrease. At low loads, cool supply air leaving the diffuser at a slow velocity will not induce enough room air to create adequate mixing. The supply air may "dump" into the space, causing perceptions of cold drafts among the occupants. Likewise, oversized and undersized VAV boxes are a problem. If undersized, a VAV box will be short of airflow capacity at peak load conditions and may induce higher noise levels. An oversized VAV box has poor modulation and control characteristics, and may have a "whistling" damper at low volumes. With Airway systems and pulse-modulated, variable-air-volume controls, the problems of traditional VAV systems disappear.

Traditional VAV devices *throttle* a control damper to adjust the airflow rate. Conversely, pulse-modulated

air valves have only two positions: fully open and fully closed. When the air valve is open, the diffuser exit velocity and throw characteristics are at the diffuser's rated conditions; when the air valve is closed, the supply is effectively stopped. Airflow is adjusted by changing the timing and ratio of open pulses to closed pulses. For instance, consider a room with a peak airflow requirement of 100 cfm (47 L/sec) that is served by a 150 cfm (71 L/sec) diffuser. At peak load, the room thermostat will adjust the pulse rate of the diffuser's air valve so that the summation of the open time is approximately equal to twice the summation of the closed time (e.g., open 12 seconds, closed 6 seconds, open 12 seconds, closed 6 seconds, etc.). Over a period of time, the net effect is that the diffuser is open two-thirds the time and closed one-third the time producing a net airflow of 100 cfm (47 L/sec). An oversized terminal with pulse-modulated, VAV control will provide good mixing, maintain its throw characteristics and not dump at part-load conditions.

To ensure quiet operation, air valves do not seal when in the OFF position. If it had seals, an air valve would make a mechanical contact noise every time the device cycled. Instead, there is a narrow clearance between the cycling damper and the stationary air valve body. The clearance gap allows a small amount of air to leak through when in the OFF position. For instance, a 150-cfm (71-L/sec) MIT²-C diffuser will provide 15 cfm (7 L/sec) when the air valve is closed and the pressure difference between the underfloor Airway space and the room is 0.05 inches w.g. (12.4 Pa).

CV Systems

In constant-volume systems, the supply terminals should not have a combined capacity greater than the supply fan capacity. For instance, if the supply fan provides 4,000 cfm (1,888 L/sec), the summation of the rated capacity of all supply terminals should not total more than 4,000 cfm (1,888 L/sec). Installing too many supply terminals prevents the underfloor Airway supply space from becoming properly pressurized.

Small, isolated areas with airflow requirements under 150 cfm (71 L/sec) may be served by PCD terminals. They have lower standard airflow ratings than MIT² style diffusers, and are individually adjustable by the room occupant. In a VAV system, a 150-cfm (71-L/sec) rated diffuser may be used because the problem of oversized diffusers (dumping) does not appear in systems using pulse-modulated controls.

SUPPLY DIFFUSERS FOR HEATING SERVICE

The nominal airflow ratings of all MIT² supply diffusers are for cooling service. Depending upon the application, YORK recommends reducing the actual airflow for heating service from 150 cfm (71 L/sec) to about 100 to 120 cfm (47 to 57 L/sec) because warm air rises. For instance, a UFE-3 or UFW-3 fan-powered terminal unit, rated at 600 cfm (283 L/sec) may supply five or six MIT²-G terminals rather than four. With five, the MIT²-G supply rate will be 120 cfm (57 L/sec) and with six the MIT²-G supply rate will be 100 cfm (47 L/sec). See Figure 2 on page 7.

DIFFUSERS USED FOR RETURN SERVICE IN HEATING SYSTEMS

When MIT²-G supply diffusers are combined with a fan-powered terminal unit in a heating system, the diffusers upstream of the fan-powered terminal unit will operate as supply diffusers while the system is in the cooling mode, and as a return diffusers when the system is in the heating mode. As a return terminal, the MIT²-G airflow rate may be increased up to 200 cfm without adverse effect. For instance, a UFE-3 or UFW-3 fan-powered terminal unit, rated at 600 cfm (283 L/sec) may draw return air through three MIT²-G terminals. See Figures 7 and 9 on page 9.

LOCATING SUPPLY DIFFUSERS

It is not necessary to specify the exact location of all MIT² diffusers on the plan drawings when using an underfloor Airway system for air distribution. Location selection for many diffusers can actually wait until partitioning is complete and tenants have arranged their furniture.

Selecting locations for perimeter heating units is a compromise between the arrangement of interior partitions and furniture, and the coverage effectiveness of diffusers. Perimeter units should be positioned with their airflow patterns uniformly directed horizontally away from or parallel to the wall and window surfaces. Although counter-intuitive, experience has shown that cold convection currents flowing down the wall (or window) will be intercepted and mixed with the warm diffuser discharge before they can become uncomfortable drafts. This also permits warm convection currents that form during the cooling season to flow upward without mixing and exit through the

TABLE D - MAXIMUM RECOMMENDED DISTANCE BETWEEN PERIMETER MIT²-G TERMINALS IN HEATING SUPPLY SERVICE

Heating Load, Btu/hr/ft (W/m)	Maximum Spacing, Feet (Meters)
<250 (240)	No Limit (Low concern for down drafts)
250 to 400 (240 to 384)	8 to 10 (2.4 to 3.0)
>400 (384)	4 to 8 (1.2 to 2.4)

return. Table D lists the maximum recommended distance between MIT²-G units.

MIT² units have removable grilles that can be turned to blow in any of 16 patterns, from straight up to a full 360-degree flare. They can be safely located almost anywhere. However, they should not be installed directly under an occupant or where there will be high pedestrian traffic. YORK also offers a tamper-resistant option for MIT² grilles.

Since MIT² terminals can be relocated in minutes, it is possible to use a trial-and-error method of finding the best locations and grille orientations for optimum comfort.

LOCATING RETURN AIR INLETS

Return air grilles should be located above occupant head level so that they do not interfere with convection air patterns. For normal ceiling heights up to 10 feet (3 meters), the returns should be mounted in the aesthetic ceiling and the space above the ceiling used for a return Airway space. In areas with higher ceilings, the return location can be in the wall as long as the bottom edge of the opening is at least 6 feet (1.8 meters) above the floor.

Return air locations in perimeter spaces should be continuous or evenly spaced in the wall above the window. Upward convection currents forming on the wall or window surface transfer a portion of the room solar and transmission load directly to the return air. This reduces the required supply air quantity and improves system efficiency.

Perimeter Heating Systems

MIT² diffusers used in FlexSys underfloor Airway systems are ideal for heating because they supply air from floor level. In the heating mode, MIT² diffusers remain consistent with the convection enhanced ventilation scheme by inducing cold air near the floor and mixing it with warm supply air. This offsets cold down drafts that may occur when the building envelope heat loss (including transmission and infiltration) exceeds 250 Btu/hr per lineal foot (240 w/m) of perimeter wall.

FlexSys underfloor air distribution systems may also be combined with traditional baseboard radiation or radiant ceiling panels. The best choice must be evaluated by considering specific project requirements and conditions. Significant decision criteria include: the source of heat, the building layout, anticipated heating loads, and budgets (e.g., electric heat offers low first cost whereas hot water heating may provide lower operating cost at somewhat higher first cost).

RECOMMENDED PERIMETER HEATING SYSTEM

YORK recommends that perimeter heating systems use model UFE/UFW fan-powered terminal units, installed under the raised access floor and combined with MIT²-G heating and cooling diffusers. This is the most efficient heating approach when using underfloor air distribution.

MIT²-G diffusers can operate in any of three modes: 1) VAV cooling, 2) CV heating, and 3) return air inlet. This multifunction capability allows system configurations similar to that shown in Figures 20 and 21.

When the system operates in the cooling mode the fan-powered terminal unit is idle. The MIT²-G diffusers operate as VAV cooling diffusers taking air from the underfloor air distribution space and responding to local thermostats. In the heating mode, the pulse-modulated air valves in the upstream and downstream MIT²-G diffusers close to the underfloor airway, and the UFE (or UFW) fan and heating coil are energized. The upstream MIT²-G (connected to the inlet side of the fan-powered terminal unit) acts as a return grille from the conditioned space. The downstream MIT²-G (connected to the fan-powered terminal outlet) operates as a constant-volume warm air supply diffuser.

The UFE, UFW, HCE and HCW fan-powered terminal units operate independently of the central cooling system. This permits perimeter heating to function while maintaining the central system for cooling interior zones, or permits heating capabilities to operate when the main supply fan is shut down (e.g., nights, weekends and holidays). Since fan-powered terminals operate only in the heating mode, ECM motors for variable-speed fan operation would not offer an advantage.

LOCATING FAN-POWERED TERMINAL UNITS IN PERIMETER HEATING APPLICATIONS

Fan-powered terminals units used for perimeter heating systems in combination with MIT²-G diffusers should be located conveniently adjacent to the diffusers. Figure 20 shows a simple arrangement of a single, 150-cfm (71 L/sec) UFW-1 fan-powered terminal unit operating with a pair of MIT²-G diffusers. During the cooling season, both diffusers operate as supply diffusers and the fan-powered terminal unit is idle. When the system enters the heating mode, the diffuser air valves close. The fan-powered terminal unit operates, drawing return air through the interior diffuser and supplying warm air to the diffuser near the building's exterior wall.

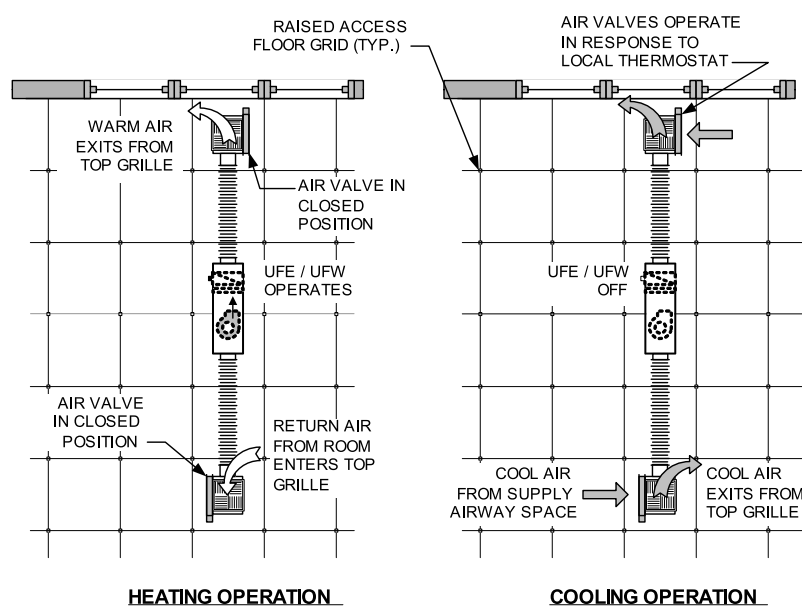


Fig. 20. Plan view of a system using MIT²-G diffusers and fan-powered terminal units (shown with a model UFW). Both heating and cooling modes of operation are shown to compare the different equipment functions in each mode.

Figure 21 shows a perimeter heating zone similar in concept to the example in Figure 20; however, this example uses a 600-cfm

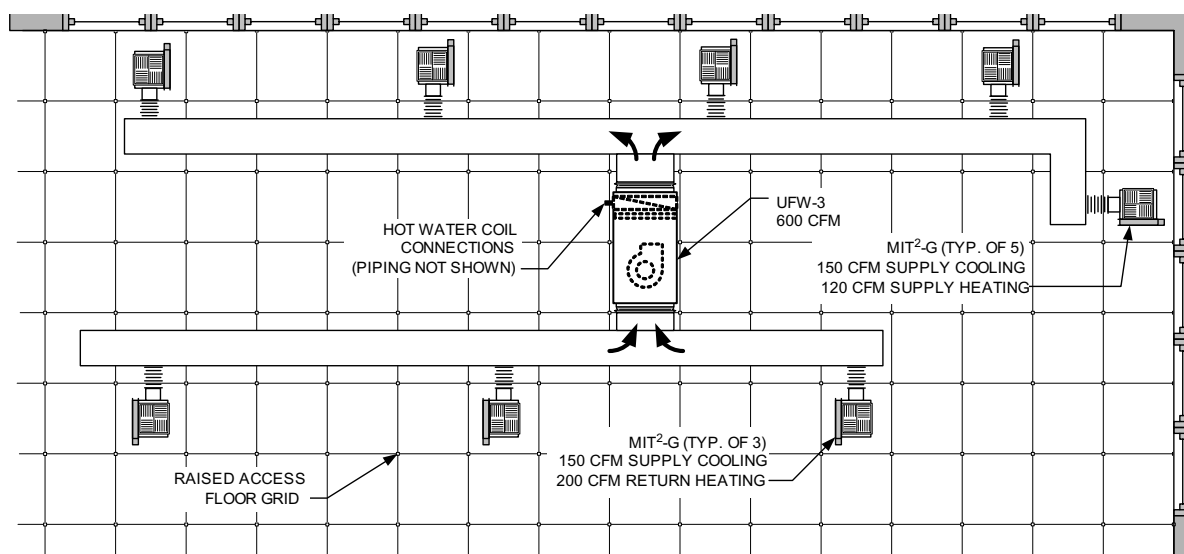


Fig. 21. Plan view of a perimeter system using a single, 600 cfm (283 L/sec) UFW-3 fan-powered terminal unit for heating service. MIT²-G diffusers along the exterior wall supply air for both heating and cooling. Interior MIT²-G diffusers supply cool air during the cooling mode and serve as return inlets while heating with the fan-powered terminal unit.

(283 L/sec) UFW-3 fan-powered terminal unit supplying air through five MIT²-G diffusers located near the building's exterior wall. Interior MIT²-G diffusers automatically convert to return service when operating in the heating mode. Short sections of ductwork connect the fan-powered terminal unit with the supply and return diffusers. If possible, fan-powered terminal units serving multiple diffusers should be positioned centrally to intrinsically balance airflow to and from the diffusers.

UFE, UFW, HCE AND HCW HEATING PERFORMANCE

Electric heating coils for UFE fan-powered terminals are available for service in several electrical voltages and capacities. Models are available for power supply from 120 volt, single-phase to 480 volt three-phase. Heating elements are finned, stainless steel sheathed.

The range of available heating elements for the UFE are shown in Table E. The HCE is available with 120/1/60, 208/1/60, 240/1/50 or 277/1/60, incoming power with one stage of heat—1.5kW (1.1kW for 240 volt). The notes in Table E apply to the HCE, as well.

Hot water heating coils for UFW fan-powered terminals are available in two physical sizes, with one or two

TABLE E - UFE HEATING OPTION

Volts / Ph / Hz	Unit Size (Airflow)	One Stage kW	Two Stage kW
120/1/60	1 (150 cfm)	1.5	N/A
	2 (300 cfm)	1.5	3.0
	3 (600 cfm)	N/A	N/A
208/1/60	1 (150 cfm)	1.5	N/A
	2 (300 cfm)	1.5	3.0 or 4.5
	3 (600 cfm)	N/A	4.5
277/1/60	1 (150 cfm)	1.5	N/A
	2 (300 cfm)	1.5	3.0 or 4.5
	3 (600 cfm)	N/A	4.5, 6.0 or 9.0
208/3/60	1 (150 cfm)	N/A	N/A
	2 (300 cfm)	N/A	4.5
	3 (600 cfm)	N/A	4.5 or 9.0
480/3/60	1 (150 cfm)	N/A	N/A
	2 (300 cfm)	N/A	4.5
	3 (600 cfm)	N/A	4.5 or 9.0
240/1/50	1 (150 cfm)	1.1	N/A
	2 (300 cfm)	1.1	3.1 or 4.5
	3 (600 cfm)	N/A	4.5, 6.0 or 8.5

Notes:

1. All electric heating coils are finned tubular design (black heat).
2. A thermal cutout is furnished standard on all fan terminals with electric heating coils.
3. An electrical disconnect is standard with all fan terminals.
4. All fan terminals are factory-wired for single-point electrical connection in the field.

Perimeter Heating Systems *(continued)*

rows, and with one or two circuits. Hot water coils for UFW Size 1 or HCW terminals are made with 3/8-inch OD seamless copper tube and have 6 aluminum fins per inch. Hot water coils for Size 2 and Size 3 terminals are made with 1/2-inch OD seamless copper tube; have 10 aluminum fins per inch and are meant for 5/8" sweat

connections in the field. Hot water heating coil capacities and performance characteristics are shown in Table F.

TABLE F - UFW/HCW HEATING OPTIONS

UFW or HCW Size 1	Description	Airflow (cfm)	Air Pressure Drop, (in. w.g.)	Coil Water Flow (gpm)				
				0.50	0.75	1.00	1.25	1.50
4" x 8" 2 Rows 1 Circuit	150	0.29		Water Pressure Drop (feet)				
				0.6	1.3	2.3	3.5	5.0
				Heating Capacity (MBH)				
				5.6	6.1	6.4	6.6	6.7
UFW Size 2	Description	Airflow (cfm)	Air Pressure Drop, (in. w.g.)	Coil Water Flow (gpm)				
				0.50	0.75	1.00	1.25	1.50
10" x 22" 1 Row 1 Circuit	300	0.02		Water Pressure Drop (feet)				
				0.04	0.08	0.14	0.21	0.29
				Heating Capacity (MBH)				
				8.5	10.6	11.4	11.9	12.2
UFW Size 2	Description	Airflow (cfm)	Air Pressure Drop, (in. w.g.)	Coil Water Flow (gpm)				
				0.50	0.75	1.00	1.25	1.50
10" x 22" 2 Rows 2 Circuits	300	0.03		Water Pressure Drop (feet)				
				0.02	0.04	0.07	0.10	0.14
				Heating Capacity (MBH)				
				12.2	13.4	15.1	16.9	17.7
UFW Size 3	Description	Airflow (cfm)	Air Pressure Drop, (in. w.g.)	Coil Water Flow (gpm)				
				0.50	0.75	1.00	1.25	1.50
10" x 22" 1 Row 1 Circuit	600	0.05		Water Pressure Drop (feet)				
				0.22	0.45	0.76	1.14	1.59
				Heating Capacity (MBH)				
				13.4	15.6	16.9	17.8	18.5
UFW Size 3	Description	Airflow (cfm)	Air Pressure Drop, (in. w.g.)	Coil Water Flow (gpm)				
				0.50	0.75	1.00	1.25	1.50
10" x 22" 2 Rows 2 Circuits	600	0.09		Water Pressure Drop (feet)				
				0.09	0.16	0.22	0.31	0.43
				Heating Capacity (MBH)				
				17.6	22.6	25.9	28.0	29.6

Notes:

1. All UFW-1 coils are constructed of 3/8" OD copper tubes with 6 aluminum fins per inch.
2. All UFW-2 and -3 coils are constructed of 1/2" OD copper tubes with 10 aluminum fins per inch.
3. Performance data based on 180 F entering water temperature (EWT), and 70 F entering air temperature (EAT).
4. For heating performance based on different EWT and EAT, use the following equation:

$$\text{Performance Correction Factor} = (\text{EWT} - \text{EAT}) / 110$$

Guide Specifications

INTRODUCTION

These guide specifications are provided for reference purposes. They are annotated to assist in editing the specifications for a particular project. They are in the standard CSI three-part format. Section and paragraph numbering may change as necessary to address

coordination with other sections of the project specifications. **Annotations** [*are shown in italics and enclosed in brackets.*] **Design options** [that must be edited by the specification writer are shown in standard font and brackets.]

SECTION 23 30 00 – UNDERFLOOR AIRWAY DISTRIBUTION SYSTEM

[The section number shown is based on CSI MasterFormat 2004. Adjust section numbers as necessary to fit in numbering system used.]

PART 1 – GENERAL

1.01 WORK INCLUDED

- A. The Contractor shall furnish and install a complete access floor air distribution system as shown on the drawings, including all wiring, controls and other accessories required for a complete system. Contractor shall provide submittals, samples, and operation and maintenance documentation. Specific equipment includes: *[List each type of terminal required on the project.]*

CX-FlexFloor, underfloor monitoring device

HCE-1, underfloor heating/cooling terminal unit with electric heat

HCW-1, underfloor heating/cooling terminal unit with hydronic heat

IBOX, communication interface (between TCD-C and building automation system)

MIT²-A, constant volume unit

MIT²-C, variable-air-volume unit, cooling only

MIT²-G, variable-air-volume cooling, constant-volume heating unit

MIT²-H, constant volume, manually adjustable unit

PAP-1, -2, -3, -4, -5, -6, and -7 modular control wiring

PCD-08R and -10R, constant-volume, manually adjustable diffuser, for round panel cutout

PM, power module

QBX-C, signal conversion device (between MIT and MIT² units)

QBX-H, signal conversion device (between TCD and heating devices)

TCD-C, DDC space thermostat for pulse-modulation control with communications and temperature display

TCD-S, DDC space thermostat for pulse-modulation control

UFE-1, 2, or 3, underfloor fan-powered electric heating units

UFW-1, 2, or 3, underfloor fan-powered hydronic heating units

1.02 RELATED WORK NOT INCLUDED

- A. The Access Floor Contractor shall furnish and install all floor panels, structural supports, underfloor Airway barriers, carpet cutouts and any other floor-related components and accessories necessary for a complete raised access floor system.
- B. The General Contractor shall be responsible for sealing the access floor system and all penetrations through the building wall and floors that occur below the raised floor elevation.
- C. All openings in access floor panels required for installation of diffusers and terminals shall be coordinated with the Access Floor Contractor who shall also be responsible for cutting the panel openings and installing panels as indicated on the drawings.
- D. The Electrical Contractor shall furnish and install all electric power-related materials and components necessary for system operation.
- E. The Controls Contractor shall furnish and install all control system interfaces, Building Automation

Guide Specifications *(continued)*

System (BAS) integration, and other control system-related materials and accessories.

- F. The Mechanical Contractor shall be responsible for sealing and repairing any holes, penetration, or openings made in the underfloor airway for items installed by the Mechanical Contractor.
- G. The Mechanical Contractor is responsible for testing described in part 3—execution.

1.03 QUALITY ASSURANCE

- A. All equipment and components shall be suitable for use in an environmental Airway space.
- B. All components within the air stream including underfloor terminals shall conform to the NFPA 90A Standard for Flame/Smoke/Fire contribution of 25/50/0.
- C. All units shall be the product of a single manufacturer who is regularly engaged in the production of underfloor air distribution system.
- D. Units shall be specifically designed for installation in an underfloor air distribution system and shall be furnished complete with all necessary controls and wiring to provide operation according to manufacturer's recommendations.
- E. Terminal operation shall be coordinated with the air-handling system and control system to assure complete compatibility.
- F. Equipment shall be listed under and conform to appropriate sections of U.L., CSA, E.T.L. and other testing laboratory requirements.

1.04 SUBMITTALS

- A. Submit dimensioned drawings, performance and product data for approval. Include listing of discharge and radiated sound power level for the second, third, fourth, fifth and sixth octave bands for fan-powered terminal units. Data shall include all wiring diagrams, control sequences and power requirements as applicable to the product and coordination with other systems.

1.05 OPERATION AND MAINTENANCE DATA

- A. Quantity: [6]
- B. Content:

- 1. Maintenance and Service Contracts: Provide a list for each product and include the name, address and telephone number of:
 - a. Subcontractor or installer.
 - b. Maintenance Contractors, as appropriate. Identify area of responsibility of each.
 - c. Local source of supply for parts and replacement.
- 2. Table of Contents: List all products in the order in which they appear in the specifications and label accordingly.
- 3. Sections: All sections shall be separated with an appropriate tabbed section divider with the appropriate specification section number. Provide the manufacturer's written installation and maintenance instructions for all items supplied.
- 4. Routine Maintenance: Provide a list indicating all routine maintenance procedures and recommended intervals.
- 5. Contents: Include copies of approved submittal data, installation instructions, operation and maintenance instructions and parts lists.

1.06 WARRANTY

- A. The underfloor Airway distribution system components, materials and workmanship shall be guaranteed to be free from defects for a period of one year after start-up or 18 months from date of shipment from the factory, whichever occurs first.
- B. Contractor and/or vendor shall maintain availability of replacement parts compatible with the terminals for no less than ten years after acceptance.

PART 2 – PRODUCTS

2.01 GENERAL DESCRIPTION

- A. The Contractor shall furnish a pre-engineered, prefabricated, access floor air terminal system that includes all necessary components from a single manufacturer. All components, including controls and wiring, shall be furnished as a "plug-and-play" system of modular and interchangeable components that are factory prepared to operate as a complete system.

2.02 SUPPLY TERMINALS

A. General Requirements: All supply air terminals shall have the following basic construction features.

1. Construction of unit shall permit easy cleaning and prevent dirt and debris from entering system; and no plastic dampers, grilles or other parts shall be exposed to the Airway space or air stream in accordance with NFPA 90A.
2. Unit chassis shall be minimum 20-gauge galvanized steel and shall enclose and support all components. Chassis construction shall admit underfloor air from only one direction to permit adjusting delivery volume independent of underfloor air velocity pressure.
3. Supply air terminals shall have grilles made of die cast aluminum material that matches the trim ring in color. Grilles shall include a means for adjusting air throw and pattern, and shall fit securely within the trim ring and chassis without mechanical fasteners. Grilles shall be capable of supporting a load of 1,250 pounds (567 kg) without permanent damage. No grille openings shall be larger than 0.30 inches (7.6 mm) for shoe heel penetration protection.
4. Grille trim rings shall be die-cast aluminum designed to engage the chassis and floor to provide complete support for the air grilles. Trim ring color shall match the grille color.
5. Panel Size: Unless noted otherwise, the nominal dimensions of all floor-mounted system components shall be suitable for installation in a standard 24-inch by 24-inch (610-mm by 610-mm) raised access floor suspension grid.
6. Airflow Performance: The manufacturer shall provide published airflow data for the all supply and return terminals in accordance with ANSI/ASHRAE Standard 70-1991.
7. Variable-Air-Volume Controls: Terminals specified for variable-air-volume service shall incorporate the following requirements:
 - a. Terminal construction shall include an integral pulse-modulation damper and motor (air valve) that is specifically designed for low static pressure air distribution. The damper motor shall be a 90-degree stepper type motor having no stops, springs, gears, belts or linkages. The motor shall directly

drive the damper blade. Modulation shall involve the timed duty cycle of fully open and closed periods to produce an average open time corresponding to the average terminal air volume required.

- b. Terminal shall include a microprocessor control that controls the damper movement in response to a remote open/close signal. The open/close signals and power shall be delivered to the device through a 4-conductor, plenum-rated modular cable. A "daisy-chain" output port shall be furnished that repeats the open/close signals with a nominal 6 second delay, and provides parallel connection of the 24 volts ac control power supply to other connected terminals. The modular cable input and output ports shall be interchangeable with no difference in operation occurring regardless of which port is used for input or output in a chain.
- c. The damper and motor shall be designed for continuous use with a nominal design life of 100,000,000 cycles. The installed damper and motor operation shall be inaudible with a background sound level of 30 dbA. The unit shall feature all solid-state electronics, self-contained within the housing using printed circuit board mounted components with no relays, mechanical switches, or other mechanical devices required for operation of the device.
- d. The terminal shall not require periodic lubrication or other maintenance. The device shall be delivered to the job site fully assembled and operational, needing no programming, setup or adjustment.

B. MIT²-A, CV Terminal Units

[These are constant-volume air supply terminals with no dampers or controls.]

1. MIT²-AS Grille: nominal 10.5 inch by 10.5 inch (267 mm by 267 mm).
2. MIT²-AR Grille: nominal 10.56 inch round (268 mm).
3. MIT²-AN Grille: nominal 5.5 inch by 10.5 inch (140 mm by 267 mm).
4. MIT²-A Supply Rating: constant-volume, 150 cfm (71 L/sec) at 0.05 inches w.g. (12.4 Pa) static pressure.

Guide Specifications *(continued)*

5. MIT²-AR Supply Rating: constant volume, 150 cfm (71 L/sec) at 0.05 inches w.g. (12.4 Pa) static pressure.
 6. MIT²-AN Supply Rating: constant-volume, 100 cfm (47 L/sec) at 0.05 inches w.g. (12.4 Pa) static pressure.
 7. Color: as shown on the finish schedule. [or manufacturer's standard color to be selected from submittal data].
[Special colors are available at additional cost.]
- C. **MIT²-C; VAV Terminal Units**
[These units provide automatic, variable-air-volume control.]
1. MIT²-CS Grille: nominal 10.5 inch by 10.5 inch (267 mm by 267 mm).
 2. MIT²-CR Grille: nominal 10.56 inch round (268 mm).
 3. MIT²-CN Grille: nominal 5.5 inch by 10.5 inch (140 mm by 267 mm).
 4. MIT²-CS Supply Rating: variable-air-volume, 150 cfm (71 L/sec) at 0.05 inches w.g. (12.4 Pa) static pressure.
 5. MIT²-CR Supply Rating: variable-air-volume, 150 cfm (71 L/sec) at 0.05 inches w.g. (12.4 Pa) static pressure.
 6. MIT²-CN Supply Rating: variable-air-volume, 100 cfm (47 L/sec) at 0.05 inches w.g. (12.4 Pa) static pressure.
 7. Color: as shown on the finish schedule; [or manufacturer's standard color to be selected from submittal data].
[Special colors are available at additional cost.]
- D. **MIT²-G; VAV Terminal Units for Heating and Cooling Service**
[These units provide control of the airflow from the Airway space for cooling and from an attached duct for heating.]
1. The unit chassis shall include a 5-inch (127 mm) diameter duct connection set in the end panel for heating air. The duct position shall be arranged to admit heating airflow into the unit chassis perpendicular to the airflow direction through the cooling air valve (damper).
 2. MIT²-GS Grille: nominal 10.5 inch by 10.5 inch (267 mm by 267 mm).
 3. MIT²-GR Grille: nominal 10.8 inch round (268 mm)
 4. MIT²-GN Grille: nominal 5.5 inch by 10.5 inch (140 mm by 267 mm).
 5. MIT²-GS Supply Rating:
 - a. Cooling: variable-air-volume, 150 cfm (71 L/sec) at 0.05 inches w.g. (12.4 Pa) static pressure.
 - b. Heating: constant-volume, 150 cfm (71 L/sec).
 6. MIT²-GR Supply Rating:
 - a. Cooling: variable-air-volume, 150 cfm (71 L/sec) at 0.05 inches w.g. (12.4 Pa) static pressure.
 - b. Heating: constant-volume, 150 cfm (71 L/sec).
 7. MIT²-GN Supply Rating:
 - a. Cooling: variable-air-volume, 100 cfm (47 L/sec) at 0.05 inches w.g. (12.4 Pa) static pressure.
 - b. Heating: constant-volume, 100 cfm (47 L/sec).
 8. Color: as shown on the finish schedule; [or manufacturer's standard color to be selected from submittal data].
[Special colors are available at additional cost.]
 9. The unit's cooling air valve (damper) shall be sequenced to remain in the closed position when operating in the heating mode. In the heating mode, the unit shall also be capable of acting as a return air grille that accepts airflow from the conditioned space and deliver it through the duct connection to a fan-powered terminal unit mounted under the raised access floor.
- E. **MIT²-H, CV, Manually Adjustable Terminal Units**
[These are constant-volume, air supply terminals with a manually adjustable damper.]
1. MIT²-HS Grille: nominal 10.5 inch by 10.5 inch (267 mm by 267 mm).
 2. MIT²-HR Grille: nominal 10.56 inch round (268 mm).
 3. MIT²-HN Grille: nominal 5.5 inch by 10.5 inch (140 mm by 267 mm).

4. MIT²-HS Supply Rating: constant-volume, 150 cfm (71 L/sec) at 0.05 inches w.g. (12.4 Pa) static pressure.
5. MIT²-HR Supply Rating: constant-volume, 150 cfm (71 L/sec) at 0.05 inches w.g. (12.4 Pa) static pressure.
6. MIT²-HN Supply Rating: constant-volume, 100 cfm (47 L/sec) at 0.05 w.g. (12.4 Pa) static pressure.
7. Color: as shown on the finish schedule; *[or manufacturer's standard color to be selected from submittal data]*.

[Special colors are available at an additional cost].

F. PCD, Manually Adjustable, Round, CV Terminals
[These are constant-volume, floor-mounted supply terminals with manually adjustable airflow and throw pattern.]

1. Grille: single round grille shall be removable from the top of the raised floor panel and made of die cast aluminum material that fits securely within the trim ring and chassis without mechanical fasteners.

[Edit as required for PCD-08R or PCD-10R]

2. PCD-08R Supply Rating: constant-volume, 60 cfm (24 L/sec) at 0.05 inches w.g. (12.4 Pa) static pressure (when adjustment is fully open).
3. PCD-10R Supply Rating: constant-volume, 90 cfm (47 L/sec) at 0.05 inches w.g. (12.4 Pa) static pressure (when adjustment is fully open).
4. Unit shall be suitable for installation in an [8-1/4 inch (210-mm)][10-9/16 inch (268-mm)] diameter round panel cutout. Unit shall install entirely from the upper side of the raised floor panel.
5. Color: as shown on the finish schedule; *[or manufacturer's standard color to be selected from submittal data]*.

[Special colors are available at an additional cost].

2.03 FAN-POWERED TERMINAL UNITS

A. General Requirements: All fan-power terminal units shall have the following construction features:

1. Unit casing: 20-gauge minimum galvanized steel lined with a removable side or top panel suitable for equipment service. Casing leakage shall not exceed 2% at 2.0 inches w.g. (498 Pa).
2. Casing Insulation: 1 inch (25 mm) thick, dual-density, thermal and acoustical fiberglass insulation meeting NFPA 90A requirements, and U.L. 181 erosion control requirements.
3. Fan assembly: Direct drive centrifugal with forward curved blades, internally suspended on rubber isolators. Motor shall be permanent split capacitor type with thermal overload protection.
4. Filter: 1 inch (25 mm) thick, throwaway type. Frame mounted on the casing interior with an easily reachable access cover.
5. *[The unit shall have an accessible, toggle-type disconnect mounted on the casing exterior.] Or as an option for single-phase units:* *[The unit shall be equipped with a modular power cable and connector.]*
6. Plug-and-play connectors shall be mounted on the casing exterior for attachment of: 24 VAC power and TCD-C (thermostat) input.
7. All factory wiring shall be internal to the unit. Internal wiring shall be rated for the application and ETL approved. Electrical components shall be UL listed.

B. UFE-1, 2, 3, Underfloor Fan-Powered Terminal Unit with Electric Resistance Heat

1. UFE-1 Power Supply: [120] [208] [240] or [277] volts, single-phase, 60 [50] Hertz; or [as indicated on the drawings].
2. UFE-2 and UFE-3 Power Supply: [120] [208][240][277] [480] volts, [single][three]-phase, 60 [50] Hertz; or [as indicated on the drawings].
3. UFE-1 Fan Capacity: 150 cfm (71 L/sec).
4. UFE-2 Fan Capacity: 300 cfm (142 L/sec).
5. UFE-3 Fan Capacity: 600 cfm (283 L/sec).
6. Electric Heating Coil:
[Edit coil requirements as necessary to distinguish between different capacity requirement for UFE-1, -2 and -3 units.]

Guide Specifications *(continued)*

- a. Heating Elements: finned, stainless steel sheathed. Coils shall be mounted on the casing interior.
 - b. Heating Capacity: [1.5 kW], [3.0 kW], [4.5 kW], [6.0 kW], [9.0 kW], [as indicated on the drawings].
 - c. Unit shall be equipped with automatic reset thermal cutouts for each element, magnetic contactor, line and control terminal blocks, interlocking disconnect, and main supply fuses.
7. Control Power Transformer: 100 volt-ampere capacity, output 24 volts ac, integral circuit breaker and thermal overload.
8. Unit shall be tested with the fan terminal in accordance with E.T.L. standards, meet all N.E.C. requirements, and shall be E.T.L. listed.
9. Electrical enclosure: NEMA 1 with single-point connection for heater and fan. Wiring diagram with specific wiring for each unit shall be included with unit.
- C. UFW-1, 2, 3, Underfloor Fan-Powered Terminal with Hot Water Heat**
- 1. Power Supply: [120][240][277] volts, single-phase, 60 [50] Hertz; or [as indicated on the drawings].
 - 2. UFW-1 Fan Capacity: 150 cfm (71 L/sec).
 - 3. UFW-2 Fan Capacity: 300 cfm (142 L/sec).
 - 4. UFW-3 Fan Capacity: 600 cfm (283 L/sec).
 - 5. Hot Water Heating Coil:
 - a. Heating coil shall be integral with the fan-powered terminal unit, with the piping connections extended beyond the unit casing on the supply and return connections on the same side of the casing.
 - b. UFW-1 Coils: constructed from seamless copper tube, 3/8-inch (10 mm) O.D., 0.020 inch (0.5 mm) wall thickness, with brazed return bends. Coils shall have [two rows].
 - c. UFW-2 and -3 Coils: constructed from seamless copper tube, 1/2-inch (12 mm) O.D., 0.020 inch (0.5 mm) wall thickness, with brazed return bends. Coil meant for 5/8-inch sweat connections. Coils shall have [one or two rows], [rows as indicated on the drawings].
- d. Fins: mechanically bonded to tubes, plate-type aluminum fins.
- e. Maximum working ratings shall be 225 psig at 325°F (1,551 kPa at 163°C).
- f. Casing: galvanized steel.
- g. Heating Capacity: as indicated on the drawings.
6. Control Power Transformer: 100 volt-ampere capacity, output 24 volts ac, integral circuit breaker and thermal overload.
7. Unit shall be tested with the fan terminal in accordance with E.T.L. standards, meet all N.E.C. requirements, and shall be E.T.L. listed.
8. Electrical enclosure: NEMA 1 with single-point connection. Wiring diagram with specific wiring for each unit shall be included with unit.
- D. HCE-1, Underfloor fan-powered heating terminal with electric resistance heat and air valve cooling.**
- 1. HCE-1 Power Supply: [120] [208] [240] or [277] volts, single-phase, 60 [50] Hertz; or [as indicated on the drawings].
 - 2. HCE-1 Fan Capacity: 150 cfm (71 L/sec).
 - 3. Electric Heat Coil:
 - a. Heating Elements: finned, stainless steel, sheathed. Coils shall be mounted on the casing interior.
 - b. Heating Capacity: 1.5 kW.
 - c. Unit shall be equipped with automatic reset thermal cutouts for each element, magnetic contactor, line and control terminal blocks, interlocking disconnect, and main supply fuses.
 - 4. Control Power Transformer; 100 volt-ampere capacity, output 24 volts ac, integral circuit breaker and thermal overload.
 - 5. Unit shall be tested with the fan terminal in accordance with E.T.L. standards, meet all N.E.C. requirements, and shall be E.T.L. listed.
 - 6. Electrical Enclosure: NEMA 1 with single-point connection for heater and fan. Wiring diagram

with specific wiring for unit shall be included with unit.

E. HCW-1, Underfloor fan-powered heating terminal with hydronic heat and air valve cooling.

1. HCW-1 Power Supply: [120] [240] or [277] volts, single-phase, 60 [50] Hertz; [or as indicated on the drawings].
2. HCW-1 Fan Capacity: 150 cfm (71 L/sec).
3. Hot-Water Heating Coil:
 - a. Heating Coil shall be integral with the fan-powered terminal unit, with piping connections extended beyond the unit casing on the supply and return connections on the same side of the casing.
 - b. HCW-1 coils: constructed from seamless copper tube, 3/8-inch (10 mm) O.D., 0.020 inch (0.5 mm) wall thickness with brazed return bands. Coils shall have 2 rows.
 - c. Fins: mechanically bonded to tubes, plate-type aluminum fins.
 - d. Maximum working ratings shall be 225 psig at 325°F (1,551 kPa at 163°C).
 - e. Casing: galvanized steel.
 - f. Heating Capacity: as indicated on drawings.
4. Control Power Transformer; 100 volt-ampere capacity, output 24 volts ac, integral circuit breaker and thermal overload.
5. Unit shall be tested with the fan terminal in accordance with E.T.L. standards, meet all N.E.C. requirements, and shall be E.T.L. listed.
6. Electrical Enclosure: NEMA1 with single-point connection. Wiring diagram with specific wiring for each unit shall be supplied with unit.

2.04 SYSTEM ACCESSORIES

A. CX-FLEXFLOOR, underfloor monitoring device. *[Required for coordinated control of the underfloor temperature and pressure conditions.]*

1. CX-FlexFloor shall manage the air pressure and temperature of the underfloor supply Airway space used in the FlexSys air distribution system. The unit shall be factory assembled in a galvanized steel housing, and shall be complete with prewired sensors and an controller.
2. The CX-FlexFloor shall be designed for recessed installation from the upper side of a raised access floor.
3. The unit shall be operable as a stand-alone device, as part of a small, local network, or as part of a Building Automation System using BACnet. Analog outputs shall be available for connection to a BAS or AHU.
4. Input sensors shall be furnished with the unit and shall include: underfloor air pressure, underfloor air temperature, slab temperature, and underfloor relative humidity. The slab temperature sensor is mounted remotely. Controller logic shall also incorporate time of day, occupied and unoccupied status, damper position, heat demand, and user set point.
5. CX-FlexFloor shall be factory pre-programmed with default set points. Set points shall be capable of being modified using a PDA, laptop computer, or *[an optional]* keypad and display module. *[Specify if the keypad and display module is to be furnished.]*
6. Access to the unit shall be through the floor grille. Operational status LED's, RS-232 and keyboard ports shall be accessible when the grille is raised.
7. Power Supply: 115/230 volts ac, single-phase.
8. Sensor Accuracy:
 - a. Airway space temperature: $\pm 0.36^{\circ}\text{F}$ ($\pm 0.20^{\circ}\text{C}$).
 - b. Airway space pressure: $\pm 1\%$ of full scale.
 - c. Airway space relative humidity: $\pm 3\%$
 - d. Slab temperature: $\pm 0.36^{\circ}\text{F}$ ($\pm 0.20^{\circ}\text{C}$).
9. Interface: local area network, BACnet MS/TP; RS-485.
10. Outputs: two, 0 to 10 volts dc analog signals.
 - a. Damper control
 - b. Variable speed drive control
11. BACnet BAS Outputs: five analog signals.
 - a. Underfloor temperature, 50°F to 100°F (10.0°C to 37.8°C).
 - b. Slab temperature, 40°F to 90°F (4.4°C to 32.2°C).

Guide Specifications *(continued)*

- c. Percent relative humidity, 0 to 100%.
- d. Differential dew point, 0°F to 20°F (0°C to -11.1°C).
- e. Supply Airway space pressure, 0 to 0.25 inches w.g. (0 to 62 Pa).

12. Sequence of Control

- a. Under-floor Pressure Monitoring and Control: The CX-FlexFloor shall measure the under-floor pressure relative to the space and provide a 0-10 VDC output signal to modulate the [supply fan VFD/under-floor supply air damper(s)]. The CX-FlexFloor shall modulate airflow into the plenum to maintain the under-floor pressure setpoint (nominal 0.05 in. w.g.). For under-floor plenums served by multiple air handling units or supply ducts, the CX-FlexFloor shall modulate all dampers in unison to maintain the under-floor pressure.
- b. Under-floor Temperature Monitoring and Control: The CX-FlexFloor shall monitor under-floor supply air temperature and provide a 0-10 VDC output to control the AHU bypass damper and bypass-heating coil in sequence to maintain under-floor supply air temperature.
- c. Under-floor Humidity/Dew point Monitoring: The CX-FlexFloor shall monitor under-floor humidity, supply air temperature and slab temperature. The CX-FlexFloor shall use these inputs to calculate the dew point temperature of the supply air and provide a 0-10 VDC output proportional to the difference between the slab temperature and the dew point. As the dew point approaches the slab temperature, the AHU controller shall use this signal to lower the dew point of the supply air by lowering the temperature of the primary air off the cooling coil.

B. IBOX, communications interface sequence

- 1. Each IBOX communications interface shall be compatible with modular, plug-and-play wiring system.

- 2. The IBOX shall communicate with the system's TCD-C AirSwitch thermostats, and gather read and write data for use by a third party building automation system using [BACnet] [LonWorks] protocol.
- 3. Each unit shall also be designed for network communication with up to 32 TCD-C AirSwitches.
- 4. Input power supply: 24 volts ac, single-phase, 60 hertz.

C. Modular Control System Cables:

[These items may be included in Division 16, but will require coordination between the Mechanical Contractor and the Electrical Contractor.]

All modular control cables shall be rated for plenum service and shall be equipped (unless indicated otherwise) with modular plug-and-play electrical connectors. All cables shall be factory-tested for continuity, shorts, opens and proper impedance.

- 1. **PAP-1**, General purpose cable: 4-conductor, 18-gauge, 25 feet (7.6 m) long, with modular receptacle at both ends. Identification color: blue.
- 2. **PAP-2**, External device (whip) cable: 4-conductor, 18-gauge, 50 feet (15.2 m) long, with modular receptacle on one end and pig tail on the other. Identification color: yellow.
- 3. **PAP-3**, Extension cable: 4-conductor, 18-gauge, 25 feet (7.6 m) long, with modular receptacle on one end and plug on the other end. Identification color: blue.
- 4. **PAP-4**, Communications Cable: 2-conductor, 22-gauge, 100 feet (30 m) long, with receptacle at one end and both receptacle and plug on the other end. Identification color: white.
- 5. **PAP-5**, Power only cable: 2-conductor, 18-gauge, 25 feet (7.6 m) long, with receptacles at both ends. One end shall have an additional short extension with a plug to permit daisy-chaining one power distribution cable to another. For 24 volts ac, single-phase, 60 hertz power only. Identification color: green.
- 6. **PAP-6**, Heating cable: 2-conductor, 22-gauge, 100 feet (30 m) long, with receptacle at one end

and both receptacle and plug on the other end.
Identification color: orange.

7. **PAP-7**, Thermostat cable: 8-conductor, 18-gauge shielded, 10 feet (3.0 m) long, with 3 plugs on one end, and 2 receptacles on the other end.
Identification color: white.

D. PM, Power Module

[This unit can serve up to a combined total of 14 MIT² terminals and TCD AirSwitches with pulse-modulated control. This item may be included in Division 16, to define furnishing and installation requirements for the Electrical Contractor.]

1. Input power: [120], [240] or [277] volts ac, single-phase, 60 [50] Hertz.
2. Transformer Output Rating: 90 volt-ampere, 24 volts ac.
3. Output connection: modular “plug-and-play” connector compatible with MIT2 wiring system.
4. Housing: steel junction box with knockouts for conduit.

E. QBX-C, Signal Conversion Device

1. QBX-C signal conversion device shall provide a communication link between early generation FlexSys system controls and MIT² components. The device shall provide isolation of the floating point circuit from the AirFixture pulse modulation circuit while allowing up to 3 amperes of drive current at 24 volts ac for proportional devices.
2. Modular connections: three required as follows
 - a. FlexSys terminal device port: shall supply up to 3 amperes at 24 volts ac to drive up to 14 terminals.
 - b. AirFixture device port: shall be capable of supplying up to 10 terminals.
 - c. Thermostat input port: for cooling-only, four-wire connection that goes to the first FlexSys device in the control chain. Compatible with W7763, T6984, FlexHeat or Flex Cool thermostat/controller.

F. QBX-H, Signal Conversion Device

[Required when connecting TCD thermostats to third party heating devices.]

1. QBX-H signal conversion device shall provide a communication link between a TCD-C and third party heating devices, such as solenoid valves or modulating control valves.
2. The device shall be powered through normal PAP cables with a 24 volts ac power supply from the original FlexSys System.
3. Outputs to third party devices shall be screw terminal connections
4. QBX-H shall have three control signal conversion capabilities. Using a TCD-C heating control signal, the output options shall be:
 - a. A 24 volts ac on/off device.
 - b. A 0 to 10 volts dc proportional device.

G. TCD-C, AirSwitch™, Heating and Cooling Space Thermostat for Pulse-Modulation Control

[Required when using pulse-modulation controlled terminals and network communications. Provides local control and display, and remote set point adjustment and monitoring.]

1. TCD-C AirSwitch shall be a wall-mounted heating and cooling thermostat device.
2. Enclosure: plastic, in accordance with UL 94. Enclosure shall be suitable for mounting on a single gang electrical box in either the horizontal or vertical orientation.
3. Wiring connections: modular.
4. Setpoint Adjustment: push button (higher and lower)
5. Display: LCD display of set point and space temperature.
6. Set point range: 45°F to 90°F (7.2°C to 32.2°C).
7. Device shall provide 63 network addresses using an integral DIP switch, and use an RS-485 network to provide remote connection to an area controller or communications device. Network protocol and voltages shall be compatible with plug-and-play modular wiring and shall be resistant to tampering by others. TCD-C Unit

Guide Specifications *(continued)*

shall operate as a stand-alone unit or as part of a proprietary area network compatible with IBOX units.

8. Device shall provide floating-point and pulse-modulation control to enable control of older-style MIT with floating point actuators.

9. Device shall have self-test capability.

10. Device shall comply with FCC Part 15, NEC Class 2, and be listed by UL.

11. Color: white.

12. Sequence of Control

- a. Temperature Sensor: The TCD monitors room air temperature as sensed by the room temperature sensor with setpoint adjustment. The TCD uses this information to determine the control action required to maintain room comfort. The single setpoint input provides the cooling setpoint, while the heating setpoint is equal to the cooling setpoint minus the deadband value. An LCD display and buttons allow the customer to adjust the temperature setpoint within defined limits.

- b. Initial Power Up: On initial power being applied or after a power failure, all MIT2 motorized dampers connected to the power source will close. After the dampers are closed, the TCD-C begins a normal operating sequence by sending pulse modulated control signals to the first MIT2 unit in the chain and by starting heating stages, as necessary with 60 second intervals between stages.

- c. Normal Operation – Cooling, temperature rise above the cooling setpoint (or lowering of the setpoint): When the sensor indicates a temperature greater than the cooling setpoint, the TCD will send open signals to the MIT2 connected to the TCD to cool the temperature of the zone. The TCD gradually and incrementally increases the amount of time the MIT2 damper stays in the open position, until the temperature reaches the setpoint and the controller takes no further action. If the temperature starts to fall below the cooling setpoint, the TCD increases the amount of time the MIT2 damper stays in the closed position, thereby reducing the cooling to the zone.

- d. Normal Operation – Heating, temperature falls below the heating setpoint (or raising of the setpoint): If the temperature continues to fall below the heating setpoint, then the TCD-C controls the MIT2 damper to stay in the closed position 98% of the time. *[for HCE or UFE heat:* Then the fan is activated to return the space temperature to the heating setpoint. If, after the fan is activated, the temperature remains below the setpoint, the first stage of electrical heating is introduced. If additional heat is required, additional stages of heat are activated, if available.] *[for HCW or UFW heat:* Then the fan is activated to return the space temperature to the heating setpoint. If, after the fan is activated, the temperature remains below the setpoint, the hydronic heating is introduced.] *[for QBX-H heating signal:* Then the heating devices are activated. *Describe heating method.*] As the temperature rises above the heating setpoint the heating stages are sequenced off.

- e. Box Calibration: All MIT2 motorized dampers are programmed to re-synch to the open or closed position within 3 cycles of the damper. 3 cycles of the damper will take a maximum of 15 minutes. This prevents the MIT2 from being out if its expected sequence.

- f. TCD-C Operating Parameters, Factory Defaults:

1. The occupied cooling setpoint is 74° F – project setting shall be *[specify setpoint]*.
2. The deadband setting is 2° F – project setting shall be *[2° F] [5° F]*.
3. Setpoint adjustment: 45-90° F – project setting shall be *[specify setpoint range]*

- g. Diagnostic Mode: Diagnostic mode is used to test MIT2 motorized dampers, heating devices, and the wiring connected to the TCD. During this mode, the MIT2 dampers are continuously cycled every 30 seconds, and the heating stages are cycled every 60 seconds. To enter diagnostic mode, use the IBOX to communicate this operating mode or enter manually by decreasing the setpoint to the minimum and pressing both setpoint adjustment buttons. Exit by pressing both setpoint adjustment buttons.

H. TCD-S, AirSwitch™, Cooling Only Space Thermostat for Pulse-Modulation Control
[Provides local control and display for pulse modulation controlled terminals.]

1. TCD-S AirSwitch shall be a wall-mounted cooling only thermostat device.
2. Enclosure: plastic, in accordance with UL 94. Enclosure shall be suitable for mounting on a single gang electrical box in either the horizontal or vertical orientation.
3. Wiring connections: modular.
4. Setpoint adjustment: push button (higher and lower)
5. Display: LCD display of set point and space temperature.
6. Set point range: 45°F to 90°F (7.2°C to 32.2°C).
7. Device shall have self-test capability.
8. Unit shall comply with FCC Part 15, NEC Class 2, and be listed by UL.
9. Color: white.
10. Sequence of Control
 - a. Temperature Sensor: The TCD monitors room air temperature as sensed by the room temperature sensor with setpoint adjustment. The TCD uses this information to determine the control action required to maintain room comfort. The single setpoint input provides the cooling setpoint. An LCD display and buttons allow the customer to adjust the temperature setpoint within defined limits.
 - b. Initial Power Up: On initial power being applied or after a power failure, all MIT2 motorized dampers connected to the power source will close. After the dampers are closed, the TCD-S begins a normal operating sequence by sending pulse modulated control signals to the first MIT2 unit in the chain.
 - c. Normal Operation – Cooling, temperature rise above the cooling setpoint (or lowering of the setpoint): When the sensor indicates a temperature greater than the cooling setpoint, the TCD will send open signals to the MIT2 connected to the TCD to cool the temperature of the zone. The TCD gradually and

incrementally increases the amount of time the MIT2 damper stays in the open position, until the temperature reaches the setpoint and the controller takes no further action. If the temperature starts to fall below the cooling setpoint, the TCD increases the amount of time the MIT2 damper stays in the closed position, thereby reducing the cooling to the zone.

- d. Box Calibration: All MIT2 motorized dampers are programmed to re-synch to the open or closed position within 3 cycles of the damper. 3 cycles of the damper will take a maximum of 15 minutes. This prevents the MIT2 from being out of its expected sequence.
- e. TCD-S Operating Parameters, Factory Defaults:
 1. The occupied cooling setpoint is 74° F – project setting shall be *[specify setpoint]*.
 2. The deadband setting is 2° F – project setting shall be *[2° F] [5° F]*.
 3. Setpoint adjustment: 45-90° F.
- f. Diagnostic Mode: Diagnostic mode is used to test MIT2 motorized dampers, heating devices, and the wiring connected to the TCD. During this mode, the MIT2 dampers are continuously cycled every 30 seconds, and the heating stages are cycled every 60 seconds. To enter diagnostic mode, use the IBOX to communicate this operating mode or enter manually by decreasing the setpoint to the minimum and pressing both setpoint adjustment buttons. Exit by pressing both setpoint adjustment buttons.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Prior to installing underfloor Airway distribution components, verify that all penetrations and openings in the area under the raised access floor have been sealed.
- B. Verify that the building area under the raised access floor has been cleaned and is free of dust, dirt, debris, standing water and other contaminants.

Guide Specifications *(continued)*

3.02 INSTALLATION - GENERAL

- A. Install all underfloor Airway distribution system components, including supply air terminals, fan-powered terminals and controls in accordance with the manufacturer's instructions.
- B. Prior to installation, all components shall be stored in a clean, dry location that is protected from weather and damage from other construction activities.
- C. Coordinate installation of underfloor Airway distribution components with the Access Floor Contractor, who is responsible for erection of the raised access floor.
- D. Coordinate location and size of all cut openings in raised access floor panels with the Access Floor Contractor.
- E. Install supply air terminals, fan-powered terminals and other components in the locations indicated on the drawings.
- F. All power and control wiring shall be installed in accordance with the requirements of specification Section [].
 - 1. All power and control wiring for the underfloor Airway distribution system components shall be installed in a neat and workmanlike manner.
 - 2. Line voltage and sensor wiring shall not be installed in the same harness.
 - 3. Low voltage and communication wiring (less than 30 volts) may be installed in the same wiring harness.

3.03 FAN-POWERED TERMINAL UNITS

- A. See schedule on Drawings.
- B. Support fan-powered terminal units from the building floor in accordance with the manufacturer's instructions.
- C. Position fan-powered terminals so that unit-mounted disconnect switch, fuses, and control cable connections are easily accessible.
- D. Position units so that the filter is easily accessible for removal and replacement.
- E. Install pipe, fittings, valves, insulation and related accessories as indicated on the Drawings and as required in specification Section [].

- F. Verify that all piping connections are tight and leak free.
- G. Fabricate and install ductwork in accordance with specification Section []. Flexible connections and other ductwork accessories shall be in accordance with specification Section [].
- H. Install all fan-powered terminal units with a 1-inch (52-mm) disposable filter that shall remain in place during construction. After construction is complete, replace the filters in all units with new filters [or remove filters].

3.04 TESTING

- A. Upon completion of all installation activities, perform the manufacturer's pre-start checkout instructions (found in Form 130.16-N1).
- B. Start-up and operate underfloor Airway distribution system components to demonstrate functional operation and compliance with specifications.
- C. Perform testing, adjustment and balancing of hydronic piping systems serving fan-powered terminal units.
- D. Perform testing, adjustment and balancing of the supply-side of the duct work served by the fan-powered terminal units.

3.05 OCCUPIED SPACE TO RETURN AIRWAY DIFFERENTIAL STATIC PRESSURE TEST

After supply Airway leakage is verified within acceptable limits, and with the system operating in its normal configuration, the Mechanical Contractor shall measure the static air pressure drop between the occupied space and the return Airway space. The pressure difference shall not exceed 0.02 inches w.g. (5 Pa). If the return air pressure differential is greater than 0.02 inches w.g. (5 Pa), then additional return air terminals or larger return air terminals must be installed in the system.

3.06 BUILDING PRESSURIZATION TEST

The return Airway space pressure shall be verified as slightly positive relative to outside ambient in the range of 0.008 to 0.01 inches w.g. (2 to 2.5 Pa). This requires the system to be operating normally with the Airways complete and all fixtures in place. With variable-air-volume systems, the Mechanical Contractor shall demonstrate the pressure controller and associated

controls are capable of maintaining a stable building pressure as the system supply volume modulates.

For constant-volume systems, the outside air damper and exhaust dampers shall modulate to maintain a stable building pressure during both unoccupied and occupied operating modes and throughout the modulating range of outside air damper if a demand control ventilation sequence (carbon dioxide measurement) is used.

3.07 AIR LEAKAGE TEST - EACH FAN SYSTEM

The purpose of this test is the determination of how much air is lost to leakage by the duct and plenum system. Too much leakage can cause loss of temperature control and poor performance. A typical good system will leak no more than 10-15% of total volume and a marginal system may leak up to 20-25%. If leakage is beyond that which was specified as the minimum VAV flow through the air handler, then the system should be repaired to yield leakage no greater than this level.

To determine plenum/duct leakage, all supply airway terminals are to be covered or sealed. (This test could be performed with blank panels, also.) This can be accomplished by using the optional self-adhesive protective sheets, if this has not been done previously to protect the supply airway terminals from construction debris. All panels and closures must be in place. Check access doors for good fit and closure. **Verify all penetrations at duct/drywall transitions are sealed airtight.**

With the plenum and supply airway terminals sealed, the system is brought to normal working pressure with the controls (typically .05 inches w.g. in the plenum). The airflow of the supply fan system is measured by the air balance personnel and compared to maximum delivery volumes. *The test volumes are recorded in the commissioning report. Correct and retest any systems that demonstrate leakage/uncontrolled flow in excess of design maximum.*

3.08 SUPPLY AIRWAY TERMINALS/MFT FUNCTION TEST AND ZONING VERIFICATION

The purpose of this test is the assurance that the supply airway terminals are correctly installed and functional. Each supply airway terminal is checked to be sure that it is installed properly and secured to the floor. Refer to the appropriate installation instructions (form 130.16-

N1). The trim ring should be tight to the floor with no gaps or rocking motion. The grilles should be open (no casting flash or debris), and correctly oriented as required on the drawings. ***Identify any damaged grilles, trim rings, scratched finishes, bent chassis, excessive dirt etc. and correct as necessary.***

Using the project documents, each zone is tested to verify the supply airway terminal units with automatic dampers are correctly wired to a thermostat, and the dampers within the supply airway terminals are operating correctly. Using the thermostat test mode each thermostat location has its connected supply airway terminal driven open and closed with the drawing marked up indicating pass/fail of each unit. MIT²-G units connected to fan-powered terminals should demonstrate little or no airflow in the heating position with the fan off and the damper in the full heating position. ***If substantial airflow is indicated in this mode then the ductwork under the floor may have excessive leakage or be disconnected.***

Incorrect operation or zoning is to be corrected and the test repeated. Manually operated supply airway terminals are to be verified as correctly located and installed. Verify fan powered terminals have filters installed if required and all stages operate correctly. Refer to fan powered terminals installation instruction form 130.16-N1.

Each thermostat should be verified as being the correct style and type for the location. If thermostats are connected to a Building Automation System, then each thermostat should be observed as communicating correctly. The drawings should identify where each thermostat is located by **address**.

3.09 AIR DELIVERY TEST AND ADJUSTMENT

The purpose of this test is the determination that the fan system can provide adequate air to all of the supply airway terminal devices as installed. If diversity is included on the design, the maximum number of supply airway terminal devices should be opened fully on a distributed basis throughout the floor plates.

After the leakage test has been passed successfully, the sealing material from the supply airway terminals is removed and all the required supply airway terminals are opened fully by means of the thermostat tester. The fan system should be under automatic control delivering a nominal 0.05 inches w.g. to the floor. Random testing

Guide Specifications *(continued)*

of MIT² units on each floor plate or area should indicate an airflow from the fully open MIT² units of design (100 or 150 CFM depending on model). Generally test one MIT per 10,000 square feet minimum. If the MIT² units are generally above or below design, the pressure control should be adjusted using program setpoint with the CX-FlexFloor) to provide the correct design volume. ***If the system fails because the fan can not lower/raise the pressure, it should be identified and corrected. The commissioning report should identify correct and incorrect operation along with the value of required settings to achieve design airflow. Fan volume (VFD speed) should be noted on the drawings.***

3.10 LOADING BALANCING

The floor plate that has multiple injection points should be observed to assure that the load is being equally

divided between systems. For example, one fan may be operating at 100% and another at 25%. The floor pressure controls may need to be adjusted to cause the fan running at 100% to be lowered to 62.5% (lower the pressure setpoint) and the fan running at 25% to be raised to 62.5% (raise the pressure setpoint). These adjustments may require very small adjustments to the pressure controls and should be observed over time to assure correct effect is achieved.

Verify that the limits on TCD setpoint have been adjusted to prevent the user from raising or lowering the setpoint past 70-80 degrees. This will prevent neighboring zones from competing with each other.

