GRILLES, REGISTERS AND DIFFUSERS—

Impact on Comfort

Understanding how grilles, registers and diffusers work with air-distribution systems will help occupants feel comfortable in their indoor environments.

BY JIM ASWEGAN AND RANDY ZIMMERMAN

All illustrations courtesy of Titus.

The design, selection, and installation process of an air-distribution system can be advanced by understanding the principles of human comfort. In general, when a person is comfortable, thermal conditions in the space allow the body's heat loss to equal the body's heat production. Because the human body loses heat through radiation, conduction, convection, and evaporation, space factors of dry bulb and radiant temperature, relative humidity and air motion are important to the occupant's comfort.

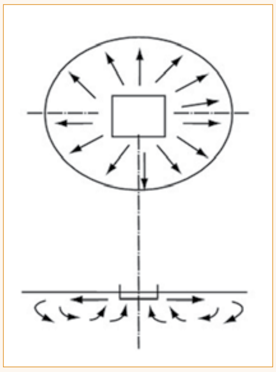
Other factors known to affect human comfort include the general metabolic-activity level of the occupant—the met rate—and the amount of clothing worn by the average occupant—the clo rate. Controlling the supply-air temperature, volume and distribution into the space are the primary means to maintaining occupant comfort in the space.

Occupant comfort limits are set by ASHRAE Standard 55, ISO Standard 773, and the *ASHRAE Applications Handbook* chapter on Room Air Distribution. In general, most occupants will be comfortable if the conditions in the occupied space (below the 6-ft level, minus the mixing zone 1 ft from interior walls and 3 ft from perimeter walls) have:

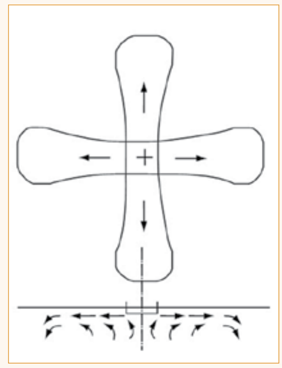
1. Air temperature maintained between 73°F–77°F;
2. Relative humidity maintained at <60%;
3. Maximum air motion in the occupied zone at <50 fpm for cooling and <30 fpm for heating; and
4. Maximum temperature gradient from floor level to 5–6-in. level <5.4°F.

There are many factors that influence the type of air-distribution devices that are selected to provide comfort conditioning in a space, including their aesthetics, cost and performance. Aesthetics is most often determined by the design demands of the building architect or owner.

Controlling cost is an important part of the selection process but may be further influenced by architectural design requirements or performance requirements for keeping the occupant comfortable. In some cases, the higher first-cost for an outlet may be offset by better performance, resulting in lower system-operating costs. Another more subtle factor may be an improvement in employee productivity as a result of the high comfort levels in the space.



‹‹ Figure 1 **This image illustrates how air is discharged through a circular pattern outlet. This type of outlet typically discharges air in a 360-degree radius to nearly equal throw distance, and is generally used in devices with higher induction and shorter throw distance from the outlet—such as with VAV-cooling applications.**



‹‹ Figure 2 **Outlets that produce a cross-flow air pattern, illustrated here, throw the air a longer distance from the outlet—but cross-flow patterns have less induction, and tend to lose surface effect during cooling conditions when the jet velocity slows to less than 100 fpm.**

Meeting the aesthetic demands and balancing the cost are important factors, but ensuring that the requirements for occupant comfort are met requires selecting and installing air outlets with adequate performance characteristics. These selection criteria should include: the supply-air pattern; ceiling effect; outlet placement (throw, drop, spread); and factors affecting room noise levels.

Air patterns

There are two basic types of air patterns produced by an air outlet. The first is the circular pattern shown in Figure 1. Outlets producing a circular pattern where air is discharged in a full 360-degree radius to nearly equal throw distance are usually devices with higher induction and shorter throw distance from the outlet.

The circular pattern is preferred for VAV-cooling applications because air hugs the ceiling better having less drop during minimum- and maximum-flow conditions.

The second air pattern type is known as a cross-flow pattern, shown in Figure 2. Outlets that produce a cross-flow pattern have an individual discharge jet that can leave the outlet in one or more directions. Cross-flow air patterns throw the air a longer distance from the outlet but with less induction, and they tend to lose surface effect during cooling conditions when the jet velocity slows to less than 100 fpm.

Air outlets

The three basic types of air outlets are grilles, registers and diffusers. Grilles or registers equipped with an integral damper may be mounted directly onto a wall or attached to a spiral duct. Diffusers are typically mounted at the ceiling, but also can be mounted exposed on the end of a vertical air duct. Linear diffusers can be mounted in either a ceiling or sidewall location.

For cooling applications, the location of an outlet relative to a horizontal surface will impact the throw distance and the vertical drop distance of the air from the centerline height of the outlet. If a cool-air jet is discharged from a sidewall outlet within 18 in. of a parallel ceiling surface, a negative pressure pocket above the jet will form to draw the air up to the ceiling surftace, which will lengthen the throw and minimize the drop distance from the outlet.

If the outlet is mounted between 2 ft and 4 ft below the ceiling and the grille is equipped with adjustable blades in a horizontal orientation, the air can be deflected up 20 degrees to push the air upward and establish ceiling effect. When the grille is located more than 4 ft below the ceiling surface, the air can be deflected up to minimize drop, but probably will not establish ceiling effect and will throw the air a shorter distance. If a sidewall outlet is equipped with adjustable blades in the vertical orientation, air can be spread from a zero-degree discharge deflection to a 45-degree deflection. The 45-degree deflection will shorten the throw and minimize the drop.

For sidewall outlets mounted directly to the side of a spiral duct, there are two rules to follow:

1. The air velocity in the main duct should be less than 800 fpm; and
2. The static pressure loss across the outlet and any damper assembly must be more than 1.4 times the velocity pressure in the main duct to prevent air from being induced through the grille by the force of the main duct supply air.

With ceiling-mounted supply-air diffusers, any obstruction in the air stream where the angle of discharge from the edge of the outlet to the obstruction is greater than 15 degrees can result in unwanted downward drafts into the occupied zone.

For ceiling supply outlets mounted more than 12 in. below the ceiling surface, when the air pattern is cross-flow, the air will discharge downward at an angle of approximately 30 degrees. For circular air patterns, the air will discharge from the outlet in a horizontal deflection, but the throw distance will be 30% shorter than with ceiling effect.

At the point of intersection where two air jets collide, the air will deflect downward. This vertical jet may cause drafts in the occupied area. With cross-flow air patterns, if the cool air jet has not reached a perpendicular wall surface before slowing to a velocity of less than 100 fpm, buoyancy may cause the jet to leave the ceiling and cause drafts in the occupied zone.

For continuous, linear air diffusers, the throw distance will be impacted by the length of the active section. To avoid excessive throw distances, place a 12-in. blank off section after every 48-in. active section; or a 24-in. blank off section after every 96-in. active section. Alternating airflow directions also can help control the throw discharge distance.

Many supply-air outlets are available with adjustable-pattern controllers to deflect the air horizontally, vertically or somewhere in between. These outlets are not adjusted by the manufacturer to match the intended field application. Care should be taken to instruct the responsible party to properly adjust the air pattern prior to system commissioning.

Sound considerations

Another important factor in the selection process is sound. ASHRAE handbooks provide guidance for the appropriate sound levels in various applications. Knowing how to manage the air-distribution product installation may impact the resulting sound level in the space after occupancy.

In order to prevent any additional sound impact from the upstream ductwork, the noise at the discharge of the terminal unit must be attenuated to a level 10 dB below the rated value of the outlet. If this noise is not attenuated, it will create an additional or dominant noise that will carry into the space being served. Internally lined ductwork at the terminal-unit discharge and acoustic flex on the diffuser inlet are common solutions.

Inlet-duct conditions also contribute to variances in sound. Manufacturers' catalog performance data is typically based on results of tests conducted in accordance with ASHRAE or ISO Standards, as specified. ASHRAE Standard 70 for Air Distribution Devices requires three diameters of straight duct with a flow straightener for proper sound tests.

Since all duct conditions at a jobsite are not going to meet the three diameters of straight duct used for testing standards, additional care should be taken to ensure inlet

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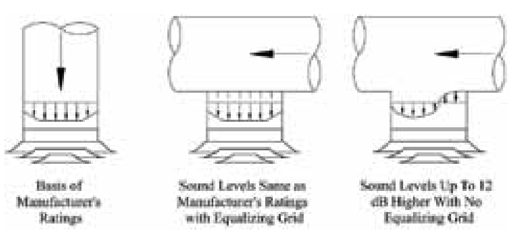

Figure 3 When the diffuser is mounted close to the supply-air duct, an equalizing grid may be installed in the diffuser inlet to provide even flow and minimize unwanted sound.

conditions are as good as possible to minimize the sound impact of application variances.

When the diffuser is mounted close to the supply air-duct as shown in Figure 3, an equalizing grid may be installed in the diffuser inlet to provide even flow and minimize unwanted sound. For round-duct or flex-duct connections, the entry should be made as long and as straight as possible. Figure 4 shows that when the entry is straight and air is distributed evenly across the inlet, the result will be near catalog performance. Altering the inlet to a 45-degree entry position, can impact the catalog noise rating by as much as 15 dB.

When ceiling plenum space is limited, and the supply-air duct travels horizontally across the ceiling but then turns abruptly into the neck of the diffuser, it will impact the catalog sound values. Catalog noise levels will increase from +3 dB for a smooth 90-degree turn to more than 10 dB for a kinked flex-entry duct.

For minimum contribution to sound, when dampers are located at the branch takeoff, the result will have little impact on the sound performance. Moving the damper to the neck of the diffuser will add 3–4 dB when the damper is fully open and increase as the damper is adjusted close.

Good design and installation practices reap many benefits over time. Comfortable employees are more productive. Paying attention to meeting the ASHRAE Standards and best practices discussed in this article will maximize the comfort

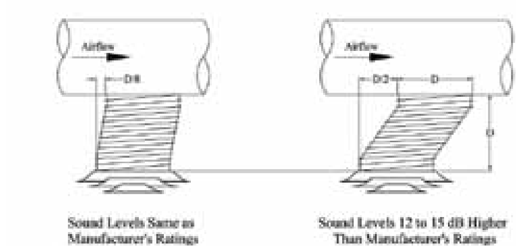

Figure 4 With round- or flex-duct connections, the entry should be made as long and as straight as possible. This illustration shows a straight entry on the left–where air is distributed evenly across the inlet—and an inlet slanted to a 45-degree entry position—where the catalog noise rating can be altered by as much as 15 dB.

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