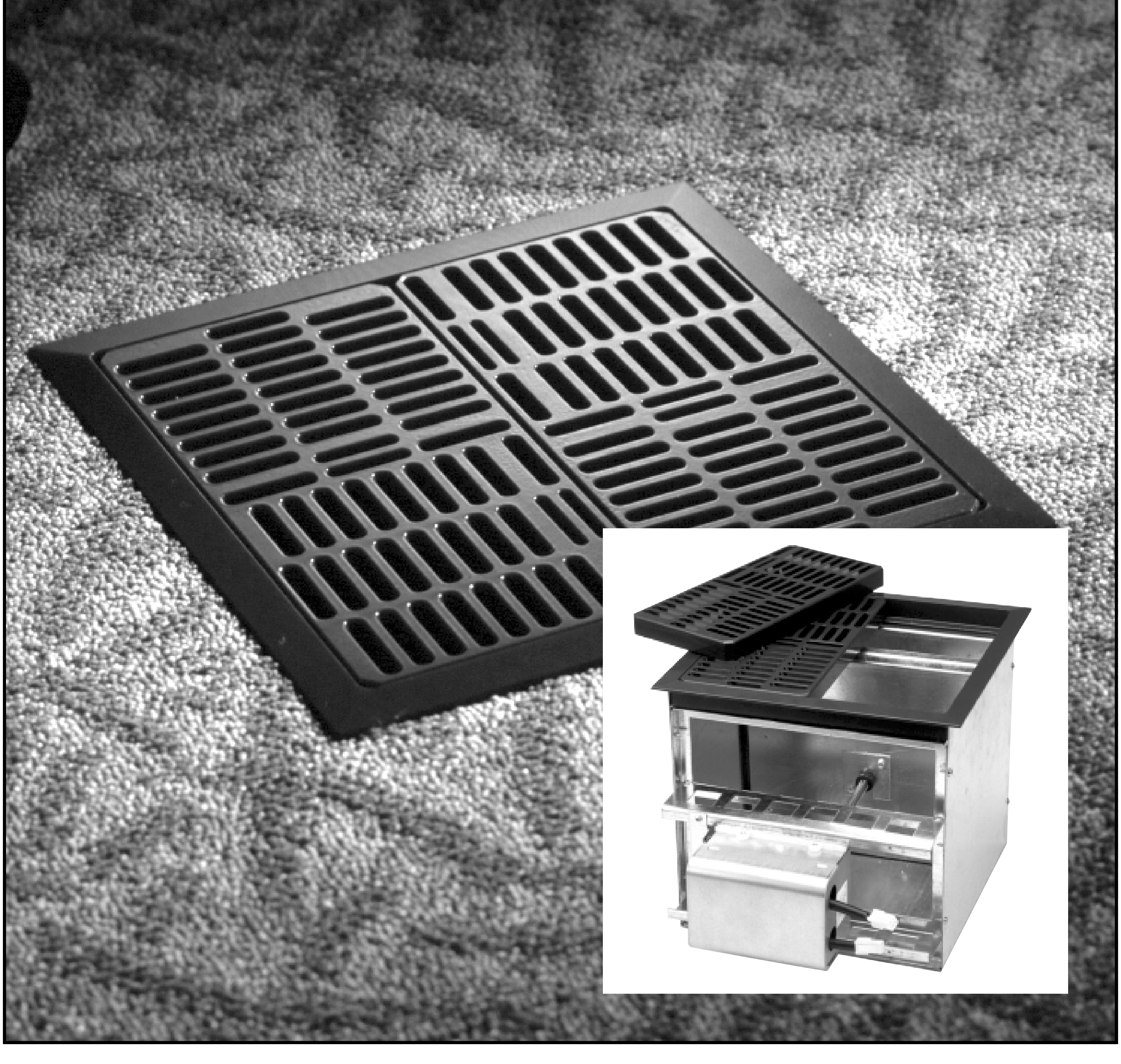
YORK® *Modular Integrated Terminals*

Convection Enhanced Ventilation

TECHNICAL MANUAL



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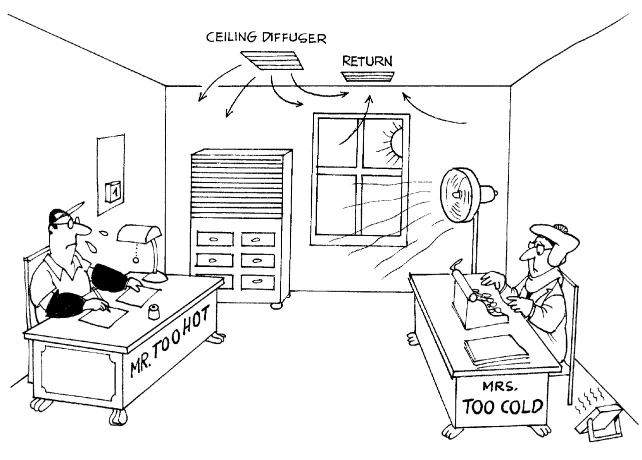
1. About This Manual

YORK is developing new products that are intended to offer unique and cost effective opportunities for solving many of the commonplace problems associated with traditional commercial air-conditioning systems. One exciting new product is the Modular Integrated Terminal (MIT) that is used for the floor up supply of conditioned air. Floor up systems are not new but they have never been widely used in the United States. These “upside down” airside systems offer the potential to solve energy and indoor air quality problems better than conventional systems. The new YORK MIT is an enhancement or second generation product that resolves many limitations of previous products while adding features needed for the U.S. market.

This manual provides technical description of this new technology with practical guidelines and recommendations for using YORK products. It is intended to identify differences between this air delivery system and the traditional well-mixed, ceiling based systems. Of particular interest is the use of floor plenums to distribute air. This method of air distribution is cost effective while providing flexibility beyond any ductwork based system. Many engineering concepts have to be adjusted for this new air delivery method and the information included offers insight into developing final design solutions. It must be emphasized that this manual is only a guide and an introduction of the complex issues involved in applying this technology. Final design parameters and equipment selection should be carefully reviewed by experienced engineers familiar with this technology.

2. Convection Enhanced Ventilation

Most commercial air-conditioning systems use the ceiling or a high wall location as the supply point for the cooling air. The thought is that “cool air drops,” and this location is therefore best. Mixing the supply air (which must be quite cold for cooling) with the room air as quickly and completely as possible avoids drafts and temperature variations everywhere in the room. Thus, this traditional system is known as a “well-mixed” system.



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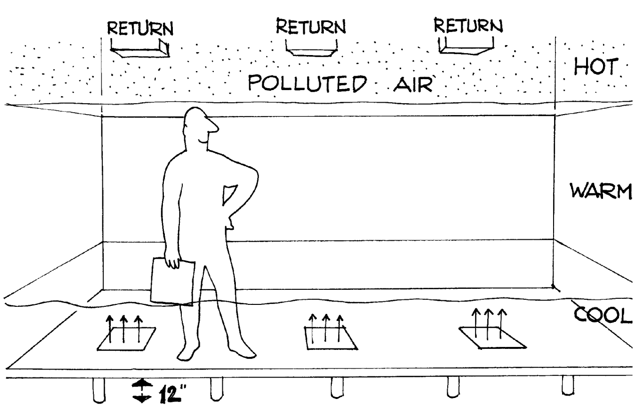
The Traditional Overhead System Problem



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Displacement Concept

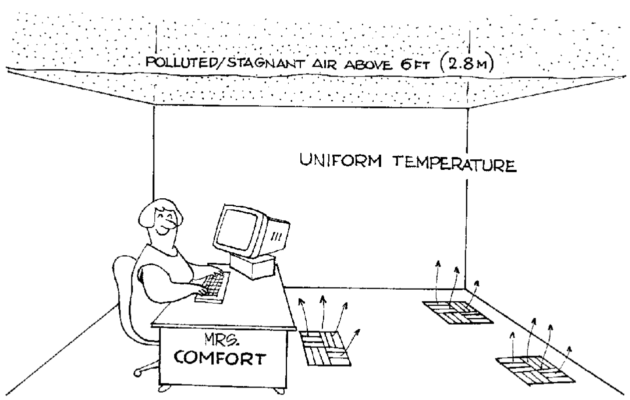
An alternative that has been called “displacement effect ventilation” has also been used. With this concept, supply air, not as cold and at a higher volume, is introduced very slowly at floor level and allowed to rise upwards as it warms and becomes buoyant. The design objective is to “displace” the room air, thus carrying heat and air pollutants more directly to the return air inlets, rather than mixing them in the room and influencing the room occupants.

York International now proposes a hybrid system, offering advantages of both the “well-mixed” and the “displacement” types of air distribution, while at the same time overcoming their disadvantages.

It is named “Convection Enhanced Ventilation,” or simply “CEV,” and it has additional features that make it superior to both previous approaches. It uses a completely new variable air volume distribution device that is installed in raised flooring systems.

CEV technology supplies the cool air vertically at floor level like displacement effect ventilation, but at a constant velocity. The design objective is to mix supply air with room air only up to head height. Above this level, stratification is allowed to occur.

What are the benefits of York’s CEV technology?



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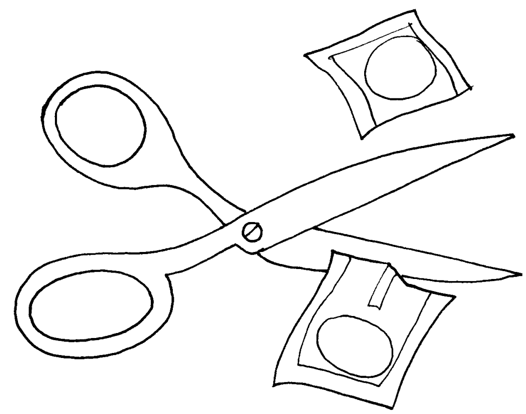
Convection Enhanced Ventilation

1. Improved comfort

- Drafts are avoided and comfortable temperatures are intended to occur only where the people are, not where they aren't (as happens with the “well-mixed” air distribution systems).
- Each of the new terminals can be controlled by its own thermostat, responding to the occupant's temperature preference.

2. Reduced energy consumption.

- CEV plenum distribution systems require less static pressure (fan energy is reduced) similar to “displacement” air distribution systems.
- CEV is truly variable air volume (unlike “displacement” air distribution systems).
- With a warmer supply air temperature, fewer hours of mechanical refrigeration operation are necessary.
- Less outside air (usually requiring dehumidification) is required for the same ventilation effectiveness.



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Operating Cost With CEV

3. Better indoor air quality

- Occupants have first benefit of cooled, filtered, and fresh air supply.
- More effective contaminant dilution in the occupied part of the room due to a unique filtration approach.
- A “dry” (60-65°F [15.6-18.3°C] 65%-80% R.H.) rather than a “moist” (55°F [12.8°C] /100% R.H.) air supply.

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You Can Feel The Better IAQ With CEV

2. Convection Enhanced Ventilation

4. More flexibility

- The air terminals can be relocated quickly and easily, changing from "master" units thermostatically controlling temperatures to "slaves" (and vice versa).

5. Lower installed costs

- When compared to quality conventional systems offering only some of the CEV system's features.

6. Lower life cycle costs

- Relocation of terminals can be done in a matter of minutes if necessary due to movement of people or equipment.

- No additional or new service techniques are necessary when compared to conventional air systems.

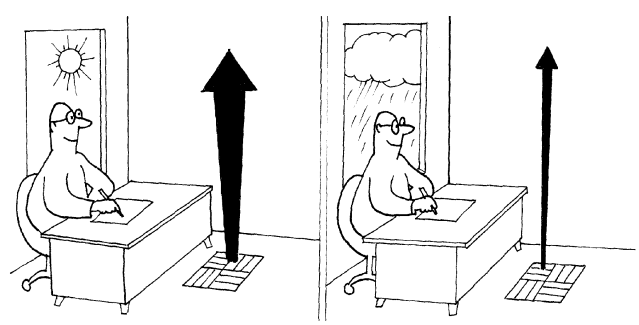
- Cleaning is done at the same time as floor cleaning and access to a unit at floor level is easier than one located overhead.

3. Comfort With The MIT

The first under floor air-conditioning systems performed best at full-load, or nearly full-load, conditions. This was often acceptable, because they were used in areas with little variation in cooling load. However, for areas where loads did vary, such as perimeter zones during intermediate seasons, when transmission and/or solar loads were less than design conditions, or in other spaces where people and lighting loads could decrease, over-cooling could occur.

The result is a lower "comfort level" than would occur with conventional overhead systems. If heating was required in perimeter zones, these early under floor systems couldn't handle this very well. They were inflexible, unable to adapt easily to changes, such as relocation of walls or office layouts, or even the movements of office equipment. Early under floor air-conditioning systems did not allow users to control their own temperature: they simply were not "people oriented."

York's MIT has changed all this. It is a second generation under floor air-conditioning system, and it overcomes limitations of earlier attempts. Each feature of the MIT is intended to enhance comfort as the primary objective. The MIT supply air grilles provide high induction mixing of the supply air with room air to lessen temperature differences within the occupied space. This reduces the cold floor effect and areas of unmixed air that an occupant could perceive as uncomfortable. This high induction ratio is maintained even as the MIT reduces supply air volume in response to the user's thermostat, because an automatic internal damper ensures a constant discharge air velocity. Previous under floor air terminals had either manual air dampers or no means of control to compensate for load or system performance variations. It should come as no surprise that comfortable conditions did not exist all the time.



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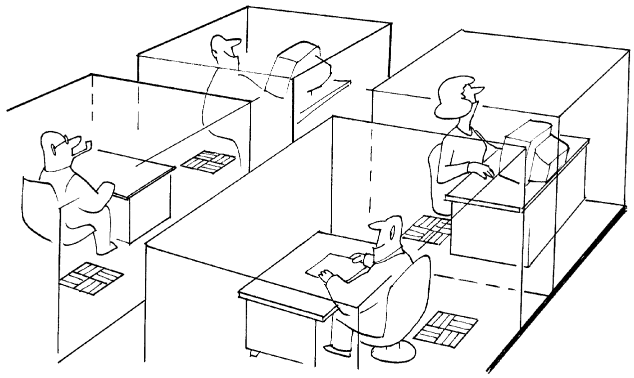
MIT Provides VAV Control With Constant Velocity for Better Mixing and Comfort



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Unlike the one-configuration “swirl” grilles used with many under floor systems, the MIT uses a grille whose orientation can be changed easily by the user, even when the air-conditioning system is “on.” This allows precise directional control of the cool air: straight up, toward, or away from the occupant(s), whatever the preference. The MIT can even be used in small cubicles, along partitions, near furniture, and within inches of the occupant, without feeling drafts. Contrast this with other, inflexible grille designs that require a distance from the occupant of three feet (one meter) or more to provide comfort.

The MIT was designed to meet the typical cooling requirement of an area occupied by one person. Individuals have control over their own thermostat, which provides a truly “personalized” air-conditioning solution, even in an open-office setting. If necessary, several units can be controlled by one zone thermostat.

The MIT family includes many different models, each one designed to match a specific application condition: cooling-only, warm-up, perimeter heating, new construction, renovation, etc. A range of control devices and schemes has been specifically engineered to complement these MIT capabilities. These can be obtained as a part of the complete under floor air-conditioning system.

A major advantage of the MIT system is its ability to handle change. Unlike overhead systems with fixed ductwork, in a plenum based MIT air distribution system the entire area under the floor can be considered an air supply source. MIT terminals can be placed virtually anywhere in the floor system to accommodate the layout of the room. If the layout changes, so can the locations of the MIT terminals; simply exchange a floor panel containing the unit with a solid one!

Control and power wiring, joined with “plug-and-play” connectors, are located under the floor, and they are simply pulled along with the unit. Grilles can be changed; units can be added or removed to meet changed loads; control zones can be rearranged or added. The York MIT is truly a flexible air-conditioning system.

4. York MIT Air Terminal

MIT is an acronym for Modular Integrated Terminal. An MIT differs significantly from all other air terminals and encompasses a whole family of configurations. The following MIT models allow a wide range of specific air distribution application needs to be met in an optimum manner:

MIT- A

A pressure dependent, constant velocity, constant air volume (no air damper), under floor air terminal with no controls. Nominal capacity of 150 CFM (71 l/s) at 0.05" w.g. (12.5 Pa) for use with pressurized cool air from under floor plenum.

MIT- B

A pressure dependent, constant velocity, constant air volume (no air damper), under floor terminal with no controls. Nominal capacity of 150 CFM (71 l/s) at 0.05" w.g. (12.5 Pa) for use with ducted cool air supply.

MIT- C

A pressure dependent, constant velocity, variable air volume (with air damper) under floor terminal with nominal capacity of 0 to 150 CFM (71 l/s) at 0.05" w.g. (12.5 Pa) for use with pressurized cool air from under floor plenum.

MIT- D

A pressure dependent, constant velocity, variable air volume (with air damper) under floor terminal with nominal capacity of 0 to 150 CFM (71 l/s) at 0.05" w.g. (12.5 Pa) for use with ducted cool air supply.

MIT- E

A pressure dependent, constant velocity, variable air volume (with air damper) under floor terminal with nominal capacity of 0 to 150 CFM (71 l/s) at 0.05" w.g. (12.5 Pa) for use with ducted cold air supply plus pressurized warm air from under floor plenum that has been transferred from ceiling or occupied space.

MIT- F

A pressure independent, constant velocity, variable air volume (with air damper) under floor terminal with nominal capacity of 0 to 150 CFM (71 l/s) at 0.20" w.g. (49.8 Pa) for use with raised floors, 6 in. (15.24 cm) or higher with pressurized cool air from under floor plenum.

MIT- G

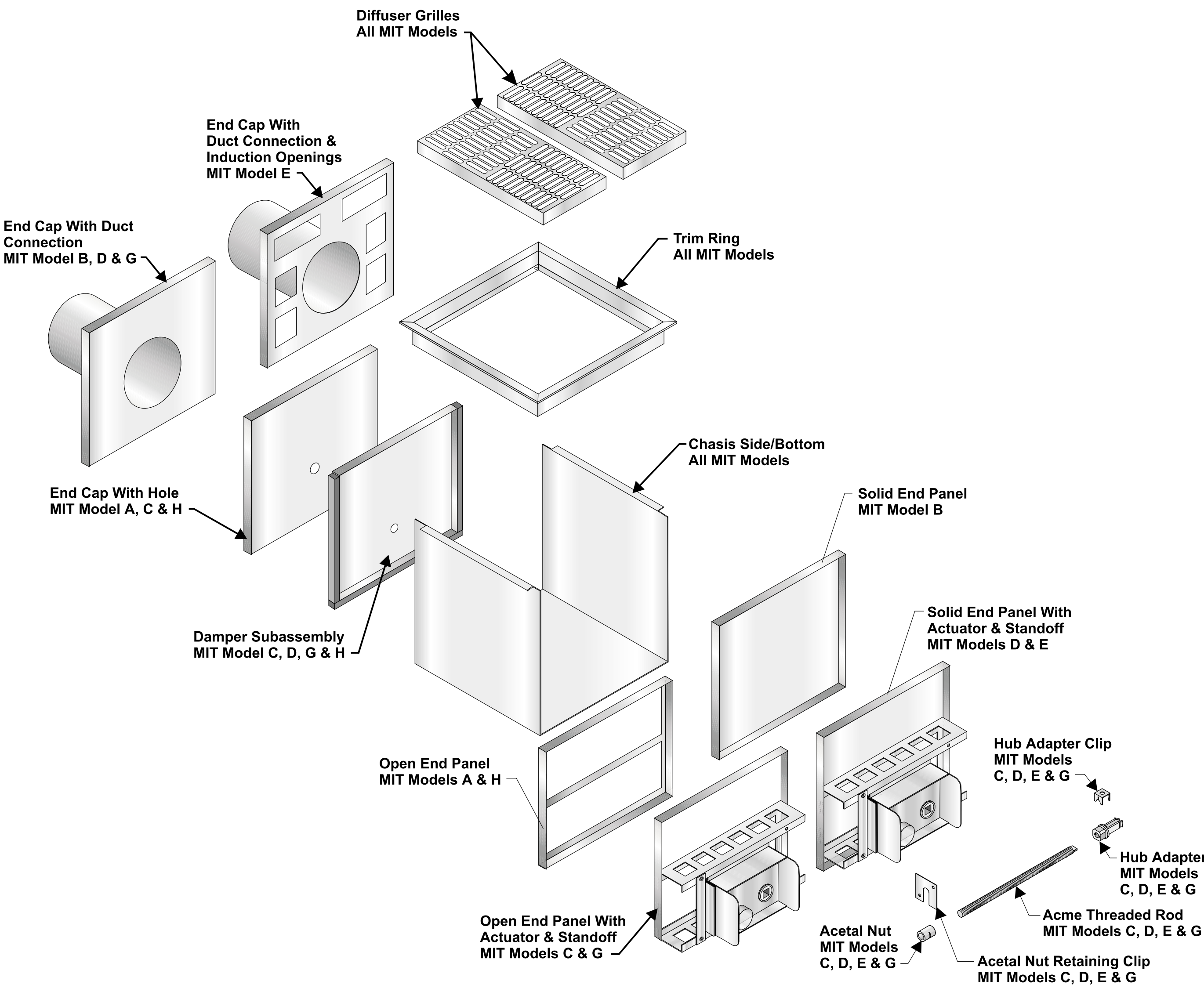
A pressure dependent, constant velocity, variable air volume (with air damper) under floor terminal with nominal capacity of 0 to 150 CFM (71 l/s) at 0.05" w.g. (12.5 Pa) for use with pressurized under floor plenum plus ducted hot air supply.

MIT- H

A pressure dependent, constant velocity, constant air volume under floor air terminal with manual volume adjustment but no controls. Nominal capacity of 150 CFM (71 l/s) at 0.05" w.g. (12.5 Pa) for use with pressurized cool air from under floor plenum.

This MIT family shares many components in an interchangeable and modular manner. Putting the parts together in the factory or assembly in the field can be accomplished with simple hand tools like a screwdriver. MITs are designed to be reusable, re-locatable and recycled for the benefit of the environment. Ideally the MIT should outlast the building itself with proper maintenance.

As this exploded view indicates, a common chassis is used as a platform for the assembly of several end cap and damper configurations that can be combined to make the various models as described. This modularity allows for quick and easy installation and repair. For example, the grilles easily remove for cleaning or adjustment of air pattern.


Diffuser Grilles
All MIT Models
End Cap With
Duct Connection &
Induction Openings
MIT Model E
End Cap With Duct
Connection
MIT Model B, D & G
Trim Ring
All MIT Models
Chasis Side/Bottom
All MIT Models
End Cap With Hole
MIT Model A, C & H
Solid End Panel
MIT Model B
Damper Subassembly
MIT Model C, D, G & H
Solid End Panel With
Actuator & Standoff
MIT Models D & E
Hub Adapter Clip
MIT Models
C, D, E & G
Open End Panel
MIT Models A & H
Hub Adapter
MIT Models
C, D, E & G
Acme Threaded Rod
MIT Models C, D, E & G
Open End Panel With
Actuator & Standoff
MIT Models C & G
Acetal Nut
MIT Models
C, D, E & G
Acetal Nut Retaining Clip
MIT Models C, D, E & G

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5. Energy Considerations

The York variable air volume CEV system can save operating energy five ways.

1. It matches each local supply air quantity to its instantaneous requirement to avoid wasting energy by over-cooling or over-heating.
2. It has a lower static pressure requirement, when using the under floor plenum to distribute the supply air, rather than higher friction loss ductwork. Air terminals and their grilles have been designed for very low air pressure loss. See typical fan horsepower comparison in Figure 5.2.

Fan Energy Reduction

Comparison of MIT System to Conventional Overhead System

Energy = CFM x Static Pressure/C

With 20% decrease in supply air load due to return air load transfer, 40% increase due to increased supply air temp, and 1.5 in. decrease in static pressure:

Energy Ratio = (0.8 x 1.4) x (2.25/3.75)/C = 68%

Energy Ratio = MIT compared to Overhead System
0.8 = 20% less Supply Air required due to stratification of Air Side Load
1.4 = Higher Supply Air Temperature requires 40% more air
2.25 = Typical MIT System Static Pressure (requires less static pressure)
3.75 = Typical Overhead System Static Pressure (requires 1.5" more static pressure)
C = Constant
68% = MIT Energy requirement is 68% of overhead system

Fig.5.2 ***20 - 30% Energy reduction typical***

3. It utilizes a warmer supply air temperature, thus allowing more hours of “free-cooling” (economizer) operation and fewer hours of mechanical refrigeration in temperate climates. See Figure 5.3 for comparison of annual extra hours of “free cooling” in selected U.S. cities.

More Hours of Free Cooling

Annual Weather Data

City	Hours @ 55°F+ (12.8°C+)	Hours Between 55-65°F (12.8-18.3°C)	% Reduction
NYC	3842	780	20%
Chicago	3619	604	17%
St. Louis	4754	586	12%
Atlanta	5779	773	13%
Dallas	6199	645	10%
San Francisco	5235	1593	30%

% Reduction = Percent of reduced mechanical refrigeration due to free cooling.
Hours Between 55-65°F (12.8-18.3°C) = Hours saved on 24 hr/day basis with 65°F (18.3°C) supply air rather than 55°F (12.8°C) air typical with overhead system.

Fig.5.3

4. Its variable supply air volume avoids reheating or air mixing for control purposes, reducing energy use at partial load. VAV also allows taking advantage of diversity in times of peak building cooling loads, saving fan and chiller energy.

5. It requires less outside air to provide the same ventilation effectiveness, because it is delivered where it is needed. See ventilation effectiveness comparison in Figure 5.5.

Reduced Outside Air Load
Proposed ASHRAE Ventilation Effectiveness

Cooling Only Overhead = 1.0

Combined Overhead Heating/Cooling = 0.8

Displacement Ventilation = 1.2

0.8/1.2 = 33% Reduction in Outside Air required for Under-floor Distribution

Fig.5.5

These five savings can total up to 50% of the energy used in many traditional systems. In no case should a York CEV system use more energy than a conventional VAV system.

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6. Indoor Air Quality

The design and operational characteristics of CEV systems give several possibilities for improving a building's indoor air quality. The following are some of them.

1. Under floor air-conditioning uses warmer supply air temperature. A “purpose built” air handling unit has been especially designed with this in mind. It has its cooling coil in parallel with high efficiency filters, yielding improved filtration of small particles (such as smoke, pollen, and organic compounds) without the usual penalty of additional high static pressure loss. Cold air from the pre-filter and cooling coil mixes with clean (but warm) air that has passed through the pre-filter and final high efficiency filter, to produce the proper temperature air for the under floor plenum.

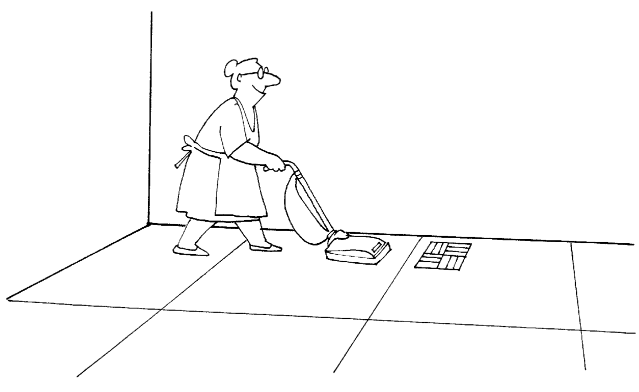
2. Many particles that might be in the supply air stream “drop out” when the air reaches the under floor plenum, because the air velocity there is very low.

3. Cleaning the under floor plenum and MIT terminals is more convenient than cleaning conventional overhead ductwork due to their under floor location and easy removal of floor panels and MIT grilles.

4. The “fresh” air delivered by the CEV system is concentrated in the occupied, “breathing” zone, not wasted above people's heads. This increases the ventilation effectiveness.

5. This concentration results in a higher effective “air change” rate. The air contaminants rise by convection directly to the air return locations.

6. Because outside air is used for longer periods (additional hours of economizer operation), the benefits of fresh outside air occur for longer periods (assuming the outdoor air is cleaner and fresher!)



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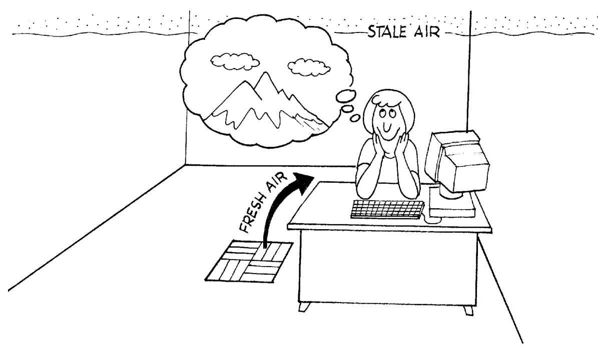

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7. Issues That Affect Load Calculations

The CEV air-moving concept affects load calculations differently from conventional systems in several ways. The following points should be taken into consideration when designing a CEV under floor air-conditioning system.

7.1 Location of cooling loads in the space

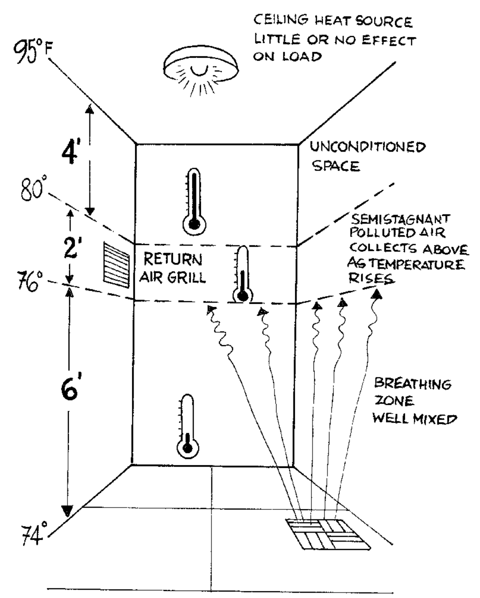
CEV systems supply cooling air from below, mix it with room air as it passes through the occupied space picking up heat and contaminants from the room, and then dissipate the mixture out from above. As a result, if a convective heat source is above head level (6 feet, 2.8 m), it does not influence the air temperature in the occupied space. Ceiling mounted lights and light shelves are examples of this type of heat source.

In open plan spaces with no “hard” perimeter wall and no blinds, solar radiation load can be spread into the interior of the space much farther than the traditional 12-14 ft. (4-5 m) perimeter depth. This helps to relieve the concentration of diffusers at the skin and permits the MIT perimeter system to perform well with much higher solar loads.

7.2 Return air location

Return air grilles should be located above head level, to ensure that they do not interfere with the convective air patterns. For normal ceiling heights up to 10 feet (3m), this can be in the ceiling itself. For areas with higher ceilings, the return air location can be in the wall, at a height of 6 feet (2.8m) or more.

Return air locations in perimeter spaces should be continuous or evenly spaced in the wall above the window. This location will transfer some of the room solar and transmission load directly to the return air, reducing the required supply air quantity, and improving system efficiency.



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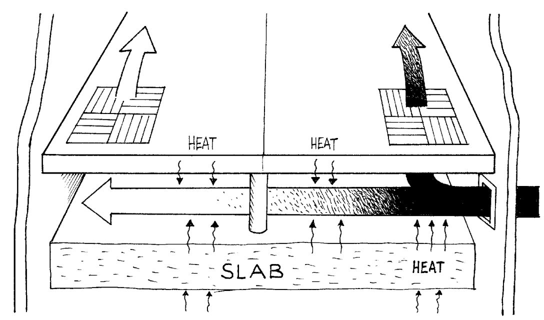
7.3 Thermal decay (loss of supply air cooling ability)

The usual method of delivering the supply air to the MIT terminals is through the under floor plenum. It yields the most flexibility and is the most cost effective. When plenum based air distribution is used (with MIT models A, C, E, and G), the supply air passing through the under floor plenum will absorb heat from the floor slab below it, and it will start picking up heat from the room through the raised-floor above it.

This is similar to the heat gain to ductwork as it passes either through conditioned or unconditioned spaces.

Frequently, this is ignored in conventional systems, but in reality it should be addressed. The low air velocity in the under floor plenum, less than 1500 feet per minute (7.62 meters per second) increases the heat gain, but, on the other hand, the low temperature difference, 12°-15°F (5°-6° C), reduces it.

This heat gain does not materially affect the total building cooling load, but it does affect the temperature of the supply air and, consequently, the amount of air supplied by each MIT unit. The MIT, however, is a variable air volume terminal and it compensates for thermal decay. The heat transferred to the plenum close to the core reduces the air requirement there, and increases the air requirement at the remote terminals, due to the increased supply air temperature. The MIT terminals simply deliver more



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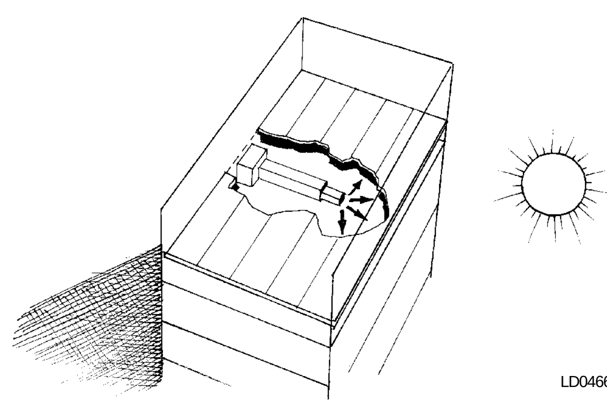
air, up to their maximum, to maintain the user-desired temperature, making system design more tolerant.

The MIT terminals also respond to part load conditions by reducing their supply air delivery, again matching air flow to load conditions.

If the entire floor area to be served is less than 15,000 ft^2 (1,394 m^2), having only one air handling unit (serving all four exposures of the building) is ideal. If the area to be served exceeds this value, the distance from air supply to the most distant MIT could exceed 50 ft (15 m), and thermal decay could start to be a problem. In this case more than one supply point, duct "stubouts," or a ducted air distribution network should be considered for this area.



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7. Issues That Affect Load Calculations

Figure 7.3 shows the effects of thermal decay at design conditions. When the supply air is distributed to the MIT terminals through insulated ductwork, no additional thermal decay occurs, only the normal duct heat gain. The MIT terminals compensate for this heat gain as well.

Air Travel Distance under raised floor as function of supply air temperature rise

Air temp rise, °F (°C)		1° (0.6°)		2° (1.1°)		3° (1.7°)		4° (2.2°)		5° (2.8°)		6° (3.3°)	
% cfm inc.		8		17		27		40		56		75	
Raised floor carpet status		with carpet	w/o carpet	with carpet	w/o carpet	with carpet	w/o carpet	with carpet	w/o carpet	with carpet	w/o carpet	with carpet	w/o carpet
Base*	Feet	21	20	35	32	47	44	58	55	70	66	84	77
	Meters	6.4	6.1	10.7	9.8	14.3	13.4	17.7	16.8	21.3	20.1	25.6	23.5
Base with 18"	Feet	25	23	42	38	55	54	72	68				
(45.7 cm) floor	Meters	7.6	7	12.8	11.6	16.8	16.5	22	20.7				
Base with 14 cfm/ft	Feet	19	17	31	28	42	39	53	49	63	59	73	70
(21.7 l/s/m) to perimeter	Meters	5.8	5.2	9.4	8.5	12.8	11.9	16.1	14.9	19.2	18	22.3	21.3
Base with no cfm (l/s)	Feet	16	14	26	24	35	33	44	42	54	51	62	60
to perimeter	Meters	4.9	4.3	7.9	7.3	10.7	10	13.4	12.8				
Base with 0.4 cfm/ft^2	Feet	20	18	33	30	45	42	56	53	67	64	80	75
(5 l/s/m^2) internal load	Meters	6.1	5.5	10	9.1	13.7	12.8	17.1	16.1	20.4	19.5		
Base with 0.4 cfm/ft^2 (5 l/s/m^2) and 14 cfm/ft	Feet	18	16	29	27	39	36	49	46	60	56	70	66
(21.7 l/s/m) to skin	Meters	5.5	4.9	8.8	8.2	11.9	11.0	14.9	14.0	18.3	17.1		
Base with 55°F (12.8°C)	Feet	53	42	81	70								
air under slab	Meters	16.2	12.8	24.7	21.3								
Base with neutral	Feet	40	33	62	54	80	72						
slab effect	Meters	12.2	10.1	18.9	16.5	24.4	21.9						

*Base includes:
60°F (15.6°) 80% RH air condition entering space
80°F (26 7°C) air beneath slab
73°F (22.8°C) air at carpet surface in conditioned space
Nominal 12 in. (30.5 cm) raised floor with 10.75 in. (27.3 cm) height of subfloor plenum
Internal cooling load = 0.6 cfm/ft^2 (3.0 l/s/m^2)
Skin cooling load = 27 cfm/ft (41.8 l/s/m)
6 in. (15.2 cm) concrete structural slab

FIG. 7.3

7.4 Thermal increase (decrease in return air temperature)

A similar phenomenon occurs when the air returning from the room passes under the slab of the floor above. It can drop in temperature from 2°-5° F (1°-3°C), depending on construction and length of travel. The heat flux of this effect is illustrated in Figure 7.4 for a typical plenum condition.

Heat Flux as function of distance from supply point through raised floor or structural slab

Distance from supply point		10 ft (3.05 m)		30 ft (9.14 m)		50 ft (15.24 m)		70 ft (21.34 m)	
Floor component		raised floor	str. Slab	raised floor	str. Slab	raised floor	str. Slab	raised floor	str. Slab
Base*	btu/ft²	8.5	13	4.5	5.5	2.5	2.5	2.5	2.5
	Joules/cm²	9.7	14.8	5.1	6.2	2.8	2.8	2.8	2.8
Base with 18"	btu/ft²	7.5	10	3.5	3.5	3	2	1	1
(45.7 cm) floor	Joules/cm²	8.5	11.4	4.0	4.0	3.4	2.3	1.1	1.1
Base with 14 cfm/ft	btu/ft²	8	11	4	4	2	2	1	1
(21.7 l/s/m) to perimeter	Joules/cm²	9.1	12.5	4.5	4.5	2.3	2.3	1.1	1.1
Base with no cfm (l/s)	btu/ft²	6.5	8	2.5	2.5	1	1	0	0
to perimeter	Joules/cm²	7.4	9.1	2.8	2.8	1.1	1.1	0	0
Base with 0.4 cfm/ft²	btu/ft²	8.5	12	4.5	5	2.5	2.5	1.5	1.5
(5 l/s/m²) internal load	Joules/cm²	9.7	13.6	5.1	5.7	2.8	2.8	1.7	1.7
Base with 0.4 cfm/ft² (5 l/s/m²) and 14 cfm/ft	bt/ft²	7.5	10	3.5	3.5	2	2	1	1
21.7 l/s/m) to skin	Joules/cm²	8.5	11.4	4.0	4.0	2.3	2.3	1.1	1.1
Base with 55°F (12.8°C)	btu/ft²	9	3.5	5.5	1.5	3.5	1	2	1
air under slab	Joules/cm²	10.2	4.0	6.2	1.7	4.0	1.1	2.3	1.1
Base with neutral	btu/ft²	9	—	5	—	3	—	2	—
slab effect	Joules/cm²	10.2	—	5.7	—	3.4	—	2.3	—

*Base includes:
60°F (15.6°) 80% RH air condition entering space
80°F (26. 7°C) air beneath slab
73°F (22.8°C) air at carpet surface in conditioned space
Nominal 12 in. (30.5 cm) raised floor with 10.75 in. (27.3 cm) height of subfloor plenum
Internal cooling load = 0.6 cfm/ft² (3.0 l/s/m²)
Skin cooling load = 27 cfm/ft (41.8 l/s/m)
6 in. (15.2 cm) concrete structural slab

FIG. 7.4

7. Issues That Affect Load Calculations

7.5 Thermal storage due to building mass

Thermal **storage** can reduce the required supply air quantity. Many times thermal storage allows smaller system components and fewer MIT terminals simply by recognizing that the materials surrounding the under floor plenum absorb heat during periods of peak building loads. Thermal storage affects the system design and operation as follows.

During normal operation, the building materials surrounding the under floor plenum cool down, almost to the supply air temperature. Thus, the system can be started several hours, or run the whole night, before occupants arrive, when especially hot weather is anticipated. In this manner, there is a residual “heat sink” ready to provide additional cooling when it is needed.

There is no easy calculation to determine how much benefit is obtained from thermal storage; it is a matter of experimentation during system operation to determine the optimum time to “pre-start” the under floor system to obtain the desired “pre-cooling.” Peak solar load savings of 20 - 30% are normal. These should not be considered an addition to normal air-conditioning thermal storage, but as part of it. The operating energy consumption of the MIT system will reflect the positive benefits of thermal storage even if it is not considered in the load calculation.

7.6 Load diversity

The MIT system is truly variable air volume: it provides cooling only where and when it is needed. Maximum cooling loads occur at different exposures of a building at different times depending primarily on the sun. With an MIT system, it is possible to select air handling equipment and chillers that are smaller than the sum of the maximum cooling loads of all areas.

To achieve this benefit, air handling units must serve more than one type of functional area or more than one solar exposure. For example, in a building with conference rooms, a dining area, and offices, the same people move from place to place during the day, and the sun can shine on only one side of the building at a time. The typical “block load” (maximum instantaneous) is 20 - 40% less than the sum of the maximum cooling loads of the individual areas.

7.7 Stratification and ceiling height

Theoretically, there is a reduction in the amount of system cooling capacity required due to warmer temperatures being allowed to occur above head height. This results from less temperature difference across the upper part of the perimeter wall and glass and from a higher enthalpy of the exhaust air than with conventional design, thus reducing sensible load. It is better to calculate the room load and resultant air-flow the same way as a conventional variable air volume system unless the ceiling height is much greater than the normal 10 feet (3m) or exact calculations can not be made to determine if the reduction in transmission is significant. The operating energy consumption of the MIT system will reflect any actual reduction in transmission load even if it is not considered in the load calculation.

8. Psychrometric Considerations

When plenum based air distribution is used, the supply air temperature generally should not be lower than 60°F (15.6°C) leaving the air handling unit or coldest air terminal. The minimum allowable supply air temperature is affected by thermal resistance of the floor, sealing effectiveness between floor panels, type of carpeting (if any), activity level and amount of space per occupant, their dress, etc. But, only in exceptional cases should a supply air temperature less than 60°F (15.6°C) be considered. The MIT model E is fed both with pressurized plenum air and ducted air. In this case, the temperature of the ducted air supply can be as low as 40°F (4.4°C), because it is mixed with the warmer plenum air prior to being introduced into the occupied space.

A psychrometric evaluation shows that mixing outside air at typical conditions with return air, and then cooling the mixture to 60°F (15.6°C), will not produce an acceptable humidity level. Some other approach is necessary to ensure adequate dehumidification.

Cooling the air mixture to a lower temperature and then **re-heating** it to avoid over-cooling the space and/or to ensure adequate ventilation air was an accepted approach in the past.

Reheat, using new energy, is wasteful, and is not permitted by most energy codes now, except in special situations. **Reclaimed** heat, however, can be used with the York MIT system to achieve the proper supply air conditions. A different approach, however, is more common with the MIT. It mixes some of the return air with the outside air, and then cools and dehumidifies this mixture to the same conditions as a conventional system. This air is mixed with the remainder of the return air from a separate air handling unit or bypassed around the cooling coil to achieve the desired 60°- 65°F (15.6°-18.3°C) drybulb supply air temperature. This ensures comfortable conditions but with a low enough moisture content to provide humidity control.

York provides air handling designs that can accomplish this. One airstream, supplied with face dampers, feeds the cooling coil, and the other airstream bypasses the cooling coil. The two airstreams then mix, and the supply air fan discharges the mixture into the under floor plenum, ductwork leading to the under floor plenums, or ductwork leading to the MIT terminals. The required supply air temperature is controlled by the amount of bypassed air. As the humidity in the space decreases, the supply air temperature leaving the cooling coil can be reset up to save energy.

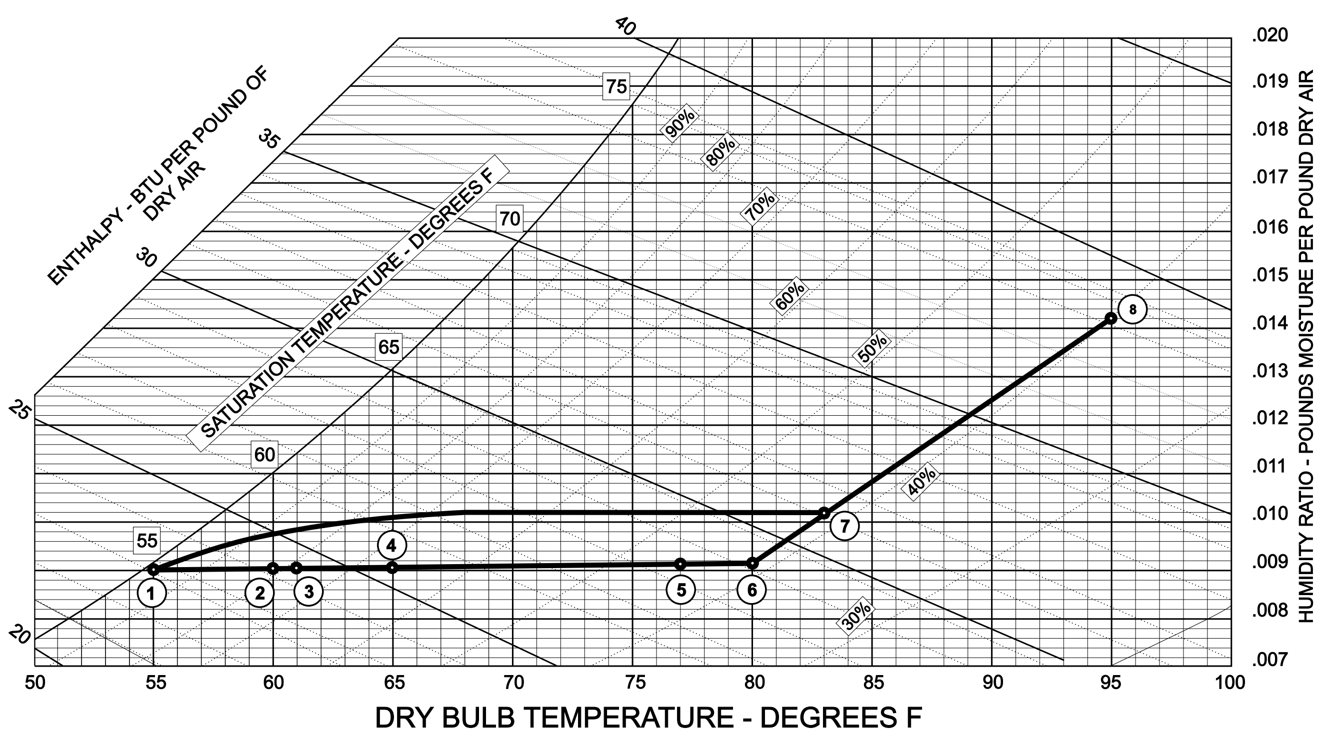
The cooling process described above can be seen on the following psychrometric charts, both at full and partial load conditions. Each point on the psychrometric chart is explained below.

Full-load conditions, 90% sensible heat factor assumed:

Point 1. Cooling coil leaving air condition, typically 55°F (12.8°C) DB & 54°F (12.2°C) WB (53°F [11.7°C] dew point) This is the condition of the air that has passed through the air handling unit cooling coil. It is comprised of all of the outside air, and about 80% of the return air.

Point 2. Mixture of air leaving cooling coil and return air diverted around it, 60°F (15.6°C) DB & 56°F (13.3°C) WB (80% RH) shown.

Point 3. Air leaving air handling unit, typically 61°F (16.1°C) DB & 56.5°F (13.6°C). A draw through air handling unit fan configuration is recommended to take advantage of fan energy for reheat. **Point 3** is the condition of the air after being warmed by the inefficiencies of the fan and fan motor. The temperature rise is typically 0.5°F (0.28°C) per inch w.g. of static pressure of the supply fan. (For a blow through configuration **Point 3** is equal to **Point 2**.). Supply air from **Point 3** to **Point 4** is distributed to the space to absorb room sensible and latent load which determines the relative humidity in the space, shown as **Point 5**. The temperature of the supply air rises from **Point 3** to **Point 4** as it picks up heat from the distribution duct, raised floor and structural slab.



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8. Psychrometric Considerations

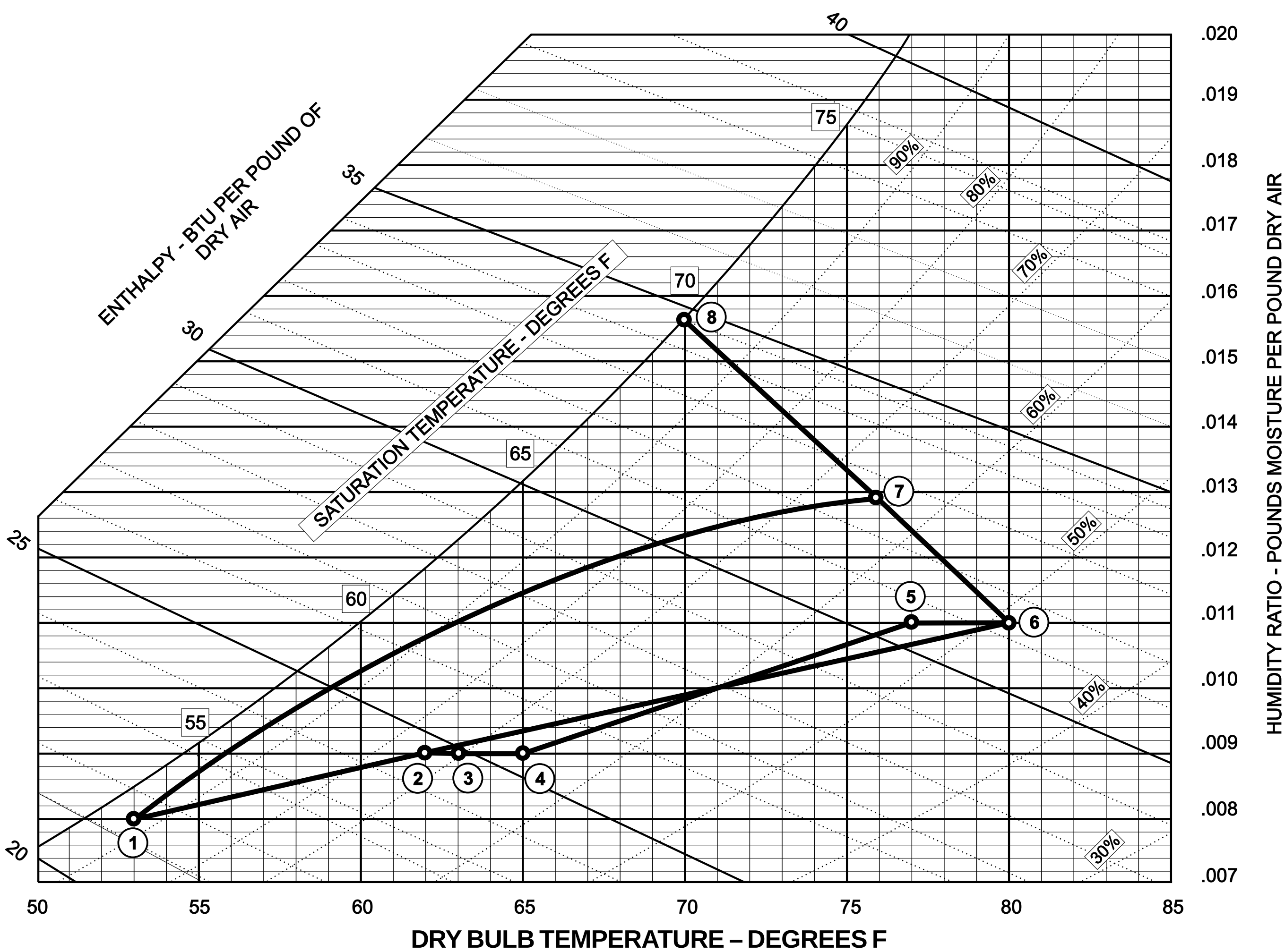
Point 4. Supply air condition in the under floor plenum at the farthest distance from the supply point. The maximum condition of the supply air in the under floor plenum (at about 50 ft. [15 m] from the air handling unit) is typically 65°F (18.3°C) DB and 58°F (14.4° C) WB. It would normally be reset down to 63°F (17.2°C) for peak design load.

Point 5. Occupied space design conditions, shown as 77°F (25°C) DB & 63°F (17.2°C) WB (48% R.H.). This corresponds to the weighted average of the drybulb temperatures selected by the occupants, using their thermostats. Because room occupants get first benefit of the conditioned air, this average room temperature can be several degrees warmer than with conventional systems.

Point 6. Return air condition, typically 80°F (26.7°C) DB & 64°F (17.8°C) WB. This is the condition of room air returning to the air handling unit. It is the room condition, plus the effect of any heat load above head height, minus any cooling due to the floor slab above (see Section 7.4). It is generally 2°- 3°F (1°- 2°C) higher than the occupied space condition 5, above.

Point 7. Cooling coil entering condition, 83°F (28.3°C) & 66°F (18.9°C) shown. This is a mixture comprising 80% of the return air and 20% outside air. (The remaining return air bypasses the cooling coil). For blow through configuration air handling units, the fan heat shown as the line between Point 2 and Point 3 would occur here instead, increasing the dry bulb temperature entering the cooling coil.

Point 8. Outside air condition, 95°F (35°C) & 75°F (23.9°C) shown. This is the condition of the outside air introduced into the building for ventilation. This air is dehumidified by the cooling coil, mixed with room return air in the air handling unit, and then distributed throughout the building by ductwork and the under floor plenums. It is also the condition of any air infiltrating the building through doors, cracks, open windows, etc. Its condition changes with weather and season.



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Typical rainy day partial load conditions, 60% sensible heat factor.

Part load operating conditions pose the biggest challenge to humidity control in air-conditioning systems, particularly constant volume direct expansion or mixing types. VAV systems, including the MIT, can control humidity better. The conditions shown below represent a cool, rainy day, resulting in a lower sensible heat factor and a higher room humidity level.

Point 1. Cooling coil leaving air condition reset to 53°F (11.7°C) DB & 52°F (11.1°C) WB. During partial load, the sensible heat factor is usually lower than at full-load. There is also less supply air, matching the reduced cooling load. For these reasons, the air leaving the cooling coil may need to be reset to a lower dew point to maintain the design room relative humidity.

Point 2. Mixture of air leaving cooling coil and return air diverted around it, 62°F (16.7°C) DB & 57.5°F (14.2°C) WB shown.

Point 3. Air leaving air handling unit, 63°F (17.2°C) DB & 58°F (14.4°C) WB

Point 4. Average supply air condition in the under floor plenum, typically 65°F (18.3°C)

Point 5. Occupied space design conditions, typically 77°F (25°C) DB & 65.5°F (18.6°C) WB (55% R.H.)

Point 6. Return air condition, typically 80°F (26.7°C) DB & 66.5°F (19.2°C) WB

Point 7. Cooling coil entering condition, 76°F (24.4°C) & 68°F (20°C) shown.

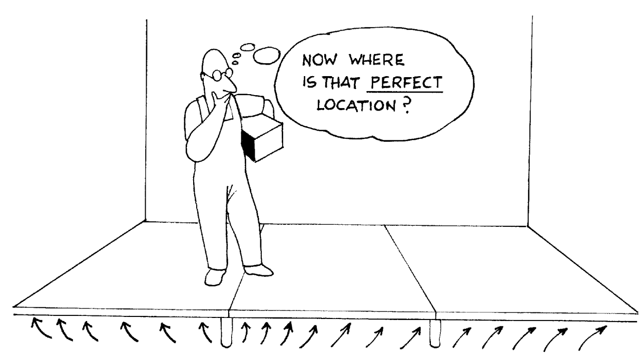
Point 8. Outside air condition, 70°F (21.1°C) & saturated shown.

9. Choosing The Best Locations for the MIT Terminals

It is not necessary to specify exact location of MIT units on the plan drawings when using plenum based air distribution. Choosing locations could even wait until partitioning is complete and tenants have arranged their furniture. Units that will be used to provide heating should be located around the perimeter (exterior walls) with air flow patterns directed up the walls and along window surfaces to offset the transmission heat loss

MIT terminals should be placed near occupants where it is most important to control the temperature. MIT units have removable grilles that can be turned to blow in any pattern from straight up to a full 360° flare. They can be safely located almost anywhere. However, they should not be installed directly under an occupant nor where there will be high pedestrian traffic.

Units under thermostatic control should be located as close to their controlling thermostats as possible with air flow discharge patterns directed away from the thermostat. Since MIT terminals are easy to relocate, it is possible to use the “trial-and-error” method of finding the best locations and grille orientations for optimum comfort.



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10. Plenum Based Air Distribution

10.1 Moisture and condensation

Moisture in the air condenses on an object whenever the temperature of that object is below the dew point of the air surrounding it. Condensation can cause bacterial, viral, and mold growth causing health hazards. Materials in a plenum-based under floor air distribution system will cool down to the supply air temperature during normal operation. They can remain cool for hours after the system is shut "off." Condensation may occur on or within the materials in the plenum if warm moist air is allowed to infiltrate.

10. Plenum Based Air Distribution

There are two common situations to avoid:

1. Warm, moist, outside air can enter the building through open windows and come in contact with the cool plenum and the floor below (slab). One solution to this problem is the application of a vapor barrier to the underside of the supply plenum, effectively keeping the moisture away from the slab. A better solution is the application of thermal insulation that includes a vapor barrier. The vapor barrier will also assist in overcoming thermal decay. The vapor barrier must be on the outside of the insulation to be most effective.

2. Restarting the air handling unit, allowing it to draw in and distribute high humidity outside air through the plenum before the cooling coil has had a chance to dehumidify it.

Though the potential for condensation exists mostly in tropical climates, the possibility should always be analyzed whenever plenum based air distribution is used. If necessary, steps should be taken to ensure that these situations do not occur.

10.2 Locating floor air supply points

The location, or locations, where cooling air is introduced into the under floor plenum is important. York offers an air handling unit that discharges air directly into each plenum, completely avoiding supply air ductwork. At the extreme, a single air handling unit may serve the entire building consisting of many under floor plenums, utilizing ductwork to each of them.

The advantage of fewer floor air supply points is lower cost due to little or no ductwork and maximum load "diversity." The disadvantages are increases in thermal decay and noise at higher air velocities due to the greater distances the supply air must travel through the under floor plenum. As a rule, the maximum distance from the supply point to the furthest MIT terminal should be less than 50 feet (15m). Refer to Figure 7.3 as an aid in determining the temperature rise of supply air as a function of distance from the supply point for a specific design. Use insulated ductwork to "stub out" if necessary to achieve the desired discharge temperatures.

10.3 Plenum air velocity and air pressure drop

The supply air velocity and the air pressure drop through the plenum should also be considered. They can become critical when the floor height is less than the normal 12" (30 cm), or when floor air supply points are minimized.

To avoid noise, the air velocity at the supply point should not exceed 1500 feet per minute (7.6 m/s). For a raised floor area of 10,000 ft^2 (929 m^2), requiring 10,000 CFM (4,719 l/s), this means a total supply air duct area of about 7 ft^2 (.65 m^2). If the clear area under the raised floor is 10" (25.4 cm), a single supply point would require a duct width of about 8½ feet (2.6m)! Four or five supply points would be a better solution to avoid excessive noise and air static pressure drop.

The nominal air flow of an MIT terminal, 150 CFM (70.8 l/s), is based on 0.05" w.g. (12.5 Pa) static pressure and little, if any, velocity pressure. If the open side of an MIT terminal is installed facing the supply point, the air velocity pressure would increase the terminal's air flow and distort the air distribution pattern. In this case, the MIT should be turned away from the supply point.

In many renovation applications, the raised floor height is less than normal: heights of 6"-8" (15-20 cm) are not unusual. A higher static pressure is required to push the supply air through these reduced height floors. The pressure independent MIT model F has an automatically controlled inlet damper to compensate for increased static pressure and is recommended for this application.

11. Ducted Air Distributuion

If plenum based air distribution is inappropriate, the MIT terminals can be individually supplied with cool or cold air from insulated ductwork. Perimeter areas with very high cooling and/or heating requirements are better served by ducted MIT terminals.

The MIT family includes models MIT-B, MIT-D, MIT-E, and MIT-F, that are designed for ducted supply systems. These models have an inlet air connection on the side of the chassis that is open on the other models. Their application follows standard duct practice for pressure dependent terminals, with a duct static pressure of 0.05” w.g. (12.5 Pa) required to obtain the nominal 150 CFM (71 l/s).

The MIT, model B, is constant volume with no damper. The model D is variable volume with a damper. The model E is variable volume with an open side in addition to the inlet air connection. It mixes cold supply air from the ductwork with warmer plenum air. The static pressures of the two air supplies must be controlled to achieve the desired mixed air temperature.

Plenum based air distribution should be used wherever possible since ductwork adds to the cost and some system flexibility is lost. However, there are situations when ducted air distribution is justified:

1. When the distance from the supply point to the MIT is long, a ducted system or a few ducted MIT terminals serving the building skin will overcome any problem of thermal decay.

2. Ducting unvitiated air from areas adjacent to critical zones may also reduce the outside air requirement, when allowed by the ventilation code.

3. When a cool plenum could cause condensation on the surrounding slab or wall construction, either inside or outside.

4. When a changeover heating/cooling system is employed.

5. For special purpose areas, like conference rooms, which might overcool during unoccupied “lights off” periods due to a cold floor.

6. For nurseries and children's playrooms where warm air in the plenum keeps the floor warm and cool air supplied through the ductwork conditions the space.

7. For space over an area such as a parking garage that will have the plenum temperature affected by exposure (It could be hot in summer and cold in winter).

A pressure damper or VAV box should be used to control static air pressure if that pressure to the MIT cannot be maintained at a constant 0.05" w.g. (12.5 Pa). Ducted and plenum fed MIT terminals can both be used in the same building and in the same areas.

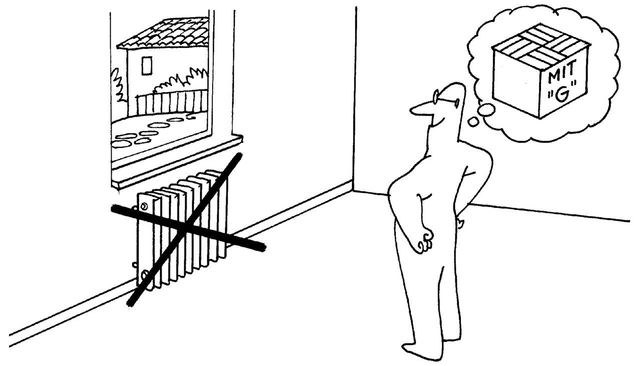
It is desirable to use multiple ducts which fit between standard 2 x 2 ft. (0.61 x 0.61 m) raised floor support pedestals. A maximum width of 22" (60 cm) permits fitting between pedestals. With a 12" (30 cm) raised floor system, a 10" x 22" (25.4 cm x 60 cm) sheet metal duct with half-inch (13 mm) thick lining will carry 1970 cfm (930 l/s) at 1500 fpm (7.6 m/s). An 8" x 22" (20 cm x 60 cm) will carry 1530 cfm (722 l/s) at 1500 fpm (7.6 m/s) which is the maximum velocity recommended for free discharge into the floor plenum. Higher velocities can be used in fully ducted systems in accordance with good design principles.

If “plug and play” cabling is used, it is recommended that duct be sized to permit about 1 in. (2.5 cm) of clear space underneath for passing cables and for air movement.

12. Heating

The MIT terminals used in the CEV system are ideal for heating because they supply air from below. Warm air is directed upward across cold surfaces eliminating the cold down drafts that occur when the skin heat loss (including transmission and infiltration) exceeds 250 Btuh per lineal foot (240 Watts per meter) of perimeter wall. The heat can be supplied at any point in the space when the skin heat loss is less than 250 Btuh per lineal foot (240 Watts per meter).

The versatile MIT model G provides heating from a duct system and cooling from the under floor plenum, both through the same grille. It is capable of changeover or simultaneous heating/cooling operation. A fan powered terminal, model MFT with an electric or hot water coil located under the floor, is the source of hot air. Heating is available with this configuration even when the main supply fan is shut down, such as at night and weekends.



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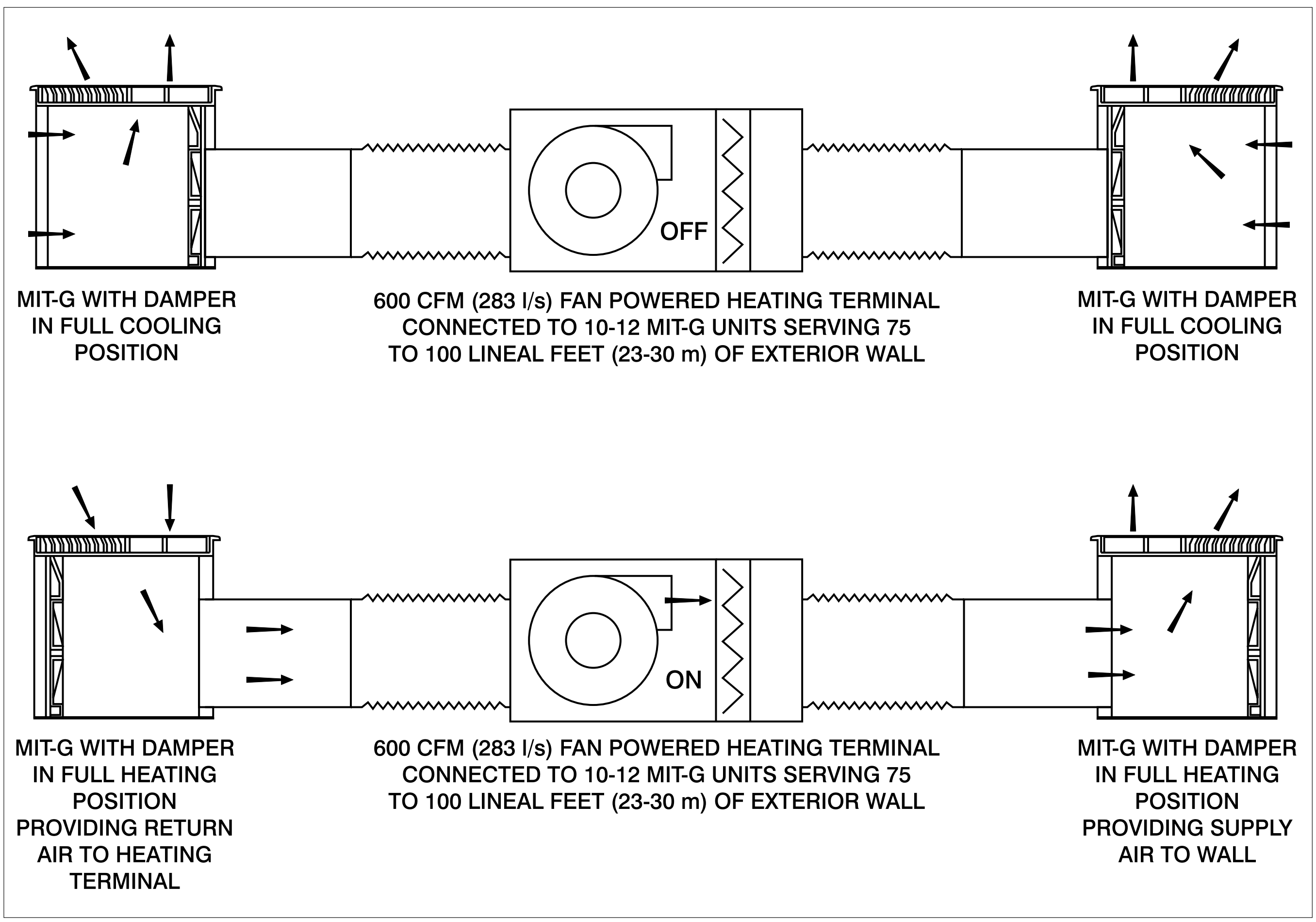
Heating Solution-MIT-G



MIT-G Configuration For Perimeter Zones

LD04675

The MIT-G supplies a constant air volume when in the heating mode. It operates as a VAV device when in the cooling mode. It can perform another function, too. It can serve as a return air device supplying air to the MFT fan powered terminal in the heating mode. It operates in the cooling mode when the fan is "off." This dual function reduces the total number of required MIT terminals.

The MIT-G includes a minimum damper position "stop" that permits the introduction of fresh air from the under floor plenum while recirculating air from the space. This feature allows the unit to maintain minimum ventilation while in the heating mode.

Other MIT models can be used for heating with the proper thermostat selection. Completely separate heating systems, such as baseboard radiation or ceiling radiant panels, can also be used with cooling-only MIT systems.

13. Zoning

Some air-conditioning systems do not allow the building to be split into separate sections to match diverse loads and different temperature preferences. These sections are called "zones" (each is an area of homogeneous loading and a single desired temperature).
Early under floor systems supplied the same temperature air everywhere with no means to vary its quantity to match changing loads or differing temperature preferences. Sometimes the under floor plenum was roughly "partitioned" to separate areas having different load characteristics. This approach was costly and did not grant future flexibility when conditions changed.

LD04671

MIT models A and B can function as constant volume terminals. This is often how conditioned air is delivered to special purpose areas, such as conference rooms. Often these areas are served by individual air handling units feeding the constant volume MIT models.

The recommended minimum number of thermal zones per floor on a rectangular free-standing building is nine: four on the corners, four between corners, and one in the center. However, more zones offer greater flexibility, improved comfort, and more energy savings.

An MIT system permits an almost unlimited number of zones, as many as one per person, if desired. The variable air volume feature delivers only the quantity of cooling air necessary to offset the heat in each area to maintain the user-preferred temperature.

However, increasing the number of zones will increase the cost of any air-conditioning system. Thermostats, controls, and air dampers all add to the cost. The increased cost of more zones must be justified through increased comfort by putting the user "in control" of his environment.

An investment can be made at any time with the MIT system: during the initial installation or after tenants have moved in and the system is in operation. Grilles can be changed, control zones can be rearranged or added, and units can be added or removed to meet load changes or higher comfort expectations. MIT units installed in a VAV system can be used to shut off individual tenant spaces in a multiple tenant building during unoccupied periods for proper apportionment of Air Conditioning costs.

14. Fire, Smoke, and Other Code Issues

All members of the MIT family have been designed and are manufactured to comply with U.S. codes NFPA 90A, BOCA, UBC, and SBC. UL listing and other normal HVAC product requirements are also met.

Local building codes and officials' interpretations may affect the installation of a plenum air distribution based system. Every project should have their approval. The under floor plenum's construction, its size, the need for fire detection and suppression methods should all be reviewed.

It is important to recognize that code officials may not be familiar with the characteristics of an under floor HVAC system. Also, they may incorrectly try to apply computer room standards to the access floor used in other occupancies and applications.

Because of this situation, it may be important to begin work early with code officials to help them appreciate the benefits this new system offers.

15. Air Handling System Features

York has incorporated specific features into some of its air handling units to allow the benefits of MIT terminals and CEV performance to be fully realized.

15.1 “Plug” (plenum) fans

Plenum based CEV systems operate at lower static pressures. Total system pressure drop can be 1.5" to 2.5" w.g. (375 - 625 Pa) less than conventional overhead VAV systems.

“Plug” (plenum) fans are a good choice because they are efficient and quieter when operating at these lower static pressures. The York Airpak, CurbPak, and Curbmaster air handling units offer the plenum fan option. The supply air can be discharged from an area as large as the air handling unit's bottom panel, ensuring minimum static pressure loss and no regenerated noise. Additionally, air splitters can be provided to reduce discharge noise further.

15.2 Sidestream Filtration

CEV air-conditioning uses warmer supply air temperature than conventional overhead VAV systems, and so face-and-bypass control on the air handling unit is a better way to ensure adequate dehumidification, while still ensuring the proper mixed supply air temperature.

The York Airpak, CurbPak, and Curbmaster air handling units offer a pre-engineered, purpose-built “face-and-bypass” option for CEV systems with the cooling coil in parallel with high efficiency filters that are located in the bypass air stream. The outside air inlet is aligned with the dehumidifying coil to ensure that no outside air is bypassed around the cooling coil.

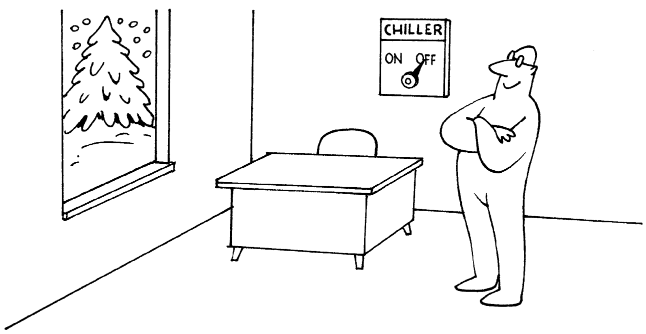
The dampering arrangement then mixes cold air from the cooling/dehumidifying coil with clean (but warm) air that has passed through the sidestream filter to produce the proper temperature air for the under floor plenum.

This design yields improved filtration of small particles (smoke, pollen, and organic compounds) without the usual operating cost penalty that would result from additional high static pressure loss if the filters were in series with the cooling coil.

These air handling units are designed in the draw-through arrangement to allow the fan heat to help warm the supply air mixture to the desired temperature.

About 60% of the supply air passes through the dehumidifying coil at design conditions. This represents all of the minimum outside ventilation air quantity plus a sufficient quantity of return air to maintain the required supply air temperature. The other 40% passes through the high efficiency, sidestream filters only.

These air handlers can also operate in the “economizer” (free-cooling) mode, with the refrigeration system turned “off,” so that the savings in operating energy can be realized.



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15.3 Direct Expansion Applications

York variable air volume CEV systems can use direct expansion air handling equipment as well as chilled water. Many smaller installations will benefit from this option. With direct expansion systems there are several specific design and operating requirements. These include:

1. Sufficient steps of condensing unit unloading to limit leaving air temperature fluctuation to 3°F (1.7°C) and to avoid coil freeze-up at minimum load.
2. At least five minute time delay on compressor restarting.
3. Face-split or interlaced cooling coils to avoid the bypass of non-conditioned air.
4. Hot gas bypass if the minimum anticipated load is less than the last step of condensing unit unloading capacity.
5. Sufficient system safety controls to ensure proper operation, including coil freeze-up, low air flow, dirty filter indication, high compressor head pressure.

If the above requirements cannot be met, a chilled water system can also be used for the smaller installations.

A unique direct expansion system approach, more appropriate for larger installations, is the use of multiple packaged roof top units arranged in a “primary/secondary” supply air loop.

The primary loop consists of several constant temperature, constant volume direct expansion air handling units, operating in parallel. The secondary loop consists of a variable volume supply air fan, an exhaust fan, economizer outside air dampers, and filters.
Cool air is drawn off the primary loop to the secondary loop by means of a supply and return damper arrangement, as needed to match the building's cooling load.

As the building's cooling load reduces, and less supply air is required, the air handlers in the primary loop are shut down, one-by-one, and dampered out of the loop. A bypass allows the primary loop to be controlled at a constant temperature. The last unit to shut down would normally be sized to deliver the minimum fresh air quantity, thus assuring constant outside air ventilation when mechanical refrigeration is in operation.

When operating in economizer (free cooling) mode, the primary loop is shut down, and the static pressure loss (usually about 1” [250 Pa]) through its dehumidifying coils and filters is avoided. The outside air, now delivered directly into the secondary loop, can be filtered as required.

Supply air pressure is maintained by modulation of the secondary fan to maintain the designed duct system pressure. Individual floor smoke/fire control dampers modulate the supply air to maintain the under floor plenum pressure constant at varying air volumes. Building static pressure is controlled by the powered exhaust. Individual control dampers should be used at the exhaust to maintain space pressure and to deal with stack effect.

16. System Controls and Air Handling Unit Operational Sequence

The most comfortable conditions can be obtained only when the MIT system is properly controlled. The system parameters whose values must be controlled are the supply air drybulb temperature, the dew point of the air leaving the cooling coil, and the under floor plenum supply air static pressure (or supply duct, if the system is duct fed).

The supply air is a mixture of dehumidified air from the cooling coil and return air diverted around it. Its dry bulb temperature must be maintained at a level that will ensure that the farthest MIT terminal is supplied with air cool enough to do its required sensible cooling when delivering its nominal air volume. This is accomplished by adjusting the mixture of dehumidified and bypassed return air in the air handling unit. The dew point of the air leaving the cooling coil must be maintained at a level low enough to ensure the supply air mixture performs the required latent cooling.

If the supply air static pressure at the MIT terminal is too low (<0.05" w.g. [12.5 Pa]), the unit will not deliver sufficient air, and the room temperature may increase beyond the user selected temperature. If it is too high (>0.06" w.g. [15 Pa]), the unit will not provide the desired air discharge patterns, and floor leakage could cause a problem.

Supply air drybulb temperature is not a single value, but a range. It need only be cool enough to do the required cooling, but must not be allowed to drop to the point where condensation forms on surfaces it contacts, nor to cause the raised floor to become too cool and uncomfortable. This minimum value depends on the type of floor covering, but generally should be limited to not less than 60°F (15.6°C).

16.1 Discharge air control – full economizer mode

When the air handling unit controller has determined that the dew point of the outside air is sufficiently low to provide cooling without mechanical refrigeration, it shall:

1. Shut down the chiller.

2. Open the cooling coil and bypass dampers.

3. Take input from the discharge sensor:

   A. On a rise in temperature, modulate the dampers for outside air and exhaust air open while simultaneously closing the return air damper.

   B. On a fall in temperature, reverse the sequence.

16.2 Discharge air control – no economizer mode

When the air handling unit controller has determined that the dew point of the outside air is not sufficiently low to provide cooling without mechanical refrigeration, it shall:

1. Energize the chiller circuit.
2. Position outside, exhaust, and return air dampers in their normal position.
3. Enable minimum outside air ventilation sequence.
4. Close cooling coil damper and open bypass air damper.
5. Take input from the discharge sensor and on a rise in temperature modulate the cooling coil damper open.
6. On a continued rise in temperature (when the cooling coil damper has reached the full open position), the bypass damper shall modulate closed to maintain air handling unit discharge temperature.
7. On a fall in temperature the bypass damper shall modulate open.
8. On a continued fall in discharge temperature (with the bypass damper fully open), the cooling coil damper shall modulate closed to maintain air handling unit discharge temperature.

16.3 Cooling coil discharge air control – no economizer mode

When the air handling unit controller has determined that the dew point of the outside air is not sufficiently low to provide cooling without mechanical refrigeration, the cooling coil discharge control loop shall be enabled.

The cooling coil discharge sensor acting through the air handling unit controller shall, on a rise in temperature, modulate the chilled water valve open to maintain cooling coil discharge temperature. The reverse shall occur on a fall in temperature.

16.4 Discharge air reset program

The RTU discharge air temperature setpoint will be reset (via the communications interface) to maintain proper plenum temperatures under the floor and to ensure that no condensation occurs. Condensation can occur when the plenum, floor tiles, and concrete floor temperature are lower than the RTU discharge air dew point temperature.

This could occur during prolonged shutdowns during cold weather. The BAS will monitor plenum temperature and humidity, and space temperature. Plenum dew point shall be calculated from humidity and temperature sensors and will be used first to reset the RTU cooling coil discharge temperature setpoint so that the RTU discharge air dew point is below that of the plenum.

If the discharge air dew point is not low enough to prevent any condensation then the RTU discharge setpoint will be reset to lower the discharge air dew point. If the discharge dew point continues to stay above the level of the plenum temperature for more than five minutes, an alarm will be generated at the BAS.

16.5 Plenum and duct distribution pressure

If there are main supply ducts, the static pressure should be controlled the same as conventional VAV systems, i.e., a duct static pressure transmitter located 2/3 of the distance from the air handling unit to the end of the duct. This transmitter should control the inlet or outlet dampers of the air handling unit, variable speed drive, or other means to set precisely the volume and pressure of the fan.

With plenum based air distribution, the under floor plenum pressures should also be controlled at 0.05" w.g. (12.5 Pa). Pressure reducing modulating dampers may be required at the floor air supply points. They should be controlled by an electronic differential pressure sensor measuring the under floor pressure relative to the room above. Typically, a sampling tube with holes located every few feet will represent the average under floor pressure well. One transmitter per floor, or maximum area of 15,000 ft2 (1,394 m2) is sufficient.

The reaction time of the plenum pressure control should be faster than that of the air handling unit to ensure air pressure and volume stability.

The control loops can be interactive, so the worst case plenum pressure modulating damper is fully open at the supply duct static setpoint. This "resetting" of duct static pressure can be achieved by monitoring the positions of the plenum supply dampers and adjusting the duct pressure to keep at least one plenum damper fully open.

The static pressure sensor, acting through the air handling unit controller shall, on a decrease in downstream duct static pressure, increase the speed signal to the supply fan variable speed drive. On a rise in downstream duct static pressure, the reverse shall occur. The variable speed fan drive shall have necessary ramp-up and ramp-down parameters set to keep the fan current within normal operating ranges during speed changes.

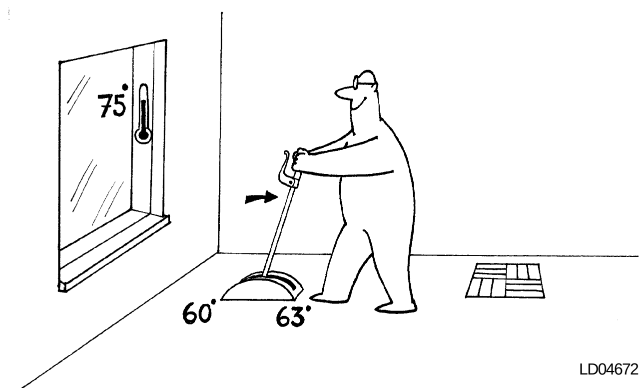
16.6 Supply air drybulb temperature reset

The supply air temperature to the MIT at maximum load conditions should not be allowed to fall below 60°F (15.6°C). However, at times when there is less than the design load, it can be reset upwards, ensuring that the required dehumidification is not impaired (see Section 8). This improves system efficiency and ensures ventilation effectiveness.

The system needs to measure the demand for cooling to implement this function. This can be accomplished by measuring fan energy consumption, air volume, and relative damper positions. Based on this measurement, the supply air temperature can be reset upwards as demand reduces. It can be accomplished automatically through the building's control system. A simple manual adjustment can be made by the building system operator for small systems.

16.7 Space pressure control

The building should be maintained at a very slight positive air pressure to limit the infiltration of non-conditioned air. A pressure that is too low would cause an increase in system energy consumption and lower air quality. A pressure that is too high would cause a loss of conditioned air to the outside.



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A high precision electronic space differential pressure transducer is necessary to achieve precise space pressure control. It compares outside pressure with inside pressure, and then signals the modulating return air dampers. The damper is closed to increase space pressure and opened to reduce it.

Because plenum based under floor systems operate at a very low static pressure, the accuracy and stability of space pressure control are essential. A careful choice of instrumentation and loop tuning is needed to produce stable and reliable system operation.

17. Applications

17.1 Occupancy types

1. The MIT excels in providing comfort in **office buildings,** especially with high densities, small cubicles and high churn rates that need flexibility.

2. **Any building** that uses a raised floor for other purposes should use a raised floor for HVAC with the exception of clean room applications that benefit from floor return systems.

3. **Schools and light manufacturing** applications that do not involve the spillage of liquids into the floor are also good candidates.

4. Any high ceiling area or room such as an **auditorium, theater, conference room or converted warehouse** space makes an ideal MIT application.

5. CEV and MIT work well when low noise and high air quality are issues. This applies to **television studios** that have high heat loads and need to cool people at the floor in a silent manner.

6. If the occupancy demands or wants many control zones, MIT is the answer. It can provide personal zoning if desired, in a manner that is more cost effective than any other system.

7. MIT with an access floor can solve retrofit and refurbishment problems with buildings that do not have room for ducts in the ceilings or those that want to avoid touching ceiling spaces (hazardous material abatement).

8. MIT is ideal for both high-end and low-end budgets because it offers high end features at low end first cost.

9. Because MIT has the best life cycle cost, it should be of primary interest to owner **occupied buildings.**

10. Because MIT can be relocated like furniture, it can appeal to lower depreciation cycles and "green" concept of reuse (lower depreciated life implies a payback in fewer years).

17. Applications

17.2 Control and other cost issues

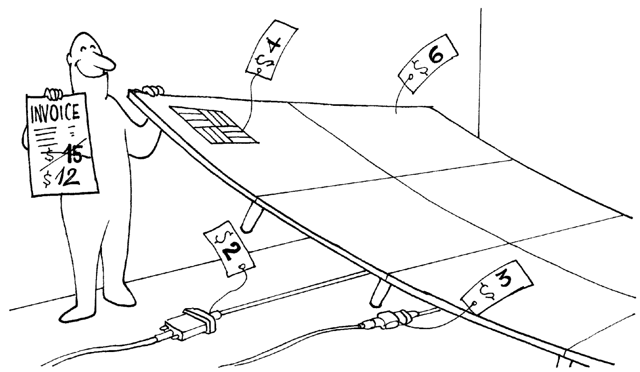
1. More controls usually provide more comfort; they always result in more cost. Smaller control zones (and consequently more of them) ensure personalized comfort conditions, but remember that an MIT thermostatically controlled unit (model C) costs about twice as much as a slave unit (model A). Fortunately, control units can be added after the installation is completed, when and where they are justified. Conversion kits are available to field modify MIT's from manual or no control to full control.

2. Fully networked building control systems, including the MIT's operation, are more expensive than using local control devices on the terminals. The level of sophistication is limited by the control system connected to the MIT network. Because MIT uses an open protocol, there are no proprietary interface problems.

3. "Plug-and-play" wiring is intended to be used with the MIT controls. It requires no special skills to install or maintain, and in a matter of seconds the wiring is snapped onto the MIT. This method of wiring not only reduces initial costs, but also the cost of any subsequent reconfiguring. In many locations only one trade is needed to do the complete MIT installation.

4. Not only do the MIT damper actuators take their electrical power from the under floor wiring, but the fan powered heaters, including resistance heaters, when fitted, can be powered from this convenient source. If modular wiring is used throughout the underfloor system, wiring costs are reduced. Items like disconnects and conduit can be replaced with plug-in cables.

5. MIT's can be networked from a single thermostat and Power Control Module (PCM) or multiple PCM's can be daisy-chained to form huge zones. A single PCM serves up to 14 MIT's (2100 cfm [991 l/s] total), but multiple PCM's can be added to provide unlimited capacity responding to a single thermostat.



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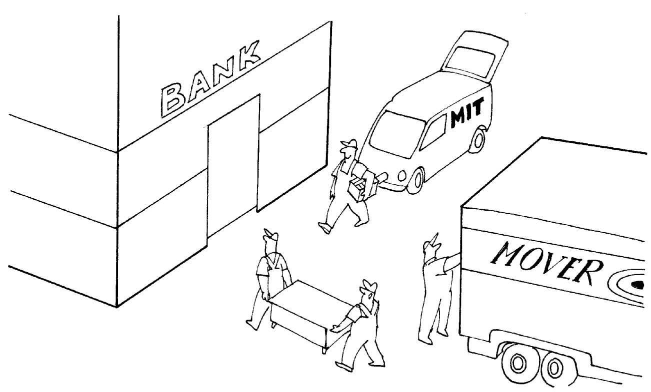
6. After installation, the plug-and-play wiring makes control changes user friendly. Relatively little skill is required to rezone an area. Adding thermostats may just be a plug-in operation. MIT's are no more difficult to move and install than furniture.



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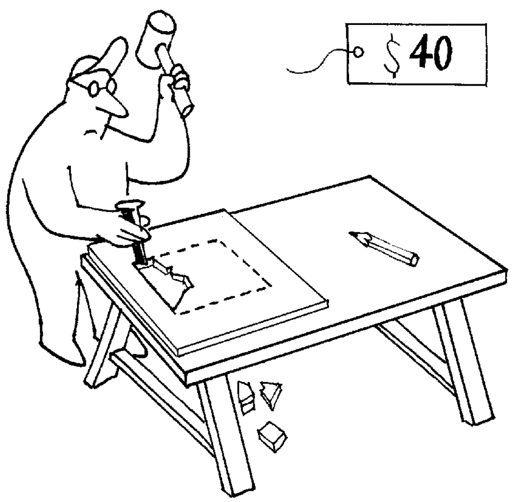
7. Installation cost can be significantly reduced if prepunched floor panels are used. York has established a standard size that allows the panel manufacturer to punch a single size hole at the factory, eliminating expensive field labor cost. MIT and electrical junction boxes can also fit the same sized hole, eliminating the need to inventory spare panels for each type of hole.



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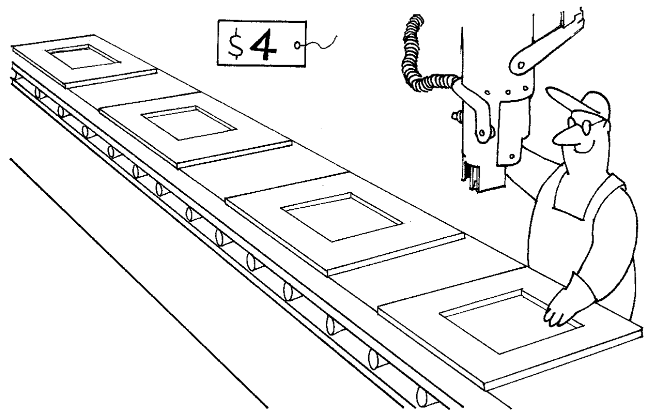
17.3 System choice issues

York's MIT air-conditioning is an integral part of the complete raised flooring system. The system normally includes all the power cabling. Tele-communications wiring will be passed through the under floor plenum as tenants move in. Consideration of the advantages and features offered by a raised-floor system as a whole will reveal a different cost story than considering each one of them separately. When considering the cost of an MIT system, "the sum is less than the total of the parts!"

- The cost of a constant volume MIT model A is about half of variable volume model C cost. If an area has a minimum air requirement, for example, to meet a ventilation requirement, it is more cost effective to deliver this minimum air quantity with the MIT model A. The same reasoning holds when the minimum load dictates more air than the nominal rating of an MIT, i.e., 150 CFM (71 l/s): use constant volume versions for the base load. This choice of models is a tool in lowering cost and preventing buying more capability than is initially needed. The user can always upgrade and modify later without a cost penalty.

- MIT terminals can be used for heating as well as cooling. The additional cost of a separate heating system is unnecessary. Model G's can double as cooling units in summer, and heating units in winter, saving on the terminals' cost.



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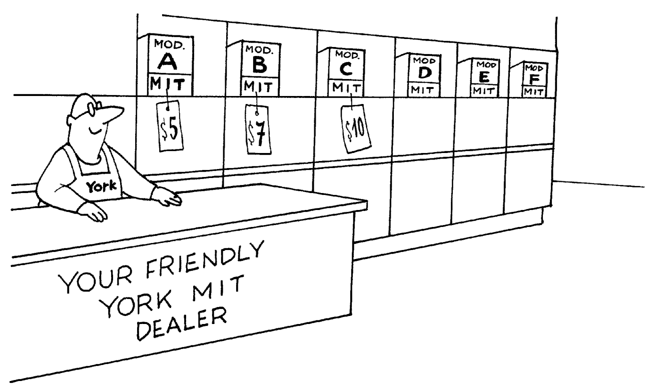
- MIT terminals do not need to be supplied by high precision, computer grade air handling units. They are tolerant of variations in the temperature and humidity of the supply air, adapting their discharge air quantity by means of the automatic air damper. However, the appropriate supply air pressure should be maintained. Several types of York rooftop, central station, floor mounted equipment, in chilled water and direct expansion versions, are suitable for use.



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17. Applications

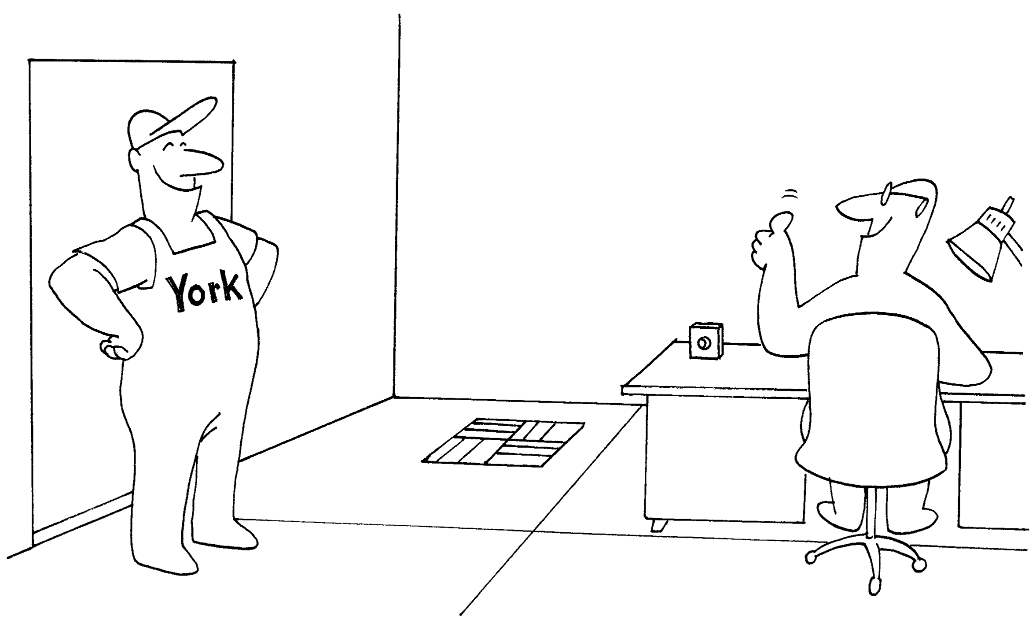
- Studies have shown that the first cost of an MIT VAV underfloor system with good zoning is about the same as an overhead system with good zoning. An MIT system with better zoning will cost less than an overhead system with poor zoning. In a constant volume system, the MIT constant volume terminals will generally cost less than competitive terminals because of their greater capacity and flexibility. However, a constant volume system with good zoning will always cost more than an MIT VAV system.

- Both the overhead VAV and constant volume underfloor systems will use more energy than a properly designed MIT VAV/CEV system. It should be noted that comfort with an MIT system should be equal or better than these systems under all conditions, due to the flexibility an MIT system provides.

- The CEV and YORK MIT are "comfort first" systems designed to meet comfort needs, IAQ, codes and energy conservation. Simple installation and easy maintenance lead to lower life cycle cost. Traditional systems cannot match the flexibility given the user in meeting individual needs.

- It is important to use the flexibility of the access floor and the MIT to address user complaints. A refreshing "cool breeze" to one person may be an annoying draft to another. Location of the MIT, grille orientation, and space temperature setpoint can be adjusted to satisfy most complaints. Tenants should be encouraged to find their individual comfort level by using the flexibility of the system.

- Just like any system, things can go wrong with CEV and MIT. There are no perfect HVAC systems. Care should be exercised to properly apply CEV and the MIT models to best meet the application. However, the MIT system flexibility should allow less costly and quicker correction of deficiencies. It is important that the primary system has adequate heating, refrigeration and fan capacity to take advantage of the MIT flexibility.



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18. Comparison of Technologies

FEATURE	MIT SYSTEM	EARLIER SYSTEMS
Discharge grille material	Aluminum, die cast, NFPA 90A compliant	Plastic, not fire/smoke code compliant
Chassis and internal parts material	Galvanized steel, NFPA 90A compliant	Galvanized steel and some plastic parts
Number of air pattern possibilities	16, from straight up to 360' flare	One, only straight up swirl" configuration, or two, vertical and flat swirl
Minimum distance, user to grille	Inches (centimeters)	3 feet (.9 meters)
Heating mode air discharge	Directly up the wall or window	Swirl pattern
System type	All-air, variable volume, constant velocity	All-air, constant volume after initial manual set, constant velocity
Control type	User thermostat, controlling air volume	Zone thermostat, controlling air temperature
Nominal unit air flow	150 CFM (71 l/s)	90 or 100 CFM (42 or 47 l/s)
Zoning method	Each unit delineates a zone	Under floor plenum dividers delineate zones
Ease of adding/changing zones	Simply move or add MIT units	Move or add under floor plenum dividers
Availability of complementary air-conditioning equipment	Entire range of complementary system equipment available from York	Complementary system equipment only available from additional/different manufacturers

19. Additional Information

In conjunction with this manual, there are **product data sheets** that fully describe the performance of all MIT terminals and associated components of the CEV system provided by YORK. These products are constantly being updated and improved so it is important to get the latest available information on this new technology. Also, specific **application guides** have been prepared that illustrate the concepts presented in this manual. For easy reference, **annotated guide specifications** are also available that cover all the CEV products available from YORK. Together these items and this manual provide a complete description of the CEV technology.

For additional information, contact your local YORK dealer.

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