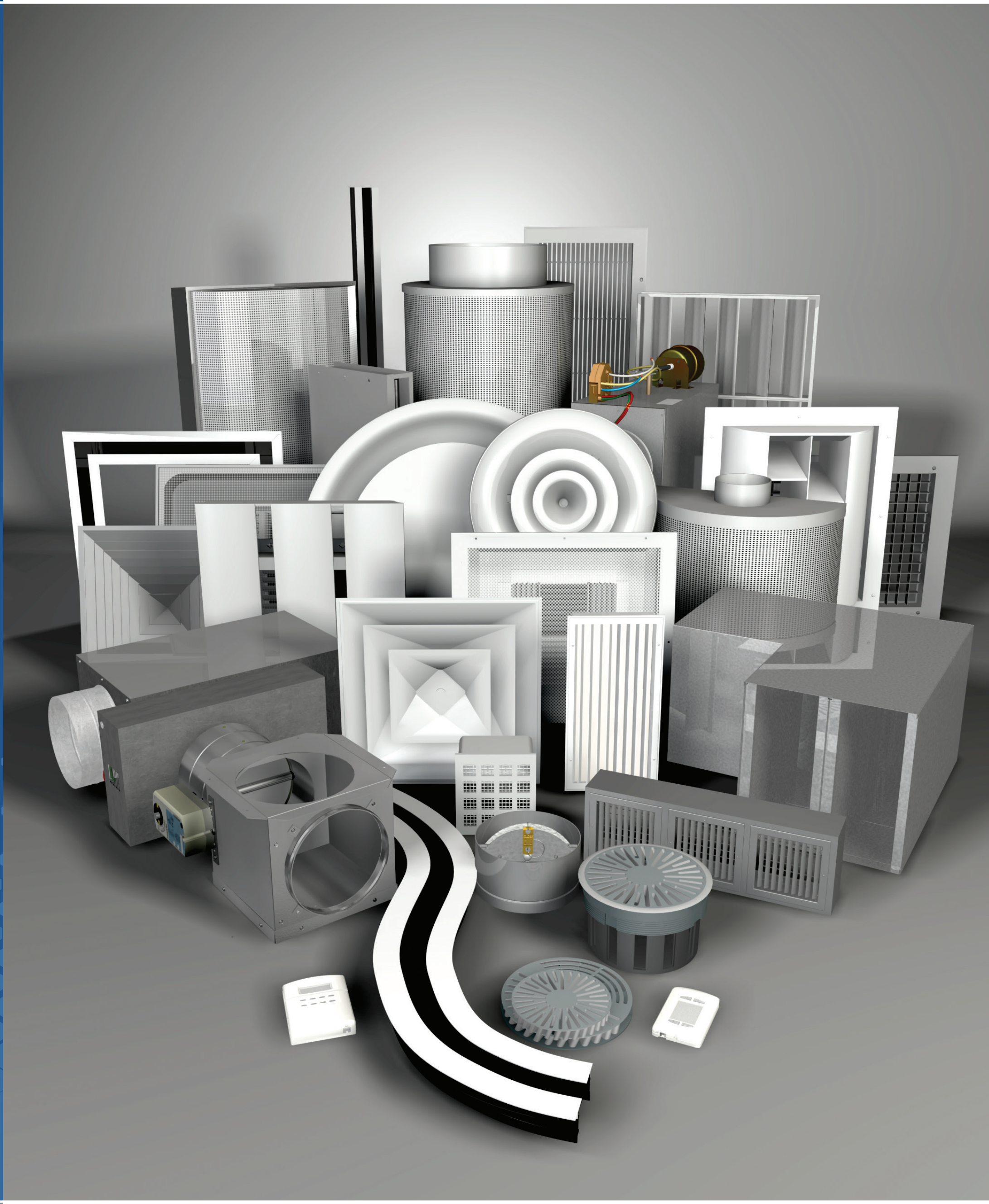
SECTION **EG**



Engineering Guide
Air Distribution

Please refer to the **Price Engineer's HVAC Handbook** for more information on Air Distribution.

Space Air Diffusion

Proper selection of air diffusion devices requires basic knowledge of the mechanics of room air distribution. **Figures 1 and 2** illustrate the interactions of the major factors influencing room air distribution.

Primary Air

Primary air is defined as the conditioned air discharged by the supply outlet. This air provides the motive force for room air motion.

Total Air

Total air is defined as the mixture of primary air and entrained room air which is under the influence of supply outlet conditions. This is commonly considered to be the air within an envelope of 50 fpm [0.25 m/s] (or greater) velocity. The temperature difference between the total air and the room air creates buoyant effects which cause cold supply air to drop and warm air to rise.

Throw

Throw is the distance from the center of the outlet face to a point where the velocity of the air stream is reduced to a specified velocity, usually 150 [0.75], 100 [0.50] or 50 fpm [0.25 m/s] (**Figure 3**). These velocities are referred to as terminal velocity and therefore indicated as T150 [T0.75], T100 [T0.50], T50 [T0.25] respectively. Throw is primarily a function of mass flow and outlet velocity and therefore can be reduced by decreasing either of these values.

Drop

The drop of cool total air, as shown in **Figure 1**, is the result of vertical spread of the air stream due to entrainment of room air, and the buoyancy effect due to the density differences between the total air package and the surrounding primary room air. The term density is very important as drop is primarily dependent upon the mass flow of the total air. Drop can be minimized by spreading air uniformly over the ceiling surface, thus reducing the mass flow per unit surface area.

Spread

The spread of an outlet is defined as the divergence of the air stream in a horizontal or vertical plane and is a function of the outlet geometry (**Figure 3**).

Surface Effect

Drop can also be effectively reduced by use of the surrounding ceiling surface. When supply air velocity is sufficiently high, a negative or low pressure area is created between the moving air mass and the ceiling at or near the supply air outlet. This low pressure area causes the moving air mass to cling to and flow close to the ceiling surface. This principle is known as the Coanda effect. See Chapter 2—Fluid Mechanics in the Price Engineer's HVAC Handbook for a more detailed explanation. Good air distribution design makes use of room surfaces to help keep the supply air outside the occupied zone.

Occupied Zone

The occupied zone is usually defined as the area within 6 ft [1.8 m] of the floor and not within 1 ft [0.3 m] of the boundaries of the space (walls, etc.). As this is the area of occupancy, it is desirable to avoid excessive draft velocities and temperature differences within this space.

Figure 1: Space air diffusion with overhead cooling

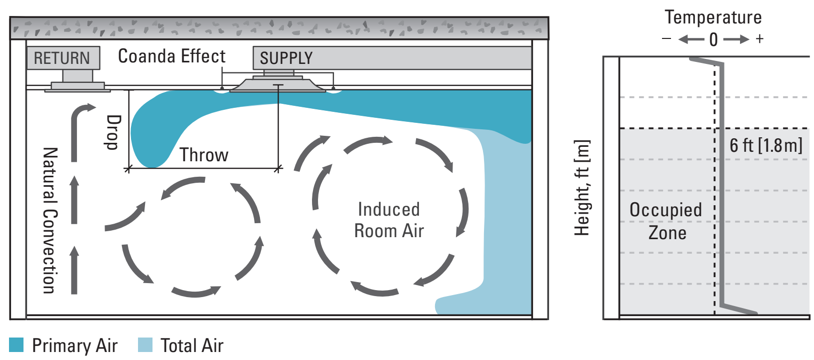


Figure 2: Space air diffusion with overhead heating

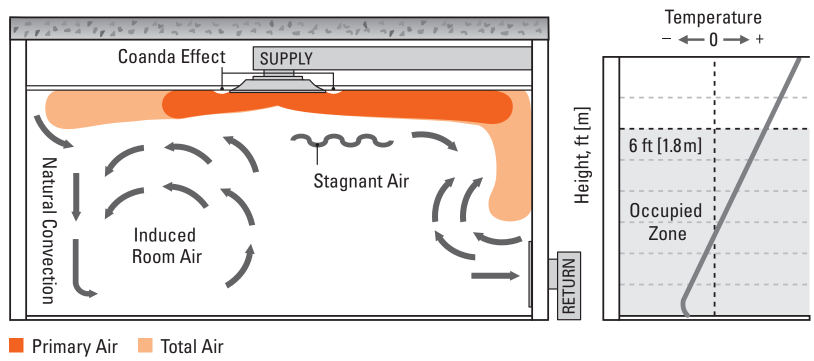
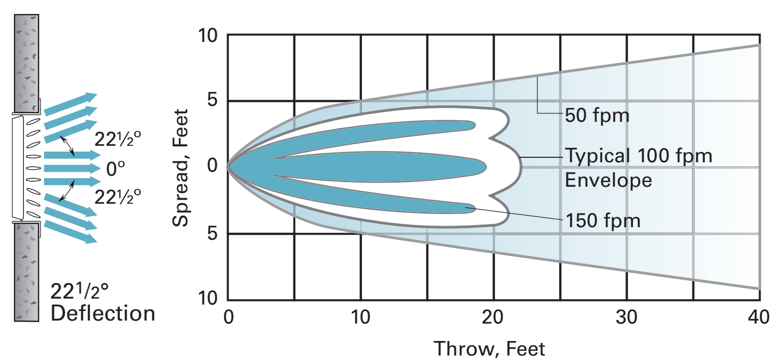


Figure 3: Throw/spread



All Metric dimensions ( ) are soft conversion.
Imperial dimensions are converted to metric and rounded to the nearest millimetre.

Space Air Diffusion

Stratification

Mixing ventilation systems generally supply air in a manner such that the entire room volume is fully mixed. The cool supply air exits the outlet at a high velocity, inducing room air to provide mixing and temperature equalization. Since the entire room is fully mixed, temperature variations throughout the space are small. See the temperature gradient curve in **Figure 1**. This variation in room air temperature from floor to ceiling is known as stratification. When warm air is introduced with a ceiling diffuser, some stratification can be expected due to the lower density of the warm supply air (see temperature gradient curve in **Figure 2**). If the stratification can be limited to occur above the occupied zone, it is not of concern from a comfort standpoint. Stratification in the occupied zone must be limited in accordance with ASHRAE Standard 55. See Chapter 4—Indoor Environmental Quality in the Price Engineer's HVAC Handbook for an explanation of how temperature stratification affects comfort.

Room Air

Finally, we come to the medium through which all metabolic heat transfer occurs and therefore is the most critical factor in controlling human comfort - the room air. The room air consists of all the other air within the space which is not included in the total air package. Proper air distribution attempts to condition the room air to maintain draft velocities and temperatures within the comfort range as defined in Chapter 4—Indoor Environmental Quality in the Price Engineer's HVAC Handbook. This velocity of air within the occupied zone is known as Room Velocity.

Room air movement is created by its gradual induction toward the primary and total air streams. It is this constant mixing that provides the mechanisms for heat transfer between the supply and room air. When air movement does not occur (usually as a result of insufficient outlet velocities or poor outlet location), a stagnant layer of room air is formed. Above that layer (or below in the case of overhead heating), proper heat transfer does not exist and temperature stratification occurs. This is illustrated by the temperature gradient curves shown in **Figure 2**. It is always desirable to keep the stagnation layer above the occupied zone in cooling and as near to the floor as possible when heating from above.

Convection Currents

The total air package can easily be influenced by several factors within the space. One of these factors that occurs in exterior zones of buildings is the natural convection currents resulting from a hot outside wall during cooling (**Figure 1**) or a cold outside wall during heating (**Figure 2**). The upward movement of air in the vicinity of the hot surface tends to oppose the total air movement in overhead cooling. This can act to reduce the outlet throw values or even cause the colder total air to leave the ceiling and create drop into the space. The downward movement of cold air in the vicinity of a cold surface (**Figure 2**) can create cold drafts within the occupied space. In the case of overhead heating, the only effective way to minimize these drafts is to direct a high velocity jet of warm air over the wall surface to reduce the difference between the temperature of the surface and that of the room air. Maintaining surface temperatures as close to the space as possible also minimizes radiation heat transfer potential between the surface and the occupants, resulting in improved comfort response. Note that increasing the perimeter surface temperature will also increase the building heat loss and should be considered in the load calculations.

Return

The return air inlet has very little effect on room air diffusion, regardless of inlet type or location. However, return air inlets should be located a sufficient distance from the supply outlet so that short-circuiting of supply air does not occur. It may also be desirable to locate the returns in the stagnant zone to remove unwanted warm or cool air. For cooling, a high sidewall or ceiling return will remove warm air from the space (**Figure 1**). For heating a low sidewall return will remove warm stagnant air (**Figure 2**).

GREEN TIP

Location of supply and return outlets to eliminate short circuiting will increase the ventilation effectiveness.

Selection Fundamentals - Performance Factors

Air Pattern

Air outlets are available with a variety of air pattern options. Some ceiling diffusers can be selected with either a 1, 2, 3 or 4 way horizontal pattern (**Figure 4**). The layout of the room and available location of the diffuser determines which pattern is selected. Some ceiling outlets also offer a vertical pattern option for high ceiling or heating applications. Plenum slot diffusers are often available with 1 or 2 way horizontal as well as vertical air pattern. Sidewall grilles can be set for straight or spread pattern, while linear bar grilles are available in several angular pattern options. The performance of the air outlet and the resultant comfort level in the space are greatly influenced by the type of air pattern selected.

Throw

Throw is, by definition, the distance the air is projected out from the center of the outlet face. When discussing throw, we must reference it to a specific air velocity, which is called the terminal velocity. Most often, throw is referenced to terminal velocities of 150 [0.75], 100 [0.50] and 50 fpm [0.25 m/s]. These velocities are indicated as T150 [T0.75], T100 [T0.50] and T50 [T0.25] respectively. Throw is primarily a function of the air volume being discharged by the air outlet and the induction rate of the air outlet. The throw can therefore be reduced by decreasing the air flow from the outlet or by selecting an air outlet with a high induction rate.

Drop

Whenever cool supply air is introduced into a warmer space its natural tendency will be downward movement. The vertical distance which the air jet extends below the ceiling is called the drop (**Figure 5**). Similar to the throw, we discuss the drop referenced to a specific terminal velocity. For simplicity we use the same three terminal velocities as for throw: 150 [0.75], 100 [0.50] and 50 fpm [0.25 m/s]. If the supply air projects into the occupied space uncomfortable drafts will occur. Drop can be minimized by utilizing the surface effect of the ceilings. Outlets located in or near the ceiling will exhibit less drop than outlets located on exposed ductwork. Typically, the drop will increase as the air volume, and subsequently the outlet throw, is increased. The vertical spread of the air jet

Selection Fundamentals - Performance Factors

increases with distance travelled. Reducing the supply air volume and increasing the supply air temperature will reduce the drop. One caution regarding reducing air volume too low is that the air jet may detach from the ceiling and fall into the occupied zone. This condition is known as 'dumping' and should be avoided.

Spread

Spread is the horizontal width of the air jet being discharged by the air outlet. Delivering the air in a spread pattern tends to reduce both the throw and the drop of an air outlet. As with the throw and drop, the same three terminal velocities are used to discuss spread: 150 [0.75], 100 [0.50] and 50 fpm [0.25 m/s]. Dissipating the air stream over a wider area increases entrainment and reduces the mass flow per unit surface area (**Figure 5**).

Pressure Drop

Every air outlet produces a pressure loss when air is passed through it. The magnitude of the pressure loss will vary depending on the model, size and geometry of the air outlet, and is measured in in. w.g. [Pa]. Pressure drop will increase proportionally with air flow. The pressure drop of the air outlet must be taken into account when calculating the system pressure when selecting the supply fan.

Noise Level

Typically, the noise level of an air outlet is rated with a Noise Criteria (NC) sound pressure value based on an industry standard 10 dB default for room absorption. This NC value assumes an average room and approximate distance of 5 ft [1.5 m] from a single source. For a detailed explanation of the NC rating method see Chapter 7—Basics of Acoustics in the Price Engineer's HVAC Handbook.

An air outlet's noise level (NC rating) is directly proportional to the air volume supplied through the outlet, with the sound increasing as more air is supplied. Larger size outlets generally are quieter at the same air flow than smaller sizes of the same model due to higher free area and/or lower inlet velocity. Outlets should be selected so that the resultant NC level does not exceed the ASHRAE recommended values for the particular space being considered.

Figure 4: Air patterns

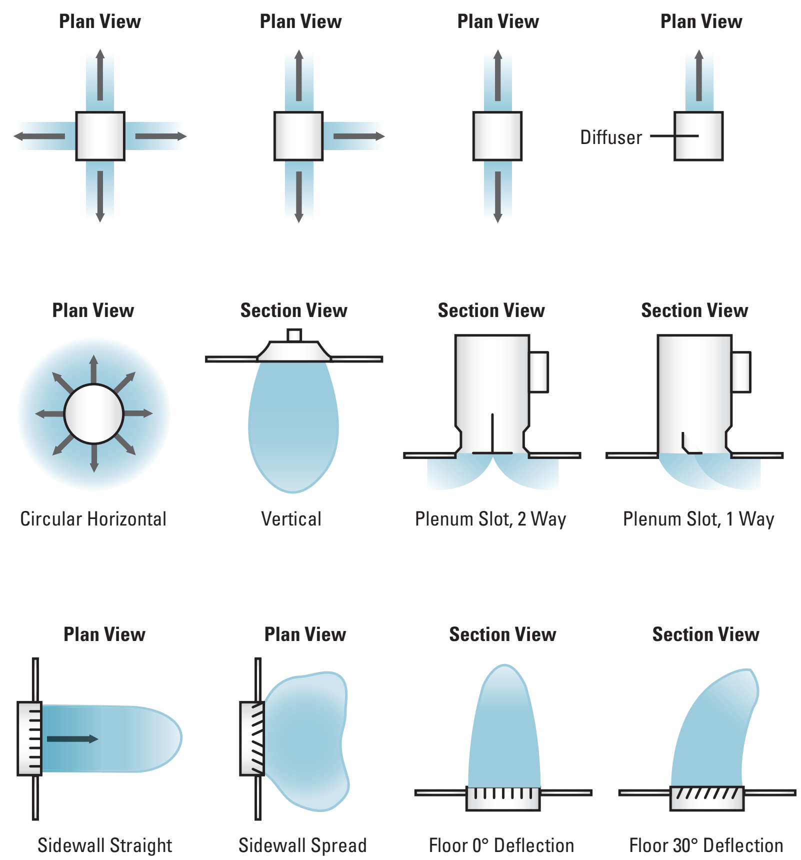
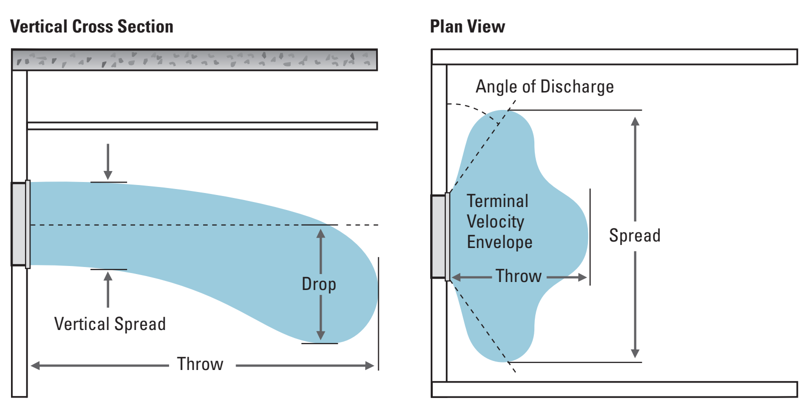


Figure 5: Drop (left), spread (right)



All Metric dimensions ( ) are soft conversion.
Imperial dimensions are converted to metric and rounded to the nearest millimetre.

Air Outlets

An important step in efficient space comfort conditioning is the proper selection of air outlets. This section presents generalized descriptions and characteristics of the types of grilles, registers and diffusers commonly used in commercial air distribution applications today.

Grilles and Registers

The term grille is commonly applied to any air outlet or intake that consists of a square or rectangular face and neck and whose facial appearance is made up of stationary or adjustable louvers which may be used to deflect the air.

A register is simply a grille which incorporates an integral damper for air volume control.

Supply grilles and registers usually have adjustable louvers and are available in single or double deflection models.

The single deflection type includes one set of blades in the horizontal or vertical orientation. Air pattern is adjustable in one plane only.

The double deflection type includes two sets of blades in both the horizontal and vertical orientation (**Figure 6**), with air pattern being adjustable in both the horizontal and vertical planes. Adjustment of the vertical blades provides spread control of the air pattern, reducing both throw and drop (**Figure 3**). Adjustment of the horizontal blades provides control over the deflection of the air pattern (**Figure 8**). Air can be directed up or down to suit the application.

Supply grilles or registers are most commonly mounted in the sidewall within 2 ft [610 mm] of a ceiling. Return grilles or registers (**Figure 7**) usually have a fixed blade or core and can be located in the sidewall or ceiling.

Linear Bar Grille

The linear bar grille is normally used where an architectural blend of the grille to its surroundings is required (**Figure 9** and **Figure 10**). These grilles may be mounted in the sidewall, sill or floor, and may be used for supply or return. Louvers are fixed with 1/4 in. [6 mm] or 1/2 in. [13 mm] bar spacing and 0°, 15° or 30° deflection. See **Figure 11** and **Figure 12** for mounting examples.

Linear Slot Diffuser

Linear slot diffusers incorporate adjustable pattern controllers in a multi-slot configuration. Slot sizes are available in ½ in. [13 mm], ¾ in. [19 mm] or 1 in. [25 mm] widths with a choice of one to ten slots. Adjustable pattern controllers allow horizontal left, horizontal right or vertical discharge for maximum flexibility. Typically used in ceiling installations, the linear slot diffuser is architecturally appealing, particularly when supplied in continuous lengths.

Figure 6: Double deflection supply grille

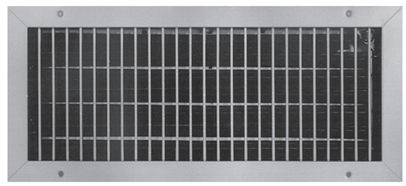


Figure 7: Return grille

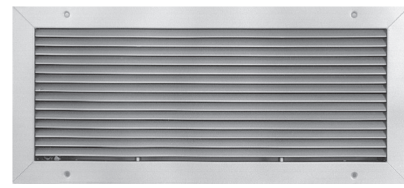


Figure 8: Upward deflection

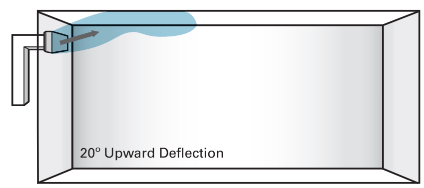


Figure 9: Linear bar grille, 1/4 in. [6mm] spacing

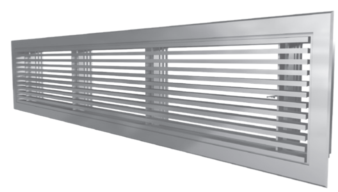


Figure 10: Linear bar grille, 1/2 in. [13 mm] spacing

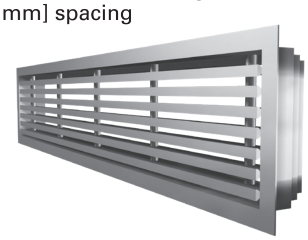


Figure 11: Sidewall application

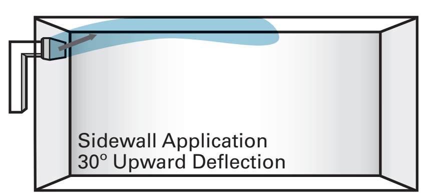


Figure 12: Sidewall application

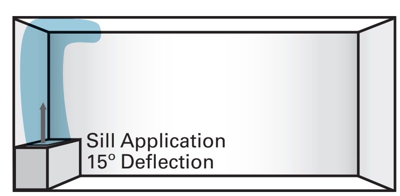
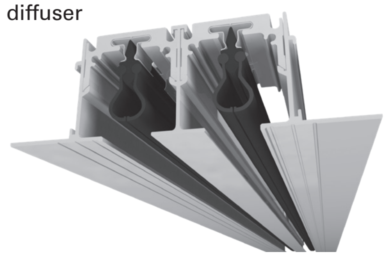


Figure 13: Linear slot diffuser



All Metric dimensions ( ) are soft conversion.
Imperial dimensions are converted to metric and rounded to the nearest millimetre.

Air Outlets

Figure 14:
Round ceiling diffuser

Figure 15:
Square ceiling diffuser

Figure 16:
Louvered face diffuser

Figure 17:
Round plaque diffuser

Figure 18:
Square plaque diffuser

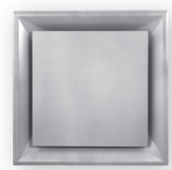


Figure 19:
Perforated ceiling diffuser

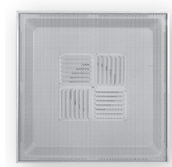


Figure 20:
Round Twist Diffuser

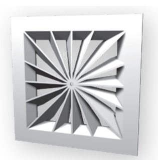


Figure 21:
Plenum slot diffuser

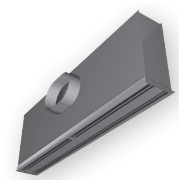
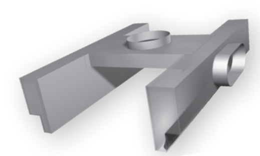


Figure 22:
Light troffer diffuser



Round Ceiling Diffuser

Round ceiling diffusers consist of several concentric cones suspended below the ceiling line by an outer cone (**Figure 14**). Neck sizes are available from 6 to 36 in. [152 to 914 mm], allowing a wide range of air volume selections. Adjustable models are available to provide either horizontal or vertical air pattern. The round diffuser's excellent horizontal pattern makes it ideal for variable air volume applications or exposed duct applications. Due to the availability of large neck sizes, the round ceiling diffuser is often used where high flow capacities are required (e.g. supermarkets, gymnasiums, halls, industrial applications).

Square Ceiling Diffuser

Square ceiling diffusers consist of several concentric square cones and a round neck (**Figure 15**). Air pattern is a uniform 360° horizontal pattern which is maintained at extremely low flows, making it ideal for variable air volume applications. Sizes are available to suit standard ceiling modules 12 in. x 12 in., 20 in. x 20 in., 24 in. x 24 in. [300 mm x 300 mm, 500 mm x 500 mm, 600 mm x 600 mm]. Adjustable pattern models are available for horizontal or vertical air pattern setting.

Louver Face Diffuser

Louver face diffusers are available with a square or rectangular face composed of a fixed modular core (**Figure 16**). This modular design allows for the selection of 1, 2, 3 or 4 way air pattern. Available neck sizes are square or rectangular. In addition to the design flexibility, the louver face diffuser is popular with architects because the louvers do not protrude below the ceiling line.

Round Plaque Diffuser

Round plaque diffusers consist of a plaque mounted inside an outer frame with a round inlet (**Figure 19**). Standard round inlet sizes are available: 8 in. [203 mm], 10 in. [254 mm], 12 in. [305 mm], and 14 in. [356 mm]. There are three available field adjustable plaque positions that allow this diffuser to go from a fully horizontal throw to a fully vertical throw. This adjustability makes this diffuser ideal for VAV as well as cooling and heating applications. The horizontal pattern is discharged in a 360° circular pattern.

Square Plaque Diffusers

Square plaque diffusers are comprised of a square plaque situated in a backpan with a round inlet (**Figure 18**). The air pattern produced is a uniform 360° circular pattern which is maintained even at very low velocities, making it ideally suited for VAV systems. Sizes are available to suit standard ceiling modules: 12 in. x 12 in., 20 in. x 20 in., 24 in. x 24 in. [300 mm x 300 mm, 500 mm x 500 mm, 600 x 600 mm]. Panels are also available to fit in different grid sizes.

Perforated Ceiling Diffuser

Perforated ceiling diffusers are available with a square or rectangular face supplied through a round or square neck (**Figure 19**). Horizontal air pattern is achieved with deflection vanes located at the diffuser face or in the neck. The vanes can be configured to achieve 1, 2, 3 or 4 way air pattern. The perforated face blends in very well with the acoustical tiles of typical suspended ceiling systems, and is therefore preferred by architects. Perforated return units (both ducted and non-ducted) are also available to match the supply units.

Radial/Twist Diffusers

Radial/twist diffusers consist of a circular or square face with multiple air vanes, either fixed or adjustable, and a round neck. Diffusers produce a horizontal or vertical twisting pattern for rapid mixing of the room air in heating or cooling modes. A distribution plenum or the outer cone can be connected directly to a round duct. Diffusers can be installed in a T-bar ceiling or exposed mounted to the ductwork. Adjustable air patterns can be manually, thermally or electronically controlled depending on a room thermostat signal. Models are available for both commercial and industrial applications.

Plenum Slot Diffuser

These diffusers consist of a factory fabricated plenum with integral pattern controllers for vertical or horizontal air pattern adjustment. Plenum slot diffusers are easy to install as they are designed to lay-in on suspended ceiling grids. This feature also provides flexibility for future tenant revisions. Diffusers are available in lengths ranging from 2 ft to 5 ft [610 mm to 1524 mm] and offer a choice of multiple slot widths ranging from 1/2 in. [13 mm] to 1½ in. [38 mm].

Light Troffer Diffuser

Light troffer diffusers are designed to integrate with commercially available light fixtures in suspended ceiling systems (**Figure 22**). The troffer consists of a plenum section, air slot and pattern controller. Troffers are available as single- or double-sided (saddle) units. Light troffer diffusers produce an excellent horizontal air pattern, ideal for VAV applications. This is also the most efficient diffuser in terms of producing optimum comfort conditions. Since the air slot is very narrow and integrated with the light fixture, it is also appealing from an architectural standpoint.

All Metric dimensions ( ) are soft conversion.
Imperial dimensions are converted to metric and rounded to the nearest millimetre.

Selection Procedures

Throw

Achieving the proper throw for a specific application is critical to proper outlet selection. Throw data is usually presented at terminal velocities of 150 [0.75], 100 [0.50] and 50 fpm [0.25 m/s]. Generally outlets should be selected so that the throw at 50 fpm [0.25 m/s] terminal velocity equals the distance from the outlet to the boundary of the conditioned space. In most cases this criteria will produce acceptable results.

When an air stream strikes a surface it tends to spread and follow the surface until the velocity dissipates. The total horizontal and vertical distance travelled by the air stream is equal to the tabulated throw of the outlet (**Figure 23**). For high ceiling applications it may be desirable for the throw to exceed the space boundary (ceiling) and travel down the wall toward the occupied zone. However, penetration of the occupied zone should usually be avoided.

In addition to physical boundaries created by walls or partitions, boundaries can be created by the collision of two air patterns (**Figure 24**). Where two patterns will meet, the outlets should be selected so that the throw is equal to one half the distance between the outlets. For high ceiling applications it may be desirable for the throw to travel downward toward the occupied zone. Throw is again equal to the horizontal and vertical distance travelled by the air stream.

It should be noted that most catalog throw data is presented for isothermal conditions (i.e., supply air temperature equals room temperature). During cooling the denser supply air will shorten the horizontal throw to approximately 75% of tabulated values (multiply by 0.75), assuming a temperature differential of approximately 15 °F [7.5 °C].

The cataloged throw data for most diffusers and grilles is developed with the outlet mounted in or adjacent to a ceiling. The ceiling or Coanda effect allows the supply air jet to be in contact with the ceiling longer, reducing induction of room air and consequently resulting in a longer throw than if the outlet was mounted in free space. If an air outlet is mounted in free space or more than 2 ft [610 mm] from a surface, the cataloged throw data should be reduced by approximately 30% (multiply by 0.70) (**Figure 25** and **Figure 26**).

When selecting outlets for VAV application, both minimum and maximum air quantities must be considered for throw. Although many models of outlets provide excellent horizontal air pattern at extremely low flows, throws may be reduced below acceptable limits.

In many applications it is desirable to limit the throw due to ceiling layout, walls, partitions or other boundaries which may obstruct the air pattern and cause unacceptable velocities in the occupied zone. There are several methods which may be used to minimize throw from outlets, including spreading the air pattern, reducing air volume per inlet and selecting the appropriate air pattern. More information on these methods will be presented on the following pages.

PRODUCT TIP

Slot diffusers and light troffer diffusers tend to maintain reasonable throws at low air volumes, and are therefore a good choice for VAV applications.

Figure 23: Throw of outlet

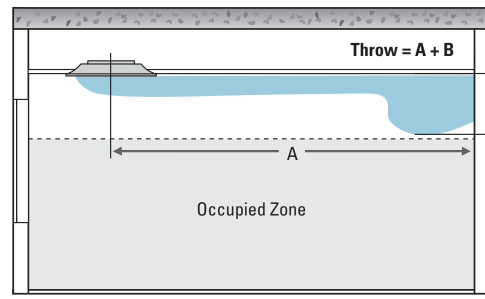


Figure 24: Boundaries created by two air patterns

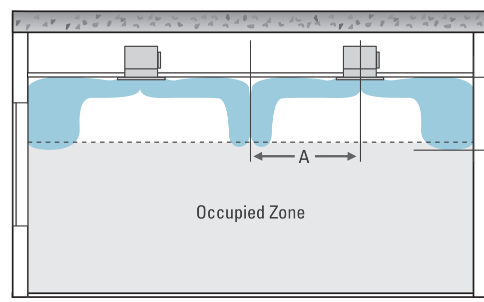


Figure 25: Ceiling diffuser free space mounting

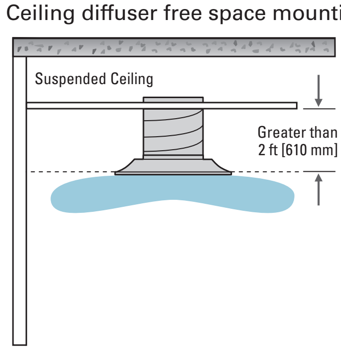
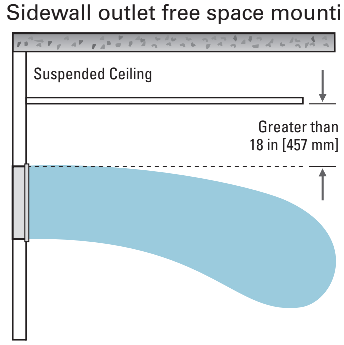


Figure 26: Sidewall outlet free space mounting



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Selection Procedures

Spread

Spreading the air pattern dissipates the air stream over a wider area and increases entrainment. This reduces the mass flow per unit surface area, which in turn reduces throw. Some outlets are designed to produce a spread pattern due to their geometry, while others such as supply grilles have adjustable vanes (**Figure 27**). Spreading the air is an effective way of reducing throw to avoid air pattern collisions with boundaries or other air jets.

PRODUCT TIP

Some models of plenum slot diffusers and linear slot plenums are constructed with a sloped shoulder plenum. The sloped plenum creates a natural spreading of the air pattern, substantially reducing the throw.

PRODUCT TIP

Louvered face supply grilles with adjustable blades provide a measure of flexibility for the designer and building operator as the throw and spread of the outlet can be field adjusted to account for changes in air volume, occupancy or ceiling layout.

Air Volume

Throw is directly related to mass flow, therefore a reduction in air volume per outlet will reduce the throw. This can be achieved by utilizing more outlets with less air volume per outlet. For linear diffusers or grilles, the same thing can be achieved by dividing the outlet into active and inactive sections (**Figure 29**). Each active section handles a smaller quantity of air, thereby reducing the throw. In order to effectively separate the air pattern, the outlet should be divided by minimum inactive length (**Table 1**).

Air Pattern

The outlet air pattern has a large influence on the throw. 1 way patterns tend to have the longest throw, while 4 way or round patterns have the shortest. The diffuser model will also affect the throw. See Table 2 for a comparison of ceiling diffuser throw at equal air volume for various diffuser models and air patterns. The layout of the ceiling and availability of installation location will determine the optimum air pattern for the application.

Mapping

One method of selecting outlets based on throw is known as 'mapping.' The cataloged throw is referenced and corrected for cooling if conditioned air is supplied. The corrected throw is plotted on the reflected ceiling plan and checked for interference with obstructions, walls or other air jets.

Figure 27: Plan view of spread vs. throw

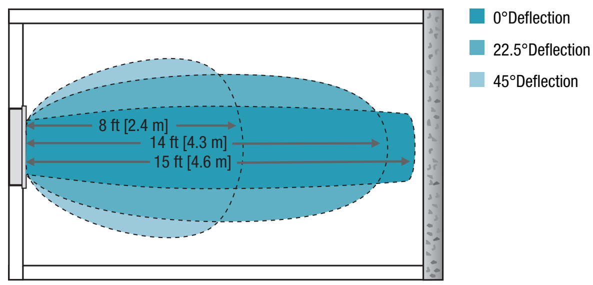


Figure 28: Continuous grille

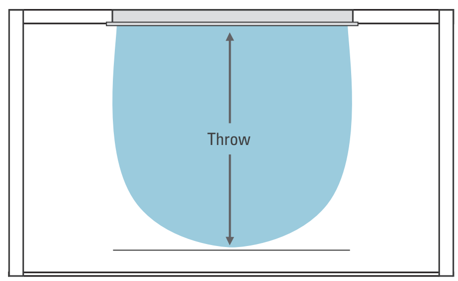


Figure 29: Active and inactive sections

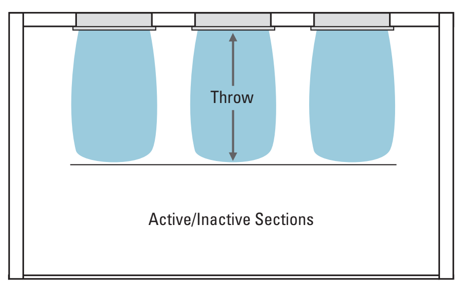


Table 1: Plan view of active and inactive sections

Length of Active Sections, ft [m]	1 [0.3]	5 [1.5]	10 [3]
Length of Inactive Sections, ft [m]	1 [0.3]	2 [0.6]	3 [0.9]

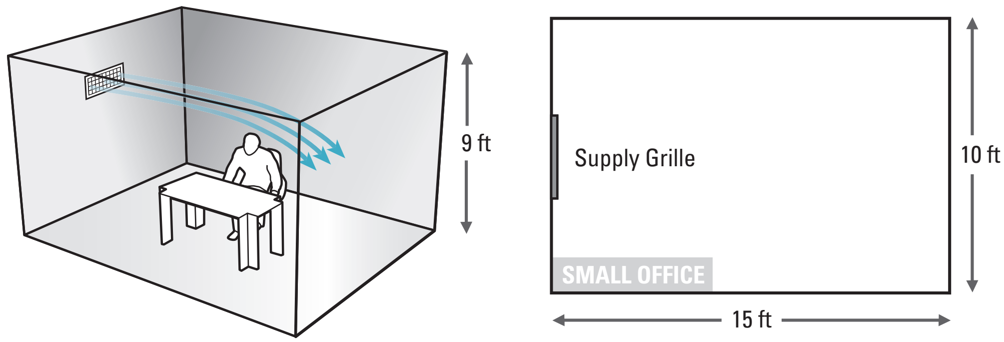
Table 2: Ceiling Diffuser Throw Comparison - 24 in. x 24 in. module [610 mm x 610 mm], 380 cfm, 700 fpm neck velocity, isothermal conditions, 50 fpm [0.25 m/s] terminal velocity

Diffuser Type	Throw Distance, ft [m]
Square Cone	10 [3.0]
Round Cone	9 [2.7]
Perforated 4 way	14 [4.3]
Perforated 1 way	33 [10.1]
Modular Core 4 way	24 [7.3]
Modular Core 1 way	36 [11]

All Metric dimensions ( ) are soft conversion.
Imperial dimensions are converted to metric and rounded to the nearest millimetre.

Example 1

A Model 520 size 6 in. x 5 in. supply grille operating at 150 cfm has been selected to supply a 10 ft x 15 ft room as illustrated in **Figure 27**. What is the best deflection setting of the diffuser blades if conditioned cool air is supplied?



Referring to the catalog page we determine the 50 fpm throw to be :
0° deflection - 22 ft isothermal or (22 x .75) = 17 ft cooling
22° deflection - 18 ft isothermal or (18 x .75) = 14 ft cooling
45° deflection - 11 ft isothermal or (11 x .75) = 8 ft cooling
As seen from the pattern diagrams in **Figure 25**, the 22° deflection provides the best coverage and would be the optimum selection.

Table 3: Model 520 series, 6 in. x 5 in. supply grille performance data

Performance Data - Model 520 Series, 6 in. x 5 in. Supply Grille								
							NC 20	**30**
Core Velocity, fpm			**500**	**600**	**700**	**800**	**1000**	**1200**
Velocity Pressure			**.016**	**.022**	**.030**	**.040**	**.062**	**.090**
Size	**Total Pressure**	**0**	.038	.052	.071	0.94	.146	.212
		22½	.045	.063	.085	.114	.176	.256
		45	.067	.093	.0126	.168	.261	.379
Ac = 0.15 ft^2 7 x 4 6 x 5	**cfm**		**75**	**90**	**105**	**120**	**150**	**180**
	NC		**-**	**-**	**15**	**19**	**26**	**31**
	Throw, ft	**0**	7-10-16	8-12-17	9-13-19	11-14-20	13-16-22	14-17-24
		22½	6-8-13	6-10-14	7-10-15	9-11-16	10-13-18	11-14-19
		45	3-5-8	4-6-9	5-7-9	5-7-10	6-8-11	7-9-12

All Metric dimensions ( ) are soft conversion.
Imperial dimensions are converted to metric and rounded to the nearest millimetre.

Selection Procedures

ADPI

Extensive studies have resulted in relationships between local temperatures, velocities and comfort reactions. On the basis of the temperature and velocity at a specific point, an effective draft temperature can be calculated for that location. The draft temperature is calculated by the equation:

$$\Theta_{ed} = (T_x - T_c) - 8(V_x - 0.15) \qquad \text{Eq.1}$$

where:

Θ = draft temperature
T_x = local temperature
T_c = control temperature
V_x = local velocity

Research indicates that a high percentage of people are comfortable when the effective draft temperature difference is between -3 °F [-2 °C] and +2 °F [+1 °C] and the air velocity is less than 70 fpm [0.36 m/s]. This comfort zone is illustrated as the shaded area in **Figure 30**.

Using this draft temperature as our criteria, the quality of room air diffusion can be determined based on the Air Diffusion Performance Index (ADPI). ADPI is defined as the percentage of locations in the occupied space which meet the comfort criteria based on velocity and temperature measurements taken at a given number of uniformly distributed points. This ADPI value has proven to be a valid measure of an air diffusion system.

The ADPI rating of an air diffusion system depends on a number of factors:

- Outlet type
- Room dimensions and diffuser layout
- Room load
- Outlet throw

When properly selected, most outlets can achieve an acceptable ADPI rating.

The higher the ADPI rating, the higher the quality of room air diffusion within the space. Generally an ADPI of 80 is considered acceptable.

Through extensive testing, relationships have been developed between ADPI and the ratio of throw over characteristic length (T/L). Throw is the isothermal throw at a selected terminal velocity taken from catalog performance charts. The characteristic length is the distance from the outlet to the nearest boundary. **Table 4** provides definition of characteristic length for various outlet types. See **Figure 31** for further clarification.

Figure 30: Comfort criteria - draft temperature

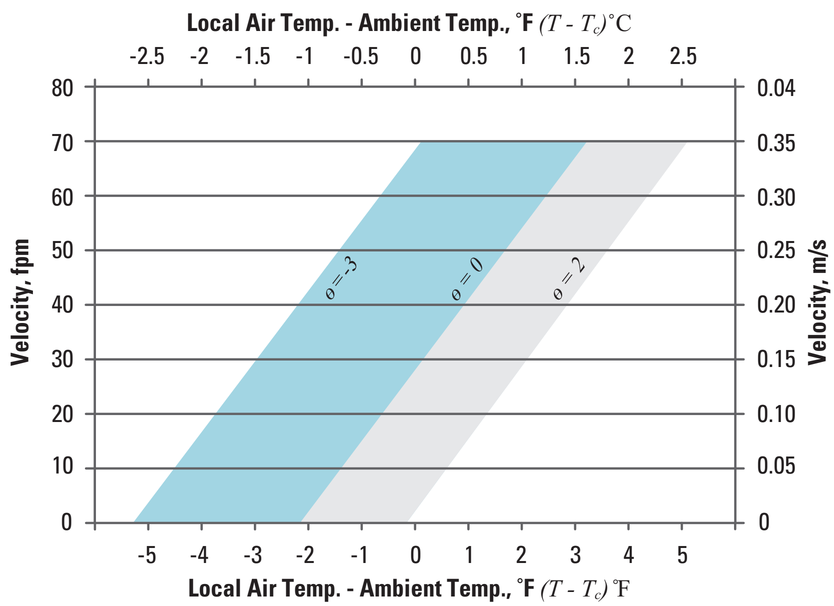


Table 4: Characteristic length for various diffuser types

Diffuser Type	Characteristic Length, L
High Sidewall Grille	Distance to wall perpendicular to jet
Circular Ceiling Diffuser	Distance to closest wall or intersecting air jet
Sill Grille	Length of room in the direction of the jet flow
Ceiling Slot Diffuser	Distance to wall or midplane between outlets
Light Troffer Diffusers	Distance to midplane between outlets, plus distance from ceiling to top of occupied zone
Perforated, Louvered Ceiling Diffusers	Distance to wall or midplane between outlets

It should be noted that **Table 4** is based on a standard 9 ft [2.7 m] ceiling height. For rooms with ceiling heights lower or higher, the characteristic length should be corrected down or up by the difference from 9 ft [2.7 m].

For example, a 20 ft [6.1 m] long room with a 12 ft [3.7 m] ceiling height and high sidewall grille:

Distance from grille to perpendicular wall = 20 ft [6.1 m], height correction: 12 - 9 = 3 ft (3.7 - 2.7 = 1 m) , characteristic length: 20 + 3 = 23 ft [6.1 + 1 = 7.1 m].

Note that the ADPI is applicable only for cooling mode conditions and can be field or lab measured using the test method described in ASHRAE Standard 113.

Selection Procedures

Heating mode conditions can be evaluated using ASHRAE Standard 55 guidelines and the test method of ASHRAE Standard 113.

Table 5 illustrates the range of T/L values which will result in optimum ADPI values for various outlet types at several room loads. By selecting a throw from the catalog data which produces the required T/L ratios, an acceptable ADPI rating can be achieved.

By studying **Table 5,** we can make several observations which are valuable to consider when selecting air outlets for maximum ADPI:

1. Generally, the higher the room load, the more difficult it is to achieve a high ADPI.
2. A value of T/L = 1.0 generally will produce an acceptable ADPI.
3. Some air outlets are better than others at achieving high ADPI values. For example, a sidewall grille has a maximum ADPI value of 85, while the circular ceiling diffuser can achieve an ADPI value of 93.
4. A wide T/L range allows the designer more flexibility in selecting the air outlet for optimum ADPI.
5. Outlets with a wide T/L range are more applicable to VAV systems as they can maintain a high ADPI even when turned down to low air volume. At 20 Btu/h/ft^2 [63 W/m^2] a ceiling slot diffuser has a turn-down ratio of 20% while maintaining an ADPI of greater than 80. At the same condition the high sidewall grille has a turn-down ratio of approximately 50%. Light troffer diffusers have the largest T/L range of all outlets, making them an excellent choice for VAV applications.

ALL-IN-ONE TIP

Price All-In-One selection software includes an ADPI calculation tool for automated calculation of ADPI for all outlet models.

PRODUCT TIP

Although not fully supported by research it is generally accepted that a high ADPI rating will produce a correspondingly high ventilation effectiveness, (i.e. approaching 1.0). If the supply air is well mixed and evenly distributed in the space, then any contaminants will also be evenly distributed, providing maximum indoor air quality.

Figure 31: Characteristic length illustration

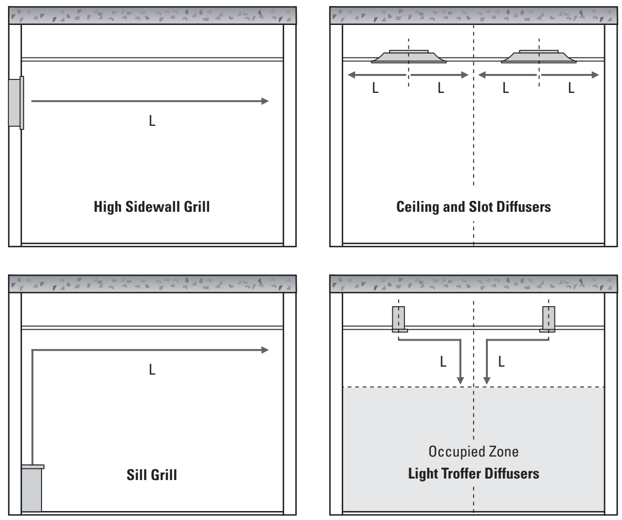


Table 5: Air diffusion performance index (ADPI) selection guide

Terminal Device	Room Load W/m2	T0.25/L for Max. ADPI	Max. ADPI	ADPI Greater Than	Range of T0.25/L
High Sidewall Grilles	250	1.8	68	-	-
	190	1.8	72	70	1.5 to 2.2
	125	1.6	78	70	1.2 to 2.3
	65	1.5	85	80	1.0 to 1.9
	< 30	1.4	90	80	0.7 to 2.1
Circular Ceiling Diffusers*	250	0.8	76	70	0.7 to 1.3
	190	0.8	83	80	0.7 to 1.2
	125	0.8	88	80	0.5 to 1.5
	65	0.8	93	80	0.4 to 1.7
	< 30	0.8	99	80	0.4 to 1.7
Sill Grille Straight Vanes	250	1.7	61	60	1.5 to 1.7
	190	1.7	72	70	1.4 to 1.7
	125	1.3	86	80	1.2 to 1.8
	65	0.9	95	90	0.8 to 1.3
Sill Grille Spread Vanes	250	0.7	94	90	0.6 to 1.5
	190	0.7	94	80	0.6 to 1.7
	125	0.7	94	-	-
	65	0.7	94	-	-
Ceiling Slot Diffusers (for T_{100}/L)	250	0.3	85	80	0.3 to 0.7
	190	0.3	88	80	0.3 to 0.8
	125	0.3	91	80	0.3 to 1.1
	65	0.3	92	80	0.3 to 1.5
Light Troffer Diffusers	190	2.5	86	80	< 3.8
	125	1.0	92	90	< 3.0
	65	1.0	95	90	< 4.5
Perforated & Louvered Ceiling Diffusers	35 to 160	2.0	96	90	1.4 to 2.7
	35 to 160	2.0	96	80	1.0 to 3.4

*Includes square cone diffusers and square plaque diffusers

All Metric dimensions ( ) are soft conversion.
Imperial dimensions are converted to metric and rounded to the nearest millimetre.

Selection Procedures

VAV Applications

When selecting air outlets for VAV applications it is important to analyze the ADPI at both the maximum and reduced flow conditions. For most outlets the throw, and consequently the T/L ratio, drops off as the air flow through the diffuser is decreased. If the T/L ratio drops too low ADPI can be compromised. Selecting an outlet for high ADPI at maximum flow does not ensure acceptable air distribution in the space when the load is reduced. Since ADPI is a measure of the air diffusion quality in the space, we are not concerned with the ADPI value when the space is unoccupied with the air outlet at minimum volume. We should, however, review the selection at low load conditions, such as when occupancy is reduced and/or external loads are at minimum.

Refer to Chapter 9—Mixing Ventilation in the Price Engineer's HVAC Handbook for examples that provide a step-by-step procedure for selection of air outlets using ADPI.

Pressure Drop

Supply air outlets produce both a static pressure loss and a velocity pressure loss. The static pressure loss is equal to the difference between the inlet static pressure (SPi) and the room pressure (usually atmospheric). The static pressure loss is dependent on outlet geometry and/or free area and must be derived by test. Static pressure loss is directly proportional to the volume of air supplied through the outlet. The velocity pressure loss is equal to the velocity pressure at the inlet (VPi) and the room velocity pressure (zero). See **Figure 32** and **Figure 33**.

The inlet velocity, and subsequently the velocity pressure loss, can be calculated from equations 2 and 3. The total pressure loss of an outlet is equal to the sum of the static and velocity pressure losses (equation 4).

Most catalog data lists the total pressure loss for a given air volume. If velocity pressure is provided, the static pressure can be derived from equation 4; however, if velocity pressure is not provided, it can be calculated based on the inlet velocity. For ceiling diffusers and plenum slot diffusers the inlet velocity is based on the inlet area. For sidewall grilles and registers the inlet velocity is based on the grille core area.

Velocity *Eq.2*

$$V = \frac{Q}{A}$$

Velocity Pressure *Eq.3*

$$V_p = \left(\frac{V}{4005}\right)^2 = \text{Neck Velocity fpm}$$

Total Pressure *Eq.4*

$$T_p = S_p + V_p$$

Figure 32: Ceiling diffuser

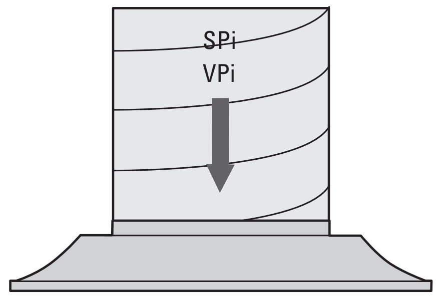
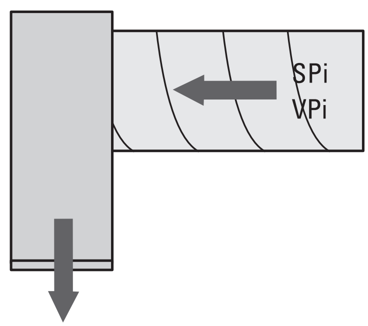


Figure 33: Slot diffuser



Example 2

A model SDB 100 2 slot, 60 in. diffuser with 8 in. round inlet is selected for 280 cfm. What is the pressure loss?

From **Table 6** performance data, the total pressure = 0.122 in. w.g. at 280 cfm.

Neck Area *Eq.5*

$$\frac{\pi D^2}{4} \quad D = \frac{8}{12} = 0.67 \text{ ft}$$

$$\frac{\pi 0.67^2}{4} = 0.349 \text{ ft}$$

Neck Velocity *Eq.6*

$$\frac{Q}{A} = \frac{280}{0.349} = 802 \text{ fpm}$$

Velocity Pressure *Eq.7*

$$V_p = \left(\frac{V}{4005}\right)^2 = \left(\frac{802}{4005}\right)^2 = 0.040 \text{ in. w.g.}$$

Static Pressure *Eq.8*

$$S_p = T_p - V_p$$

$$0.122 - 0.40 = 0.082 \text{ in. w.g.}$$

Table 6: Model SDB 100, 2-slot, 60 in. diffuser - 8 in. round inlet performance data

Performance Data - Model SDB 100, 2-slot, 60 in. diffuser - 8 in. Round Inlet								
Capacity, cfm			160	190	220	250	280	310
36 in. (6 in. Inlet)	Projection, ft	H	7-14-20	11-15-22	13-16-23	14-17-24	15-19-26	16-19-27
		V	17	19	21	23	24	25
	Tp		0.122	0.171	0.229	0.293	0.368	0.452
	NC		24	29	34	37	41	44
48 in. (7 in. Inlet)	Projection, ft	H	5-13-20	7-16-23	10-17-24	12-18-26	16-19-28	17-20-29
		V	17	19	22	23	24	26
	Tp		0.060	0.087	0.114	0.150	0.188	0.228
	NC		-	-	23	27	30	33
60 in. (8 in. Inlet)	Projection, ft	H	4-9-20	5-14-22	7-17-23	9-18-25	10-20-26	13-20-29
		V	14	17	20	22	23	25
	Tp		0.040	0.055	0.076	0.098	0.122	0.149
	NC		-	-	-	21	24	27

Selection Procedures

Noise Criteria

The first step in selection of an air outlet is defining the actual model type. A large variety of outlet styles, shapes and configurations are available. In many cases the outlet model selection is based on architectural or economic considerations. This decision on outlet type or model has significant influence on the resultant noise levels of the application since noise generation of air outlets depends on their design and geometry. Outlets with aerodynamic components and high free area will generally have lower noise levels at the same air flow.

Table 7 lists the NC level for several ceiling diffusers at the same air volume and neck velocity. The resultant NC level varies from a barely perceptible NC 17 for the square cone to a marginally acceptable NC 37 for the PDN. The table illustrates several points to consider when selecting air outlets.

1. The square plaque and square cone diffuser are an excellent choice for acoustically sensitive applications or when high air volumes per outlet are desired. This is due to the aerodynamic cones and high free area.
2. Perforated diffusers tend to be noisier than other available models at the same air volume. This is due to the restricted free area of the perforated face and pattern deflectors in the air stream.
3. There is a fairly large variation in generated noise levels, even between various perforated diffuser types. The curved pattern controllers of the perforated curved diffuser generates less sound than the less aerodynamic neck deflectors of the perforated neck deflector diffuser.
4. Selecting outlets based on neck velocity is a poor indication of acoustic performance.
5. To ensure predictable sound levels it is essential to reference the manufacturers' cataloged sound levels for the specified product.

Table 8 illustrates a similar noise level comparison for several models of plenum slot diffusers selected at the same conditions. Again, a wide range of acoustic performance is seen as a result of the diffuser design. The linear slot diffuser can be seen as the obvious choice for high capacity, noise-sensitive applications.

Table 7: Diffuser sound comparison - 24 in. x 24 in. module [610 mm x 610 mm], 380 cfm [180 L/s], 700 fpm [3.6 m/s] neck velocity

Diffuser Type	NC Level
Square Cone	17
Square Plaque	18
Round Cone	22
Modular Core	26
Perforated Curved Vane	28
Louvered Face	31
Perforated Face Deflector	33
Perforated Neck Deflector	37

Table 8: Plenum slot diffuser sound comparison - 1 in. slot, 4 ft [1.2 m], 270 cfm [127 L/s], 8 in. [203 mm] neck, 800 fpm [4.1 m/s] neck velocity

Diffuser Type	NC Level
Linear Slot	31
Linear Fixed Curved	36
Linear Ice Tong	39
Linear Wiper Blade	46

All Metric dimensions ( ) are soft conversion.
Imperial dimensions are converted to metric and rounded to the nearest millimetre.

Selection Procedures

Guidelines to Minimize Noise in an Air Distribution System

- Size the ductwork and duct elements for low air velocity.
- Avoid abrupt changes in duct cross-sectional area or direction.
- Provide smooth air flow at all duct elements, including branches, elbows, transitions and air outlets.
- When flexible duct is used it should be pulled taught and installed as straight as possible.
- Provide straight ductwork (preferably five to ten duct diameters) between duct elements.
- Use equalizing grids when non ideal inlets cannot be avoided.
- Balance the duct system for lowest reasonable fan speed with dampers generally open.
- Locate volume control dampers a minimum of three (preferably five to ten) duct diameters away from air outlets.

Selection Procedure

Table 9 illustrates the ASHRAE recommended space NC values for many commercial air conditioning applications. Outlets should be selected so that the tabulated NC levels are within these design goals.

Refer to Chapter 9—Mixing Ventilation in the Price Engineer's HVAC Handbook for noise selection procedures and examples.

Table 9: Design guidelines for HVAC system noise in unoccupied spaces

Room Types	RC / NC
Private Residences	**25-35**
Hotels/Motels	
Individual rooms or suites	25-35
Meeting/banquet rooms	25-35
Corridors, lobbies	35-45
Service/support areas	35-45
Office Buildings	
Executive and private offices	25-35
Conference rooms	25-35
Teleconference rooms	< 25
Open-plan offices	< 40
- With sound masking	< 35
Corridors and lobbies	40-45
Hospitals and Clinics	
Private rooms	25-35
Wards	30-40
Operating rooms	25-35
Corridors and public areas	30-45
Performing Arts Spaces	c
Drama theaters	25
Music teaching studios	25
Music practice rooms	30-35
Schools	d
Classrooms	25-30
Large lecture rooms	25-30
Large lecture rooms, without speech amplification	25
Laboratories (with Fume Hoods)	
Testing/research, minimal speech communication	45-55
Research, extensive telephone use, speech communication	40-50
Group teaching	35-45
Church, Mosque, Synagogue	
General assembly	25-35
With critical music programs	c
Libraries	30-40
Courtrooms	
Un-amplified speech	25-35
Amplified speech	30-40
Indoor Stadiums, Gymnasiums	
Gymnasiums and natatoriums[e]	40-50
Large seating-capacity spaces with speech amplification[e]	45-55

[a] The values and ranges are based on judgment and experience, not quantitative evaluations of human reactions. They represent general limits of acceptability for typical building occupancies. Higher or lower values may be appropriate and should be based on a careful analysis of economics, space use and user needs.

[b] When quality of sound in the space is important, specify criteria in terms of RC(N). If the quality of the sound in the space is of secondary concern, the criteria may be specified in terms of NC or NCB levels of similar magnitude.

[c] An experienced acoustical consultant should be retained for guidance on acoustically critical spaces (below RC 30) and for all performing arts spaces.

[d] Some educators and others believe that HVAC-related sound criteria for schools, as listed in previous editions of this table, are too high and impede learning for affected groups of all ages. See ANSI Standard S12.60-2002 for classroom acoustics and a justification for lower sound criteria in schools. The HVAC component of total noise meets the background noise requirement of that standard if HVAC-related background sound is RC 25(N).

[e] RC or NC criteria for these spaces need only be selected for the desired speech.

Reference
- 2007 ASHRAE Applications Handbook, Table 42, page 47.34
- AHRI Standard 885-2008, Table 15, page 31

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Low Temperature Systems

Description

Low temperature air distribution systems typically supply conditioned air at nominal temperatures of between 42 °F [6 °C] and 47 °F [8 °C], as compared to conventional systems which supply air at temperatures between 55 °F [13 °C] and 59 °F [15 °C]. Low temperature air distribution systems have been applied mainly in conjunction with ice storage systems to take advantage of the low temperature chilled water produced by these systems.

Ice storage systems have been applied to reduce electrical demand during peak periods. Electric chillers are used to freeze water at night when utility rates are low. During the day the ice is used to cool the building, reducing operation of the electric chiller during peak periods. Electric utilities in some areas also offer incentives to owners installing ice storage systems.

Design Considerations

Several design considerations must be taken into account when considering a low temperature air distribution system. Some common concerns include condensation, comfort and indoor air quality.

Low Temperature Air Outlets

If low temperature air is to be supplied directly to the space, supply air outlets must be designed and tested to provide good mixing and maintain a horizontal air pattern at low flow conditions. In addition, the diffuser must be properly insulated and sealed to prevent condensation from forming on the diffuser surface.

Low temperature air outlets have been developed specifically for the supply of low temperature air. All outlets feature high induction jets which rapidly mix supply and room air as well as maintain a good horizontal air pattern at low flow conditions. These features ensure comfort conditions are provided in the space.

When supplying low temperature air directly to the space, the terminal unit and accessories such as reheat coils, attenuators, etc., must also be specifically constructed to prevent condensation.

Variable Volume Supply with Low Temperature Air Outlets

Some manufacturers have developed various air distribution components which can provide a supply of low temperature air to the space while maintaining comfortable conditions under variable air volume operation.

Figure 35 presents various low temperature diffuser options utilized in conjunction with a single duct VAV reheat terminal designed for low temperature operation.

Figure 34: Low temperature air outlets

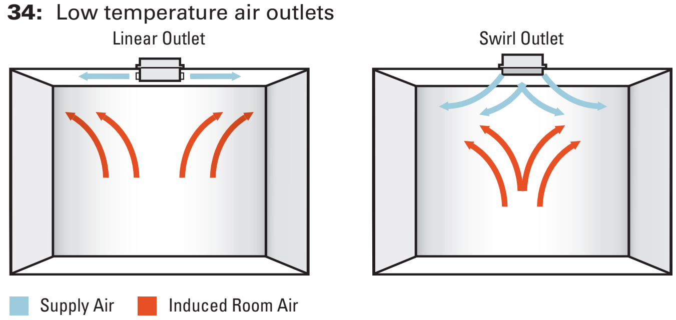
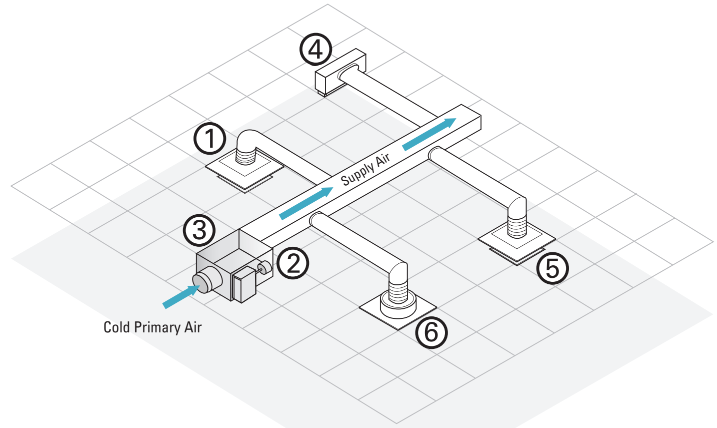


Figure 35: Variable volume supply with low temperature air outlets



1. Low Temperature Perforated Face Diffuser
   - Induction chamber aids rapid mixing of low temperature air.
   - Aerodynamic shape of backpan ensures excellent horizontal air pattern.
   - Perforated face blends well with suspended ceiling tiles.
   - Factory insulated and sealed to prevent condensation.
2. Hot Water Coil
   - Factory insulated and sealed with external foil faced insulation to prevent condensation.
   - Available with insulated access door.
   - One or two row coils available.
3. Single Duct Terminal with Low Temperature Supply Option
   - Factory insulated and sealed to prevent condensation.
   - Isolated and insulated inlet duct foil faced internal insulation.
4. Low Temperature Linear Diffuser
   - Induction chamber aids rapid mixing of low temperature air.
   - 1 or 2 way horizontal air pattern.
   - Factory insulated and sealed to prevent condensation.
5. Low Temperature Square Plaque Diffuser
   - Induction chamber aids rapid mixing of low temperature air.
   - Flush face of plaque provides architectural appeal.
   - Factory insulated and sealed to prevent condensation.
   - Aerodynamic shape of backpan ensures excellent horizontal air pattern.
6. Low Temperature Radial Vane Diffuser
   - High induction vortex air pattern provides rapid mixing of low temperature air.
   - Factory insulated and sealed to prevent condensation.

PRODUCT TIP

Low temperature outlets are available with cataloged performance data at reduced supply air temperature, ensuring proper selection.

PRODUCT TIP

Low temperature construction for single duct terminals include internal vapor barrier, thermally isolated inlet valves and insulated inlet collar.

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Imperial dimensions are converted to metric and rounded to the nearest millimetre.

Industrial Ventilation

The purpose of an industrial ventilation system is to reduce the exposure to excess heat and contaminants generated in an industrial environment. The most effective method of removing excess heat and contaminants is at the source with a local exhaust system. Another method is dilution with general ventilation by either a fan system, natural draft or a combination of the two. In some cases cooling is required to maintain acceptable space conditions, either for people or processes. Many industrial applications require a combination of local exhaust, general ventilation supply and general exhaust to handle simultaneous removal of heat and contaminants. This section will focus on general ventilation supply air systems.

Air Supply Methods

Similar to commercial spaces, there are several methods of supplying air to an industrial space. The following are the most common:

Mixing Air Distribution

Supply air exits the outlet at a high velocity, inducing room air to provide mixing and temperature equalization before the air jet reaches the occupied zone. Since the air jet induces the surrounding air, the contaminant concentration in the space is diluted.

Displacement Ventilation

Introduces air into the space at low velocities, which causes minimal induction and mixing. Displacement outlets may be located almost anywhere within the space, but have been traditionally located at or near floor level. The system utilizes buoyancy forces generated by heat sources such as people or processes to remove contaminants and heat from the occupied zone. See Volume 4, Section J for Displacement Ventilation Outlets.

Localized Ventilation

Introduces the air directly to a specific area of a space or toward the breathing zone of an occupant to provide comfort conditions and/or control of contaminants. The close proximity of the outlet to the source prevents entrainment of contaminants, providing a much cleaner work area than the surrounding space.

Unidirectional or Plug Flow

Introduces non turbulent or laminar supply air to the space to control contaminants and obtain a high level of cleanliness.

Air Outlets

Due to the unique and extreme conditions experienced in the industrial environment, specific air outlet models have been developed for this application. Several are presented below:

Industrial Supply Grilles and Registers

Similar to commercial models, the grille or register has adjustable louvers in single or double deflection; however, the louvers are deeper (up to 3 in. [76 mm]) and spaced wider. The deeper louver is stronger and more effective for pattern deflection. Construction is generally extruded aluminum louvers and heavy duty aluminum or steel frame. The heavy duty construction of the industrial supply grilles and registers withstands frequent adjustment, high velocity and air volumes, turbulent supply air, and contaminants in the air stream. Options include gang operators, quick-release trunk latch frame and heavy duty balancing damper (**Figure 36**).

Figure 36: Industrial supply grille

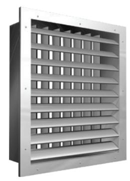


Figure 37: Drum louver

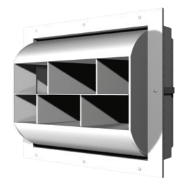
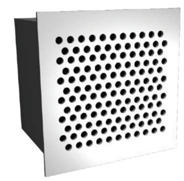


Figure 38: Nozzle

Figure 39: Industrial return grille

Figure 40: Security grille



Drum Louver

Drum louvers consist of adjustable vanes mounted in a rotating drum which is adjustable up or down to provide directional control of the air pattern. The deep adjustable vanes can be used to achieve varying amounts of spread pattern. The depth of the drum and vanes produces a long air projection and high degree of directional control. Construction can be heavy gauge steel or extruded aluminum. Options include pole operator bracket, motorized drum and heavy duty balancing damper (**Figure 37**).

Nozzle

Similar to the drum louver, the nozzle achieves a very long air projection due to its depth and geometry. Generally round in shape, nozzles are available in a variety of models including adjustable versions which allow directional control of the air pattern. Construction can be steel or aluminum. Options include motorized direction control and twist elements for throw and spread adjustment (**Figure 38**).

Industrial Return Grilles or Registers

Grilles or registers have fixed blades of various deflection and blade spacing and are constructed of heavy gauge steel or extruded aluminum with welded frame. Options include stainless steel construction and heavy duty balancing damper (**Figure 39**).

Security Grilles

Due to their heavy duty construction, security grilles are a good option for severe industrial environments in addition to institutional applications (**Figure 40**).

Construction Features

When selecting outlets for industrial applications there are several construction and functional features to consider. Supply grilles or nozzles should include a means of adjusting the direction of air flow to facilitate changes to the work area layout or changes due to seasonal variations. On multi-blade grilles a gang operator option simplifies blade adjustment. Often the air outlets are subjected to high velocities and turbulent flow conditions. Vibration of the ductwork due to close coupled fans or other equipment can also be present. To prevent grille blades or the nozzle drum from moving under the influence of these conditions, a locking mechanism is recommended.

Other options to consider are:

- Quick-release fastening frame for easy removal and replacement for cleaning
- Filter frame for return grilles
- Stainless steel construction for corrosive environments
- Heavy duty industrial grade balancing dampers with locking mechanism
- Heavy duty gym grilles or security grilles for return applications to prevent damage in low areas

Air Outlet Selection

Refer to Chapter 9—Mixing Ventilation in the Price Engineer's HVAC Handbook for Industrial Outlet selection procedures and examples.

Conversion Factors

	Item	To Convert From Imperial Units	To SI Units	Multiply By
Length	inches inches feet	millimetres metres metres	mm m m	25.4 0.0254 0.3048
Area	square inches square inches square inches square feet	square millimetres square centimetres square metres square metres	mm^2 cm^2 m^2 m^2	645.16 6.4516 0.000 645 16 0.092 903 04
Volume — Air Flow	std. cubic feet per minute std. cubic feet per minute std. cubic feet per minute	cubic metres per second cubic metres per hour litres per second	m^3/s m^3/h L/s	0.000 471 947 1.699 0.471 947 **Under $1m^3/s$ use L/s**
Volume — Liquid & Liquid Flow	gallon (Can.) gallon (U.S.) gallons per minute (Can.) gallons per minute (U.S.) gallons per hour (Can.) gallons per hour (U.S.)	litre liter litre per second liter per second litre per second liter per second	L L L/s L/s L/s L/s	4.546 090 3.785 412 0.075 768 0.063 09 0.001 263 0.001 051
Velocity	feet per second feet per minute	metres per second metres per second	m/s m/s	0.3048 0.005 080
Pressure	inches of water (60 °F) foot of water (39.2 °F) inches of mercury (60 °F) lb force per square inch (psi) lb force per square foot	pascal (20 °C) pascal (20 °C) pascal pascal pascal	Pa Pa Pa Pa Pa	248.84 2 988.98 3 376.85 6 894.757 48.880 26
Energy	btu	joule	J	1 055.056
Power	Horsepower	watt kilowatts	W KW	746 0.746
Temperature (see next page)	Rankin Fahrenheit	kelvin Celsius, Centigrade	K C	5/9 (F-32) (5/9)
Heat flow rate	btu per hour	watt kilowatt	W KW	0.293 071 0.000 293 071
Weight	ounce pound	gram kilogram	g kg	28.350 0.4536
Density	pounds per cubic foot	kilograms per cubic meter	kg/m^3 kg/m^3	16.018

Temperature

1. To convert from degree Fahrenheit to degree Celsius, subtract 32 and divide by 1.8.
2. To convert from degree Celsius to degree Fahrenheit, multiply by 1.8 and add 32.
3. To convert from degree Fahrenheit to Kelvin, add 459.67 and divide by 1.8.
4. To convert from Kelvin to degree Fahrenheit, multiply by 1.8 and subtract 459.67.
5. To convert from degree Celsius to Kelvin, add 273.15.
6. To convert from Kelvin to degree Celsius, subtract 273.15.
7. To convert from degree Rankin to Kelvin, divide by 1.8.

Example

A) Grilles & Registers

Price 20 in. x 4 in. 22/C/S at 550 cfm, 0.156 in. w.g. total pressure, core velocity = 1200 fpm will be described in SI units as follows:

Price 508 mm x 102 mm, 22/C/S at 275 L/s. 39 Pa total pressure, core velocity = 6 m/s.

B) Diffusers

Price 24 in. x 24 in., 10 in. round inlet SCD at 490 cfm, .098 in. w.g. total pressure neck velocity = 900 fpm will be described in SI units as follows:

Price 600 mm x 600 mm, 250 mm round inlet SCD at 231 L/s, 25 Pa total pressure, neck velocity = 5 m/s.

Note:

Dimensions are 'soft' conversion, and rounded to the nearest millimetre.

The conversion data presented in this catalog is based on the following reference standards:

1. National Standard of Canada, “Metric Practice Guide" CAN3-Z234. 1-76 (Canadian Standards Association, 178 Rexdale Boulevard, Rexdale, Ontario M9N 1R3).
2. “ASHRAE SI Metric Guide for Heating, Refrigerating, Ventilating, and Air Conditioning” (ASHRAE Inc., 1791 Tullie Circle, NE, Atlanta, Georgia, 30329.
3. “Supplementary Metric Practice Guide for Heating, Ventilating, Air Conditioning, Refrigeration, Plumbing and Air Pollution Equipment Manufacturing Industries” (Heating, Refrigerating and Air Conditioning Institute of Canada; 385 The West Mall, Suite 267, Etobicoke, Ontario M9C 1E7)

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Kirkpatrick, A. T., & Elleson, J. S. (1996). *Cold air distribution system design guide.* Atlanta, GA: American Society of Heating, Refrigeration and Air-Conditioning Engineers.

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All Metric dimensions ( ) are soft conversion.
Imperial dimensions are converted to metric and rounded to the nearest millimetre.