THERMA-FUSER™

THERMALLY POWERED VAV DIFFUSER

DESIGNING MODULAR VAV SYSTEMS

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MODULAR VAV SYSTEMS

The Therma-Fuser diffuser is a simple stand alone device that provides VAV control when supplied with air in a suitable range of temperature and pressure.

SUPPLY AIR TEMPERATURE

When supplied with cool air, the Therma-Fuser dampers modulate open on a rise in room temperature. When supplied with warm air, the dampers open on a room temperature drop. Cool air should be a constant temperature not less than 50°F/10°C (40°F/4.5°C for model LT-HC) and warm air at a constant temperature of not more than 120°F/49°C.

Changeover from cooling to heating occurs as the supply air rises from 76°F/24.5°C to 80°F/26.5°C and change back from heating to cooling occurs when the supply air drops from 72°F/22°C to 68°F/20°C. During changeover the Therma-Fuser diffuser is either closed or in partial control.

STATIC PRESSURE

Static pressure at the inlet of the Therma-Fuser diffuser must be high enough (.05"wg/12 Pa or more) to obtain the required air volume. Above .25"wg / 62 Pa the sound level becomes noticeable (NC35) and around .40"wg/100 Pa the dampers begin to leak. When the static pressure is held constant, the sound level will decrease as the Therma-Fuser dampers close.

The following chapters have more about supply air temperature, static pressure and other fundamentals of hvac system design.

WHAT IT NEEDS

Supply Air Temperature

- Constant temperature. May be reset to another constant temperature.
- Cooling between 50°F/10°C and 68°F/20°C.
- Heating between 80°F/26.5°C and as low as possible but not to exceed 120°F/49°C.

Static Pressure

- High enough for required air volume. No lower than .05"wg/12 Pa.
- Below rated static pressure for design sound level. No higher than .25"wg/62Pa suggested.

SYSTEM DESIGN CHECKLIST

Note: This is a general checklist. For detailed recommendations about specific systems see Acutherm "How To's" in catalog section 6.

Job Name ____

1. THERMA-FUSER DIFFUSER SIZE AND LOCATION

- ☐ Air volume sufficient for room needs. Correct inlet sizing for available static pressure.
- ☐ All Therma-Fuser diffusers within two feet of wall equipped with three way blow away from wall.
- ☐ Multiple Therma-Fuser diffusers in same room—space no less than two times the 150 fpm throw, use three way blow if closer.

2. SUPPLY AIR TEMPERATURE—Cooling Min. 50°F/10°C (40°F/4.5°C for Model LT-HC)
Heating Max. 120°F/49°C
Changeover: To Heating 80°F/26.5°C
To Cooling 68°F/20°C

- **Source of cooling:**
  ☐ Chilled water AHU ☐ DX

- **Source of heating:**
  ☐ AHU heat
  ☐ Duct heat } ☐ Gas ☐ Hot Water ☐ Electric ☐ Steam
  ☐ Heat pump
  ☐ Separate perimeter heat — ☐ Baseboard ☐ Radiant panels ☐ Separate duct

- **Portions of building in one master zone:**
  ☐ One exterior *Note: Separate master zones are preferred for the interior and each exposure*
  ☐ More than one exterior
  ☐ Interior
  ☐ Other ____

- **Supply air fan**
  ☐ Fan runs continuously
- **Location of thermostat (or BMS sensor) used to control the AHU water valves or DX compressor.**
  Note: Do not use a return air thermostat (sensor)
  ☐ System using some Therma-Fuser diffusers and some fixed opening diffusers
    ☐ Room thermostat or sensor located in room of highest heating and cooling load. Fixed opening diffuser used in this room.
  ☐ Complete Therma-Fuser System
  Preferred approach—Supply air control/Room changeover
    ☐ Supply air temperature controlled by discharge air thermostats (sensors)
    ☐ Mode selected by changeover thermostat (sensor) in the room. Therma-Fuser diffuser with minimum flow stops in this room.
    ☐ Acutherm SMC

3. STATIC PRESSURE— Inlet Min. .05"wg / 12 Pa Or High Enough For Required Air Volume
Inlet Max. .25"wg / 62 Pa For NC 35 Or Less

- **Control**
  ☐ Less than 30% turndown of system air—Static pressure control usually not necessary.

  ☐ Over 30% turndown of system air.
  Static Pressure Control With:
    ☐ Fan control
      ☐ Variable speed drive ☐ Other ___________________
    ☐ Discharge damper
    ☐ Zone control damper
    ☐ Bypass } Acutherm PIM™
      ☐ Damper
      ☐ R-Rings—Use only with ceiling plenum return
    ☐ Both fan and zone control
  } ☐ Static pressure sensor located 2/3 to 3/4 of the equivalent duct length between control and end of duct.

- **Duct Design**
  Supply:
  ☐ Static pressure no higher than .25"wg / 62 Pa at the first takeoff downstream from the static pressure control.
  ☐ Sufficient static pressure at the last Therma-Fuser diffuser to obtain the required airflow. Size last Therma-Fuser diffusers larger to achieve required flow at lower static pressures.

  Zone dampers are necessary where pressure losses in ducts are too high.

  Manual balancing dampers should be used at the takeoff for each diffuser. Manual balancing dampers may not be required with ducts designed to Acutherm specifications.

  Return:
  ☐ Ceiling plenum } One return for each Therma-Fuser diffuser preferred.
  ☐ Ducted } Minimum of one return per room.

  ☐ Other_________________________________

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CHAPTER 1: SIZING AND LOCATION OF THERMA-FUSER DIFFUSERS

Therma-Fuser diffusers are sized for the design or maximum air volume required using the published performance guide. Use a larger inlet size at a lower static pressure when lower sound or NC levels are required and when Therma-Fuser diffusers are at the end of a duct run where less static pressure is available. **Therma-Fuser diffusers may be oversized.** They will simply turndown air flow to match the space load. Unlike fixed diffusers used with VAV boxes, Therma-Fuser diffusers won't dump when turned down.

Locating Therma-Fuser diffusers is no different than locating standard diffusers. Spacing is determined by the largest air volume and throw expected, usually the maximum cooling volume. Most guidelines suggest that diffusers be placed so that the 50-100 fpm/.25-.50 m/s velocity just reaches the wall, with the **maximum velocity at the wall being 150 fpm/.76 m/s** (our preference for outside walls).

Standard guidelines should also be followed when putting multiple diffusers in the same room. When possible the diffusers should be **no closer together than twice the throw at the 150 fpm/.76 m/s level.** Ideally they should be located somewhere between twice the 50 fpm/.25 m/s and 100 fpm/.50 m/s levels.

Therma-Fuser diffusers can be located closer together than other diffusers without risk of opposing air jets forcing cool air into the occupied zone while in the cooling mode. Because of high entrainment and thorough mixing, the supply air reaches room temperature before it enters the occupied zone.

Maximum installation height for effective heating is 12 ft/3.37 m. Heights below 10 ft/3 m are preferred. Cooling only Therma-Fuser diffusers can operate well at heights around 20 ft/6 m.

Because Therma-Fuser diffusers control room temperature by sensing room air induced up the center of the space, **care should be taken not to disturb room air induction and entrainment.** For example, location next to walls or dropped lights results in the reflection of primary air back at the Therma-Fuser diffuser. Avoid this with a three-way blow pattern or relocate either the Therma-Fuser diffuser or the light.

Use miminum flow stops on the Therma-Fuser diffuser located in the same room as the changeover thermostat for the system.

For individual temperature control, **a return for each Therma-Fuser** diffuser is preferred. This tends to avoid air below one Therma-Fuser diffuser drifting below an adjacent Therma-Fuser diffuser. As a minimum install at least one return in each room. Do not use through the door or over the wall returns.

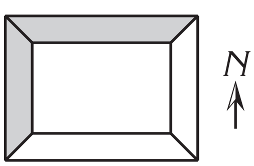
Manual balancing dampers should be used at the takeoff for each diffuser. Manual balancing dampers may not be required with ducts designed to Acutherm specifications.

CHAPTER 2.1: SOLVING THE PROBLEM OF SIMULTANEOUSLY HEATING PARTS OF A BUILDING WHILE COOLING OTHERS

Problem:

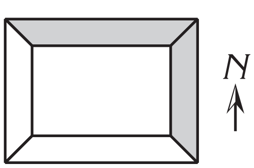
During winter conditions parts of a building need heating while other parts require cooling. (Shown for Northern hemisphere.)

Sunny Winter Morning



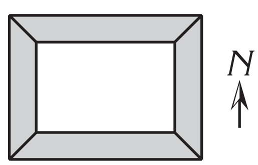
Heating required north and west exposures.
Cooling required interior* and east and south exposures.

Sunny Winter Afternoon



Heating required north and east exposures.
Cooling required interior* and south and west exposures.

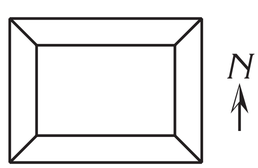
Cloudy Winter Day



Heating required all exposures.
Cooling required interior.*

Note that this is not a problem for summer conditions.

Summer Day



Cooling required all portions of the building.

* *Sometimes interiors may need heat due to losses at the ceiling or floor.*

Solutions:

Solutions involve providing master zoning. Master zones are sources of heating and cooling. Subzones are Therma-Fuser VAV diffusers which provide individual temperature control.

Master zone options described in this chapter are:

1. **Multiple AHU**
2. **Separate perimeter heat**
3. **Perimeter duct heat stations**
4. **One heat/cool zone per floor**
5. **Corner offices**

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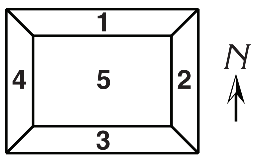
CHAPTER 2.1: CONTINUED

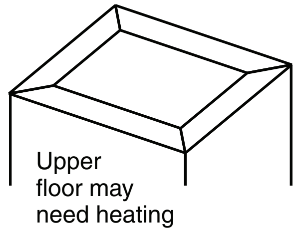
1) Multiple AHU

This is the simplest and perhaps the easiest to control of all master zone options. A disadvantage might be the need for more risers in multi-story buildings. AHUs may be chilled water, DX, heat pumps or fan coil units.

A square building requires five AHUS, one for each exposure and one for the interior.

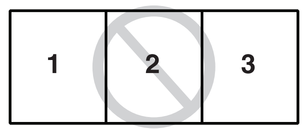


These can be five AHU per floor or with vertical master zones, five per building.

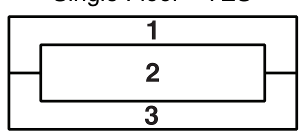


Many buildings are long and narrow enough (sometimes no windows on the end) for three AHU's.

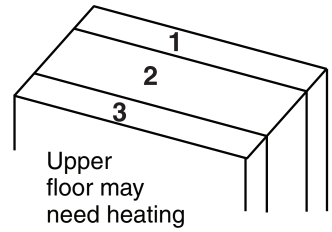
Single Floor—NO



Single Floor—YES



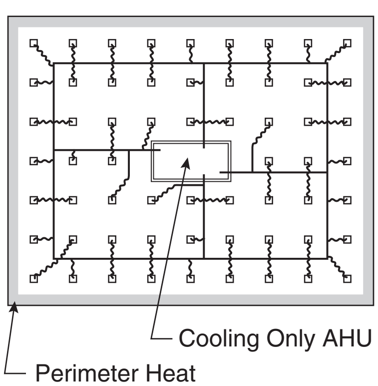
Multiple Floors with
Three Vertical Master Zones



Each AHU is subzoned with Therma-Fuser diffusers to achieve individual temperature control. For control of the heating-cooling AHU's see Chapter 2.2.

2) Separate Perimeter Heat

Because a separate perimeter heat system is sized to handle the heat loss through the skin of the building, the need for separate heating and cooling in the various parts of the building is eliminated. The central system can be one cooling only master zone. Therma-Fuser subzones provide individual temperature control. See Form 6.7, page 2.



Small perimeter heating zones (one per office) combined with Therma-Fuser subzones for the central system are the best for handling traveling shadows.

Options for separate perimeter heat are:

1) Baseboard—electric, hot water or steam.
2) Radiant panels—electric or hot water.
3) Ducted air from a separate AHU—electric, hot water, gas or steam.

This heat is sized to only handle the heat loss through the skin of the building plus the reheat load of any minimum air flow. The thermostat must be located to sense the skin loss. Preferred locations are in the baseboard, or within two feet from the outside wall on a wall perpendicular to the outside wall. Do not use the common location by the door on the wall opposite the outside wall.

Use TF-C Therma-Fuser diffusers where there is no central heat. TF-HC Therma-Fuser diffusers are recommended with central heat for warm-up to avoid overheating some spaces.

To avoid conflict between the perimeter heat and the Therma-Fuser diffuser use a deadband between the setpoints. Achieve the deadband with a high limit stop of say 70°F/21°C on the perimeter heat and a cooling setpoint of say 74°F/23°C on the Therma-Fuser diffuser.

Where electric heat is necessary, save energy by using less expensive central heat when zoning is not important (unoccupied times) and when heating loads are the largest (nights). The electric heat can provide small master zones during occupied hours. Use central heat with gas, hot water or steam for unoccupied times and warm-up.

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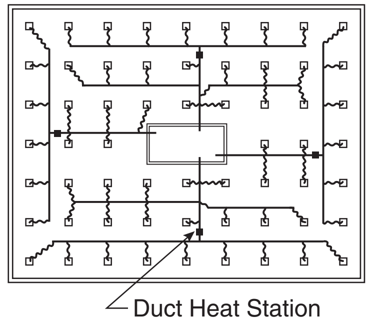
CHAPTER 2.1: CONTINUED

3) Perimeter Duct Heat Stations

Size perimeter duct heat stations as large as possible—perhaps only one per exposure. The simplest is a heating coil, either electric or hot water. The heating coil may be combined with a zone damper for static pressure control when downstream of higher pressure systems. Or a VAV reheat box can be used. Another alternative is an intermittent fan powered box. Therma-Fuser diffusers provide individual temperature control. (The interiors may also require zone dampers for static pressure control).



When electric heat is used, consider using less expensive central heat during unoccupied time and warm-up.

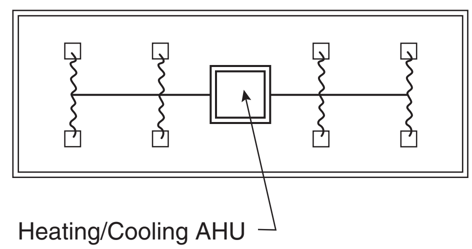
Other Acutherm references:

	How to subzone with Therma-Fuser diffusers	SMC Control
Heating Coil	Form 6.6	40.4
VAV Reheat Box	Form 6.12	40.4
Intermittent Fan Powered Box	Form 6.14	40.5

4) One heat/cool AHU per floor

One heating cooling AHU can be used for one floor or one building. These are usually DX; either a heat pump or with some form of central heat such as a gas furnace. This approach is more common in smaller buildings which have little or no interior area.

The economics of a simple system may be more important than resolving the problem caused by winter conditions. Using TF-HC Therma-Fuser diffusers will not resolve the problem but they may ease it. If cooling is being supplied, the TF-HC Therma-Fuser diffusers will close in areas requiring heating. When heating is supplied, the TF-HC Therma-Fuser diffusers will close in areas requiring cooling. Of course, when open the Therma-Fuser diffusers will still provide individual temperature control—varying air flow to suit the loads beneath them. See Forms 6.5 and 40.1.

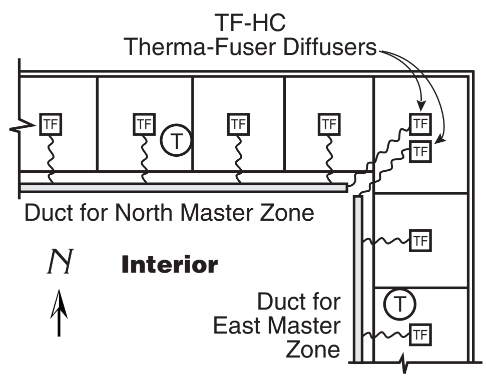


5) Corner offices

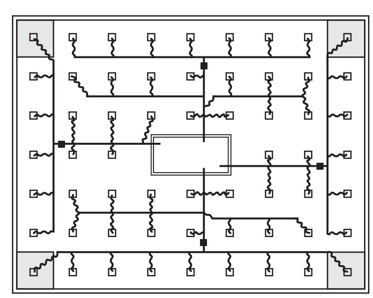
Corner offices may have a need between cooling on one side and heating on another. This is resolved with separate perimeter heat but could be a problem for multiple AHU's and perimeter duct heat stations. Solutions for situations other than separate perimeter heat are:

a) Provide a **separate master zone** for the corner office. This is the most expensive solution.

b) The most preferred solution is to **supply from two master zones** which at times could have one in heating and one in cooling. Subzone with TF-HC Therma-Fuser diffusers.
Depending on the load when one master zone is heating and the other is cooling, one TF-HC will be closed and the other modulating. See Form 6.15.



c) **Supply from one master zone selected because it probably will dominate.** There is also the risk that it may not. This approach probably would supply the SE and SW corner offices from the south master zone. The NE corner is supplied from the east master zone. The NW corner from the west master zone. Using TF-HC Therma-Fuser diffusers will reduce the risk.



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CHAPTER 2.2: SUPPLY AIR TEMPERATURE CONTROL

Location of the BMS sensor or the thermostat to control the DX compressor, AHU water valve or heat is important to having enough cooling or heating to satisfy the separate zones in a VAV system. If the system control cuts off too early, the areas of the building with the greatest needs will not be satisfactorily conditioned. Most VAV devices, including Therma-Fuser diffusers, can not make up for lack of air or lack of temperature.

Objectives of supply air temperature control are:

1) **Provide a constant supply air temperature.** Variable air volume systems require a constant supply air temperature. Variable supply air temperature is for constant volume systems.
Using variable supply air temperature control with a VAV system may result in constant volume supply.
Where resetting is required, reset to another constant supply air temperature.
DX equipment and on/off heating, such as electric or gas, can only approximate constant supply air temperature by cycling within limits.

2) **Limit supply air temperature.** Cool air supplied to Therma-Fuser diffusers should not be less than 50°F/10°C (40°F/4.5°C for model LT-HC) and hot air not more than 120°F/49°C.
Low limits prevent DX coil freezing when bypass static pressure control is used.
Limiting hot air temperature also reduces room stratification.

3) **Provide changeover from heating to cooling.** Therma-Fuser diffusers changeover from cooling to heating as the supply air rises from 76°F/24.5°C to 80°F/26.5°C. Change back from heating to cooling occurs when the supply air drops from 72°F/22°C to 68°F/20°C. During changeover the Therma-Fuser diffuser is in partial control.

Options for locating the Temperature Sensor or Thermostat

1) **Supply air—**best for constant supply air temperature. Always able to satisfy design air temperature for each space. Not able to control heating/cooling changeover.

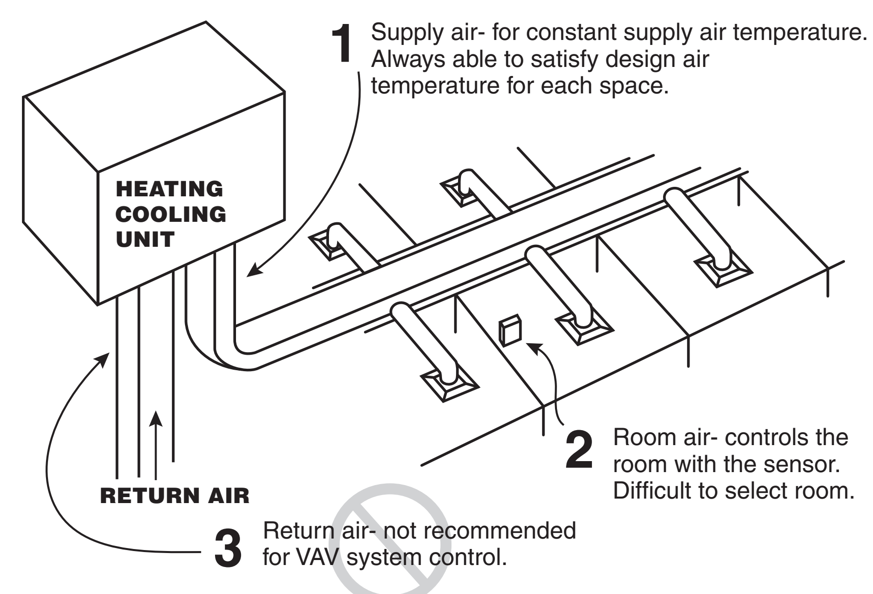
2) **Room air—**controls the room with the sensor. Should be in the room with the greatest heating and cooling needs – the Therma-Fuser diffusers then turn down in other rooms. Difficult to select the room. Greatest heating and cooling needs are seldom in the same room and the room may be unoccupied at times. Does not limit supply air temperature. Use room air sensors for heating/cooling changeover selection; especially good when sensing in more than one room.

3) **Return air—**not recommended for VAV systems. Senses average system need which may not satisfy areas of maximum need. Often used for constant volume system control.

Objectives and options

		SUPPLY AIR	ROOM AIR	RETURN AIR
1)	Constant supply air temp.	X		
2)	LImit supply air temp.	X		
3)	Changeover		X	

CONTROL OPTIONS



Systems with part fixed diffusers

Where part of the system has fixed diffusers and part has Therma-Fuser diffusers, control supply air from a room sensor or thermostat located with one of the fixed diffusers. This should be an area of greatest heating/cooling need if that can be determined. Or it may be simply in the most important room such as the bosses office.

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CHAPTER 2.2: CONTINUED

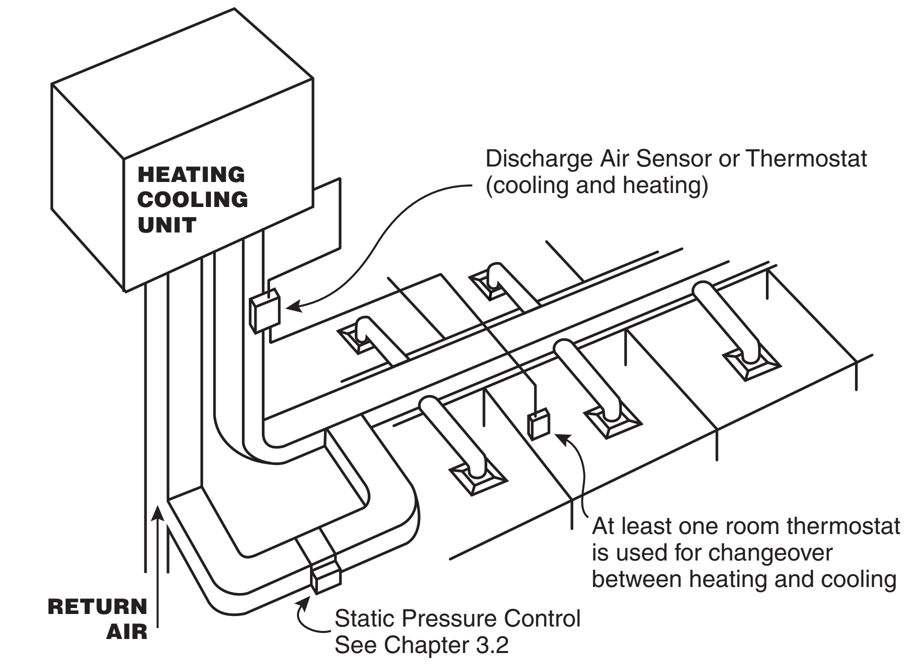
Preferred where all diffusers are Therma-Fuser diffusers

The preferred control where all diffusers are Therma-Fuser diffusers is with a discharge air sensor or thermostat. Whenever possible, cooling is modulated to maintain a constant supply air temperature below 68°F/20°C and above 50°F/10°C. For DX equipment this is a low limit. A limit at a higher temperature is used for a second stage cooling and higher again for additional stages. Where a bypass for static pressure control is used, locate the discharge air sensor upstream of the bypass.

Heating, like cooling, whenever possible is modulated to maintain a constant supply air temperature above 80°F/26.5°C and below 120°F/49°C. To reduce stratification the hot supply air temperature should be no higher than necessary on a design day. For on/off heat this control becomes a high limit. A limit at lower temperature is used for second stage heat and lower again for additional stages.

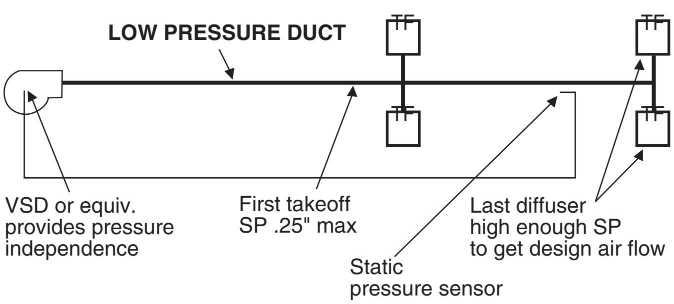
At least one room sensor or thermostat is used to determine changeover between heating and cooling. Where multiple room sensors or thermostats are used, one may call for heating while another calls for cooling. Resolve this with either a cooling dominant or majority rules approach.

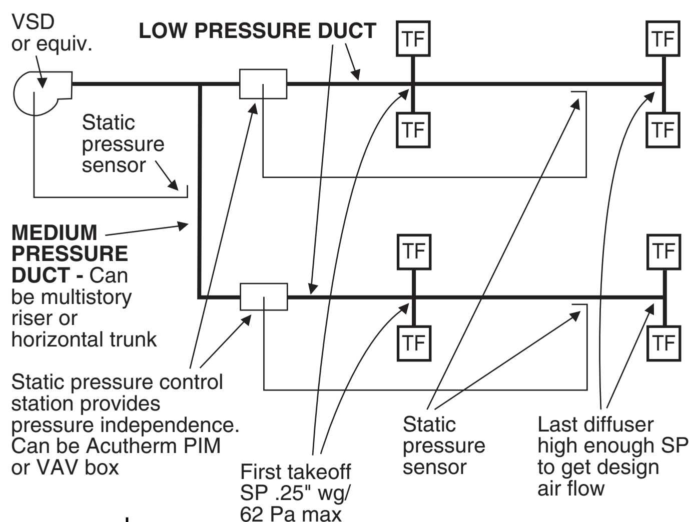
PREFERRED CONTROL



CHAPTER 3.1: ALL LOW PRESSURE / PART MEDIUM OPTIONS

All diffusers including Therma-Fuser VAV diffusers should be supplied with low pressure air (.25"wg/62 Pa or less) to avoid noise (NC 35 or greater). Manual balancing dampers should be used at the takeoff for each diffuser. Manual balancing dampers may not be required with ducts designed to Acutherm specifications.





VSD = Variable speed drive

Systems with low pressure ductwork from the fan on should be used whenever possible because of the high energy savings of a much smaller fan motor.

In many cases such as multiple floors served by a single air handler complete low pressure systems become impractical because of the lengthy duct runs involved. (A practical limit for low pressure may be equivalent duct lengths between 200 ft/61m and 250 ft/76m.) In these situations systems are designed as part medium pressure between the fan and static pressure control stations and part low pressure from the static pressure control stations to the end of the run.

CHAPTER 3.2: STATIC PRESSURE CONTROL OPTIONS

Objectives of static pressure control are:

1) Provide high enough static pressure (.05"wg/12 Pa or more) to obtain the required air volume at each Therma-Fuser diffuser.
2) Limit the static pressure at both full flow and turndown to avoid diffuser noise (.25"wg/62 Pa for NC 35) and leakage (.40"wg/100 Pa). When the static pressure is held constant the sound level will decrease as the Therma-Fuser dampers close.
3) Pressure independence: consistent operation as the system air flow changes.

Manual dampers will not satisfy these objectives because the pressure drop across them varies as the air flow changes.

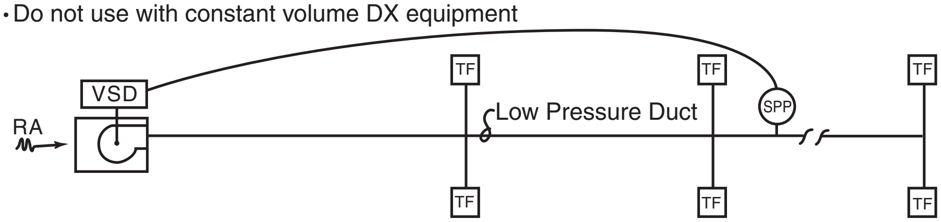
These objectives can be achieved with the usual methods of automatic static pressure control; bypass dampers, discharge dampers, zone dampers, and fan control (variable speed drives, inlet vanes, etc.). In addition, R-Rings, unique to VAV diffusers, provide bypass at the diffuser where the system has a ceiling plenum return.

Location of the static pressure probe for all options except the R-Rings should be at least 2/3 to 3/4 down the duct from the first takeoff. Do not locate it right after the damper or fan. The down stream location provides a lower static pressure control point which results in quieter turndown operation.

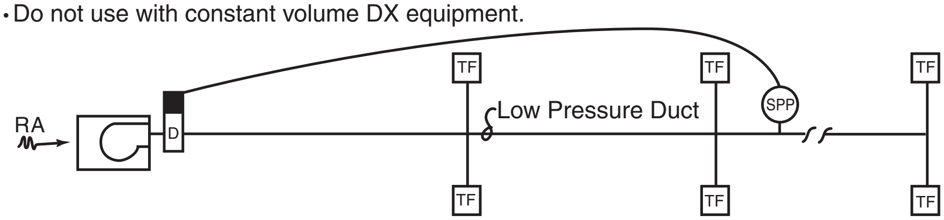
Acutherm Pressure Independence Modules (PIM™) are designed for use as bypass dampers, discharge dampers and zone dampers.

For systems with part fixed diffusers, system turndown may be 30% or less. If so, static pressure control is not necessary provided the static pressure remains below .25"wg/62 Pa at the diffusers.

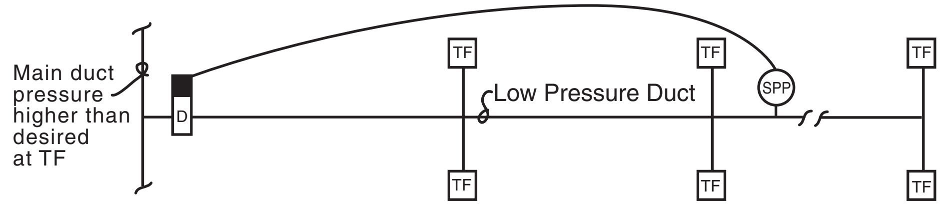
Fan Speed Control
- Do not use with constant volume DX equipment



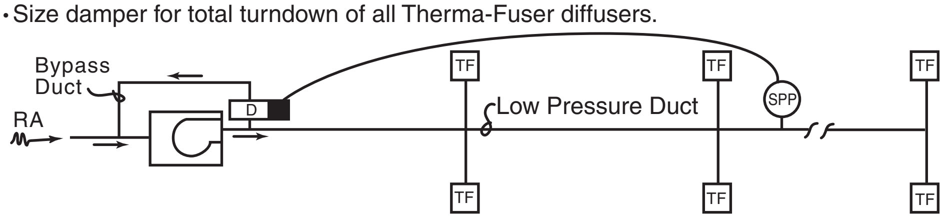
Discharge Damper
- Do not use with constant volume DX equipment.



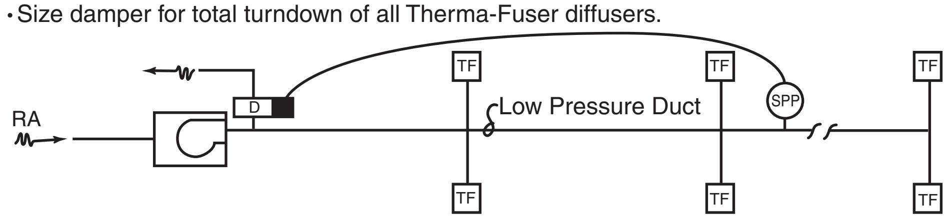
Zone Damper
- May also need static pressure control at fan.
- Sound attenuation after the damper may be required for higher pressure drops.



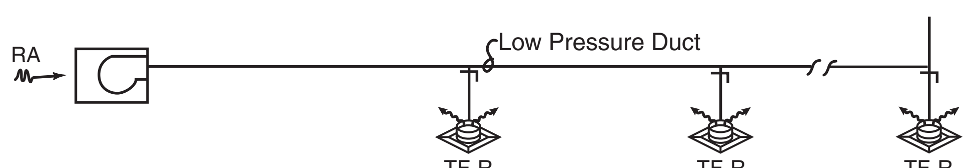
Bypass Damper—Ducted Return
- Size damper for total turndown of all Therma-Fuser diffusers.



Bypass Damper—Ceiling Plenum Return
- Size damper for total turndown of all Therma-Fuser diffusers.



R-Ring Ceiling Plenum Bypass
- Do not use with ducted returns.
- Do not use with 3-, 2- or 1-way blow patterns. 4-way blow only.



D: Damper with controller and actuator
TF: Therma-Fuser diffuser
TF-R: Therma-Fuser diffuser with R-Ring
SPP: Static pressure probe, locate approx. 2/3 to 3/4 down duct from first diffuser
VSD: Variable speed drive

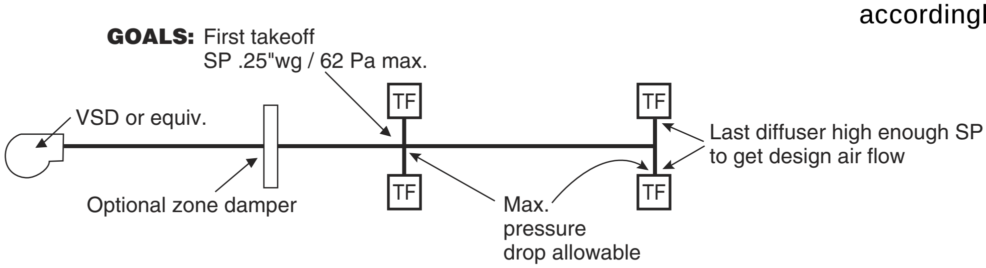
CHAPTER 3.3: SIZING DUCTS FOR MODULAR VAV SYSTEMS

Objectives of duct sizing are:

1) Limit maximum static pressure at the inlets of all Therma-Fuser diffusers to .25"wg/62 Pa or below at both design and turn-down conditions.

2) Maintain minimum static pressure at the diffusers especially those further away from the fan, at least .05"wg/12 Pa or enough to provide design air flow.

To accomplish these objectives first determine the maximum pressure drop allowable between the first takeoff and last diffuser. Once maximum pressure drop is determined choose one of the duct sizing methods listed and assign duct sizes accordingly.



Determining allowable pressure drop:

1) Locate Therma-Fuser diffusers and approximate duct runs on the building plan. Determine the air volume required for each diffuser.

2) From the performance ratings determine the static pressure for design air volume at the last diffuser furthest from fan. Sometimes selecting a larger inlet size will lower the static pressure required.

3) Determine the static pressure required at the takeoff to the first diffuser after the fan or static pressure station. This is usually .25"wg/62 Pa – sometimes less if a lower NC is required at the first diffuser.

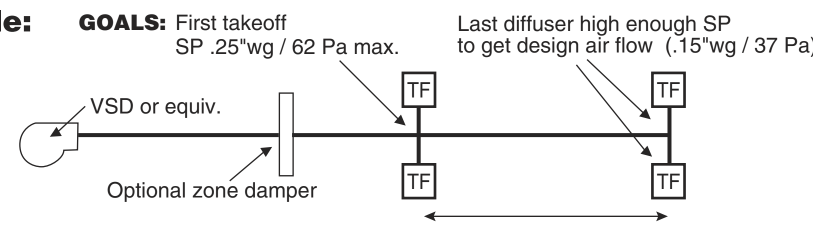
4) Subtract #2 from #3 for the pressure drop allowable.

5) Determine the equivalent length of duct, in feet or meters, from the takeoff of the first diffuser to the last diffuser. Equivalent duct length is total length of duct plus equivalent length of fittings.

6) Divide #4 x 100 by #5 for the pressure drop per 100 feet, or divide #4 by #5 for the pressure drop per meter.

7) Select duct sizing method. A description follows for:
a) Equal friction method.
b) Friction loss reduction method.

Example:



Pressure drop = .25"wg / 62 Pa – .15"wg / 37 Pa
= .10"wg / 25 Pa

If equivalent length = 100 feet / 30 m,
design for .10"wg drop per 100 feet / .82 Pa per m.

If equivalent length = 150 feet / 46 m,
design for .06"wg drop per 100 feet / .49 Pa per m.

Equal friction method

The simplest method of duct sizing is equal friction. Using the equal friction method the same pressure drop per 100 feet/meter is used from the beginning of the duct to the end.

1) Select duct sizes by matching #6 (above) and the required air volume on a duct calculator.

2) Select remaining diffuser sizes for design air volume at the available static pressure.

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CHAPTER 3.3: CONTINUED

Modified Equal Friction (Friction Loss Reduction) Method

The friction loss reduction method can be used in cases where the equal friction method yields duct sizes near the fan which are too large for the available space. This method uses higher pressure drops near the fan and reduced pressure drops downstream. The goal is to get a total pressure drop for the entire duct equal to #4 (from page 9).

- **Friction losses selected should be between .10"wg/100 feet or .82 Pa/m and .04"wg/100 feet or .33 Pa/m**
- **Velocities selected should be between 1300 fpm / 6.6 m/s and 700 fpm / 3.5 m/s**

1) Divide the first 100 – 150 feet / 30-46 m of duct into sections 20-30 feet / 6-9 m long at appropriate transition points. For ducts longer than 150 feet / 46 m treat the remainder of the duct as one continuous section. Note these measurements are in equivalent length not actual length.
2) Next, friction loss figures are assigned to each section so that when pressure losses are analyzed total pressure drop is equal to #4 (from page 9). Assign friction loss to the section closest to the fan first. The remaining subsequent friction loss factors should be .01"wg / 2.5 Pa lower than the previous one.
3) A good starting point for the first friction loss factor is 1.5 x #6 (from page 9) with a maximum value of .10"wg / 25 Pa. A good minimum value for the last section is .04"wg / 10 Pa.

Calculating pressure drop in fittings

Three possibilities exist for calculating pressure drop in fittings. The first method suggested by both ASHRAE and SMACNA uses loss coefficients for particular fittings to calculate the total pressure drop through the fittings. Explanation of this method is listed in both the ASHRAE Fundamentals chapter 32 and SMACNA HVAC Systems Duct Design chapter 5.

The second method uses published tables to determine equivalent length of straight duct with the same pressure drop as the fittings. The equivalent lengths can then be added to the total length of the duct system.

The third method uses the SMACNA HVAC Duct Fitting Loss Calculator. This calculator will provide fitting loss for various round and rectangular fittings as listed on the calculator itself. The pressure drop can then be added to the total pressure drop of the duct sections.

Equivalent foot tables and fitting loss calculator for duct fittings

Tables providing equivalent feet of duct lengths for fittings are available in the Carrier system design manual part 2 pages 2-42 through 2-45, available from Carrier for $5.50.

To order contact:
Carrier Literature Services,
Bldg. TR-8
P.O. Box 4808
Syracuse NY, 13221
Fax (315) 432-3418.

The SMACNA Duct System Calculator has both a fitting loss and duct loss calculator. It is available from the SMACNA Bookstore for $24.00.

To order contact:
SMACNA
4201 Lafayette Center Drive
Chantilly VA, 20151
Phone (703) 803-2989
Fax (703) 803-3732.

CHAPTER 3.4: USING EXISTING DUCTS

The objectives in using existing ducts are the same as those for designing new ductwork:

1) Limit maximum static pressure at the inlets of all Therma-Fuser diffusers to .25"wg/62 Pa or below at both design and turn-down conditions.
2) Maintain minimum static pressure at the diffusers (especially those furthest away from the fan) at least .05"wg/12 Pa, or enough to provide design air flow.

The characteristics of the existing duct system might be determined by theoretical calculation if both duct sizes and air volumes of the system are known.

Duct sizes are best obtained from “as built” drawings. Sometimes the original drawings are close enough to “as built”. Otherwise a site survey might be required.

Existing air volumes may be used if the building envelope, lighting and office equipment have not changed over the years. Otherwise you may want to assume 1 cfm/sq. ft. or 5 L/s/m² for the interior and 1.5 cfm/sq. ft. or 7.6 L/s/m² for perimeter space.

Theoretical calculation may not be necessary for short duct runs, i.e. less than 50 equivalent feet or 50 actual feet/15 m of straight duct (no elbows, tees etc.). Static pressure control at the fan or AHU will be sufficient. See chapter 3.1. For longer duct runs use the Existing Duct Worksheet and apply the procedure below.

Duct System Analysis:

1) Start at the end of the duct farthest from the fan or static pressure station. List the air volume required from the last diffuser on line 1, column 2.
2) Use Therma-Fuser diffuser ratings to determine static pressure required for this air volume and list on line 1, column 5 & 6. Note: A larger inlet size often results in a lower static pressure for the same air volume.
3) List the duct sizes for each portion of the duct between each takeoff in column 1 “size”.
4) List air volumes (cfm or L/s) through each portion of the duct in column 2 – “Air volume”.
5) List the equivalent length of each portion of the duct corresponding to 1 & 2 in column 4 “Equivalent Length”. Note: Equivalent length is actual length plus a factor for fittings such as elbows. (Elbows usually are around 50 ft/15 m equivalent length for low velocity ducts.
6) Enter the information in 1 & 2 in a duct calculator to obtain "wg/100 ft or Pa/m and list in column 3 "wg/100 ft or Pa/m".
7) Obtain ∆P. Multiply column 3 by column 4 and divide by 100 or for metric multiply column 3 by column 4. List in column 5 “∆P”.
8) Add ∆P from this line to all proceeding ∆P’s in column 5 for the cumulative ∆P and list in column 6.
9) Stop when column 6 reaches .25"wg/62 Pa. This is the highest allowable. Install a zone damper (PIM) here. Install additional zone dampers as shown on page 12.

Existing Duct Worksheet

SIZE Column 1	Air Volume Column 2	"wg/100 ft. or Pa/m Column 3	Equiv. Length Column 4	∆P Column 5	Cumulative ∆P Column 6
AIR VOL. & S.P. @ INLET OF LAST DIFFUSER		NA	NA		

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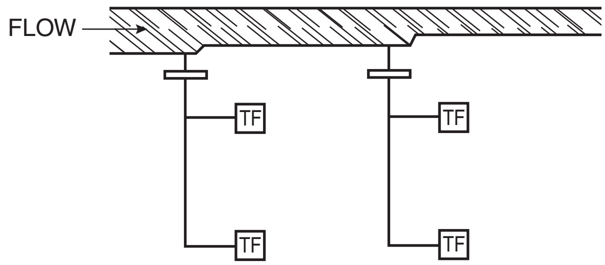
CHAPTER 3.4: CONTINUED

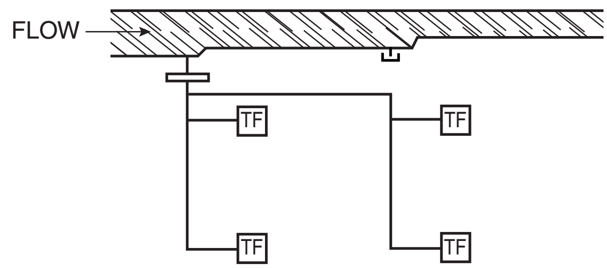
Additional zone dampers:

Use zone dampers (PIM's) for branches or takeoffs upstream of the zone dampers from #9 on page 11. Fewer zone dampers can be used if several Therma-Fuser diffusers are grouped on a new branch known as a parallel duct. See chapter 3.3 for sizing of the parallel duct.

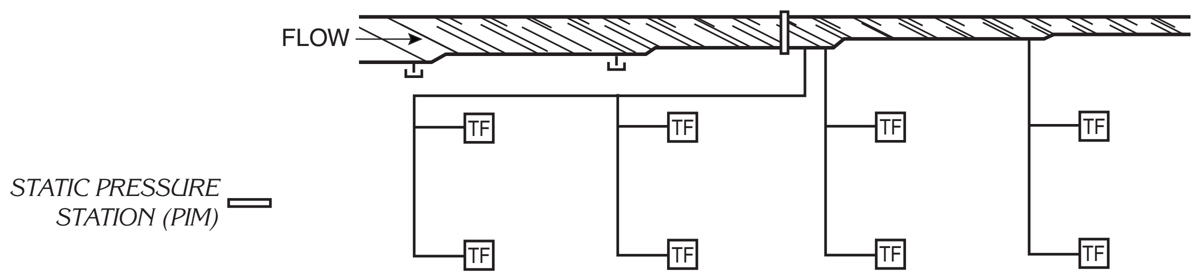
Zone Damper Per Takeoff



Parallel Duct



Parallel Duct Using Zone Damper From #9 On Page 11



Alternatives to theoretical calculations are:

1) Field examination may indicate what the duct static pressure will be at full air volume. Open all manual balancing dampers to achieve maximum system air flow and measure static pressure at the first and last takeoff. The difference is the pressure drop of the duct system at maximum air flow. If the drop is greater than .25"wg/62 Pa, zone dampers will be necessary.
2) The owner may elect to undergo the upgrade with the knowledge that more ductwork may have to be added later if the existing ducts prove to be too small. In this option the owner tolerates some experimentation because it is intended to save money.

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