Temperature Control and Zoning of UFAD Systems

Presented by TROX USA

Raised access flooring systems have become a very popular conduit for the delivery of power, voice and data services, as their accessibility affords easy relocation and reconfiguration of the space and its services. The addition of an underfloor air distribution (UFAD) can extend this flexibility to the HVAC services as well.

This document explores the effects of the floor cavity on the performance of UFAD systems and discusses various temperature control and zoning alternatives that have been commonly used in these applications.

Underfloor Air Distribution

Underfloor air distribution systems reside in the space beneath the raised floor system, and rely primarily on the pressurization of that void to deliver conditioned air to diffusers and terminals located throughout the floor plate. As the cavity also houses the other services which rely on modular cabling, it is desirable to minimize the amount of ductwork within the plenum as it represents a potential obstruction to the relocation of the other services.

Unlike overhead systems whose conditioned air delivery is accomplished exclusively by ductwork and a series of automatically controlled dampers, a good UFAD design utilizes ductwork only where absolutely necessary.

TROX FB series floor diffusers are the cornerstone to an efficient UFAD design. These outlets are designed to induce large volumes of room air and mix it with the supply air stream to rapidly reduce the temperature and velocity differentials between it and the ambient air. This results in well mixed conditions in the lower few feet of the space (and provides a comfortable environment for the space occupants) while maintaining displacement ventilation of respiratory contaminants.

FB series diffusers incorporate a patented damper which affords the occupants adjustment of the outlet airflow by simply rotating the diffuser face. This accommodates individual comfort preferences and makes the occupants feel like they can control their own thermal environment. FB series diffusers are designed for airflow rates and clear zones that encourage their placement in each office and workstation. Doing so allows the formation of a personal relationship between the occupant and his/her diffuser which has proven to significantly improve thermal comfort perception.

Plenum Effects in UFAD Systems

The use of the cavity as a supply plenum also introduces certain heat transfer effects that do not normally affect ducted HVAC systems. If they are not anticipated and considered in the design, they can significantly compromise the system's ability to condition the space.

Conditioned air is usually delivered to the floor cavity at 60 to 63°F. The use of colder air is not recommended because it is desirable to maintain the relative humidity on the slab surface below 80%. Once discharged into the open plenum the velocity of the air decreases very rapidly as its residence time is quite lengthy. Velocities in the floor cavity are very low (typically between 25 and 50 FPM) so friction losses in the floor plenum are minimal and good distribution of the air is almost always assured. The air distribution performance capabilities of the system are dependent primarily on the sealing of the plenum cavity. As the vertical plenum boundaries are formed by structural elements such as drywall, visual inspection of the surfaces (to assure a sufficient seal) is recommended prior to installation of the raised floor platform.

Although the distribution of air in a well sealed plenum is rarely an issue, heat transfer through the plenum boundaries should be understood and its effects considered when sizing and selecting components for UFAD systems. In most UFAD systems, return air (at 80 to 84°F) travels across the under side of the slab which forms the lower surface of the supply air plenum. Heat transferred to the slab eventually enters the floor

plenum and warms the supply air as its travels across its surface. Although the exact effect of this heat transfer is dependent on numerous factors (building construction, air velocities, supply and return air temperatures, etc.), it is generally agreed that the temperature rise (ΔT_P) of supply air traveling through the floor plenum can be estimated by the following equation:

$$\Delta T_P = (0.05 \times \text{Distance traveled, ft})^{1.5}$$

For example, this equation would predict the temperature rise of supply air traveling 50 feet through the open floor plenum to be about 4°F. This effect can be reduced by keeping the supply air within a duct or "air highway" to minimize its travel within the open plenum. Many designers specify such ductwork to assure that the distance from the air injection point to the furthest diffuser or air terminal doesn't exceed 30 to 40 feet. It should, however, be noted that air highways will likely obstruct the future relocation of cabling within the floor plenum and as such their size and employment should be limited.

Another heat transfer effect that should be considered is the conduction of heat from the building façade to the perimeter extremities of the floor slab. Solar energy which impinges the façade is either transmitted into the space (through the glass), absorbed or reflected. The absorbed portion of this energy is transformed to heat which is either transferred to the outside air or other building elements contacting the façade. While the effect of this transmission is neither immediate nor extensively spread, it can cause a significant temperature rise (6 to 10°F) in the outer 4 to 6 feet of the slab. This may result in a similar temperature rise of the supply air entering air terminals and diffusers located directly adjacent to the façade.

This effect is more pronounced on Eastern and Southern exposures which encounter peak solar loads earlier in the day as the thermal storage capacities of the slab creates a thermal lag of several hours.

Return Air Considerations in UFAD Systems

Efficient operation of UFAD systems requires that all return openings be located at least eight feet above the floor. It is also imperative that any partitioned space be provided with either a return outlet or a high level transfer grille. The objective of the return air strategy should be to remove the warmest and most contaminated air, which is always found at the ceiling when thermally stratified air systems are employed. With respect to this, perimeter areas are best treated with an ample return located directly adjacent to the perimeter wall. This will afford warm air currents rising up the wall to escape naturally and avoid mixing this heat back into the occupied levels of the space.

Heating Considerations in UFAD Systems

Perimeter areas in UFAD systems usually require heating of the space during certain portions of the year. In addition, some degree of early morning warm-up is often required in interior spaces. It is not generally recommended that warm air be delivered through the floor air cavity as the slab will be heated and may require a significant amount of cooling before it is returned to equilibrium and adequate space cooling is restored. Instead, any heating (or reheating) of the air should be accomplished within the terminal units in the floor cavity where the warm air can be discharged directly to the space.

Static heat (such as baseboard and trench radiation) is very effective and economical for UFAD systems. A portion of the floor plenum adjacent to the building façade can be sectioned off and fin tube coils located below the surface of the access floor. A thin (3 to 4 inch wide) section of linear grille can then be ran continuously between the façade and the access floor termination which allows downdrafts to enter the floor void and heated air to rise up the outer wall.

When fan terminals are utilized for heating perimeter spaces, high induction floor diffusers

should be preferred over linear grilles. These diffusers induce large quantities of room air and mix it quickly with the supply air stream. This helps deliver the heat throughout the occupied levels of the space as opposed to blasting it up the wall at high velocities, essentially short circuiting the heat to the overhead return.

Temperature Control and Zoning

Efficient UFAD designs provide excellent thermal comfort while minimizing ductwork and other obstructions that might affect future relocation in the space and configuration of space services. In order to arrive at such a design, each area of the floor plate should be analyzed as to its current (and possible future) use and the thermal load profiles associated with its use. An appropriate temperature control and zoning strategy can then be tailored for each area that assures occupant comfort while minimizing the task of future space and services reconfiguration.

The subsequent sections of this document are intended to assist the designer in developing such an efficient temperature control and zoning strategy by profiling the types of thermal loads that may be found in various parts of the building and discussing alternative methods of treating these areas.

Interior Open Office Areas

The heat gains in these areas predominantly emanate from people, equipment and lighting which do not vary quickly or significantly. There is generally no heating requirement in these areas.

As such, the employment of manually adjustable floor diffusers (TROX FB series) within each workstation areas results in a very high degree of thermal comfort. Each occupant can adjust their diffuser to their own liking while a constant static pressure is maintained in the floor plenum to prevent the opening and closing of individual diffusers from affecting the airflow delivery to other workstations. Strategy G101 illustrates such operation.

Interior Area Partitioned Offices

Partitioned offices with no external exposure are subjected to intermittent loads. During occupied periods, loads are primarily attributable to people, equipment and lighting and do not vary much. However, when the occupants leave, the loads go away. If conditioned air continues to be delivered when loads are not present, the space will be overcooled.

TROX FB-VAV series diffusers are fitted with an integral actuator which repositions the damper in response to a space thermostat signal. These are also ideal for retrofit as the actuator and all of its associated components are contained in a basket that can be dropped into an existing FB diffuser carpet flange and do not require removal, modification or alteration of the access floor or its carpeted surface. They are ideal for use in interior private offices in either ON/OFF operation (by a motion sensor) or VAV operation (controlled by a space thermostat). Control strategy G102 illustrates this application.

Interior Conference and Assembly Areas

The load in these areas is also dependent on occupancy, but that occupancy can vary considerably as well. Large conference areas may be designed for upward of 20 occupants but have periods where only a few occupants are present. In this case, a variable air volume solution that is capable of shutting off the airflow during unoccupied periods is optimal.

TROX TMFT-C fan terminals are designed specifically for conference and assembly area applications. These terminals, which deliver up to 325 CFM each, are provided with dual blowers whose rotational speed is varied according to the space cooling demand indicated by the space thermostat. Airflow is delivery to the space through two FB series floor diffusers located in the floor tile directly above the terminal. There is

no inlet or discharge ductwork making the relocation of these terminals a breeze. Control strategy C101 illustrates the use of TMFT-C terminals in conference areas.

Smaller conference and assembly areas may have airflow requirements below the delivery capacity of the TMFT terminals. In this case, FB-VAV diffusers (prescribed previously for private offices) can be controlled by a space thermostat. This is illustrated in control strategy C102.

Prevention of Overcooling in Interior Zones

If a substantial part of the workforce is not present (and their diffusers are left in an open position), the airflow delivery may exceed the cooling requirements of the space. In order to prevent this, some type of plenum pressure or supply air temperature reset should be considered. Resetting the supply air temperature is risky because it may compromise the ability of the system to simultaneously cool perimeter areas. A better solution is to reset the plenum pressure, which in turn reduces the airflow delivery through all of the non-fan assisted outlets on the floor. Areas conditioned by fan assisted outlets (whose cooling requirements are sensed and adjusted by a space thermostat) will not be affected by the plenum pressure reduction as their associated fans will overcome the slight changes in pressure to deliver the required airflow. A single temperature sensor (per floor) within the open office area can be used to monitor the space temperature and control the plenum pressure.

Perimeter Areas

Unlike interior spaces, loads in perimeter areas may vary significantly and frequently due to external heat gain fluctuations. In particular, heat gains due to solar transmission largely determine the cooling requirements in these spaces. These gains can fluctuate greatly over short time periods as the sun passes in and out from behind clouds. In addition, this perimeter heat transfer usually demands that space heating be accomplished during parts of the year. As such, some type of automatic temperature control is required for all perimeter areas.

Fan terminals have been a popular solution for these perimeter areas as their air volume delivery and/or its temperature can be easily varied. If fan terminals are to be used for perimeter zone treatment, they must be designed to fit within the support structure of the access floor. It should be noted that gaining access to fan terminals is often difficult or impossible once furniture and or partitions have been located on top of the access floor platform. This is a considerable drawback as fan terminals require routine maintenance and have numerous moving parts that are subject to failure.

TROX FT series fan terminals are designed to coordinate with the support structure of the raised access flooring system and provide variable volume and/or temperature supply of conditioned air to perimeter areas. These terminals are available in four sizes and seven basic models, each of which can be furnished with either hot water or electric reheat coils.

There are several operational decisions that must be made regarding the application of fan terminals in UFAD systems, including,

- What reheat medium is to be used?

  Although terminals with electric heat are much easier to install and relocate, some area building codes discourage their use due to energy considerations. Hot water coils are also available and offer the advantage of having much simpler controls which are less likely to require maintenance.

- What is to be the source of air for heating?

  Overhead fan terminals use return air from the ceiling plenum as their reheat source. It is readily available (does not require ducting) and it is some 25 degrees warmer than the alternative air source (primary air). In the case

of fan terminals in UFAD systems, any return air must be ducted creating a potential sound path for unwanted fan noise to enter the room. In addition, room air pulled from the floor level will only be 7 to 8°F warmer than the conditioned air in the floor plenum (64 to 67°F) at the perimeter. It is questionable whether the heat recovery created by the use of room air is worth potentially creating a noise problem and significantly reducing the ease of relocation of the terminal.

- How are they to vary the delivery of cooling and heating to the occupied space?

  There are models available that operate at a continuous constant volume delivery and vary the temperature of that delivery by reducing the volume of conditioned air from the floor plenum and supplementing it with recirculated room air. This operation is identical to that of series type fan terminals used in overhead systems. Unfortunately, ductwork must be provided from the inlet side of the fan to a return inlet in the access floor to capture the room air. This can also create a unwanted sound path for the transmission of fan noise. TROX FTR series fan terminals (see strategy P103) employ this operational strategy.

  Other models are available that vary the conditioned air volume to the space (without supplementing it with recirculated air). These terminals may employ variable speed motors to provide continuous operation while varying the delivered air volume. Strategy P101 illustrates the use of TROX FTV series fan terminals to accomplish this operation. In this case the fan speed is varied in response to the space thermostat demand. TMFT-E series terminals can also be used in for variable speed operation (see strategy P102) and provide optimal control and ease of space relocation as they require no inlet or outlet ductwork.

  Another method of achieving a variable air volume delivery is to cycle the fan according to the space thermostat demand. In this case the fan operates at a constant volume when energized, but is intermittently cycled on and off. Strategy P105 illustrates the use of TROX FTU series terminals to perform this operation. In this case, the fan is operated during peak cooling and heating operation while an damper in the downstream section of the terminal varies the delivery of conditioned air in response to the thermostat during normal cooling operation (the fan remains off).

  Finally, the perimeter zone treatment illustrated in strategy P104 is promoted by one major supplier of UFAD equipment. It utilizes the fan terminal only during heating operation. Floor diffusers fed by a dual entry plenum box with an automatically controlled damper are connected to both the inlet and discharge side of the terminal via flexible duct. During cooling operation, the dampers on all of these assemblies vary the delivery of cool air to the space in response to the space thermostat. Upon a drop in space temperature, these dampers close, the fan and reheat coil is energized and deliver a constant volume of reheated room air to the space through the diffusers on the discharge side of the terminal. The diffusers on the inlet side of the fan become returns and deliver room air to the fan terminal. Although this operation is illustrated using TROX FTC series terminals, its employment is not encouraged due to several drawbacks. First of all, perimeter area HVAC design in most North American climates is driven primarily by the space cooling demands. It does not seem prudent to supply a fan terminal in perimeter areas but provide no provisions that allow its use during peak cooling periods. More importantly, the heat transfer effect (previously discussed) between the façade and the slab threatens to compromise the perimeter cooling capabilities of non-fan assisted terminals

located closely adjacent to the perimeter wall. Finally, the reset of plenum pressure (in response to an interior space temperature drop) cannot be employed with non-fan assisted outlets on the perimeter as their airflow will be reduced proportionally to that of the interior areas.

Hydronic Treatment of Perimeter Zones

Passive chilled beams represent an attractive alternative to fan terminals for the treatment of perimeter spaces. The operation of these beams is illustrated in the figure below. Convective cooling coils are placed in a soffit which is positioned between the structural beams and directly above the exterior exposure. Warm air along the perimeter surface rises into the cabinet of the beam, is cooled by the coil, then drops back into the space. The flow rate of chilled water (at 60 to 62°F) through the coil is varied in accordance with the space thermostat demand. The se beams are selected to offset the heat gains associated with the perimeter exposure plus some portion of the occupant, equipment and lighting load. Manually adjustable floor diffusers (FB series) are also located in the perimeter spaces to provide space ventilation and dehumidification. As these beams do not perform during heating operation, a low level hydronic (or electric resistance) heating system accompanies it. This operation is illustrated in strategy P106.

This publication was prepared and distributed by TROX USA and is intended for use by engineers and architects involved in the design of underfloor air distribution systems. For further details on the subject of UFAD design, please contact:

TROX USA
926 Curie Drive
Alpharetta, Georgia 30005

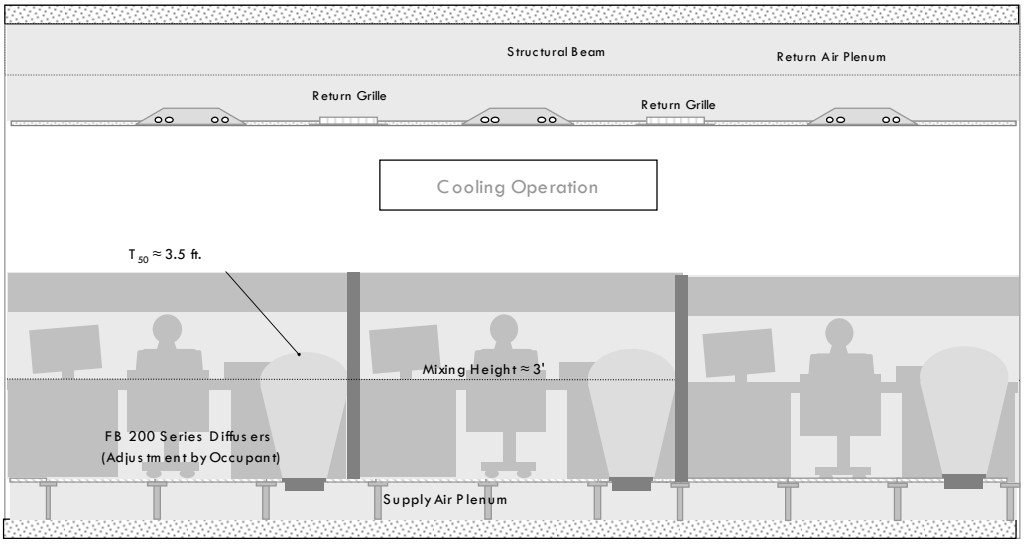
Telephone: (770) 569-1433
Telefax: (770) 569-1435

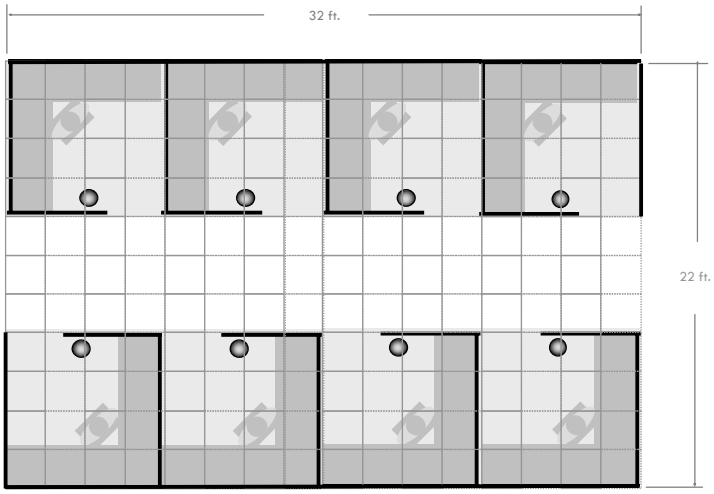
e-mail: ufad@troxusa.com

www.troxusa.com

Temperature Control and Zoning of Interior Areas in UFAD Systems

Strategy G101, Open Office Area Cooling with Manually Adjustable Floor Diffusers





PLAN VIEW

OPERATIONAL DESCRIPTION

Manually adjustable floor diffusers are located within each work station. Occupants are allowed to adjust the airflow of the outlet in their workstation to their individual preference. A constant static pressure is maintained in the supply air cavity. This pressure set point can be reduced in response to a signal from a representative wall mounted temperature sensor indicating the space temperature level has dropped.

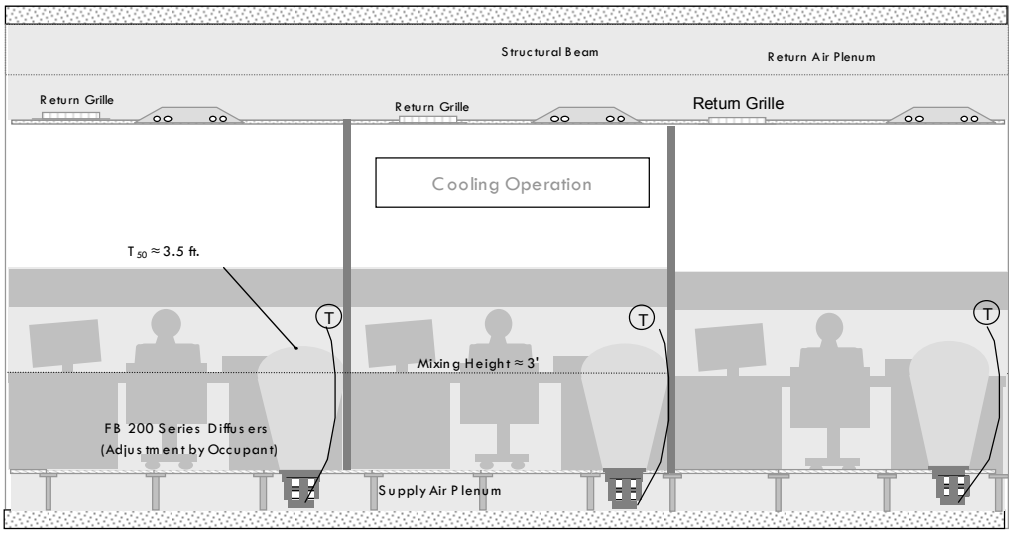
Room air conditions are highly stratified, mixed conditions exist to approximately the 3 foot level of the space. Displacement ventilation of space respiratory contaminants is accomplished.

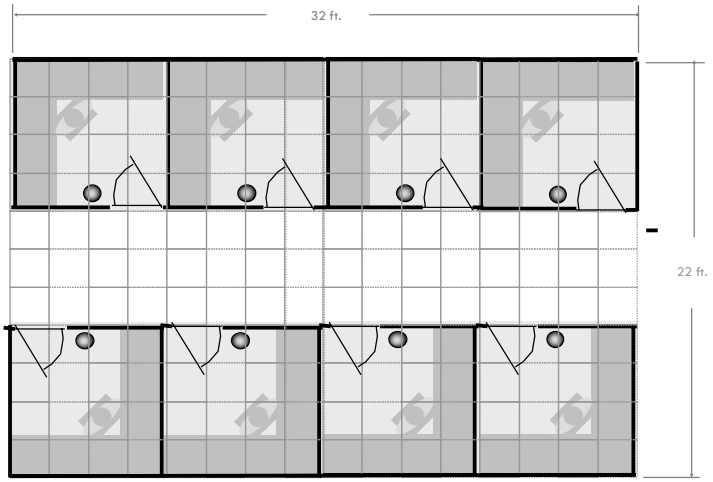
TYPICAL PERFORMANCE CHARACTERISTICS

- **Design Cooling:** 0.4 to 0.8 CFM per ft^2
- **Stratification :** 35 to 40%
- **Ventilation Effectiveness:** 1.2
- **Mobility** Excellent
- **Accessibility** Excellent
- **Acoustics:** Fair
- **Slab Effects:** Low Risk

Temperature Control and Zoning of Interior Areas in UFAD Systems

Strategy G102, Private Office Cooling with Thermostatically Controlled Floor Diffusers





PLAN VIEW

OPERATIONAL DESCRIPTION

During occupied periods, FB-VAV series diffusers deliver cool air (from the pressurized supply plenum) at flow rates proportional to the space cooling demand in response to a space thermostat. When the space is unoccupied, an occupancy sensor signals the VAV dampers to close, shutting off the flow of cool air to the space.

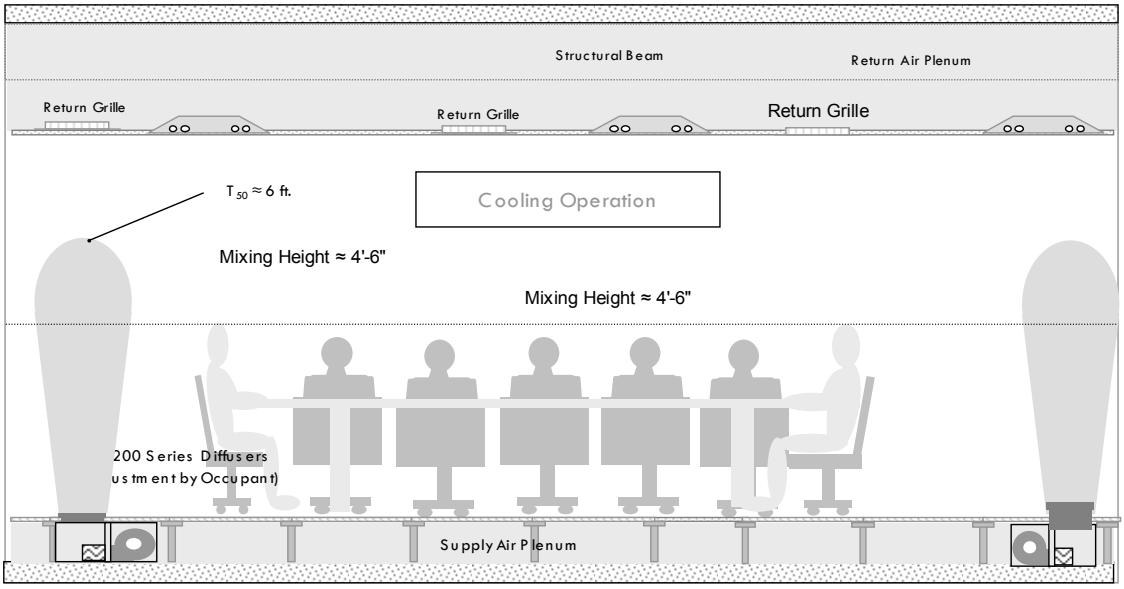
Room air conditions are highly stratified, mixed conditions exist to approximately the 3 foot level of the space. Displacement ventilation of space respiratory contaminants is accomplished.

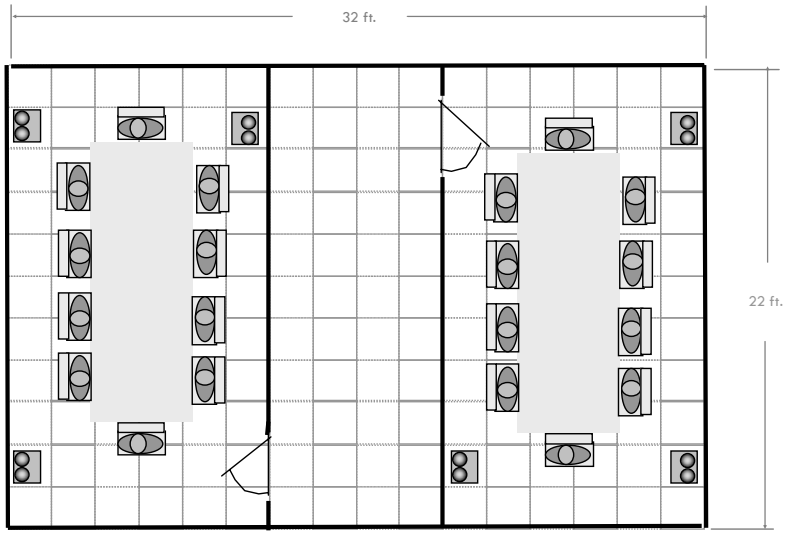
TYPICAL PERFORMANCE CHARACTERISTICS

- **Design Cooling:** 0.4 to 0.8 CFM per ft^2
- **Stratification :** 35 to 40%
- **Ventilation Effectiveness:** 1.2
- **Mobility** Excellent
- **Accessibility** Excellent
- **Acoustics:** Fair
- **Slab Effects:** Low Risk

Temperature Control and Zoning of Interior Areas in UFAD Systems

Strategy C101, Conference Area Cooling with Modular (VAV) Fan Terminals





PLAN VIEW

OPERATIONAL DESCRIPTION

Fan speed modulation allows the delivery of cool air (from the pressurized supply plenum) in flow rates proportional to the actual space cooling demand. This airflow ranges between a maximum (design cooling) and a predetermined minimum airflow rate. During heating operation the fan delivers a constant volume of reheated air to the space. The heating airflow rate is independent of the cooling maximum or minimum airflow rate.

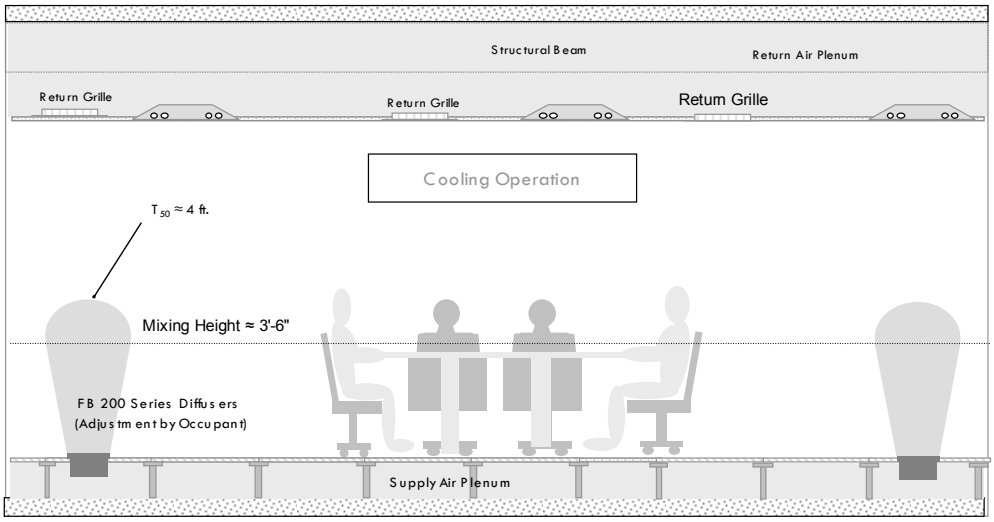
Room air conditions are slightly stratified, but mixed conditions exist to approximately 6 foot level during design cooling and heating operation, negating most displacement advantages.

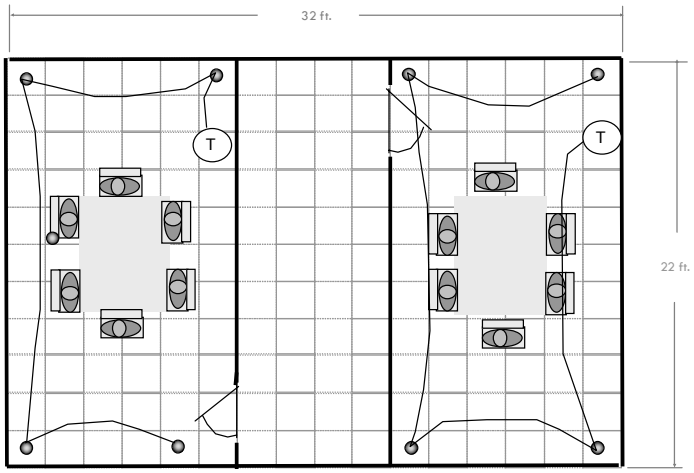
TYPICAL PERFORMANCE CHARACTERISTICS

- **Design Cooling:** 1..0 to 3.0 CFM per ft^2
- **Stratification :** 15 to 20%
- **Ventilation Effectiveness:** 0.9
- **Mobility** Good
- **Accessibility** Excellent
- **Energy Use:** Good
- **Acoustics:** Good
- **Slab Effects:** Low Risk

Temperature Control and Zoning of Interior Areas in UFAD Systems

Strategy C102, Conference Area Cooling with Thermostatically Controlled Floor Diffusers





PLAN VIEW

OPERATIONAL DESCRIPTION

During occupied periods, FB-VAV series diffusers deliver cool air (from the pressurized supply plenum) at flow rates proportional to the space cooling demand in response to a space thermostat. When the space is unoccupied, an occupancy sensor signals the VAV dampers to close, shutting off the flow of cool air to the space.

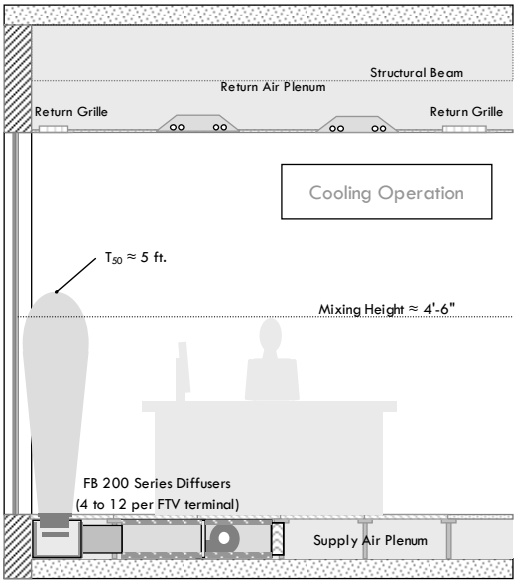
Room air conditions are highly stratified, mixed conditions exist to approximately the 3 foot level of the space. Displacement ventilation of space respiratory contaminants is accomplished.

TYPICAL PERFORMANCE CHARACTERISTICS

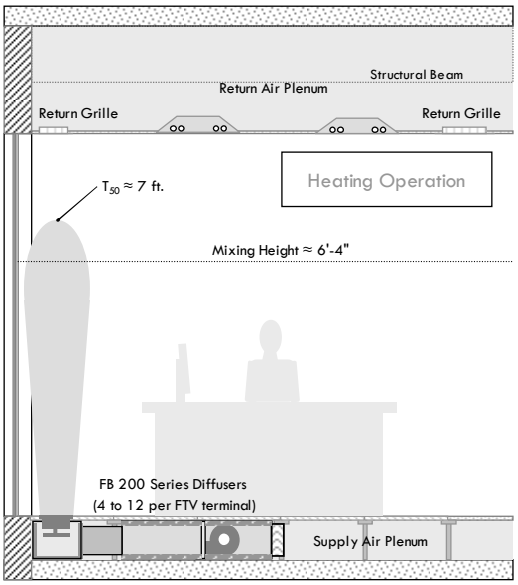
- **Design Cooling:** 1..0 to 3.0 CFM per ft^2
- **Stratification :** 35 to 40%
- **Ventilation Effectiveness:** 1.2
- **Mobility** Good
- **Accessibility** Excellent
- **Energy Use:** Good
- **Acoustics:** Good
- **Slab Effects:** Low Risk

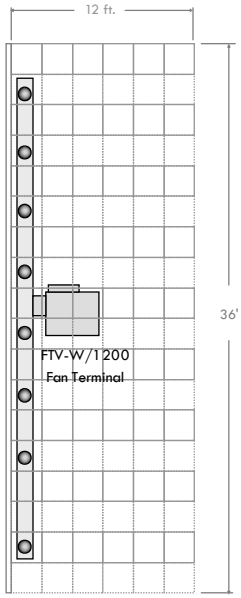
Temperature Control and Zoning of Perimeter Areas in UFAD Systems

Strategy P101, Variable Speed Fan Terminals (FTV Series)



FTV-W Fan Terminal



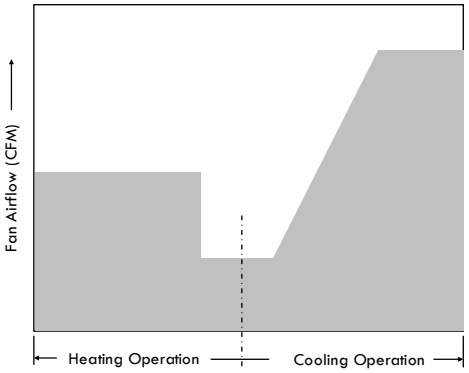


PLAN VIEW

Fan terminal and diffuser layout illustrated is based on a cooling design airflow of 30 CFM/lf (of perimeter wall) and heating requirements of 15 CFM/lf.

Fan Terminal Models:

- FTV-W Series (Hot Water Reheat)
- FTV-E Series (Electric Reheat)



OPERATIONAL SEQUENCE

OPERATIONAL DESCRIPTION

Fan speed modulation allows the delivery of cool air (from the pressurized supply plenum) in flow rates proportional to the actual space cooling demand. This airflow ranges between a maximum (design cooling) and a predetermined minimum airflow rate. During heating operation the fan delivers a constant volume of reheated air to the space. The heating airflow rate is independent of the cooling maximum or minimum airflow rate.

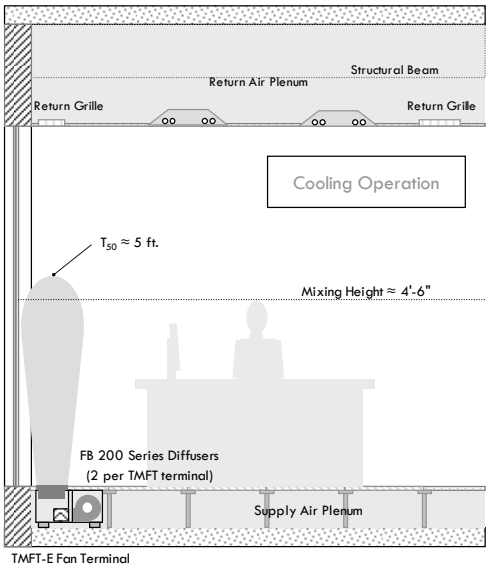
Room air conditions are slightly stratified, but mixed conditions exist to approximately 6 foot level during design cooling and heating operation, negating most displacement advantages.

TYPICAL PERFORMANCE CHARACTERISTICS

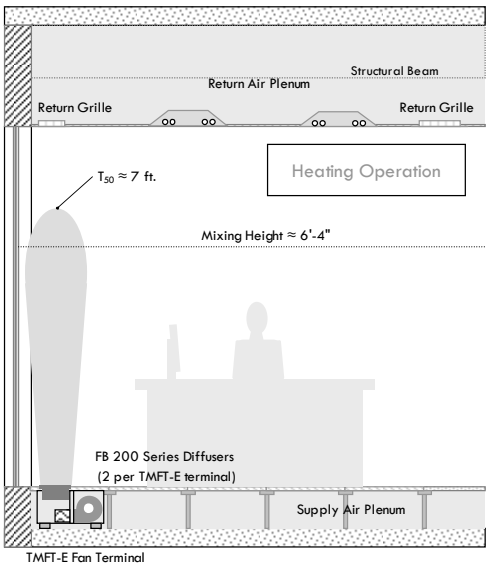
- **Design Cooling:** 2..0 to 3.2 CFM per ft^2
- **Design Heating:** 0.5 to 1.0 CFM per ft^2
- **Stratification :** 15 to 20%
- **Ventilation Effectiveness:** 0.9
- **Reheat Air Source:** Plenum Air
- **Reheat Coil:** Hot Water or Electric
- **Mobility** Fair
- **Accessibility** Poor
- **Energy Use:** Good
- **Acoustics:** Fair
- **Slab Effects:** Low Risk

Temperature Control and Zoning of Perimeter Areas in UFAD Systems

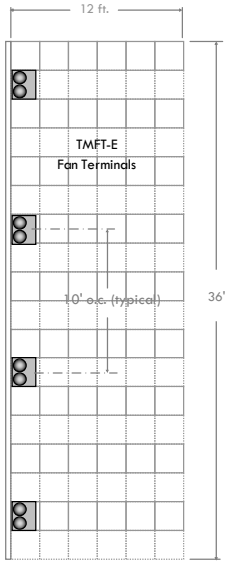
Strategy P102, Modular Fan Terminals (TMFT Series)



TMFT-E Fan Terminal



TMFT-E Fan Terminal

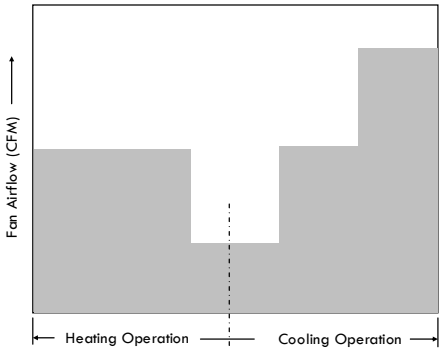


PLAN VIEW

Fan terminal and diffuser layout illustrated is based on a cooling design airflow of 30 CFM/lf (of perimeter wall) and heating requirements of 15 CFM/lf.

Fan Terminal Models:

- TMFT-E Series (Electric Reheat)



OPERATIONAL SEQUENCE

OPERATIONAL DESCRIPTION

Fan speed sequencing (stepped) allows the delivery of cool air (from the pressurized supply plenum) in flow rates proportional to the actual space cooling demand. This airflow ranges between a maximum (design cooling) and a predetermined minimum airflow rate. During heating operation the fan delivers a constant volume of reheated air to the space. Heating is accomplished on either the high or medium fan sped setting.

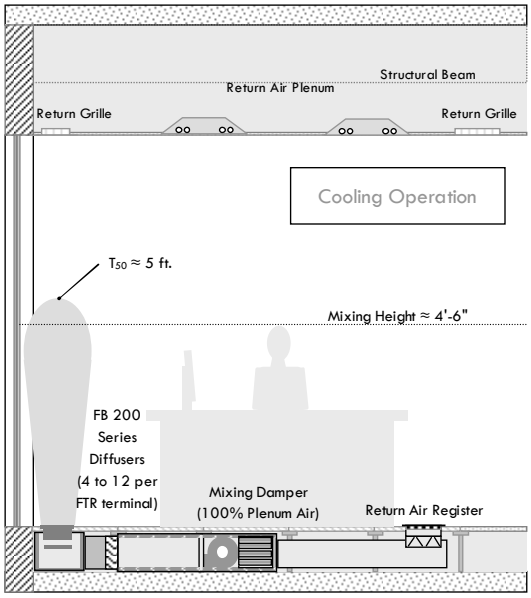
Room air conditions are slightly stratified, but mixed conditions exist to approximately 6 foot level during design cooling and heating operation, negating most displacement advantages.

TYPICAL PERFORMANCE CHARACTERISTICS

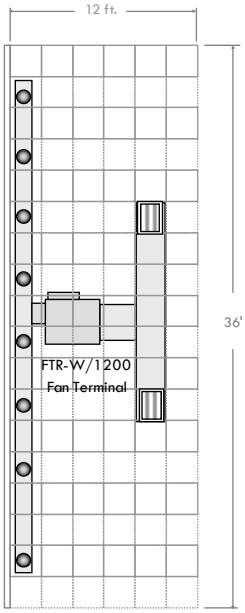
- **Design Cooling:** 2..0 to 3.2 CFM per ft^2
- **Design Heating:** 0.5 to 1.0 CFM per ft^2
- **Stratification :** 15 to 20%
- **Ventilation Effectiveness:** 0.9
- **Reheat Air Source:** Plenum Air
- **Reheat Coil:** Electric only
- **Mobility** Excellent
- **Accessibility** Good
- **Energy Use:** Fair
- **Acoustics:** Good
- **Slab Effects:** Low Risk

Temperature Control and Zoning of Perimeter Areas in UFAD Systems

Strategy P103, Constant Volume Fan Terminals (FTR Series)

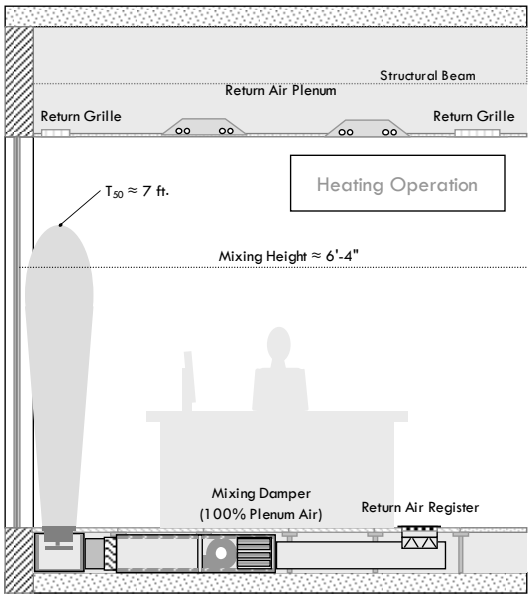


FTR-W Fan Terminal



PLAN VIEW

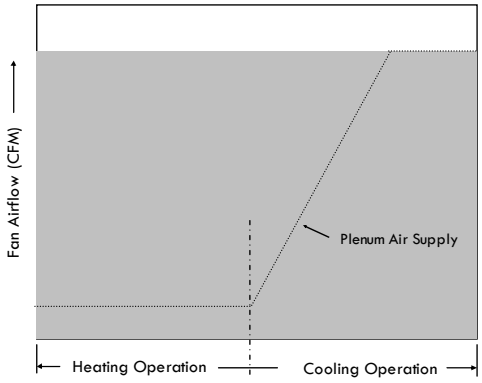
Fan terminal and diffuser layout illustrated is based on a cooling design airflow of 30 CFM/lf (of perimeter wall) and heating requirements of 15 CFM/lf.



FTR-W Fan Terminal

Fan Terminal Models:

- FTR-W Series (Hot Water Reheat)
- FTR-E Series (Electric Reheat)



OPERATIONAL SEQUENCE

OPERATIONAL DESCRIPTION

Total airflow delivery to the room remains constant as integral mixing damper adjusts the temperature of the supply air by varying the mixture of plenum and room air. Mixture varies from 100% plenum air (at design cooling operation) to minimum plenum air (at minimum cooling operation). As the space temperature continues to drop an integral (hot water or electric) reheat coil is energized. Reheat is accomplished with minimum plenum air.

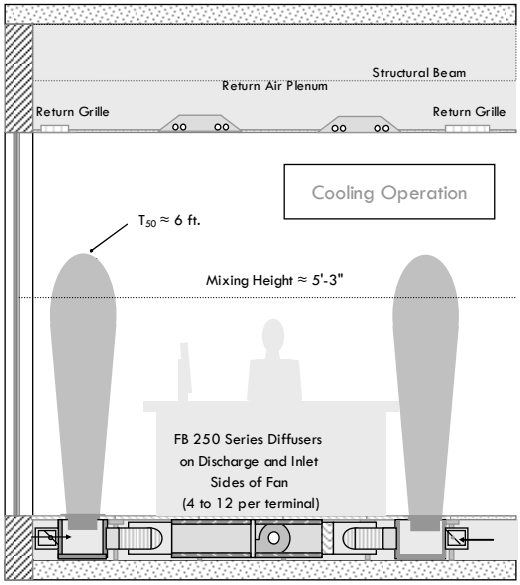
Room air conditions are slightly stratified, but mixed conditions exist to approximately 6 foot level during design cooling and heating operation, negating most displacement advantages.

TYPICAL PERFORMANCE CHARACTERISTICS

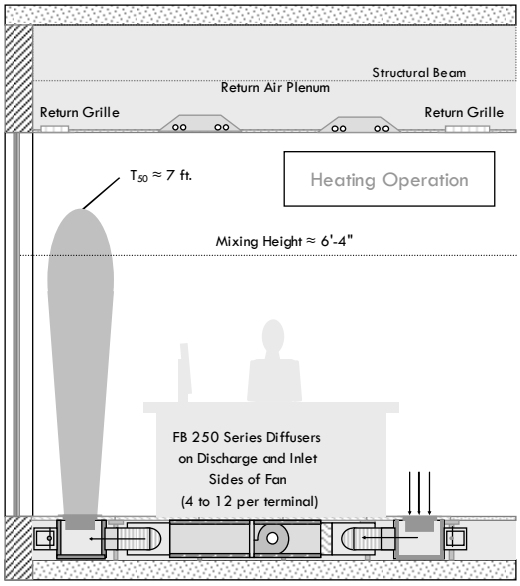
- **Design Cooling:** 2..0 to 3.2 CFM per ft^2
- **Design Heating:** 0.5 to 1.0 CFM per ft^2
- **Stratification :** 15 to 20%
- **Ventilation Effectiveness:** 0.9
- **Reheat Air Source:** Room Air
- **Reheat Coil:** Hot Water or Electric
- **Mobility** Poor
- **Accessibility** Poor
- **Energy Use:** Poor
- **Acoustics:** Fair
- **Slab Effects:** Medium Risk

Temperature Control and Zoning of Perimeter Areas in UFAD Systems

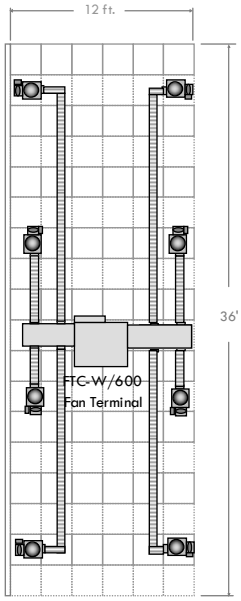
Strategy P104, Variable Volume Cooling with Fan Assisted Reheat



FTC-W Fan Terminal (OFF)



FTC-W Fan Terminal (ON)

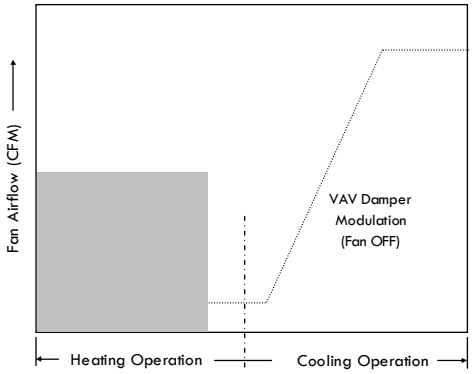


PLAN VIEW

Fan terminal and diffuser layout illustrated is based on a cooling design airflow of 30 CFM/lf (of perimeter wall) and heating requirements of 15 CFM/lf.

Fan Terminal Models:

- FTC-W Series (Hot Water Reheat)
- FTC-E Series (Electric Reheat)



OPERATIONAL SEQUENCE

OPERATIONAL DESCRIPTION

Cool air (from the pressurized supply plenum) is modulated by dampers within the diffuser terminals (on the inlet and discharge side) according to the space cooling demand, while the fan terminal remains off. Upon a further drop in space temperature, the dampers close and the integral fan and heating coil is energized. The diffusers on the inlet side of the fan become return inlets while those on the discharge supply a constant volume of reheated air to the space.

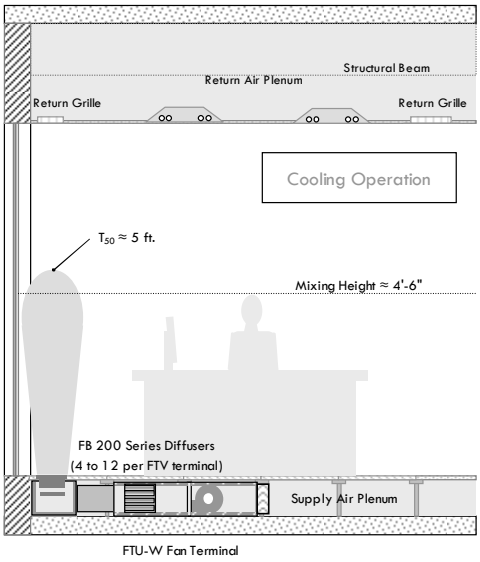
Room air conditions are slightly stratified, but mixed conditions exist to approximately 6 foot level during design cooling and heating operation, negating most displacement advantages.

TYPICAL PERFORMANCE CHARACTERISTICS

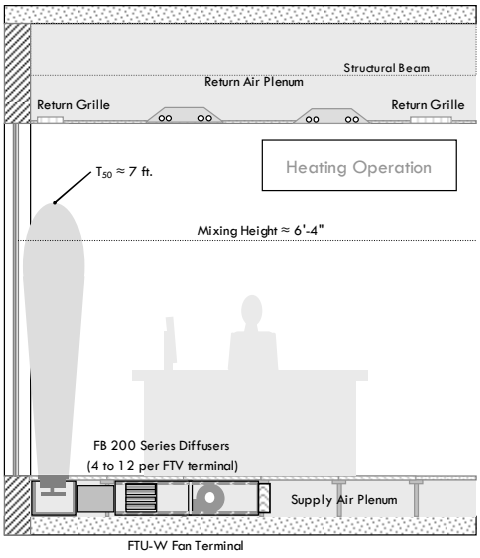
- **Design Cooling:** 2..0 to 3.2 CFM per ft^2
- **Design Heating:** 0.5 to 1.0 CFM per ft^2
- **Stratification :** 15 to 20%
- **Ventilation Effectiveness:** 0.9
- **Reheat Air Source:** Room Air
- **Reheat Coil:** Hot Water or Electric
- **Mobility** Poor
- **Accessibility** Poor
- **Energy Use:** Fair
- **Acoustics:** Poor
- **Slab Effects:** High Risk

Temperature Control and Zoning of Perimeter Areas in UFAD Systems

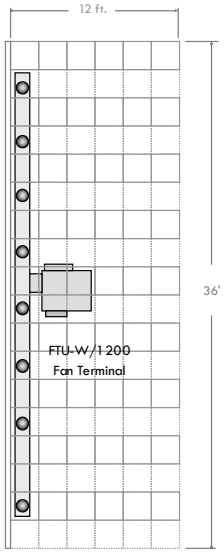
Strategy P105, Intermittent Fan Terminals (FTU Series)



FTU-W Fan Terminal



FTU-W Fan Terminal

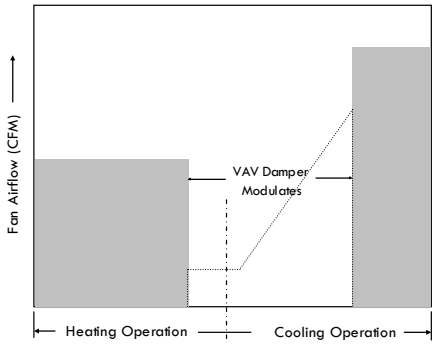


PLAN VIEW

Fan terminal and diffuser layout illustrated is based on a cooling design airflow of 30 CFM/lf (of perimeter wall) and heating requirements of 15 CFM/lf.

Fan Terminal Models:

- FTU-W Series (Hot Water Reheat)
- FTU-E Series (Electric Reheat)



OPERATIONAL SEQUENCE

OPERATIONAL DESCRIPTION

Upon maximum demand, cool air (from the pressurized plenum) is delivered to the space at a constant flow rate. During normal cooling demand, the unit fan is off while a VAV damper (parallel to the fan) throttles conditioned air according to the space demand. During heating operation the fan delivers a constant volume of reheated air to the space. The VAV damper closes during fan operation (heating or cooling).

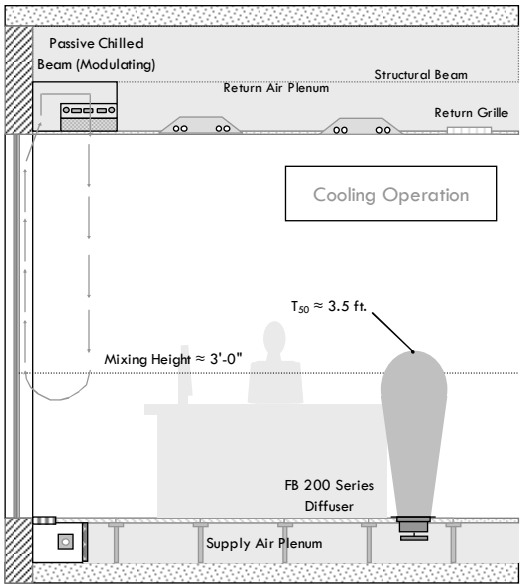
Room air conditions are slightly stratified, but mixed conditions exist to approximately 6 foot level during design cooling and heating operation, negating most displacement advantages.

TYPICAL PERFORMANCE CHARACTERISTICS

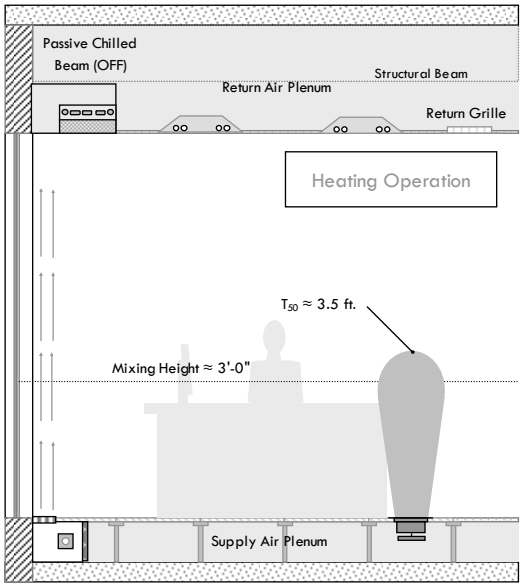
- **Design Cooling:** 2..0 to 3.2 CFM per ft^2
- **Design Heating:** 0.5 to 1.0 CFM per ft^2
- **Stratification :** 15 to 20%
- **Ventilation Effectiveness:** 0.9
- **Reheat Air Source:** Plenum Air
- **Reheat Coil:** Hot Water or Electric
- **Mobility** Fair
- **Accessibility** Poor
- **Energy Use:** Good
- **Acoustics:** Fair

Temperature Control and Zoning of Perimeter Areas in UFAD Systems

Strategy P106, Hydronic Perimeter Treatment



Hydronic Fin Tube Coil (OFF)



Hydronic Fin Tube Coil (Modulating)

OPERATIONAL DESCRIPTION

Sensible heat gains and losses of the building skin are offset by the passive chilled beam and fin tube heating coil respectively. Chilled water is supplied at 60 to 63°F to assure that the coil surfaces and supply piping remains above the space dew point (to prevent any possibility of condensation). Constant volume floor diffusers provide conditioned air from the pressurized floor plenum primarily to maintain space ventilation and relieve space latent gains.

Room air conditions become stratified within three feet of the floor, providing displacement ventilation of respiratory contaminants.

TYPICAL PERFORMANCE CHARACTERISTICS

- **Design Cooling:** 0.5 to 0.8 CFM per ft^2
- **Design Heating:** 0.5 to 0.8 CFM per ft^2
- **Stratification :** 40 to 50%
- **Ventilation Effectiveness:** 1.2
- **Reheat Air Source:** Room Air
- **Reheat Coil:** Hot Water or Electric
- **Mobility** Not Applicable
- **Accessibility** Excellent
- **Energy Use:** Excellent
- **Acoustics:** Excellent
- **Slab Effects:** Minimal Risk