This type of installation affects all factors previously discussed. Since the air stream entrains air on both its upper and lower surfaces, a higher rate of induction is obtained and results in a throw shortened by about ¼. Air loadings for these outlets can therefore be increased. Air drop from ceiling diffusers is increased by installation on exposed ducts, because there is no surface effect, and temperature differentials in summer air-conditioning systems must be restricted to a range of 25 to 28 F deg. Air streams from slot diffusers and grilles may exhibit a marked tendency to drop because of the lack of the surface effect.

Smudging is a problem frequently encountered with ceiling and slot diffusers. It occurs when the diffuser is mounted against the ceiling surface. For diffusers mounted flush with the ceiling, smudging is greatly minimized. The dirt suspension in the room air is subjected to turbulence at the outlet face due to induction, and is primarily responsible for the marked areas of black and white that characterize smudging. Smudging can be expected in areas which have a high dirt content in the room air, such as areas of high pedestrian traffic (lobbies, stores, etc.). When ceiling diffusers are installed on smooth ceilings (plaster, mineral tile, metal pan, etc.), smudging is in the form of a narrow band of discoloration around the diffuser. Anti-smudge rings are quite effective in preventing this type of smudging. On highly textured ceiling surfaces such as rough plaster or sprayed-on composition, smudging can be expected to occur over a more extensive area. In such cases anti-smudge rings are less effective.

PROCEDURE FOR OUTLET LOCATION AND SELECTION

The following procedure is generally used in selecting outlet locations and types of outlets:

1. Determine the amount of air to be supplied to each room. Refer to Chapters 26 and 27 for determination of air quantities for heating and cooling.) Determine the amount of outdoor air to be introduced according to ventilation requirements of state or local codes.

2. Select the type of outlet and quantity of outlets for each room, considering such factors as air quantity required, distance available for throw or radius of diffusion, structural characteristics and architectural concepts. Table 1 is based on experience and typical ratings of various types of outlets. It may be used as a general guide to the types of outlets which may or may not be applicable for use with various room air loadings. Special conditions such as ceiling heights greater than the normal 8–12 ft, exposed duct mounting, etc., as well as product modifications, and unusual conditions of room occupancy can all modify this table. Manufacturers' rating data should be consulted for final determination of the suitability of the types of outlets to be used.

3. Locate outlets in the room to distribute the air as uniformly as possible throughout the room. Outlets may be sized and located to distribute air in various portions of the room in proportion to the heat gain or loss in those areas.

4. Select proper outlet size from manufacturers' ratings according to the air quantities, discharge velocities, distribution patterns, sound levels, etc. Note manufacturers' recommendations with regard to use, method of installation, minimum velocities, maximum temperature differentials and any air distribution characteristics which may limit the performance of the outlet.

Table 1 .... General Guide to Use of Various Outlet Types

Air Loading, CFM/Sq Ft of Floor Area	Type of Outlet	Average Room Velocity
1 to 1.5	Grille	25–35
1.5 to 3.0		35–70
1.5 to 2.5	Slot	20–35
2.5 to 4.0		35–55
2.5 to 3.5	Diffuser	25–35
3.5 to 5.0		35–50
5.0 to 6.5		50–65

Noise Control

The sound level of an outlet is comprised of the sound generation of the outlet, which is a function of the discharge velocity, and the transmission or systemic noise, which is a function of the size of the outlet. Higher frequency sounds can be the result of excessive outlet velocity but may also result from sounds generated in the duct by the moving air stream. Lower pitched sounds are generally the result of transmission of mechanical equipment noise through the duct system and outlet. The cause of higher frequency sounds can be pinpointed as outlet or systemic sounds by removing the outlet during operation. A reduction in sound level indicates that the outlet is causing noise. If the sound level remains essentially unchanged, then the system is at fault.

High pressure air distribution systems pose severe systemic sound problems, and these conditions must be treated separately. Special attenuation devices are generally used in conjunction with these systems. (See section on Equipment For All-Air High-Pressure Systems, this chapter.).

Refer to Chapter 14 on Sound Control, for more complete information on design criteria, acoustic treatment, selection procedures, etc.

GRILLE OUTLETS

Adjustable bar grille. This is the most common type of grille used as supply outlet. The single deflection grille consists of a frame enclosing a set of vertical or horizontal vanes. Vertical vanes deflect the air stream in the horizontal plane and horizontal vanes deflect the air stream in the vertical plane. The double deflection grille has a second set of vanes, installed behind and at right angles to the face vanes. This grille controls the air stream in both the horizontal and vertical planes.

The opening between two adjacent bars must not exceed the depth of the vanes for effective control of the direction of the air stream discharged from adjustable bar grilles.

Fixed bar grille. This grille type is similar to the single deflection grille, except that the vanes are not adjustable. The vanes may be straight or set at a certain angle. The angle at which the air is discharged from this grille depends on the type of deflection vanes.

Stamped grilles (sometimes referred to as perforated grilles). These grilles are made from a single sheet of metal which is stamped out to form a fretwork through which air can pass. Various designs are used, varying from square or rectangular holes to intricate ornamental designs. This type of outlet offers no directional control.

The air handling capacity of stamped grilles varies widely with their design, but, in general, stamped grilles have considerably less capacity than vane type grilles. Their main advantage is structural strength, and pleasing appearance.

Applications

Properly selected grilles operate satisfactorily from high sidewall locations and from perimeter locations in the sill, curb, or floor. Ceiling mounted grilles which discharge the air stream downward, are generally not acceptable in comfort air-conditioning installations in interior zones, and may cause complaints of draft in perimeter applications.

High sidewall location generally presents two problems in distributing the air properly in the space; (1) how to spread the discharged air properly in a horizontal plane in order to diffuse it over the entire area being served by the outlet, and (2), how to prevent stratification of hot air, or premature drop into the occupied zone of cold air. Therefore, use of a double-deflection grille generally provides the most satisfactory solution. The vertical face louvers of a well-designed grille will deflect the air approximately 60 deg to either side and thus provide ample coverage of the conditioned space. Its rear louvers deflect the air at least 15 deg in the vertical plane, which is ample to control the elevation of the discharge pattern.

In *perimeter installations*, the grille must be selected to fit the specific job. When small grilles must be used, adjustable vane grilles improve the coverage of perimeter surfaces. Where the perimeter surface can be covered with long grilles, the fixed vane grille is satisfactory. Where grilles are located more than 8 in. from the perimeter surface, it is usually desirable to deflect the air stream towards the perimeter wall. This can be done with adjustable or fixed deflecting vane grilles.

Stamped outlet grilles should not be used as supply outlets because of their restricted capacity and their lack of pattern control. They may find some use, however, in perimeter installations as covers for supplementary heating openings, or for the discharge of extremely small amounts of supply air.

Accessory Devices

Various accessory devices, designed to improve the performance of grille outlets, are available as standard equipment.

Opposed-blade dampers can be attached to the back of grilles (the combination of a grille and a damper is called a register), or they may be installed as separate units in the duct. See Fig. 1 (A). Adjacent blades of this damper rotate in opposite direction, and therefore may receive air from any direction, discharging it in a series of jets without adversely deflecting the air stream to one side of the duct.

Multi-shutter dampers have a series of gang-operated blades which rotate in the same direction. See Fig. 1 (B). This uniform rotation deflects the air stream when the damper is partially open.

Most dampers are operated by removable keys, or by fixed or removable levers.

Gang-operated turning vanes are used for installation in collar connections to branch ducts. The device shown in Fig. 1 (C) has vanes which pivot and remain parallel to the duct air flow regardless of the setting. The second device, Fig. 1 (D), has a set of fixed vanes. Both devices restrict the area of the duct in which they are installed. They should only be used when the duct is sufficiently wide to allow the device to open to its maximum position without causing undue restriction of air flow in the duct which might limit downstream air flow.

Individually adjusted turning vanes are used in the device shown in Fig. 1 (E). Two pairs of vanes are used. The downstream set of vanes equalizes flow across the collar, while the upstream vanes act as turning vanes. They can also be adjusted at various angles to act as a damper. However, it is not practicable to use this device as a damper, because its balancing requires removal of the grille to gain access, and reinstallation to measure air flow. This is a time-consuming procedure.

Other miscellaneous accessories which are available as standard equipment are fusible-link attachments to close dampers in case of fire, remote control devices to operate the dampers from locations other than the grille face, maximum-minimum stops to limit damper travel, etc.

Special Construction Features

Materials and Finishes. Grilles are made of aluminum, brass, and bronze. Most commercially available finishes, such as paint, enamel, lacquer, electroplating, anodizing, and polishing are used in their manufacture.

Special Features. Hand-hole doors in grilles for perimeter units, insect screens, reinforcements for grilles for added strength, tamper-proof installation devices, protective screens or grids over outlets, and special frame shapes and widths, are made to order.

SLOT DIFFUSER OUTLETS

The slot diffuser is an elongated outlet consisting of a single or a multiple number of slots. It is usually installed in long continuous lengths, and is well suited to the present-day architectural trend toward straight, clean lines and unobtrusive appearance. Outlets with dimensional aspect ratios of 25 to 1 or greater, and a maximum height of approximately 3 in., generally meet the performance criteria for slot diffusers discussed in the section Supply Air Outlets.

Two basic types of slot diffusers are perpendicular flow slot diffusers, and parallel flow slot diffusers.

Perpendicular Flow Slot Diffusers. The air discharge direction is perpendicular to the surface of the diffuser. The use of bars, vanes, or internal deflection devices, may permit deflection of the air up to 30 deg from the perpendicular flow path.

Parallel Flow Slot Diffusers. The air is discharged parallel with the surface of the diffuser. Bars, vanes, or internal deflection devices are required to achieve this flow pattern.

Applications

High Side-Wall Installation. The perpendicular-flow slot diffuser is best suited to high side-wall installations and perimeter installations in sills, curbs and floors. The air discharged from a perpendicular diffuser will not drop, if the diffuser is located within 6–12 in. from the ceiling, and is of

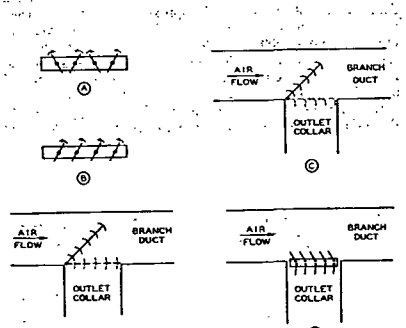


Fig. 1 .... Accessory Control Devices for Grille and Register Outlets