Space Air Diffusion - Introduction

- The major objective of an HVAC system is to provide comfort and suitable indoor air quality within the occupied zones of a building.
- The air should be introduced into the spaces at optimum locations and with sufficient velocity.
- The mixing of the jet and the room air permits the carrying away of contaminants.
- The challenge is to provide good mixing without creating uncomfortable drafts and to assure that there is reasonable uniformity of temperature.
- This must be done without unacceptable changes in room conditions.
- The design also involves selection of suitable diffusing equipment so that noise and pressure drop requirements are met.

Space Air Diffusion - Behavior of Jets

- Conditioned air is normally supplied to air outlets at velocities much higher than would be acceptable in the occupied space.
- The conditioned air temperature may be above, below, or equal to the temperature of the air in the occupied space.
- The air projection from round-free openings, grilles, perforated panels, ceiling diffusers, and other outlets is related to the average velocity at the face of the air supply opening.

Space Air Diffusion - Behavior of Jets

The full length of an air jet, in terms of the center-line velocity, can be divided into four zones

- **Zone 1. A short zone, extending about four diameters or widths from the outlet face, in which the velocity and temperature of the airstream remains practically (T&V)constant.**

- **Zone 2. A transition zone, the length of which depends on the type of outlet, the aspect ratio of the outlet, and the initial air-flow turbulence.**

- **Zone 3. A zone of fully established turbulent flow that may be 25 to 100 air outlet diameters long.**
- **Zone 4. A zone of jet degradation where the air velocity and temperature decrease rapidly. The air velocity quickly becomes less than 50 feet per minute. (15.4=m/min)**

Zone 1- length = 4x Diameter T & V = constant

Zone 2- Transition length depends on Type , Aspect ratio and turbulence

Zone 3- length = (20-30)x Diameter

Zone 4- Degeneration of V, T & V more less than 15.4 m/min

Space Air Diffusion - Behavior of Jets

- In zone 3, which is the **most important** one, the relation between the jet centred -line velocity and the initial velocity is given by

$$\frac{\overline{V}_x}{\overline{V}_0} = K\frac{D_0}{x} = 1.13K\frac{\sqrt{A_0}}{x} \qquad (21\text{-}1)$$

or

$$\overline{V}_x = \frac{1.13K\dot{Q}_0}{x\sqrt{A_0}} \qquad (21\text{-}2)$$

where:

$\overline{V}_x$ = center-line velocity at distance x from the outlet, ft/min or m/s
$\overline{V}_0$ = average initial velocity, ft/min or m/s
A_0 = area corresponding to initial velocity, at diameter D_o, ft^2 or m^2
x = distance from outlet to point of measurement of $\overline{V}_x$, ft or m
$\dot{Q}_0$ = air-flow rate at outlet, cfm or m^3/s
K = constant of proportionality, dimensionless

Space Air Diffusion - Behavior of Jets

- **The throw** is the distance from the **outlet** to where the **maximum velocity** in the jet has decreased to some specified value such as 50, 100, or 150 ft/min **(0.25, 0.5, or 0.75 m/s).**
- The constant **K** varies from about **5 to 6 for free jets** to about **1** for **ceiling diffusers.** For **slots** with **aspect** ratios less **than 40, K** ranges from about **4.5 to 5.5.**
- The jet expands because of entrainment of room air; the air beyond zone 2 is a mixture of primary and induced air.
- The induction ratio for **zone 3 circular** jets is

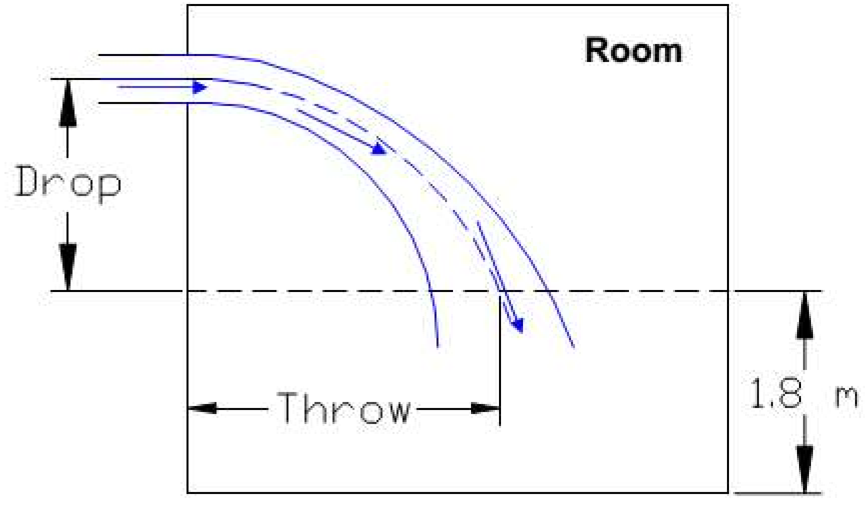


Fig.39.2. *Definition of drop and throw*

$$\frac{\dot{Q}_x}{\dot{Q}_0} = 2\frac{\overline{V}_0}{\overline{V}_x} \quad (21\text{-}3)$$

where $\dot{Q}_x$ = total air mixture at distance x from the outlet, cfm or m^3/s.

In zone 4, where the terminal velocity is low, Eqs. 21-3 will give values about 20% high.

Space Air Diffusion - Behavior of Jets

❑ **General statements may be made concerning the characteristics of air jets:**

1. **Surface effect increases the throw and decreases the drop compared to free space conditions.**
2. **Increased surface effect may be obtained by moving the outlet away from the surface somewhat so that the jet spreads over the surface after impact. Also by spreading the jet when it is discharged.**
3. **Spreading the airstream reduces the throw and drop.**
4. **Drop primarily depends on the quantity of air and only partially on the outlet size or velocity. Thus the use of more outlets with less air per outlet reduces drop.**

Space Air Diffusion – Room Air Motion

- Room air near the jet is entrained and must then be replaced by other room air.
- The room air moves toward the supply and sets all the room air into motion.
- Whenever the average room air velocity is less than about 50 ft/min (0.25 m/s), buoyancy effects may be significant.
- About 8 to 10 air changes per hour are required to prevent stagnant regions (velocity less than 15 ft/min [0.08 m/s]).
- The relationship between the center-line velocities and the temperature differences is given approximately by

$$\Delta t_x = 0.8 \Delta t_o \frac{\bar{V}_x}{\bar{V}_0} \qquad (21\text{-}4)$$

- Δ_{tx} and Δ_{to} are the differences in temperature between the local stream temperature and the room (t_x - t_r) and between the outlet air and the room (t_o - t_r)

Space Air Diffusion – Room Air Motion

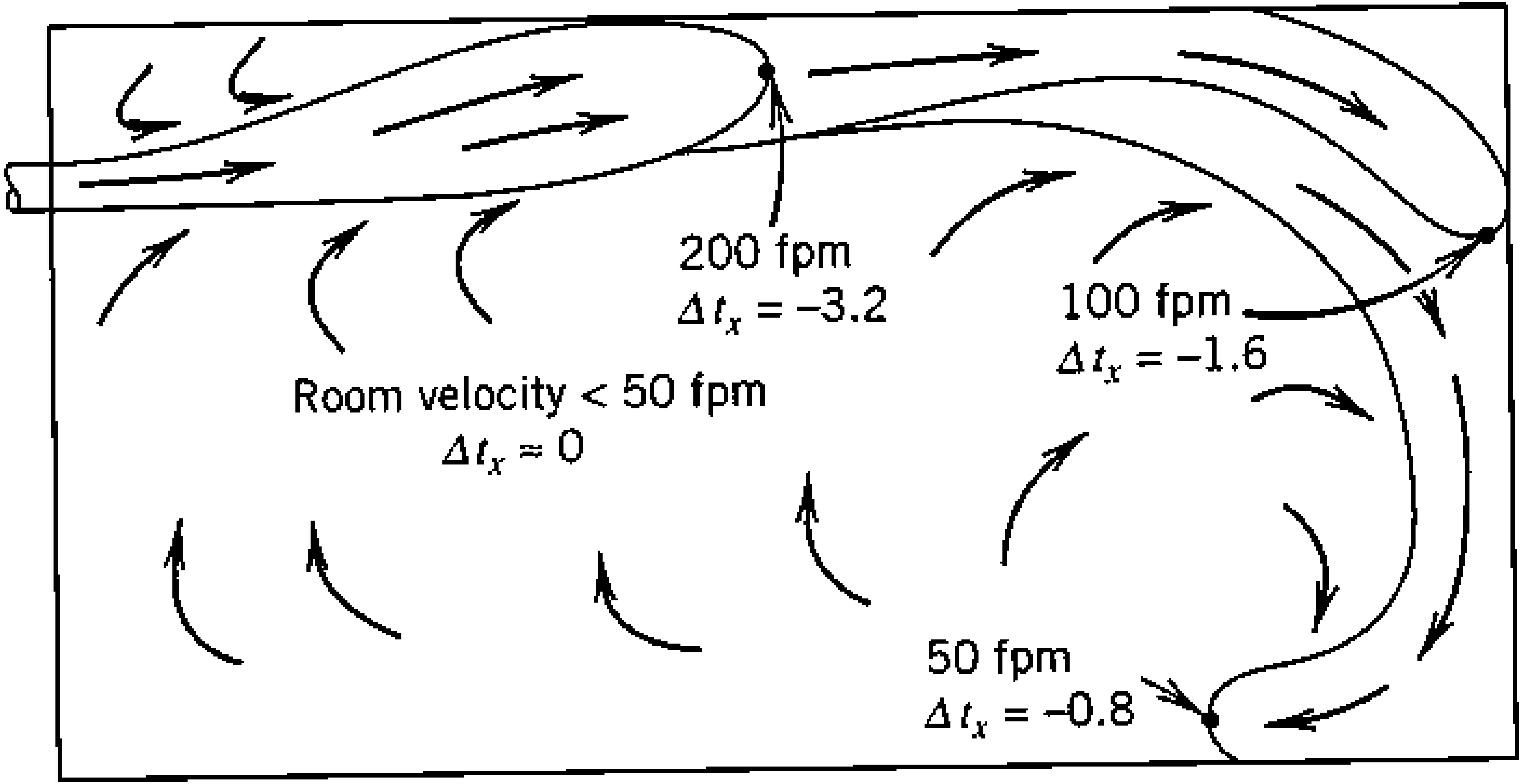


Figure 21-1, Jet and room air velocities and temperatures for $\overline{V_o} = 1000$ ft/min (5m/s) and Δt_o = 20 F. (-6.5 C)

Space Air Diffusion – Basic Flow Pattern

❑ Diffusers have been classified into five groups :

Group A.

Diffusers mounted **in or near the ceiling** that discharge air horizontally.

Group B.

Diffusers mounted in or near the floor that discharge air vertically in a non-spreading jet.

Group C.

Diffusers mounted in or near the floor that discharge air vertically in a spreading jet.

Group D.

Diffusers mounted in or near the floor that discharge air horizontally.

Group E.

Diffusers mounted in or near the ceiling that project air vertically down.

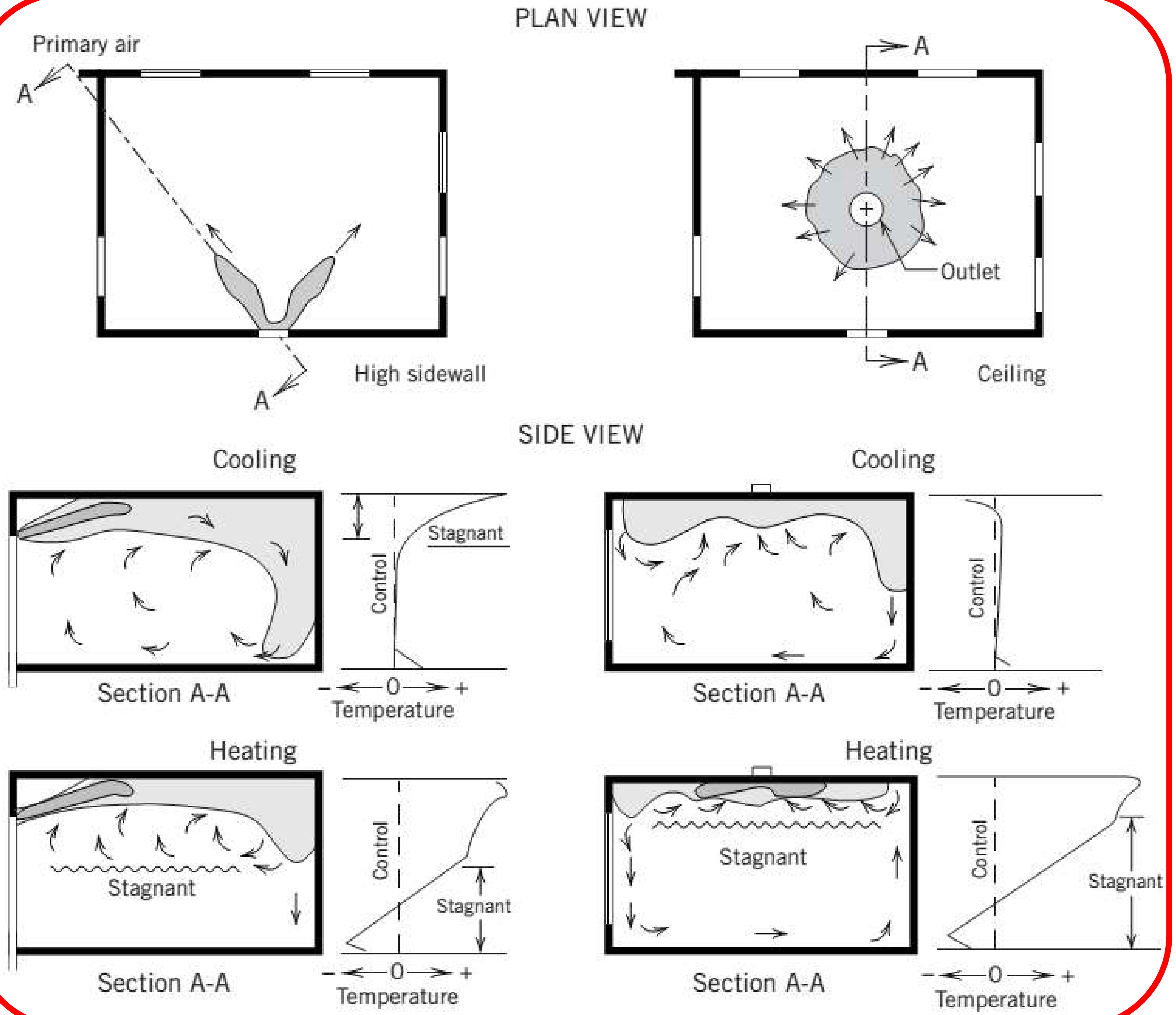
Space Air Diffusion – Basic Flow Pattern

Figure 21-2,

Air motion characteristics of Group A outlets.

(Diffusers mounted in or near the ceiling that discharge air ***horizontally***)

The high-velocity primary air is shown by the shaded areas



Space Air Diffusion – Basic Flow Pattern

- **Air motion characteristics of Group A outlets.**

This high sidewall type of diffuser

- ✓ **is used in mild climates and on the second and succeeding floors of multi-story buildings. It is not recommended for cold climates or with unheated floors.**
- ✓ **A temperature gradient may exist between floor and ceiling when heating, have good air motion and uniform temperatures in the occupied zone for cooling application. popular in commercial applications.**

This ceiling diffuser

- ✓ **higher velocities enables handling larger quantities of air at than most other types.**
- ✓ **Linear or T-bar diffusers generally favoured in variable air-volume (VAV) applications due to their better flow characteristics at reduced flow.**

Space Air Diffusion Basic Flow Pattern

❑ **Air motion characteristics of Group B outlets.**

- **Satisfactory for cooling.**
- **It can be seen that the non-spreading jet is less desirable for heating because a larger stratified zone will usually result.**
- **Diffusers are available that may be changed from the spreading to non-spreading type according to the season.**

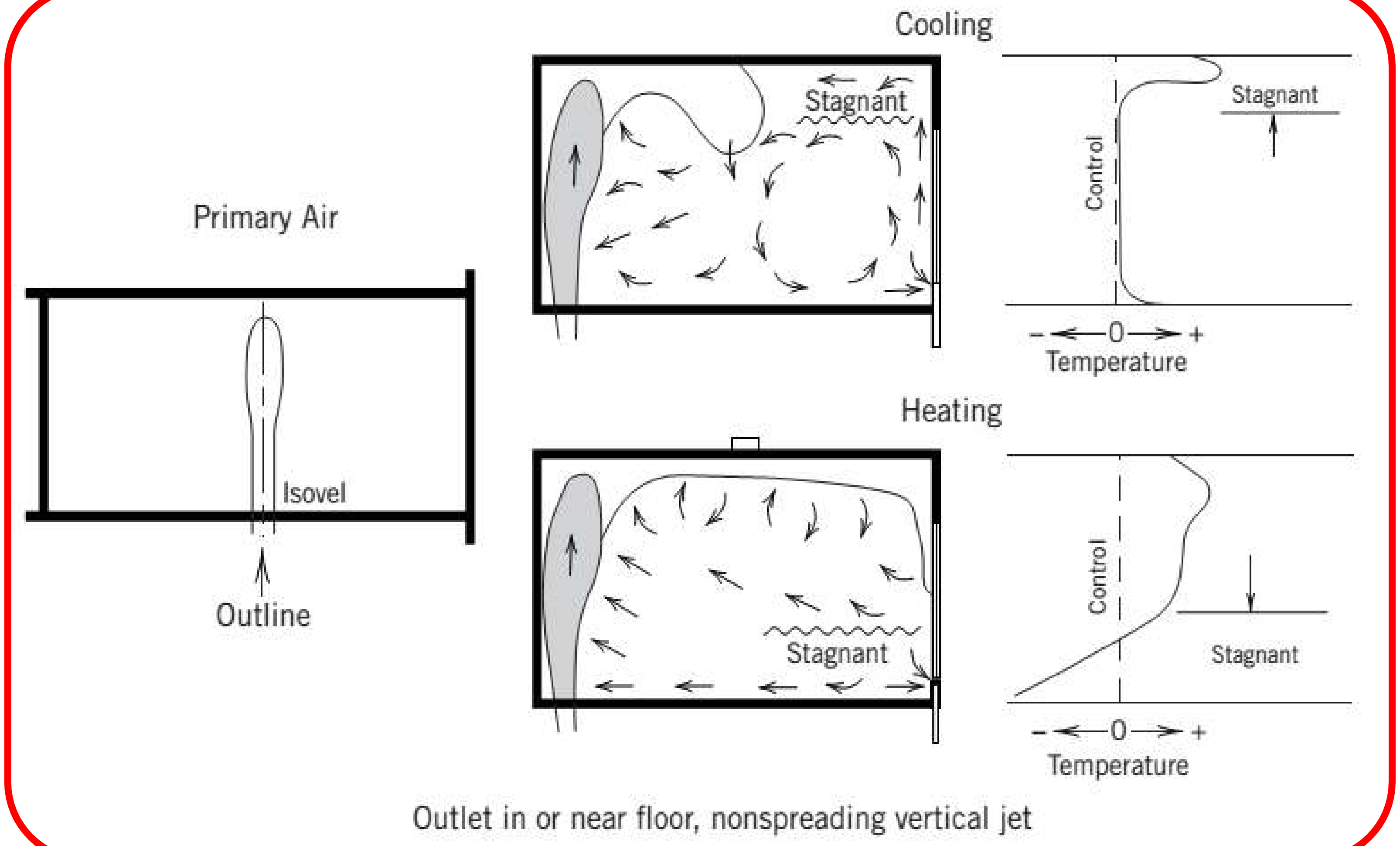


Figure 21-3, Air motion characteristics of Group B outlets. (Diffusers mounted in or near the floor that discharge air vertically in a non-spreading jet)

Space Air Diffusion – Basic Flow Pattern

- **Air motion characteristics of *Group C outlets.***

- Generally regarded as superior for heating applications.
- It is useful when the floor is over an unheated space or a slab and where glass area exists in the wall.
- Diffusers with a wide spread are usually best for heating because buoyancy tends to increase the throw.
- For the same reason, the spreading jet is not as good for cooling applications because the throw may not be adequate to mix the room air thoroughly.

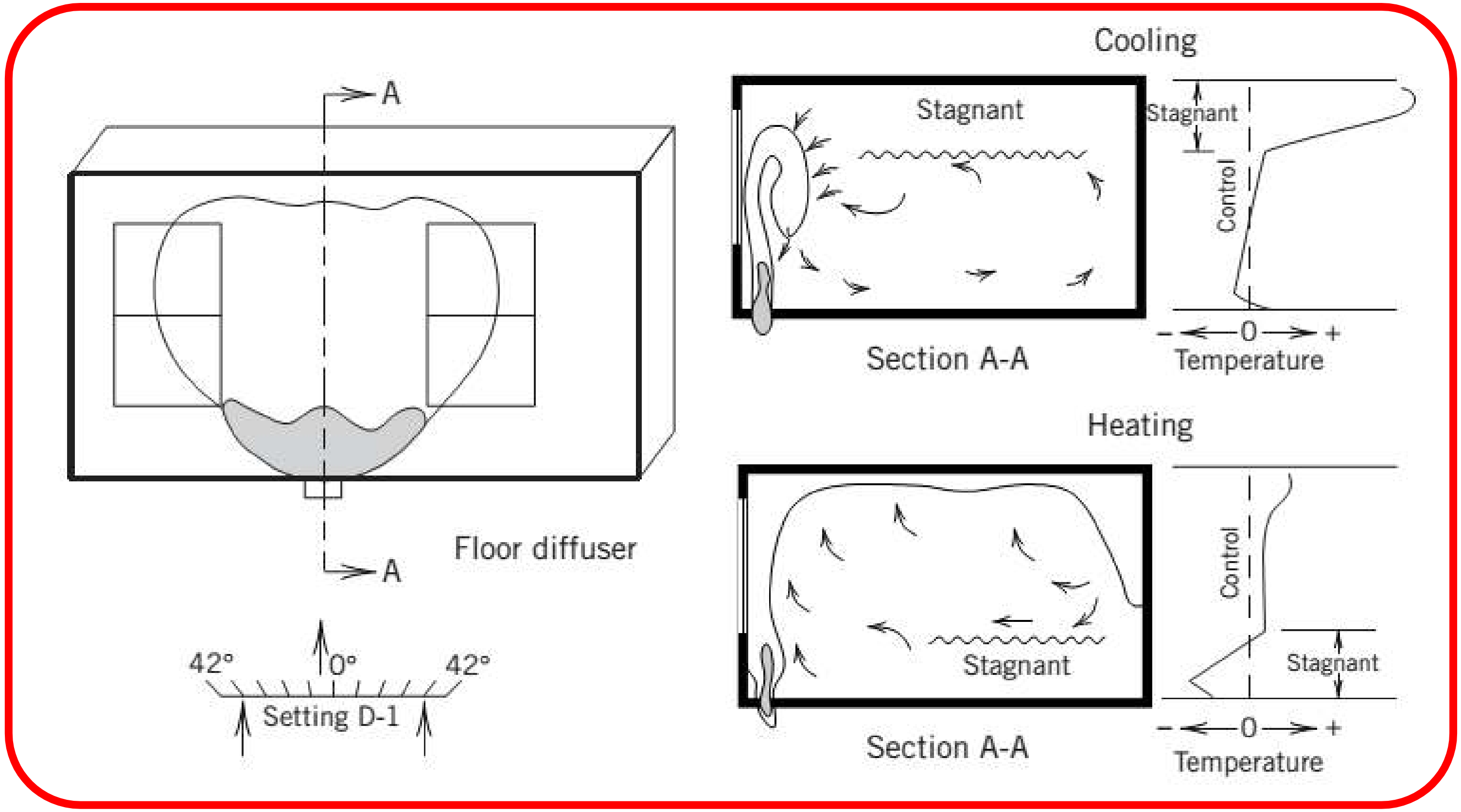


Figure 21-4, Air motion characteristics of Group C outlets. (Diffusers mounted **in or near** the floor that discharge air **vertically in a spreading jet**)

Space Air Diffusion – Basic Flow Pattern

- **Air motion characteristics of Group D outlets.**

- These are for special applications such as displacement ventilation, which is often used to remove **contaminants from a space**

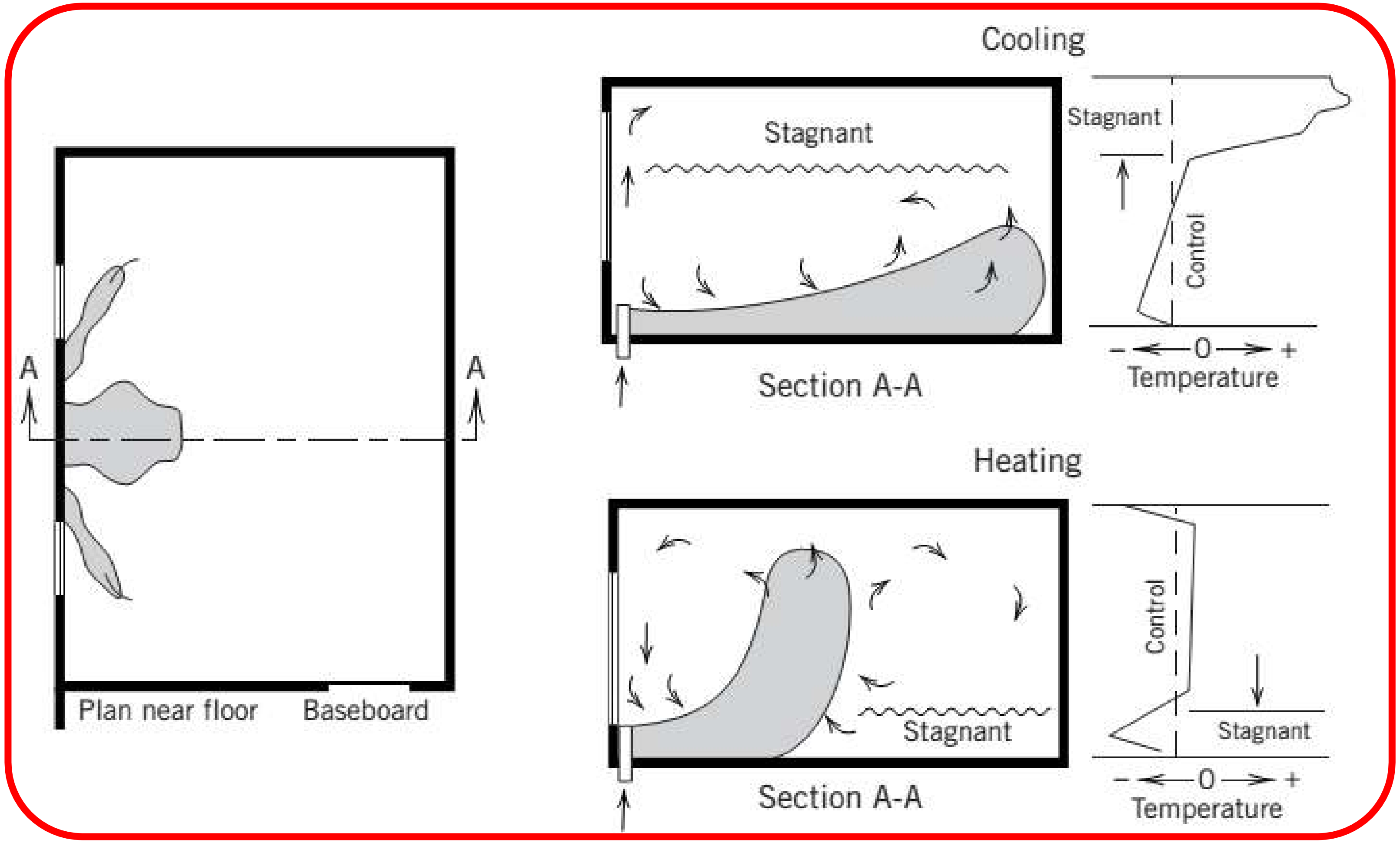
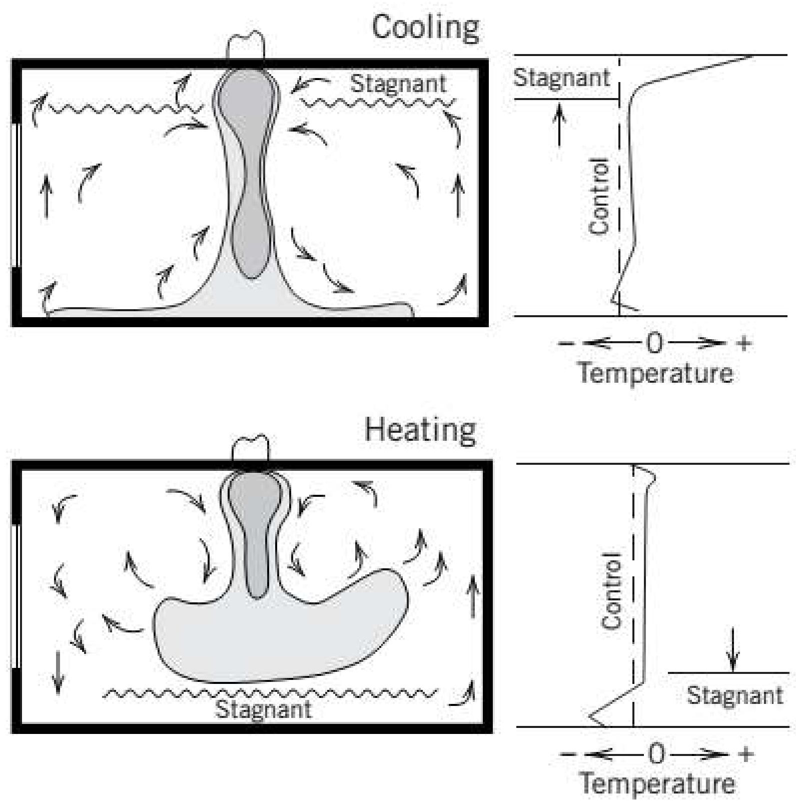


Figure 21-5, Air motion characteristics of Group D outlets. (Diffusers mounted in or near the floor that discharge air horizontally)

Space Air Diffusion – Basic Flow Pattern

Figure 21-6, Air motion characteristics of Group E outlets. (Diffusers mounted in or near the ceiling that project air vertically down)



- **Air motion characteristics of Group E outlets.**

- **This covers downward-projected air jets, which are usually a linear type and used for special applications such as cooling large glass areas.**

- **The high-velocity primary air is shown by the shaded areas which represent the high-momentum regions of the room air motion.**
- **Stagnant zones always have a large temperature gradient.**
- **An ideal condition would be uniform room temperature from the floor to about 6 ft above the floor.**
- **However, a gradient of about 4 F (2 C) should be acceptable to about 85 percent of the occupants.**

Selection of supply air outlets: Selection depends on:

1. **Requirement of indoor environment control**: If the indoor environment requires controlled air movement, then a high side outlet should not be used
2. **Shape, size and ceiling height of the building**: Ceiling and slot diffusers are ideal for buildings with limited ceiling height. For large buildings with large ceiling heights, high side wall mounted outlets are recommended.

3. **Volume flow rate per unit floor area**: Sidewall outlets are limited to low specific volume flow rates as they give rise to higher air velocities in the occupied zone. Compared to slot diffusers, the ceiling diffusers can handle efficiently a larger volumetric flow rates. Table 39.3 shows the specific volume flow rate of different outlets

4. **Volume flow rate per outle**t: The volume flow rate per supply outlet depends on the throw required to provide a satisfactory room air distribution. For linear slot diffusers, the volume flow rate per unit length is important. Its value normally lies between 23 to 62 L/s.m for linear slot diffusers. Ina closed office with a floor area of about 14 m2
and only one external wall, one ceiling diffuser is normally sufficient

5. **Throw**: High side wall outlets have a longer throw than ceiling diffusers. Square ceiling diffusers and circular ceiling diffusers have similar throw

6. Noise level

7. **Total pressure drop**: The total pressure loss of supply air as it flows through a slot diffuser of 19 mm width is normally between 12 to 50 Pascal's, whereas it is between 5 to 50 Pascal's for ceiling diffuser. Normally the pressure loss across the supply outlet should not exceed 50 Pascal's

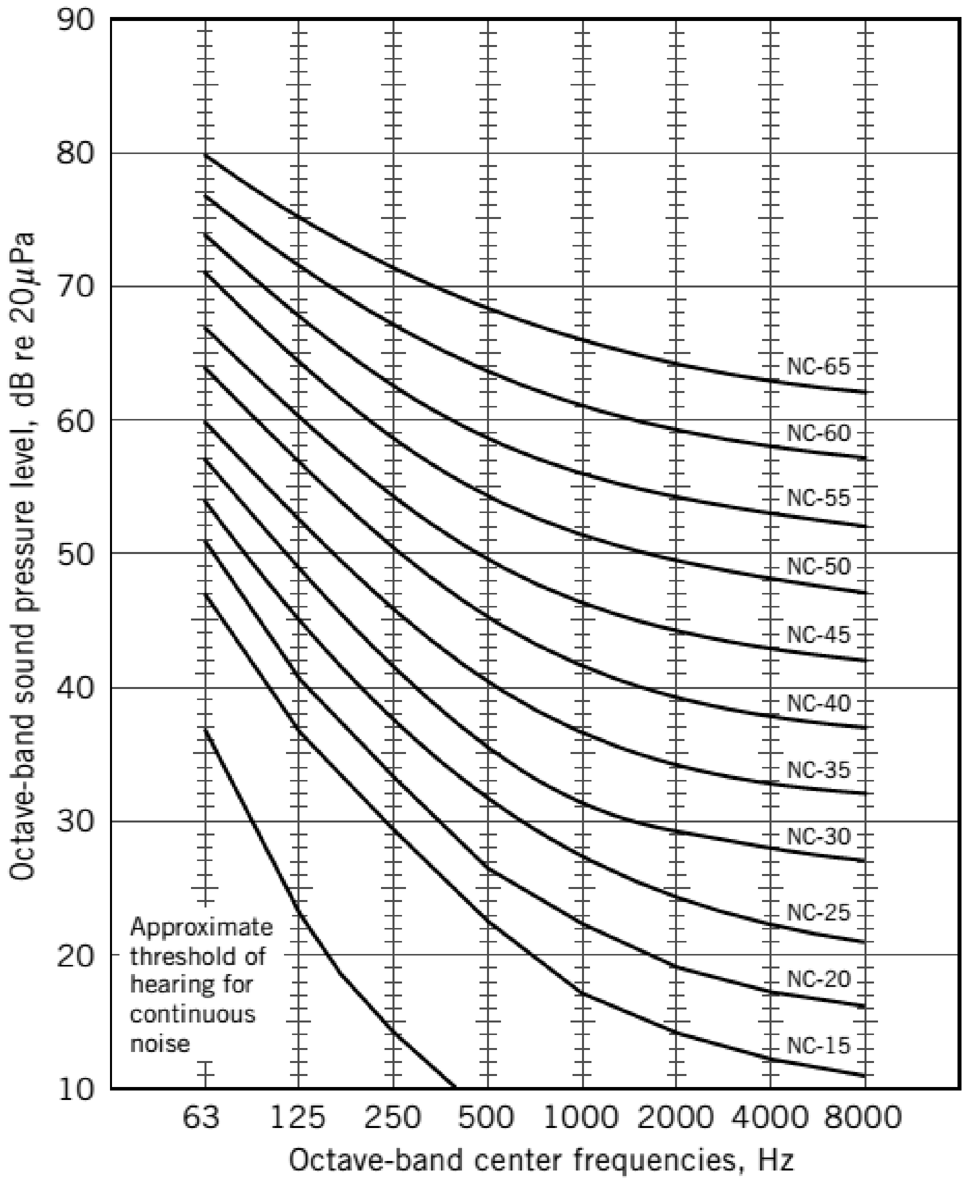
8. **Cost and Appearance**: Finally the cost and appearance of the supply air outlets also have to be considered depending upon the specific application Performance of various types of supply air outlets are provided by the manufacturers in the form of tables and charts, using which one can select a suitable supply air outlet

Space Air Diffusion – Noise

- Noise produced by the air diffuser can be annoying to the occupants of the conditioned space.

- Noise Criterion (NC) curves and numbers shown **in Fig. 21-7** is widely used method of providing information on the spectrum content of noise for air diffusion devices.

- Levels below an NC of 30 are considered to be quiet, whereas levels above an NC of 50 are considered noisy.



- **Figure 21-7, NC curves for specifying design level in terms of maximum permissible sound pressure level for each frequency band.**

Air-Distribution Performance Index

- A measure of the effective temperature difference between any point in the occupied space and the control conditions is called the **effective draft temperature.**

- It is defined by the equation proposed by Rydberg and Norback

$$\mathrm{EDT} = (t_x - t_r) - M(\overline{V}_x - \overline{V}_r) \qquad (22\text{-}1)$$

where:

t_r = average room dry bulb temperature, F or C
$\overline{V}_r$ = 30 ft/min or 0.15 m/s
t_x = local airstream dry bulb temperature, F or C
$\overline{V}_x$ = local airstream velocity, ft/min or m/s
M = 0.07 (F-min)/ft or 7.0 (C-s)/m

- This takes into account the **feeling of coolness produced by air motion**.

Air-Distribution Performance Index

- In summer, $t_x < t_r$, hence both temperature and velocity terms are negative when $\overline{V_x} > \overline{V_r}$ and both of them add to the feeling of coolness.

- If in **winter** $\overline{V_x}$ is above $\overline{V_r}$, it will reduce the **feeling** of warmth produced by $\boldsymbol{t_x}$.

- Research indicates that a high percentage of people in sedentary occupations are comfortable where the effective draft temperature is between *-3 F (-1.7 C) and +2 F (1.1 C)* and the air velocity is less than 70 ft/min (0.36 m/s).

- These conditions are used as criteria for developing the air-distribution performance index (ADPI).

Air-Distribution Performance Index

- The ADPI is defined as the percentage of measurements taken at many locations in the occupied zone of a space that meet the **-3 F (-1.7 C) and +2 F (1.1 C)** effective draft temperature criteria.
- Objective is to select and place the air diffusers so that an ADPI approaching 100% is achieved.
- Note that ADPI is based only on $\overline{V}_x$ **and EDT** and is not directly related to the level of db temperature or relative humidity ϕ.
- The ADPI provides a means of selecting **air diffusers** in a rational way.
- The **space cooling load** per **unit area** is an important consideration.

Air-Distribution Performance Index

- Heavy loading tends to lower the ADPI.
- Each type of diffuser has a characteristic room length, as shown in Table 22-1.
- Table 22-2 is the ADPI **selection guide**. It gives the recommended **ratio of throw to characteristic length** that should **maximize** the ADPI.
- A range of **throw-to-length ratios** that should give **a minimum ADPI** is also shown.
- Note that the throw is based on a terminal velocity of 50 ft/min (0.254)for all diffusers except the ceiling slot type.

Air-Distribution Performance Index

- **The general procedure for use of Table 22-2 is as follows:**

1. **Determine the *air-flow* requirements and the room size.**
2. **Select the number, location, and type of diffuser to be used.**
3. **Determine the room characteristic length.**
4. **Select the recommended throw-to-length ratio from Table 22-2.**
5. **Calculate the throw.**
6. **Select the appropriate diffuser from data such as those in Table 22-3, 23-1, 23-2, 23-3,23-**
7. **Make sure any other specifications are met (noise, total pressure, etc.)**

AIR-DISTRIBUTION SYSTEM DESIGN

Table 11-1 Characteristic Room Length for Several Diffusers

Diffuser Type	Characteristic Length *L*
High sidewall grille	Distance to wall perpendicular to jet
Circular ceiling diffuser	Distance to closet wall or intersecting air jet
Sill grille	Length of room in direction of 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

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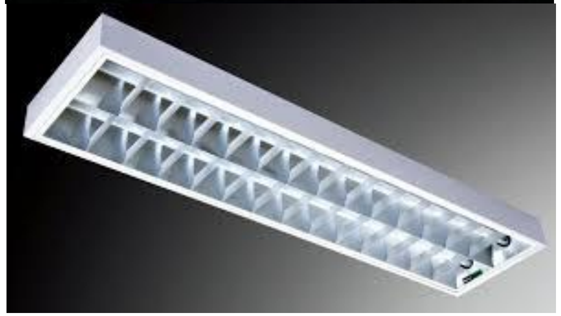
Table 22-1, Characteristics Room Length for Several Diffusers



AIR-DISTRIBUTION SYSTEM DESIGN

Table 22-2, Air Diffuser Performance Index (ADPI) Selection Guide

Table 11-2 Air Diffusion Performance Index (ADPI) Selection Guide

Terminal Device	Room Load, Btu/hr-ft^2	x_{50}/L^a for Maximum ADPI	Maximum ADPI	For ADPI Greater Than	Range of x_{50}/L^a
High sidewall grilles	80 (252)	1.8	68	—	—
	60 (189)	1.8	72	70	1.5–2.2
	40 (126)	1.6	78	70	1.2–2.3
	20 (63)	1.5	85	80	1.0–1.9
Circular ceiling diffusers	80 (252)	0.8	76	70	0.7–1.3
	60 (189)	0.8	83	80	0.7–1.2
	40 (126)	0.8	88	80	0.5–1.5
	20 (63)	0.8	93	90	0.7–1.3
Sill grille, Straight vanes	80 (252)	1.7	61	60	1.5–1.7
	60 (189)	1.7	72	70	1.4–1.7
	40 (126)	1.3	86	80	1.2–1.8
	20 (63)	0.9	95	90	0.8–1.3
Sill grille, Spread vanes	80 (252)	0.7	94	90	0.6–1.5
	60 (189)	0.7	94	80	0.6–1.7
	40 (126)	0.7	94	—	—
	20 (63)	0.7	94	—	—
Ceiling slot diffusers (for $T_{100}/L)^a$	80 (252)	0.3	85	80	0.3–0.7
	60 (189)	0.3	88	80	0.3–0.8
	40 (126)	0.3	91	80	0.3–1.1
	20 (63)	0.3	92	80	0.3–1.5
Light troffer diffusers	60 (189)	2.5	86	80	<3.8
	40 (126)	1.0	92	90	<3.0
	20 (63)	1.0	95	90	<4.5
Perforated and louvered ceiling diffusers	11–51 (35–160)	2.0	96	90	1.4–2.7
				80	1.0–3.4

[a]For SI units, $x_{0.25}/L$ and $T_{0.5}/L$

Table 4. Relationship between ADP1 and T_{50}/L and T_{100}/L.

Terminal Device	Load Density Btu/Hr. Sq. Ft.	T_{50}/L	Maximum ADPI	For ADPI greater than	Range of T_{50}/L
High Side Wall Grilles	80	1.8	68	-	-
	60	1.8	72	70	1.5 - 2.2
	40	1.6	78	70	1.2 - 2.3
	20	1.5	85	80	1.0 -1.9
Circular Ceiling Diffusers	80	0.8	76	70	0.7 - 1.3
	60	0.8	83	80	0.7 - 1.2
	40	0.8	88	80	0.5 - 1.5
	20	0.8	93	90	0.7 - 1.3
Still Grille Straight Vanes	80	1.7	61	60	1.5 - 1.7
	60	1.7	72	70	1.4 - 1.7
	40	1.3	86	80	1.2 - 1.8
	20	0.9	95	90	0.8 - 1.3
Still Grille Spread Vanes	80	0.7	94	90	0.8 - 1.5
	60	0.7	94	80	0.6 - 1.7
	40	0.7	94	-	-
	20	0.7	94	-	-
Slot Diffusers	80	0.3	85	80	0.3 - 0.7
	60	0.3	88	80	0.3 - 0.8
	40	0.3	91	80	0.3 - 1.1
	20	0.3	92	80	0.3 - 1.5
Light Troffer Diffusers	60	2.5	86	80	<3.8
	40	1.0	92	90	<3.0
	20	1.0	95	90	<4.5
Perforated And Louvered Diffusers	35 - 160	2.0	96	90	1.4 - 2.7
				80	1.0 - 3.4

AIR-DISTRIBUTION SYSTEM DESIGN

Table 22-3 gives performance data for a type of diffuser that may be used for perimeter systems having a vertical discharge from floor outlets or as a linear diffuser in the ceiling or sidewall. Note that the data pertain to the capacity, throw, total pressure loss, noise criteria, and free area as a function of the size. Some corrections are also required when the diffuser is used as a return grille.

- The throw values for three different terminal velocities are given.
- The diffuser may be almost any length, but The capacity is based on a length of 1 ft,
  - ✓ The throw is based on a 4 ft active length,
  - ✓ The NC is based on 10ft of length.

Noise Criterion (NC)

AIR-DISTRIBUTION SYSTEM DESIGN

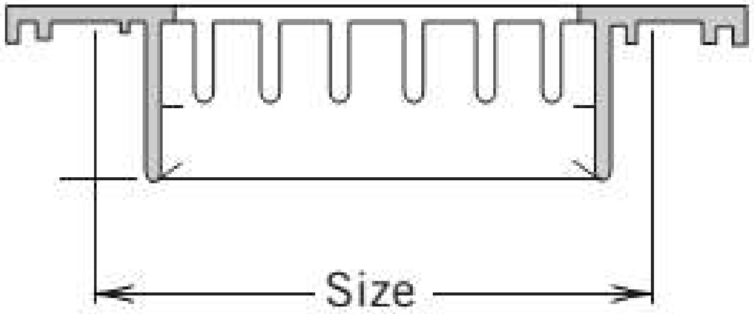
Table 22-3, Performance Data for a Typical Linear Diffuser. gives performance data for a type of diffuser that may be used for perimeter systems having a vertical discharge from floor outlets or as a linear diffuser in the ceiling or sidewall.

Minimum throw values refer to a terminal velocity of *150 ft/min,(0.762m/s) middle to 100 ft/min,(0.508m/s) and maximum to 50 ft/min,(0.252 m/s) for a 4 ft* active section with a cooling temperature differential of 20 F.The multiplier factors listed at the bottom are applicable for other lengths.NC on the table is based on a room absorption of 80 dB referred to 10^{-12} W, and a 10 ft active length.

Table 11-3 Performance Data for a Typical Linear Diffuser

Size, in.	Area, ft^2/ft	Total Pressure, in. wg	Flow, cfm/ft	NC[b]	Throw,[a] ft		
					Min.	Mid.	Max.
2	0.055	0.009	22	—	1	1	1
		0.020	33	—	4	4	4
		0.036	44	12	7	7	7
		0.057	55	18	9	9	10
		0.080	66	23	11	11	12
		0.109	77	27	13	14	16
		0.143	88	31	14	16	18
		0.182	99	34	15	17	20
		0.225	110	37	17	19	21
4	0.139	0.009	56	—	3	3	3
		0.020	83	—	9	9	9
		0.036	111	12	13	13	13
		0.057	139	18	16	16	17
		0.080	167	23	20	20	21
		0.109	195	27	22	23	24
		0.143	222	31	24	25	26
		0.182	250	34	27	27	27
		0.225	278	37	30	30	30
6	0.221	0.009	88	—	5	5	5
		0.020	133	—	10	10	10
		0.036	177	13	15	15	15
		0.057	221	19	18	18	18
		0.080	265	24	23	23	23
		0.109	310	28	25	25	25
		0.143	354	32	28	28	28
		0.182	398	35	31	31	31
		0.225	442	38	32	32	32

Active Length, ft	Multiplier Factor for Throw Value at Terminal Velocity, ft/min		
	150	100	50
1	0.5	0.6	0.7
10 or continuous	1.6	1.4	1.2



Active Length, ft	NC Correction	Active Length, ft	NC Correction
1	–10	10	0
2	–7	15	+2
4	–4	20	+3
6	–2	25	+4
8	–1	30	+5

Noise Criterion (NC)

[a]Minimum throw values refer to a terminal velocity of 150 ft/min, middle to 100 ft/min, and maximum to 50 ft/min, for a 4 ft active section with a cooling temperature differential of 20 F. The multiplier factors listed at the bottom are applicable for other lengths.

[b]Based on a room absorption of 80 dB referred to 10^{-12} W, and a 10 ft active section.

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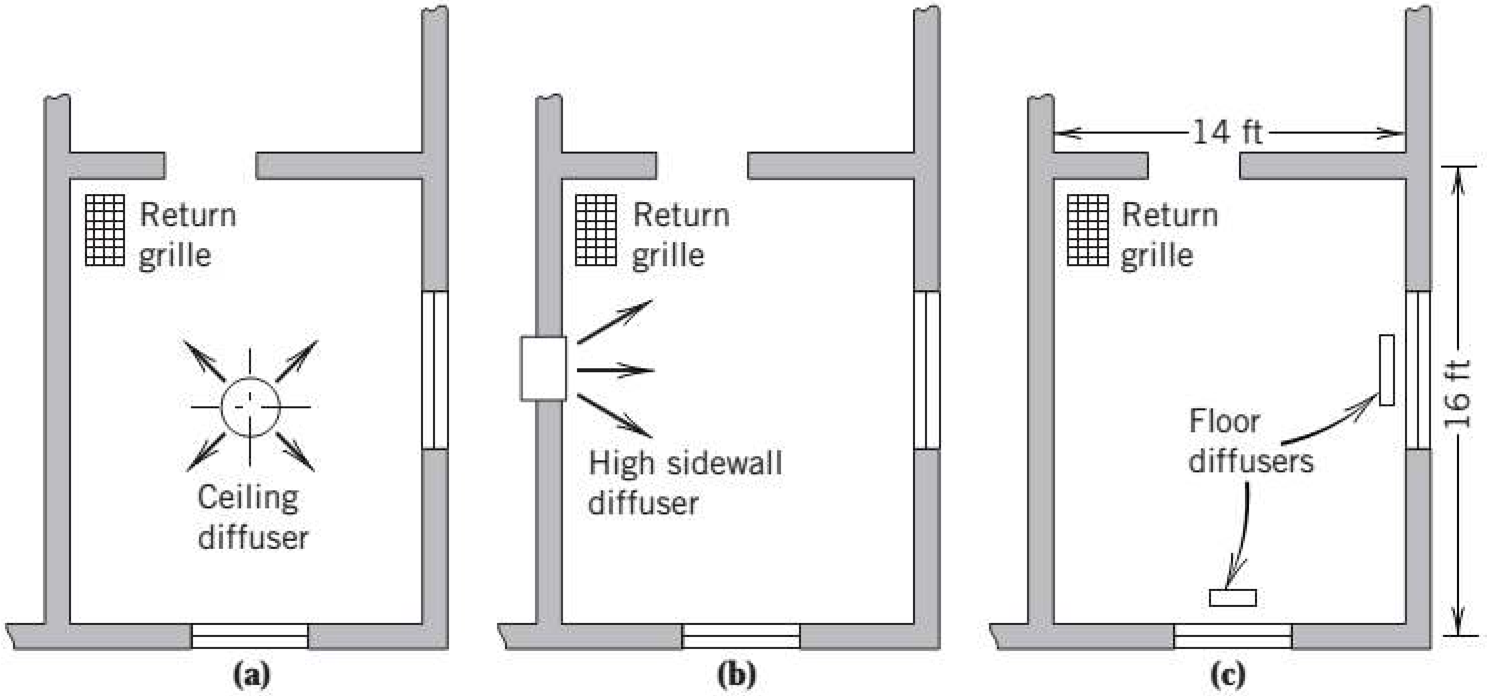
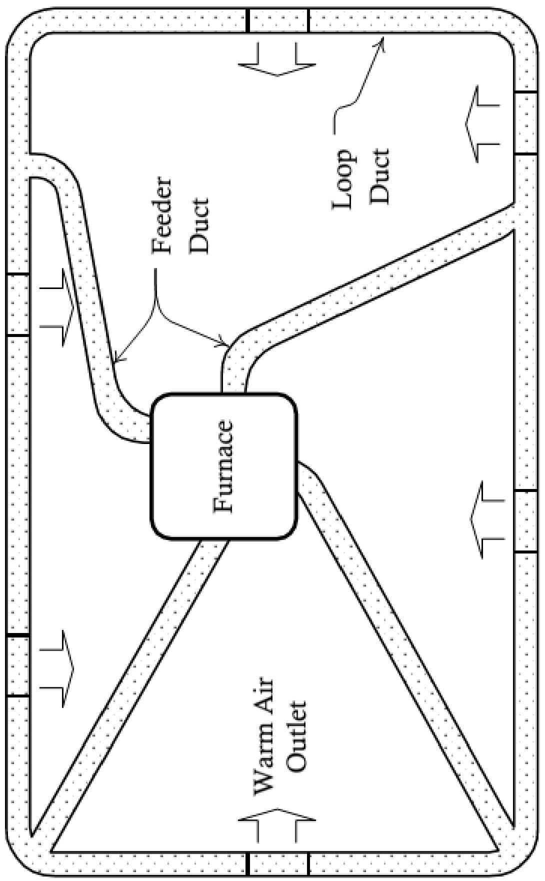
AIR-DISTRIBUTION SYSTEM DESIGN-Example 1

The room shown is part of a single-story office building. A perimeter air-distribution system is used. The air quantity required for the room is **250 cfm**. Select diffusers for the room based on cooling.



Plan view of a room showing location of different types of outlets.



Perimeter loop system with loop duct in concrete slabs.

AIR-DISTRIBUTION SYSTEM DESIGN-Example 1

The room shown is part of a single-story office building. A perimeter air-distribution system is used. Air quantity required for room is **250 cfm.** Select diffusers for room based on cooling.

- Diffusers of the type shown in **Table 22-3** should be used for this application.
- A diffuser should be placed under each window in the floor near the wall because the room has two exposed walls. This will promote mixing with the warm air entering through the window.
- The total air quantity is divided equally between the **two diffusers**.
- The **NC** should be about **30 to 35.**

Noise Criterion (NC)

- If we assume that the room has an **8 ft** ceiling and a room cooling load of **40 Btu/(hr-ft^2)**, the room characteristic length is **8 ft.**
- **Table 22-2** gives a **throw-to-length** ratio of **1.3** for a straight vane diffuser.
- Then

$$x_{50}/L = 1.3 \quad \text{and} \quad x_{50} = 1.3(8) = 10.4 \text{ ft}$$

From Table 22-3

From Table 11-3, a 4 × 12 in. diffuser with 125 cfm has a throw, corrected for length, between

$$x_{50} = 13(0.7) = 9.1 \text{ ft} \quad \text{and} \quad x_{50} = 17(0.7) = 11.9 \text{ ft}$$

because 125 cfm lies between 111 cfm and 139 cfm. The NC is quite acceptable and is between 12 and 18, uncorrected for length. The total pressure required by the diffuser is between 0.036 and 0.057 in. wg and is about

$$\Delta P = (125/111)^2 (0.036) = 0.046 \text{ in. wg}$$

An acceptable solution is listed as follows:

Size, in.	Capacity, cfm	Throw, ft	NC	ΔP_0, in. wg
4 × 12	125	10.5	<15	0.046

The loss in total pressure for the diffuser is an important consideration. The value shown above would be acceptable for a light commercial system.

Air-Distribution System Design – Example - 2

Suppose the room in the figure is located in the southern latitudes where overheat systems are recommended. Select a round ceiling diffuser system and a high sidewall system. Also select a return grille.

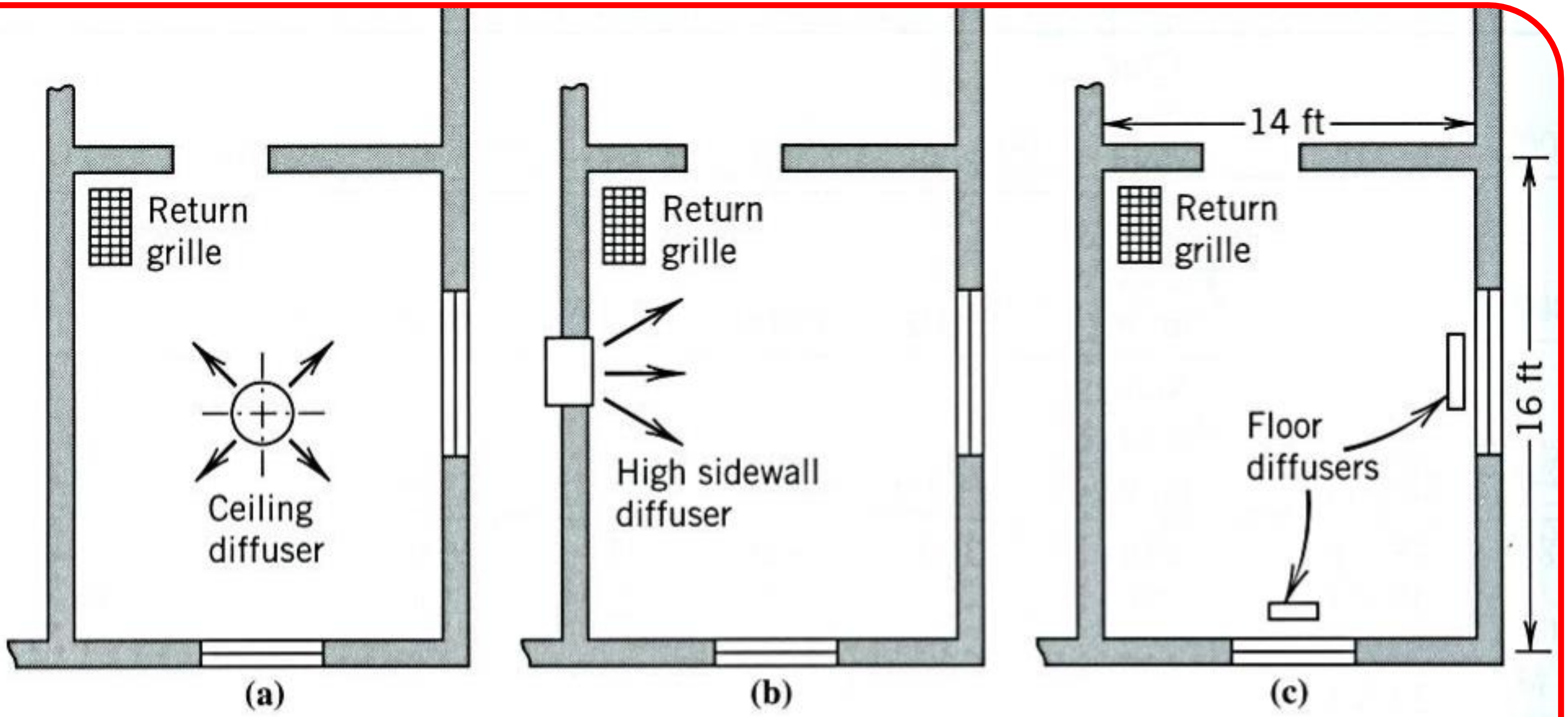


Figure 11-9 Plan view of a room showing location of different types of outlets.

Air-Distribution System Design – Example - 2

- ✓ **Tables 22-1, 22-2 and 23-1** will be used to solve this problem
- ✓ The characteristics length is **7 or 8 ft** and the throw-to-length ratio is **0.8**
- ✓ Then

$$x_{50} = 0.8(7.0) = 5.6 \text{ ft}$$

The best choice would be

Size, in.	Throw, ft	NC	ΔP_0, in. wg
10	$7\frac{1}{2}$	10	0.035

- ✓ The throw is larger than desired, but the throw-to-length ratio is within the range to give a minimum ADPI of 80 percent. Figure (11-9a)shows this application. A high side-wall diffuser may be selected from Table 23-2.

10	400	0.010	0.027	220	3	4	7	—
	500	0.016	0.043	270	3	5	8	11
	600	0.023	0.062	330	4	6	10	17
	700	0.031	0.084	380	5	7	11	21
	800	0.040	0.108	435	5	8	13	26
	900	0.051	0.138	490	6	9	15	30
	1000	0.063	0.170	545	7	10	16	33
	1200	0.090	0.243	655	8	12	20	39

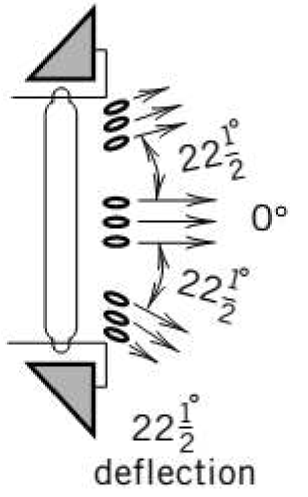
Air-Distribution System Design – Example - 2

- **A high sidewall** diffuser may be selected from **Table 22-2**. In this case The t**hrow-to-length** ratio should be about **1.6** and the characteristics length is **14 ft, then**

$$x_{50} = 1.6(14) = 22.4 \text{ ft}$$

✓ The following units using the **22.5 degree** spread would be acceptable:

Size, in.	Throw, ft	NC	ΔP_0, in. wg
16 × 4 12 × 5 10 × 6	22	18	0.063



✓ **Figure (11-9 b)** shows the **diffuser** location . For heating purposes, the return air intake should be located **near the floor**

✓ For cooling purposes, the return air intake should be located near the ceiling

Air-Distribution System Design – Example - 2

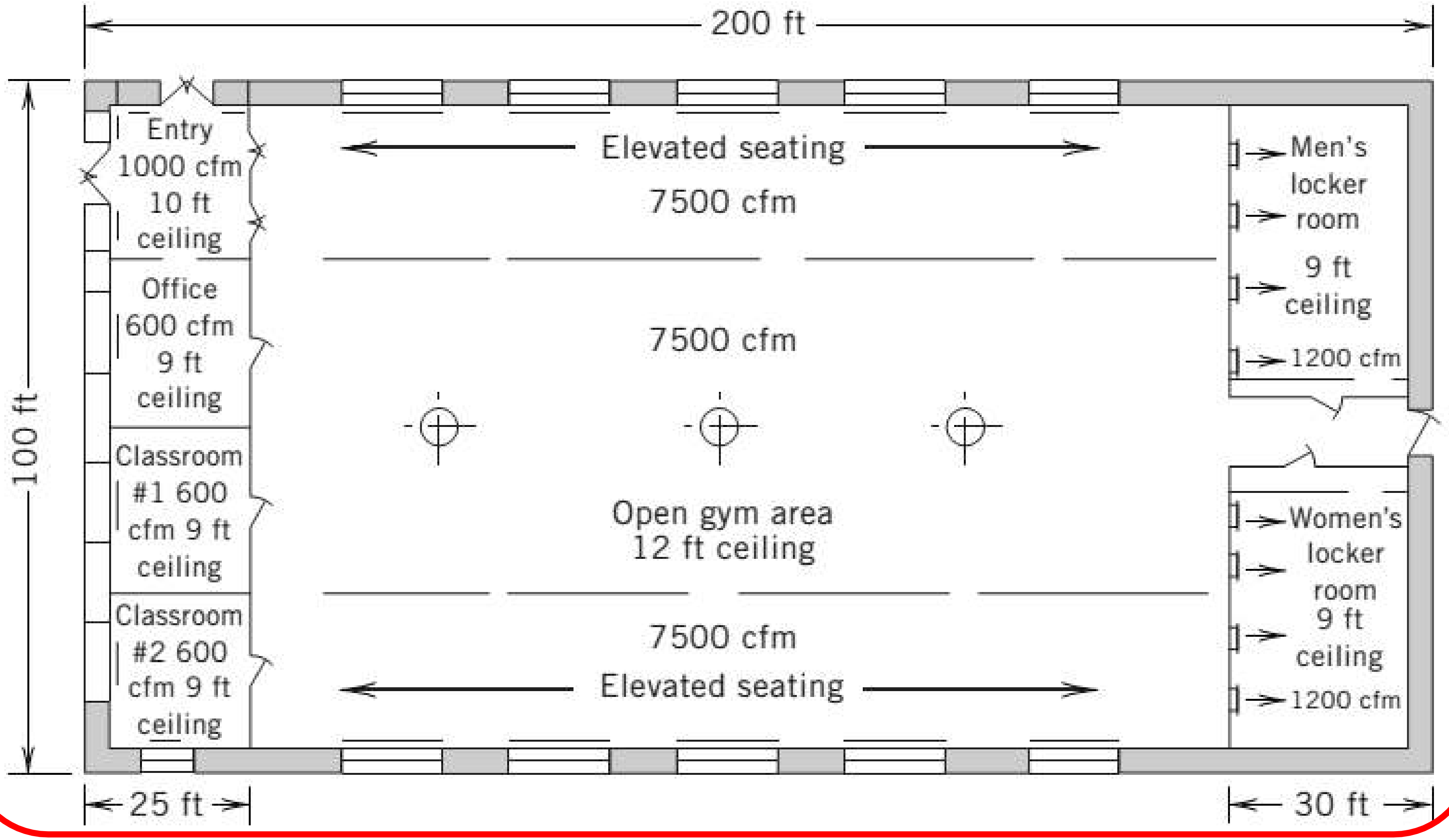
Suppose the room in the figure is located in the southern latitudes where overheat systems are recommended. Select a round ceiling diffuser system and a high sidewall system. Also select a return grille.

- ✓ **More than one return is not generally used except in extreme cases**
- ✓ **For this example we assumed that the building design prevents practical location of the return near the floor The following grille is selected from Table 23-4 with the total pressure corrected for 250 cfm:**

Size, in.	NC	ΔP_0, in. wg
24×4, 16×6	22	0.067
12×6, 8×8	27	0.12

Air-Distribution System Design – Example - 3

The figure below shows a sketch of a recreational facility with pertinent data on ceiling height, air quality, and building dimensions. The elevated seating rises 6 ft from the floor. The floor area and ceilings are not available for air outlets in the locker room. The structure is located in mid-America. Select an air diffuser system for the complete structure



Air-Distribution System Design – Example - 3

- ✓ It would be desirable to use a perimeter system throughout the structure; floor area is not available in all of the spaces.
- ✓ Air motion will **be** enhanced in the central part of the gymnasium by an overhead system.
- ❑ The entry area is subject to large infiltration loads and has a great deal of glass area.
- ✓ Therefore, outlets should be located in the floor around the perimeter.
- ✓ There is 50 ft of perimeter wall, with 12 ft taken up by doors.
- ✓ Then about 38 ft of linear diffuser could be used if required.
- ✓ Noise is not a limiting factor, and the throw should be about 12 ft.

Air-Distribution System Design – Example - 3

- ✓ If we refer to **Table 22-3**, the **2 in**. size has a throw of **12 ft,** a total pressure loss of **0.08 in. wg**, an NC of **23,** and a capacity of **66 cfm/ft**.
- ✓ The total length of the required diffusers would then be:

$$L_d = \frac{1000}{66} = 15 \text{ or } 16 \text{ ft}$$

- ✓ The total length should be divided **into 4 equal** sections and located as shown
- ❑ **The office and classrooms** should also be equipped with perimeter air inlets.
- ✓ The throw should be about **12 to 15 ft and a NC of-about 30** would be acceptable.
- ✓ Referring to Table **22-3**, a **4 in.** size may be used with a capacity of **111 cfm/ft.**
- ✓ The **NC is 12**, and the throw is **13 in**, with a loss in total pressure of **0.036 in. wg.**

Air-Distribution System Design – Example - 3

- ✓ The total length of diffuser is then computed as:

$$L_d = \frac{600}{111} = 5.4 \text{ ft}$$

- ✓ The total length may be divided into **two 3 ft** sections, or a single **5 ft length** will function adequately as shown in the figure.
- ✓ The corner classroom should have two diffusers of **3 ft length**.
- ❑ **The elevated seating** on each side of the gym should al a be equipped with perimeter **up-flow air outlets** because of the exposed walls and glass .
- ✓ A throw of **10 ft** would be acceptable because seating is elevated about **6 ft.**
- ✓ Noise is not a major factor.

Air-Distribution System Design – Example - 3

- There is about **145 ft** of exposed wall on each side and **7500 cfm** is required.
- Therefore, a capacity of at least **52 cfm/ft** is required. (**7500 cfm/145 ft**)
- From **Table 22-3 a 2 in. size** with a capacity of **55 cfm/ft** will give a throw of **10 ft** with a loss in total pressure of **0.057 in. wg**.
- The total length of diffuser is computed as

$$L_d = \frac{7500}{55} = 136.4$$

- The total length should be divided into at **least five sections** and located beneath each window as shown in the figure.

Air-Distribution System Design – Example - 3

- **The central portion** of the gymnasium should be equipped with round ceiling diffusers. **Table 23-1** has data for this type of outlet.

- ✓ The total floor area is divided into **imaginary squares**, and a diffuser selected with a capacity to serve that area with a throw just sufficient to reach the boundary of the area.

- **LAYOUT 1**

- ✓ If the total area is divided into **12** equal **squares of about 25 x 25 ft, a 12 in**. diffuser in **each area** with a capacity of about **630 cfm (7500 cfm/12 ft)** would be in the acceptable range, with a **throw of 12 to 13 ft.**

- ✓ This arrangement requires a large number of diffusers.

Air-Distribution System Design – Example - 3

- **LAYOUT 2**

- ✓ Imagine that the area is divided into **three equal square of about 50 x 50 ft**.
- ✓ Then each diffuser should provide **2500 cfm** and have a throw of about **20 to 25 ft.**
- ✓ **A 24 in. size**, which ha a capacity **of 2510 cfm and** a throw of nearly **30 ft** would be acceptable even though the throw is larger than desired.
- ✓ The loss in total pressure is about **0.094 in. wg.**
- ✓ The throw is slightly high, but is within the range given in **Table 22-2.**
- ✓ Three diffusers should be located a shown in the figure.

Air-Distribution System Design – Example - 3

The figure below shows a sketch of a recreational facility with pertinent data on ceiling height, air quality, and building dimensions. The elevated seating rises 6 ft from the floor. The floor area and ceilings are not available for air outlets in the locker room. The structure is located in mid-America. Select an air diffuser system for the complete structure

- **The locker room** area will be equipped with high **sidewall outlets** because the **floor area is all covered near** the wall and ceiling diffusers were ruled out.

- ✓ If **four 18 x 4 in. diffusers with capacity of 310 cfm** are selected from **Table 23-2**, **a throw** of about **30 ft (zero deflection**) will result in a loss in total pressure of **0.069 in.** with an **NC of 22.**
- ✓ The diffuser should be equally spaced about **12 in.** below the ceiling as shown.

Air-Distribution System Design – Example - 3

The figure below shows a sketch of a recreational facility with pertinent data on ceiling height, air quality, and building dimensions. The elevated seating rises 6 ft from the floor. The floor area and ceilings are not available for air outlets in the locker room. The structure is located in mid-America. Select an air diffuser system for the complete structure

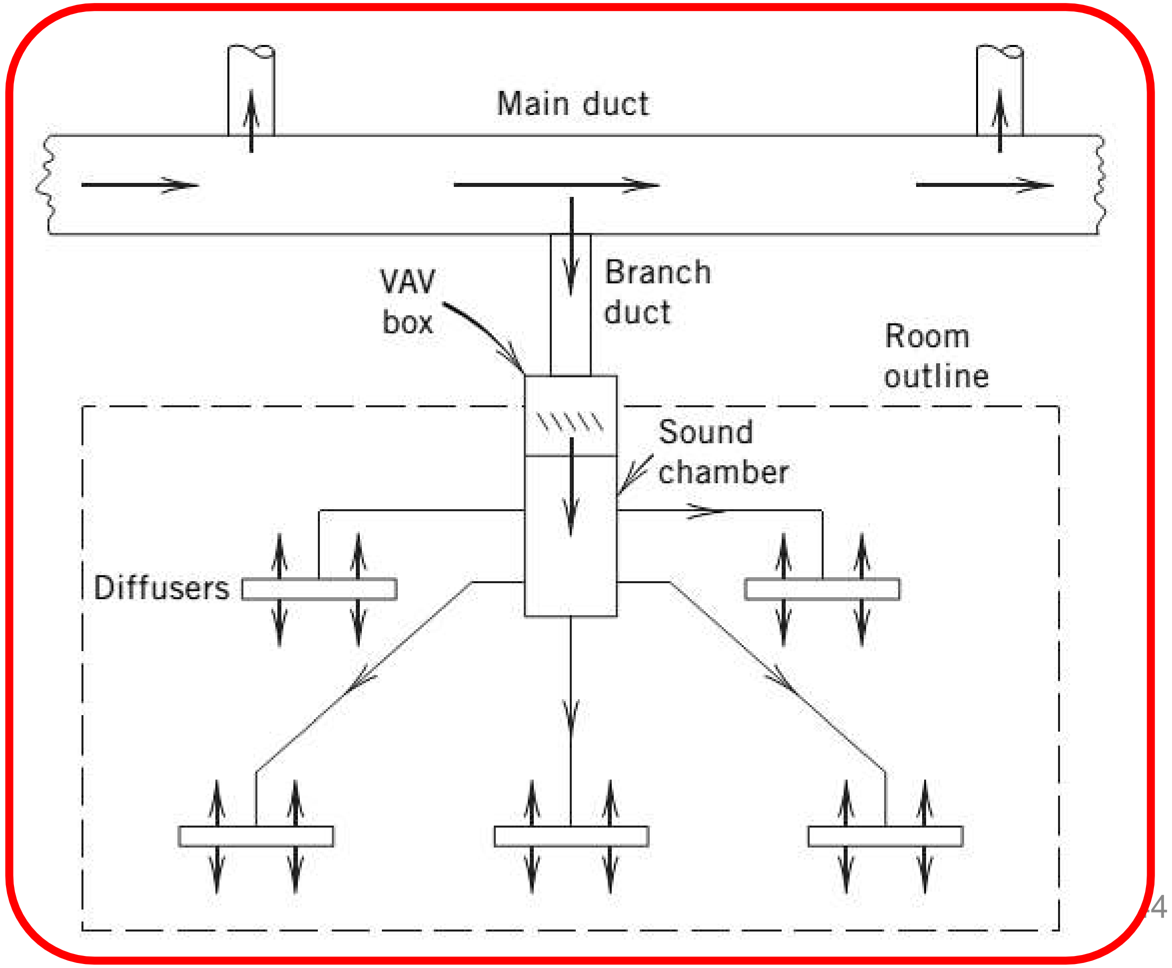
- ❑ **The air return grilles** should all be placed in the **ceiling** unless the structure has a basement, which would make placement of grilles near the floor feasible if desired.
- ✓ Because **cooling and ventilation** will be important factor in the gym and locker room area, a ceiling type of return air system will be utilized.
- ✓ The locker rooms should have a separate exhaust system to remove a total of **2400 cfm**.
- ✓ **Return grilles** may be selected from **Table 23-4 a follows**:

No.	Size, in.	Capacity, cfm	ΔP_0, in. wg	NC	Location
1	24 × 12	900	0.07	30	Entry
1	24 × 8	590	0.07	28	Office
1	24 × 8	590	0.07	28	Classroom 1
1	24 × 8	590	0.07	28	Classroom 2
12	24 × 20	1875	0.103	39	Gym
1	24 × 16	1220	0.07	32	Men's L.R.
1	24 × 16	1220	0.07	32	Women's L.R.

Air-Distribution System Design – VAV

- ✓ Variable air-volume air-distribution systems usually involve the use of linear or T-bar diffusers and a thermostat-controlled metering device, referred to as a VAV terminal box.
- ✓ There are almost infinite variations in these device, depending on the manufacturer.

- ✓ Some are self-powered, using energy from the flowing air, whereas others use power from an external source.
- ✓ Many of the self-powered boxes require a high static pressure and therefore are adaptable only to high-velocity systems.



AIR-DISTRIBUTION SYSTEM DESIGN - Tables

- **Tables 23-4**, and Table **23-2** show the performance data for one type of **round ceiling** adjustable diffuser that would generally be used for **high sidewall** applications.
- Table **23-2** shows a diffuser that has **adjustable** vanes and **throw** data are given for **three** different **settings 0, 22.5**, and **45** degrees.
- Figure **22-1** shows a **T-bar** type diffuser, which is used extensively with **modular ceilings**. Table **23-3** gives its performance data.
- Table **23-4** gives data for one **style** of **Grille**
- The **total** pressure **loss** for the grilles, **Pt = Ps + Pv** is **negative** because the **total pressure** must **decrease below** the **room total pressure**, approximately zero gage pressure, as **air flows through the grilles.**

AIR-DISTRIBUTION SYSTEM DESIGN - Tables

Table 11-4 Performance Data for a Typical Round Ceiling Diffuser

Size, in.	Neck Velocity, ft/min	Velocity Pressure, in. wg	Total Pressure, in. wg	Flow Rate, cfm	Radius of Diffusion,[a] ft Min.	Mid.	Max.	NC[b]
6	400	0.010	0.026	80	2	2	4	—
	500	0.016	0.041	100	2	3	5	—
	600	0.023	0.059	120	2	4	6	14
	700	0.031	0.079	140	3	4	7	19
	800	0.040	0.102	160	3	5	8	23
	900	0.051	0.130	180	4	5	9	26
	1000	0.063	0.161	200	4	6	10	30
	1200	0.090	0.230	235	5	7	11	35
8	400	0.010	0.033	140	2	4	6	—
	500	0.016	0.052	175	3	4	7	15
	600	0.023	0.075	210	4	5	9	21
	700	0.031	0.101	245	4	6	10	26
	800	0.040	0.130	280	5	7	11	31
	900	0.051	0.166	315	5	8	13	34
	1000	0.063	0.205	350	6	9	14	37
	1200	0.090	0.292	420	7	11	17	44

Table 23-1, Performance Data for a Typical Round Ceiling Diffuser.

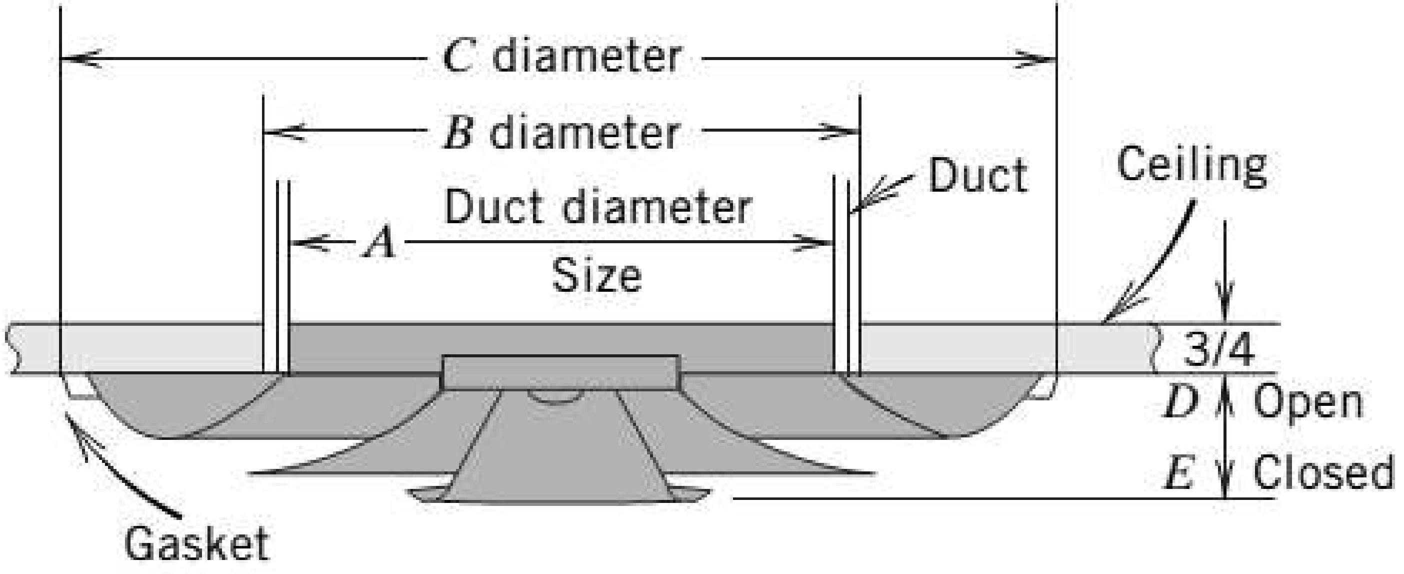
Table 23-1, Performance Data for a Typical Round Ceiling Diffuser.

Size, in.	Neck Velocity, ft/min	Velocity Pressure, in. wg	Total Pressure, in. wg	Flow Rate, cfm	Radius of Diffusion,[a] ft			NC[b]
					Min.	Mid.	Max.	
6	400	0.010	0.027	220	3	4	7	—
	500	0.016	0.043	270	3	5	8	11
	600	0.023	0.062	330	4	6	10	17
	700	0.031	0.084	380	5	7	11	21
	800	0.040	0.108	435	5	8	13	26
	900	0.051	0.138	490	6	9	15	30
	1000	0.063	0.170	545	7	10	16	33
	1200	0.090	0.243	655	8	12	20	39
12	400	0.010	0.026	315	3	5	8	—
	500	0.016	0.042	390	4	6	10	11
	600	0.023	0.060	470	5	7	12	17
	700	0.031	0.081	550	6	8	13	22
	800	0.040	0.105	630	6	10	15	26
	900	0.051	0.134	705	7	11	17	30
	1000	0.063	0.166	785	8	12	19	33
	1200	0.090	0.236	940	10	14	23	39
18	400	0.010	0.030	710	5	7	12	—
	500	0.016	0.048	885	6	9	15	15
	600	0.023	0.069	1060	7	11	18	21
	700	0.031	0.093	1240	9	13	21	26
	800	0.040	0.120	1420	10	15	24	30
	900	0.051	0.153	1590	11	17	27	34
	1000	0.063	0.189	1770	12	19	30	37
	1200	0.090	0.270	2120	15	22	36	43
24	400	0.010	0.024	1260	6	9	15	—
	500	0.016	0.038	1570	8	12	19	13
	600	0.023	0.054	1880	9	14	22	19
	700	0.031	0.073	2200	11	16	26	24
	800	0.040	0.094	2510	12	19	30	28
	900	0.051	0.120	2820	14	21	34	32
	1000	0.063	0.148	3140	16	23	37	35
	1200	0.090	0.211	3770	19	28	45	41

AIR-DISTRIBUTION SYSTEM DESIGN -Tables

Table 11-4 Performance Data for a Typical Round Ceiling Diffuser *(continued)*

Dimensions				
Size *A*	*B*	*C*	*D*	*E*
6	$6\frac{1}{2}$	$11\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{1}{8}$
8	$8\frac{1}{2}$	$14\frac{3}{4}$	$2\frac{1}{8}$	$1\frac{1}{2}$
10	$10\frac{1}{2}$	$18\frac{1}{4}$	$2\frac{7}{8}$	$2\frac{1}{8}$
12	$12\frac{1}{2}$	22	$3\frac{1}{8}$	$2\frac{3}{8}$
24	$24\frac{1}{2}$	$43\frac{1}{4}$	$7\frac{3}{4}$	$6\frac{5}{8}$



[a]Minimum radii of diffusion are to a terminal velocity of 150 ft/min, middle to 100 ft/min, and maximum to 50 ft/min.

[b]The NC values are based on a room absorption of 18 dB referred to 10^{-13} W (8 dB referred to 10^{-12} W).

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Table 23-1, Performance Data for a Typical Round Ceiling Diffuser.

AIR-DISTRIBUTION SYSTEM DESIGN -Tables

Table 11-5 Performance Data for an Adjustable-Type, High Sidewall Diffuser

Sizes, in.	A_c, ft^2	Flow, Rate, cfm	Veloc., ft/min	Veloc. Press., in. wg	Total Pressure, in. wg			NC	Defl., deg	Throw, ft		
					0°	$22\frac{1}{2}$°	45°			Min.	Mid.	Max.
8 × 4	0.18	70	400	0.010	0.017	0.019	0.029	—	0	6	8	15
7 × 5,									$22\frac{1}{2}$	5	6	12
6 × 6									45	3	4	8
10 × 4,	0.22	90						—	0	7	10	17
8 × 5,									$22\frac{1}{2}$	6	8	14
7 × 6									45	3	5	9
12 × 4,	0.26	105						—	0	7	11	19
10 × 5,									$22\frac{1}{2}$	6	9	15
8 × 6									45	4	5	9
16 × 4,	0.34	135						—	0	8	12	21
12 × 5,									$22\frac{1}{2}$	6	10	17
10 × 6									45	4	6	11
18 × 4,	0.39	155						—	0	9	13	23
14 × 5,									$22\frac{1}{2}$	7	10	18
12 × 6,									45	4	6	11

Table 23-2, Performance Data for an Adjustable – Type, High Sidewall Diffuser.

AIR-DISTRIBUTION SYSTEM DESIGN -Tables

Table 11-5 Performance Data for an Adjustable-Type, High Sidewall Diffuser *(continued)*

Sizes, in.	A_c, ft^2	Flow, Rate, cfm	Veloc., ft/min	Veloc. Press., in. wg	Total Pressure, in. wg 0°	$22\frac{1}{2}$°	45°	NC	Defl., deg	Throw, ft Min.	Mid.	Max.
12 × 6,									45	4	6	11
8 × 4,	0.18	90	500	0.016	0.028	0.031	0.047	—	0	7	11	17
7 × 5,									$22\frac{1}{2}$	6	9	14
6 × 6									45	4	5	9
10 × 4,	0.22	110						—	0	8	12	19
8 × 5,									$22\frac{1}{2}$	6	10	15
7 × 6									45	4	6	10
12 × 4,	0.26	130						—	0	9	13	21
10 × 5,									$22\frac{1}{2}$	7	10	17
8 × 6									45	4	7	10
16 × 4,	0.34	170						—	0	10	15	24
12 × 5,									$22\frac{1}{2}$	8	12	19
10 × 6									45	5	8	11
18 × 4,	0.39	195						—	0	11	16	25
14 × 5,									$22\frac{1}{2}$	9	13	20
12 × 6,									45	5	8	13

continues

Table 23-2, Performance Data for an Adjustable – Type, High Sidewall Diffuser.

AIR-DISTRIBUTION SYSTEM DESIGN -Tables

Table 23-2, Performance Data for an Adjustable – Type, High Sidewall Diffuser.

Table 11-5 Performance Data for an Adjustable-Type, High Sidewall Diffuser *(continued)*

Sizes, in.	A_c ft^2	Flow, Rate, cfm	Veloc., ft/min	Veloc. Press., in. wg	Total Pressure, in. wg 0°	$22\frac{1}{2}$°	45°	NC	Defl., deg	Throw, ft Min.	Mid.	Max.
8 × 4,	0.18	110	600	0.022	0.038	0.043	0.064	10	0	9	13	19
7 × 5,									$22\frac{1}{2}$	7	10	15
6 × 6									45	4	7	10
10 × 4,	0.22	130						10	0	9	15	21
8 × 5,									$22\frac{1}{2}$	7	12	17
7 × 6									45	5	7	10
12 × 4,	0.26	155						11	0	10	16	23
10 × 5,									$22\frac{1}{2}$	8	13	18
8 × 6									45	5	8	11
16 × 4,	0.34	205						12	0	12	19	26
12 × 5,									$22\frac{1}{2}$	10	15	21
10 × 6									45	6	9	13
18 × 4,	0.39	235						13	0	13	19	28
14 × 5,									$22\frac{1}{2}$	10	15	22
12 × 6,									45	7	10	14
8 × 4,	0.18	125	700	0.030	0.052	0.058	0.088	15	0	10	15	20
7 × 5,									$22\frac{1}{2}$	8	12	16
6 × 6									45	5	7	10
10 × 4,	0.22	155						15	0	11	16	23

AIR-DISTRIBUTION SYSTEM DESIGN -Tables

Table 11-5 Performance Data for an Adjustable-Type, High Sidewall Diffuser *(continued)*

Sizes, in.	A_c, ft^2	Flow, Rate, cfm	Veloc., ft/min	Veloc. Press., in. wg	Total Pressure, in. wg			NC	Defl., deg	Throw, ft		
					0°	$22\frac{1}{2}$°	45°			Min.	Mid.	Max.
8 × 4,	0.18	125	700	0.030	0.052	0.058	0.088	15	0	10	15	20
7 × 5,									$22\frac{1}{2}$	8	12	16
6 × 6									45	5	7	10
10 × 4,	0.22	155						15	0	11	16	23
8 × 5,									$22\frac{1}{2}$	9	13	18
7 × 6									45	6	8	11
12 × 4,	0.26	180						16	0	12	17	24
10 × 5,									$22\frac{1}{2}$	10	14	19
8 × 6									45	6	9	12
16 × 4,	0.34	240						17	0	14	20	28
12 × 5,									$22\frac{1}{2}$	11	16	22
10 × 6									45	7	10	14
18 × 4,	0.39	275						18	0	15	22	30
14 × 5,									$22\frac{1}{2}$	12	18	24
12 × 6,									45	8	11	15
8 × 4,	0.18	145	800	0.040	0.069	0.078	0.117	19	0	11	16	22
7 × 5,									$22\frac{1}{2}$	9	13	18
6 × 6									45	6	8	11
10 × 4,	0.22	175						19	0	13	17	24

Table 23-2, Performance Data for an Adjustable – Type, High Sidewall Diffuser.

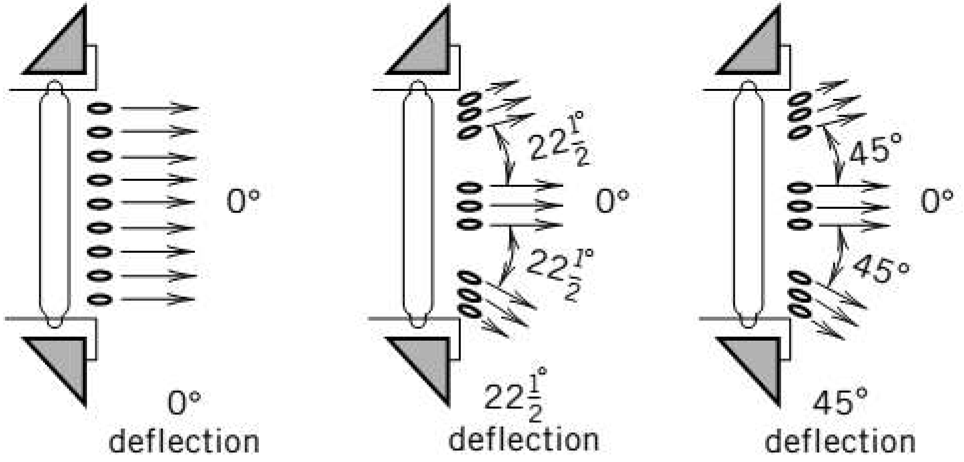
Table 11-5 Performance Data for an Adjustable-Type, High Sidewall Diffuser *(continued)*

Sizes, in.	A_c ft^2	Flow, Rate, cfm	Veloc., ft/min	Veloc. Press., in. wg	Total Pressure, in. wg 0°	22 $\frac{1}{2}$°	45°	NC	Defl., deg	Throw, ft Min.	Mid.	Max.
10 × 4,	0.22	175						19	0	13	17	24
8 × 5,									22 $\frac{1}{2}$	10	14	19
7 × 6									45	6	9	12
12 × 4,	0.26	210						20	0	14	19	26
10 × 5,									22 $\frac{1}{2}$	11	15	21
8 × 6									45	7	9	13
16 × 4,	0.34	270						21	0	16	22	30
12 × 5,									22 $\frac{1}{2}$	13	18	24
10 × 6									45	8	11	15
18 × 4,	0.39	310						22	0	17	23	32
14 × 5,									22 $\frac{1}{2}$	14	18	26
12 × 6,									45	9	12	16
8 × 4,	0.18	180	1000	0.062	0.107	0.120	0.181	25	0	14	17	24
7 × 5,									22 $\frac{1}{2}$	11	14	19
6 × 6									45	7	9	12

continues

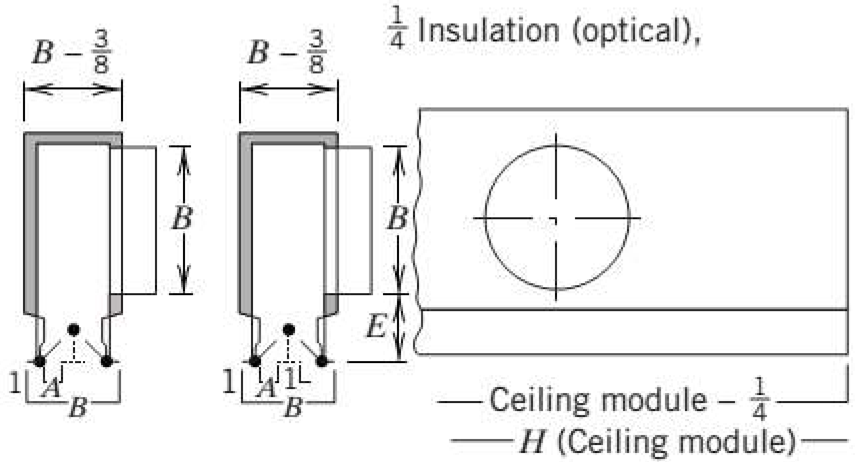
Table 11-5 Performance Data for an Adjustable-Type, High Sidewall Diffuser *(continued)*

Sizes, in.	A_c, ft^2	Flow, Rate, cfm	Veloc., ft/min	Veloc. Press., in. wg	Total Pressure, in. wg 0°	$22\frac{1}{2}$°	45°	NC	Defl., deg	Throw, ft Min.	Mid.	Max.
10 × 4,	0.22	220						25	0	16	19	27
8 × 5,									$22\frac{1}{2}$	13	15	22
7 × 6									45	8	10	13
12 × 4,	0.26	260						26	0	17	21	19
10 × 5,									$22\frac{1}{2}$	14	17	23
8 × 6									45	8	11	15
16 × 4,	0.34	340						27	0	20	24	33
12 × 5,									$22\frac{1}{2}$	16	19	26
10 × 6									45	10	12	17
18 × 4,	0.39	390						28	0	21	26	36
14 × 5,									$22\frac{1}{2}$	17	21	29
12 × 6,									45	11	13	18



AIR-DISTRIBUTION SYSTEM DESIGN -Tables

Table 23-3, Performance Data for a T-Bar Diffusers of Figure 23-1



Model	*A*	*H*	*B*	*C*	*D*	*E*
27	1/2	24	4	12	5	5 7/8
		48			7	3 7/8
28	1/2	24	4 7/8	12	6	4 7/8
		48			8	2 7/8

Figure 23-1, A typical T-Bar Diffusers assembly

Table 11-6 Performance Data for the T-Bar Diffusers of Fig. 11-5

Model		Flow Rate, cfm	Horiz. Proj.,[a] ft			Total Press., in. wg	NC[b]
			Min.	Mid.	Max.		
27	H-24	55	2	3	4	0.04	—
		62	2	3	4	0.06	11
		68	2	3	5	0.07	14
		80	2	4	6	0.10	19
		95	3	5	7	0.14	24
		110	3	6	8	0.18	28
		120	3	6	9	0.22	32
		135	4	7	10	0.28	35
		150	4	8	11	0.34	38
	H-48	104	2	4	5	0.04	—
		120	2	4	6	0.05	14
		135	3	5	7	0.07	17
		160	3	6	8	0.10	22
		185	4	6	9	0.13	27
		215	4	7	10	0.18	31
		240	5	8	12	0.22	35
		270	5	9	13	0.28	38
		295	6	10	14	0.34	41
28	H-24	80	2	3	5	0.05	17
		90	2	3	5	0.06	21
		100	2	4	6	0.08	24
		120	3	5	7	0.11	29
		140	3	6	8	0.15	34
		160	4	7	9	0.20	38
		180	4	6	10	0.25	42
		200	5	8	12	0.31	45
		215	5	8	12	0.36	48
	H-48	140	2	4	6	0.04	15
		155	3	4	6	0.05	19
		175	3	5	7	0.06	22
		210	4	6	8	0.08	27
		245	5	7	10	0.11	32
		280	5	8	11	0.15	36
		315	5	9	13	0.19	40
		350	6	10	14	0.23	43
		385	7	12	16	0.28	46

Return grilles are quite varied in design. The construction of the grille has very little to do with the overall performance of the system except to introduce some loss in pressure and noise if not properly sized. The appearance of a return grille is important, and the louver design is usually selected on this basis. Table 23-4 gives data for one style of grille. The capacity, pressure loss, and noise criteria are the main performance data given. Note that the total pressure loss for the grilles, $P_t = Ps + P_v$, is negative because the total pressure must decrease below the room total pressure, approximately zero gage pressure, as air flows through the grilles.

AIR-DISTRIBUTION SYSTEM DESIGN -Tables

Table 23-4, Performance Data for One Type Return Grille

Table 11-7 Performance Data for One Type of Return Grille

		Core Velocity, fpm	200	300	400	500	600	700	800
		Velocity Pressure, in. wg	0.002	0.006	0.010	0.016	0.023	0.031	0.040
A_c, ft^2	Sizes, in.	Static Pressure, in. wg	–0.011	–0.033	–0.055	–0.088	–0.126	–0.170	–0.220
0.34	16 × 4	cfm	70	100	135	170	205	240	270
	10 × 6	NC[a]			13	20	25	30	33
0.39	18 × 4	cfm	80	115	155	195	235	275	310
	12 × 6	NC			14	21	26	31	34
0.46	20 × 4	cfm	90	140	185	230	275	320	370
	14 × 6	NC			15	22	27	32	35
	10 × 8								
0.52	24 × 4	cfm	105	155	210	260	310	365	415
	16 × 6	NC			16	23	28	33	36
0.60	28 × 4	cfm	120	180	240	300	360	420	480
	18 × 6	NC			17	24	29	34	37
	12 × 8								
0.69	30 × 4	cfm	140	205	275	345	415	485	550
	20 × 6	NC			17	24	29	34	37
	14 × 8								
	12 × 10								
0.81	36 × 4	cfm	160	245	325	405	485	565	650
	22 × 6	NC		10	18	25	30	35	38
	16 × 8								
	14 × 10								

0.90	40 × 4	cfm	180	270	360	450	540	630	720
	26 × 6	NC		11	19	26	31	36	39
	18 × 8								
	16 × 10								
	12 × 12								
1.07	48 × 4	cfm	215	320	430	535	640	750	855
	30 × 6	NC		12	20	27	32	37	40
	18 × 10								
	14 × 12								
1.18	34 × 6	cfm	235	355	470	590	710	825	945
	24 × 8	NC		13	21	28	33	38	41
	20 × 10								
	16 × 12								
1.34	60 × 4	cfm	270	400	535	670	805	940	1070
	36 × 6	NC		13	21	28	33	38	41
	18 × 12								
	16 × 14								
1.60	30 × 8	cfm	320	480	640	800	960	1120	1280
	24 × 10	NC		14	22	29	34	39	42
	22 × 12								
	18 × 14								

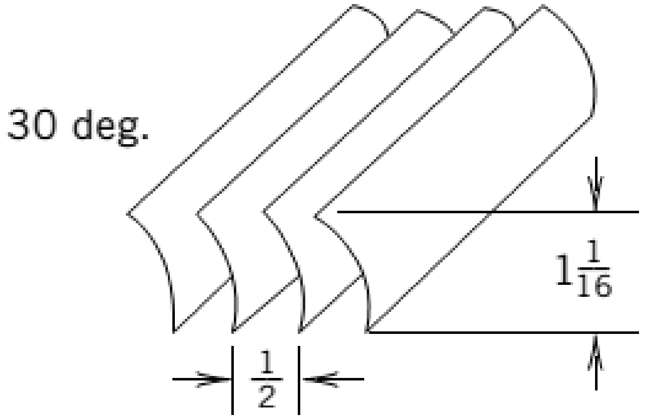
continues

Table 11-7 Performance Data for One Type of Return Grille *(continued)*

A_c, ft^2	Sizes, in.								
		Core Velocity, fpm	200	300	400	500	600	700	800
		Velocity Pressure, in. wg	0.002	0.006	0.010	0.016	0.023	0.031	0.040
		Static Pressure, in. wg	–0.011	–0.033	–0.055	–0.088	–0.126	–0.170	–0.220
1.80	48 × 6	cfm	360	540	720	900	1080	1260	1440
	36 × 12	NC		15	23	30	35	40	43
	30 × 10								
	24 × 12								
2.08	60 × 6	cfm	415	625	830	1040	1250	1460	1660
	40 × 8	NC		16	24	31	36	41	44
	36 × 10								
	30 × 12								
	24 × 14								
	20 × 16								
2.45	48 × 8	cfm	490	735	980	1220	1470	1720	1960
	26 × 14	NC		17	25	32	37	42	45
	24 × 16								
2.78	36 × 12	cfm	555	835	1110	1390	1670	1950	2220
	30 × 14	NC		18	26	33	38	43	46
	26 × 16								
	24 × 18								

3.11	40 × 12	cfm	620	935	1240	1560	1870	2180	2490
	36 × 14	NC		19	27	34	39	44	47
	30 × 16								
	24 × 20								
3.61	48 × 12	cfm	720	1080	1440	1800	2170	2530	2890
	36 × 16	NC		20	28	35	40	45	48
	24 × 24								

[a] Based on a room absorption of 8 dB, with respect to 10^{-12} watts, and one return.



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A free isothermal jet is discharged horizontally from a circular opening. There is no nearby surface. The initial velocity and volume flow rate are 850 ft/min (4.3 m/s) and 300 cfm (142 L/s), respectively. Estimate (a) the throw for terminal velocities of 50, 100, and 150 ft/min (0.25, 0.50, 0.75 m/s) and (b) the total volume flow rate of the jet for each terminal velocity in (a).

(a) Using Eq. 11-1b

$$x = \frac{1.13K\dot{Q}_o}{\bar{V}_x\sqrt{A_o}} \;;\; A_o = \frac{300}{850} = 0.353 \text{ ft}^2; \text{ Assumed } K = 6$$

$$x_{50} = \frac{1.13 \times 6(300)}{50\sqrt{0.353}} = 68.5 \text{ ft};\; x_{100} = 34.2 \text{ ft};\; x_{150} = 22.8\text{ft}$$

(b) $\dot{Q}_x = C\dot{Q}_o\bar{V}_o/\bar{V}_x$; C = 2 ; Eq. 11-2a

$$(\dot{Q}_x)_{50} = 2(300)850/50 = 10{,}200 \text{ ft}^3/\text{min}$$

$$(\dot{Q}_x)_{100} = 600(850)/100 = 5{,}100 \text{ ft}^3/\text{min}$$

$$(\dot{Q}_x)_{150} = 600(850)/150 = 3{,}400 \text{ ft}^3/\text{min}$$

A 10 in. (25 cm) round ceiling diffuser from Table 23-1 is to be used with 650 cfm (307 L/s). Compute the total pressure, throw, and noise criteria for this application.

10 in. round diffuser, Table 11-4; 650 cfm

Interpolation between 600 & 700 cfm is required

NC = 0.5 x (21 – 17) + 17 = 19

x_{50} = 0.5(11-10) + 10 = 10.5 ft

$$P = 0.062\left(\frac{650}{600}\right)^2 = \underline{0.073 \text{ in. wg}}$$

A linear floor diffuser is required for a space with an air supply rate of 600 cfm (283 L/s). The room has a 12 ft ceiling and a cooling load of 40 Btu/(hr-ft²) (126 W/m²). (a) Select a diffuser from Table 22-3 for this application. (b) Determine the total pressure and NC for your election

(a) Room char. Length = 14 ft, Table 11-1

$(x_{50}/L)_{max}$ = 0.8, Table 11-2

Range of x_{50}/L = 0.5 to 1.5; x_{50} = 0.8 x 14 = 11.2 ft

The best choice would be a 12 in. size with 600 cfm

(b) $x_{50} = 13 + \frac{50}{80}(2) \doteq 14.3$ ft; $x_{50}/L = \frac{14.3}{14} = 1.02$ (in the range)

$\Delta P_o = 0.081\left(\frac{600}{550}\right)^2 = 0.096$ in. wg.; $NC = 22 + \frac{50}{80}(4) = 24.5$

From Table 11-1, L = 12 ft. Then from Table 11-2 at

$\dot{q}$ = 40 Btu/(hr-ft²), $(X_{50}/L)_{max}$

=1.3 and the range is 1.2 - 1.8, and X_{50} = 1.3 x 12 = 15.6 ft

A good solution would be to use the 4 in. size with 150 cfm/ft. with uncorrected throw of 18 ft and NC = 19.

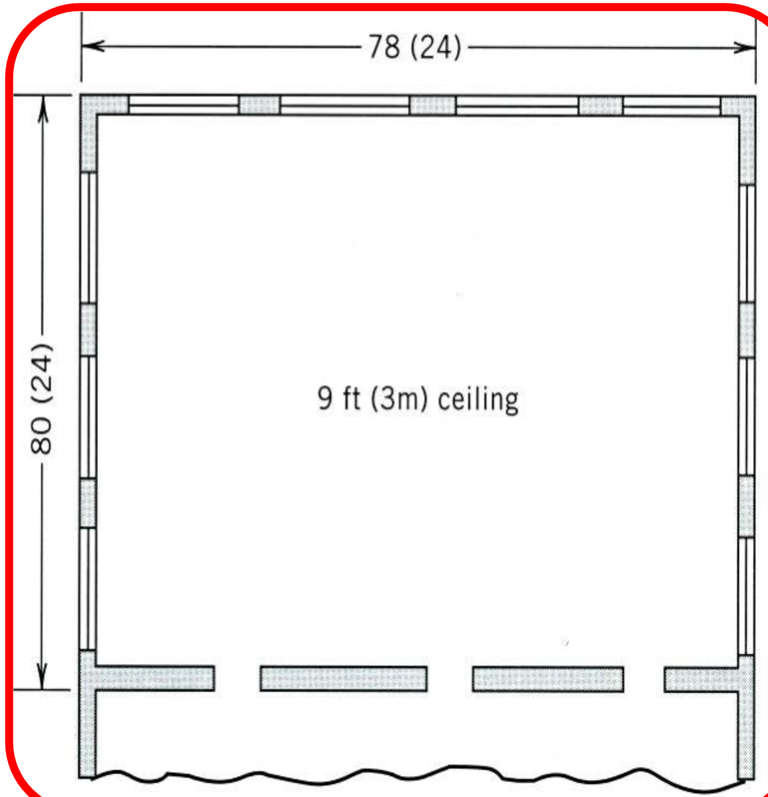
The corrected throw is:

X_{50} = 18 x 0.85 = 15.3 ft and NC = 19 – 4 = 15

$P = 0.057\left(\frac{150}{139}\right)^2$ = <u>0.066 in. wg</u>

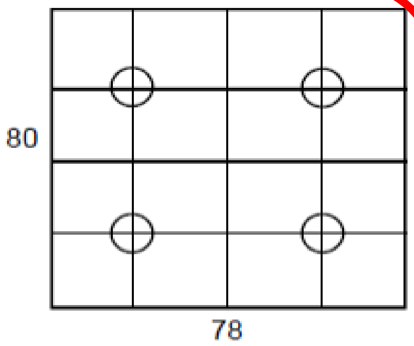
Suppose a round ceiling diffuser is to be used in the situation described in Problem 3. The room has plan dimension of 26 x 28 ft (8 x 8.5 m). (a) Select a diffuser from Table 23-1 for this application. (b) Determine the total pressure and NC for the diffuser.

Select round ceiling diffusers for the room shown in the figure. The room has a cooling load of 112,000 Btu/hr (32.8 kW) and a design air supply rate of 2600 cfm (1225 L/s). Locate the diffuser on the floor plan. A maximum total pressure of 0.12 in. wg (30 Pa) is allowed.



Use 4-12 in. size from Table 11-4

650 cfm/diffuser; L = 20 ft



$$\text{Room Load} = 18 \frac{\text{Btu}}{(\text{hr} - \text{ft}^2)}$$

$x_{50}/L = 0.8$; Table 11-2

x = 16 ft (desired)

$$x_{actual} = \frac{(650 - 630)}{(705 - 630)}(17 - 15) + 15 = 15.5 \text{ ft}$$

$$\frac{x_{act}}{L} = \frac{15.5}{20} = 0.78 \text{ (in acceptable range)}$$

$$NC \doteq 27;\ \Delta P_o = 0.105 \left(\frac{650}{630}\right)^2 = 0.112 \text{ in. wg.}$$

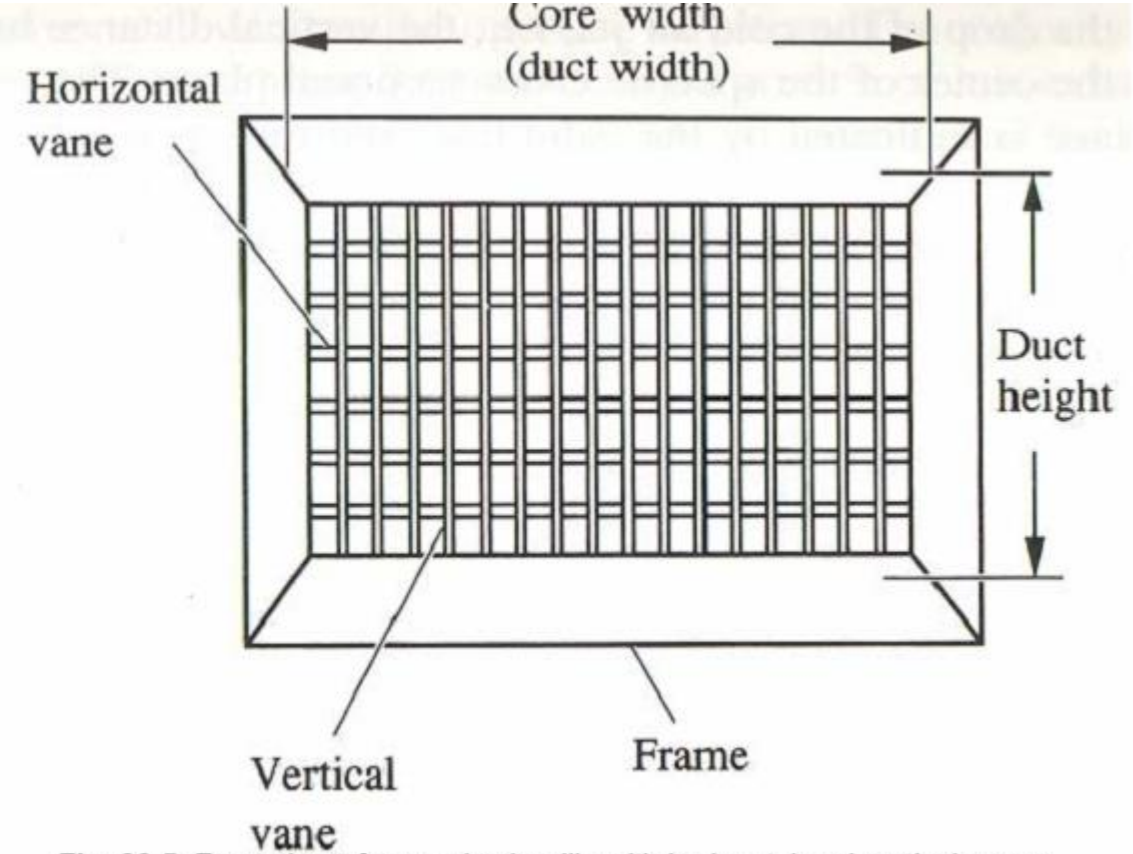


Fig. 39.5. Front view of a supply air grille with horizontal and vertical vanes

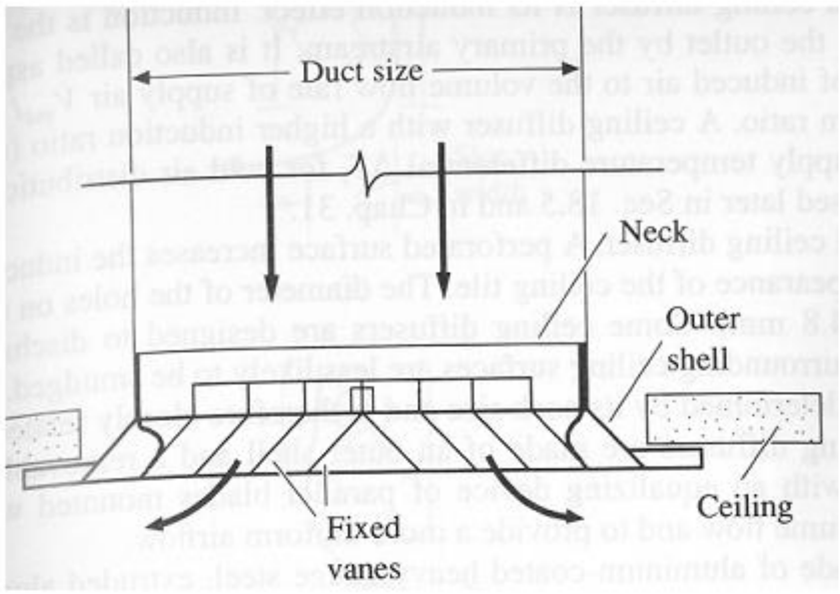


Fig.39.6(a): Schematic of a ceiling diffuser

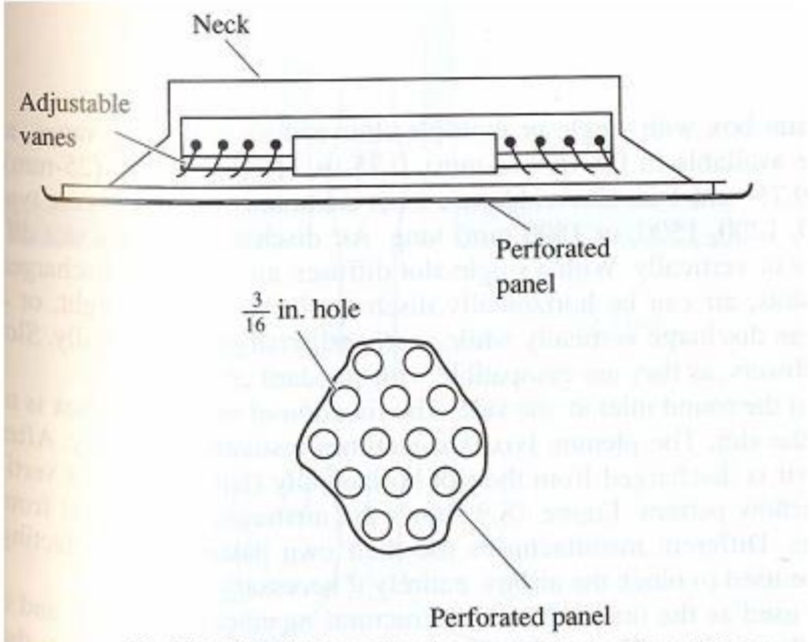
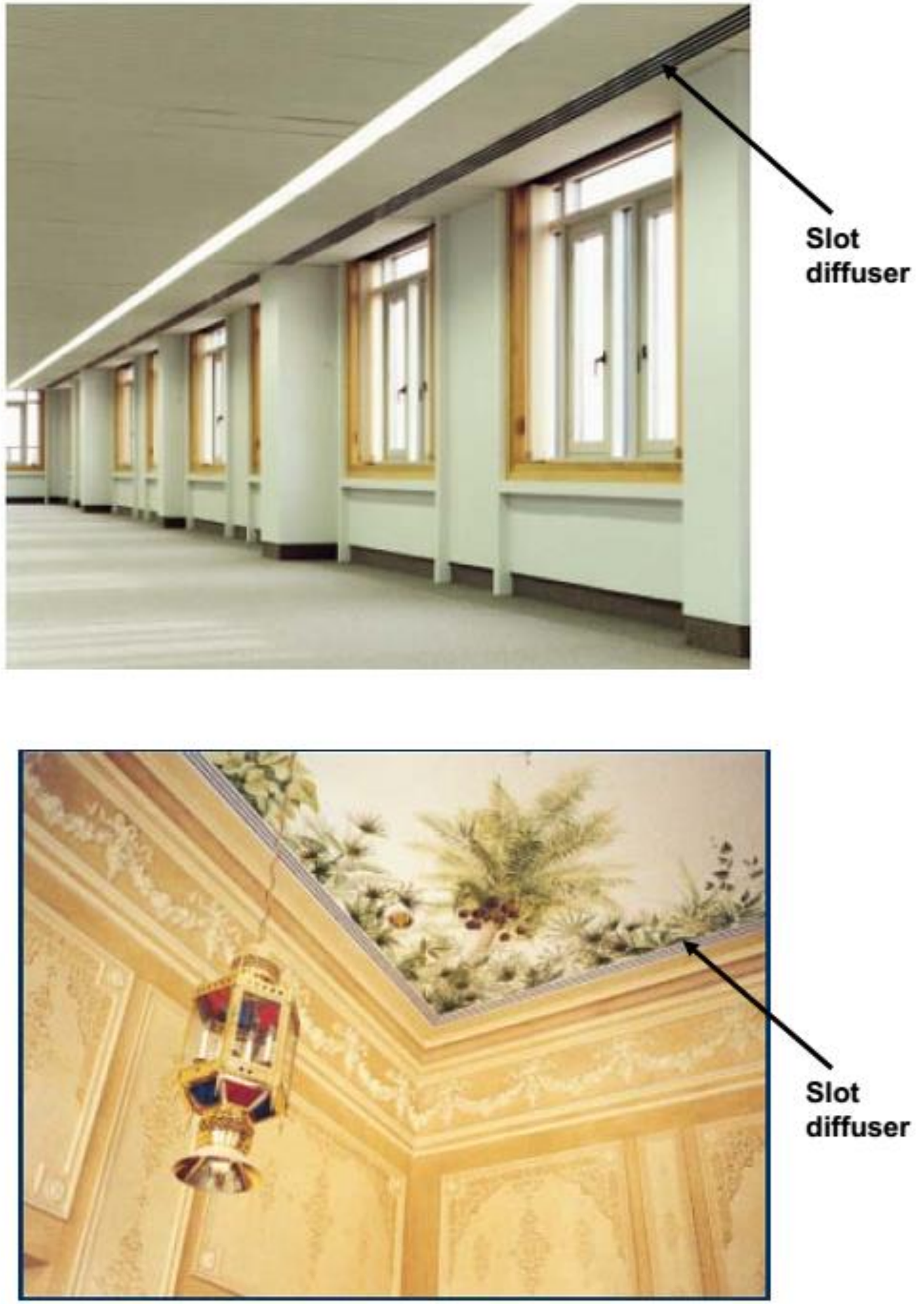


Fig.39.6(b): Schematic of a perforated ceiling diffuser



ig.39.7(a) and (b): Photographs of conditioned space with linear slot diffusers mounted in the ceiling

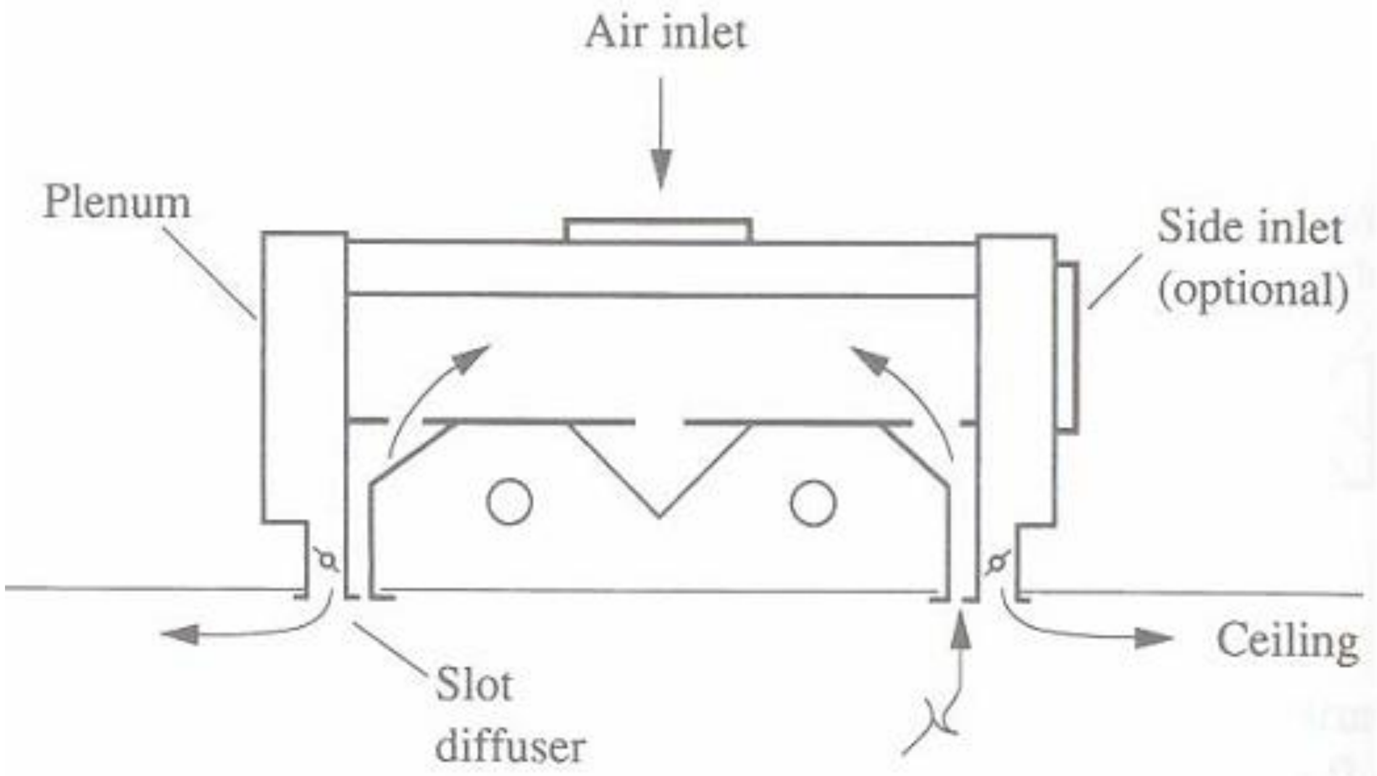


Fig.39.8: *Light troffer-diffuser slot*

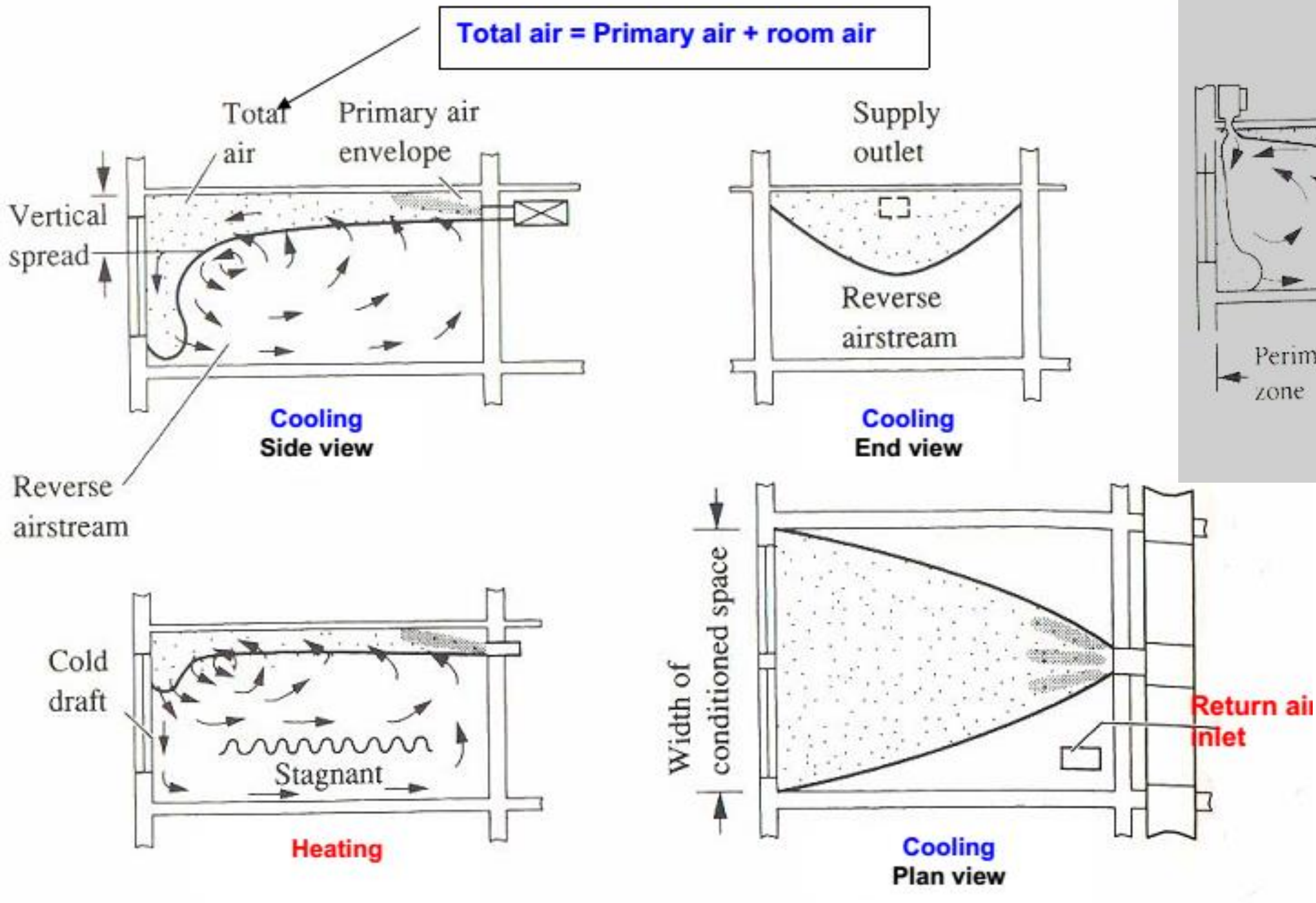


Fig.39.9: Airflow pattern using high side outlets for cooling and heating applications

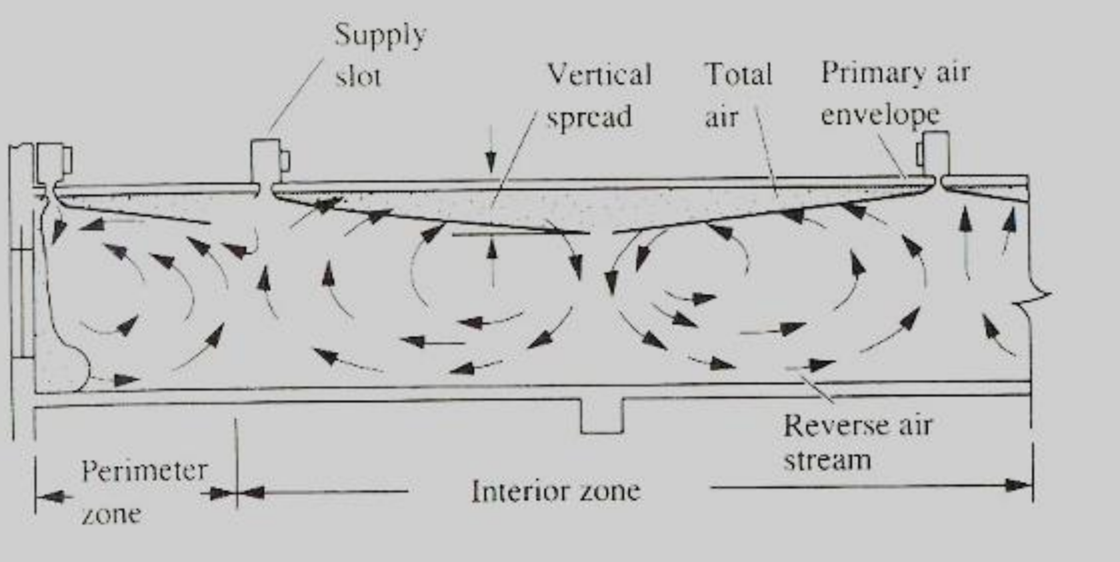


***Fig.39.11**: Airflow pattern for cooling using slot diffusers*

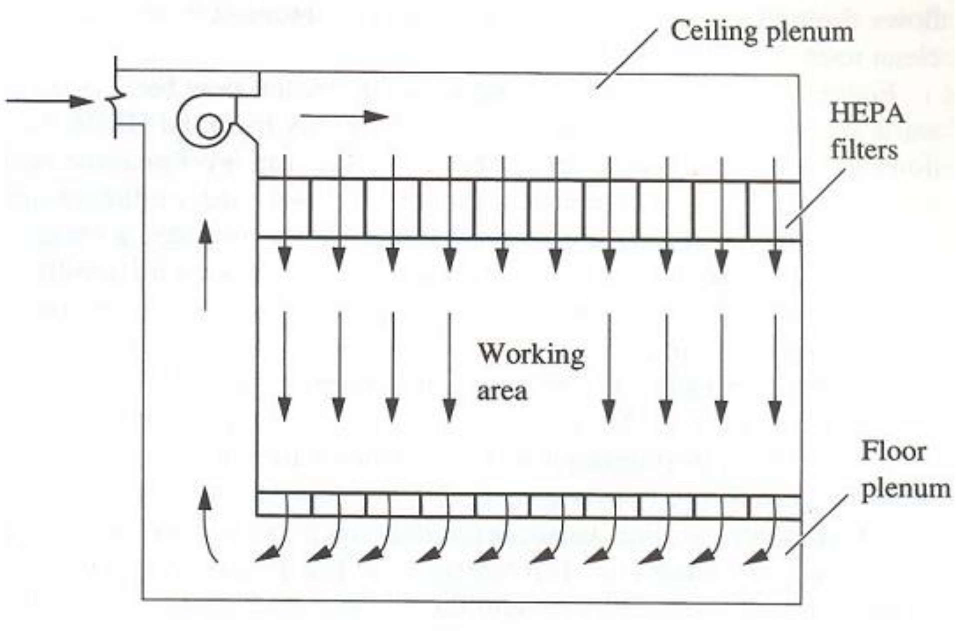


***Fig.39.12(a)**: Downward unidirectional flow*

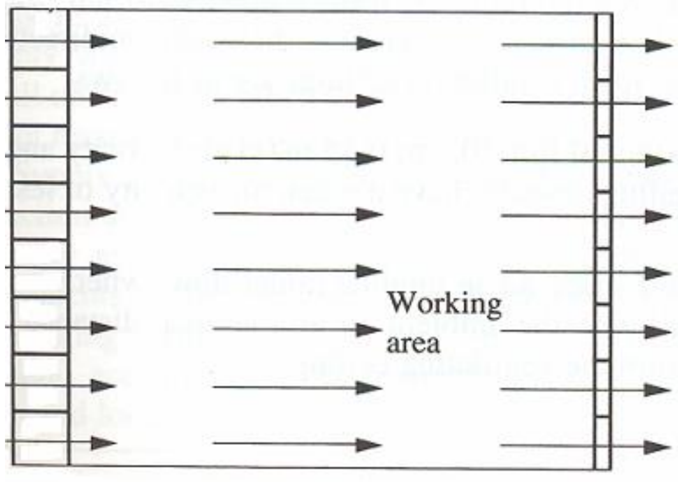


***Fig.39.12(b)**: Horizontal unidirectional flow*

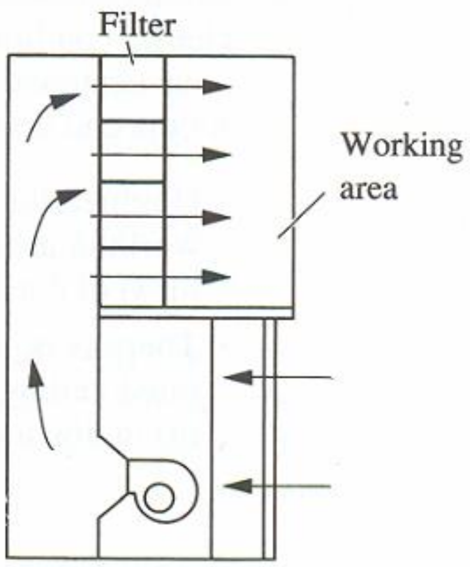


***Fig.39.12(c)**: Unidirectional flow for work stations*