

Exercise 03 – Space Air Diffusion

1. Define the following terms used in the design of space air diffusion.
 - i) Age of air
 - ii) Air change effectiveness
 - iii) Air diffusion performance index (ADPI)
 - iv) Confined air jet
 - v) Entrainment ratio

Answer: (* Outline of the solution only)

- i) Age of air = Time period that outdoor ventilation air has been in a zone, space or building; the “youngest” air = freshest air
- ii) Air change effectiveness = Air system’s ability to deliver ventilation air; how well outdoor air is diffused to various locations; for proper air distribution, $\varepsilon_N = 1$
$$\varepsilon_N = \tau_N / \theta_{\text{age}, N} \quad \tau_N : \text{nominal time constant (min. or hr.)}$$
- iii) Air diffusion performance index (ADPI):
$$\text{ADPI} = (N_\theta \times 100) / N$$
 where θ = effective draft temperature
 N_θ : number of points measured in occupied zone in which $-1.7^\circ\text{C} < \theta < 1.1^\circ\text{C}$
 N : total number of points measured in occupied zone
- Higher the ADPI, higher % of occupants who feel comfortable
- iv) Confined air jet: envelope confined by ceiling, floor, walls, windows, furniture, etc (Air jet approaches a free air jet if $\sqrt{Ar} / Do > 50$)
- v) Entrainment ratio = Ratio of volume flow rate to the total air at a specific cross-sectional plane of the air jet to volume flow rate of the supply air discharged from outlet (primary air)

2. A rectangular room length 5 m, width 4 m and height 3 m is ventilated by a supply air flow rate of 100 l s^{-1} . Calculate the air exchange rate and the time constant of the supply air.

Answer: (* Outline of the solution only)

Calculate the air exchange rate and the time constant of the supply air:

- Interior volume = $5 \times 4 \times 3 = 60 \text{ m}^3$
- Air exchange rate = $100/1000 / 60 \times 3600 = 6$ air change per hour (ACH)

Time constant = $1 / 6$ hour = 10 minutes

3. Briefly discuss the advantages and disadvantages of underfloor air distribution.

Answer: (* Outline of the solution only)

Advantages of underfloor air distribution

- Integrated well with raised floor plenum
- Can be very flexible for future changes/relocations
- Conditioned air is supplied directly to occupants
- Stagnant air can be reduced (if ceiling return)
- Upward flow lifts some unneutralised heat
- It can utilise thermal mass of access floor & slab to reduce peak demands

Disadvantages

- Higher initial costs
- Need for raised floor system & floor diffusers

4. Briefly explain the main advantages and drawbacks of using cold air distribution with low-temperature supply air for HVAC systems.

Answer: (* Outline of the solution only)

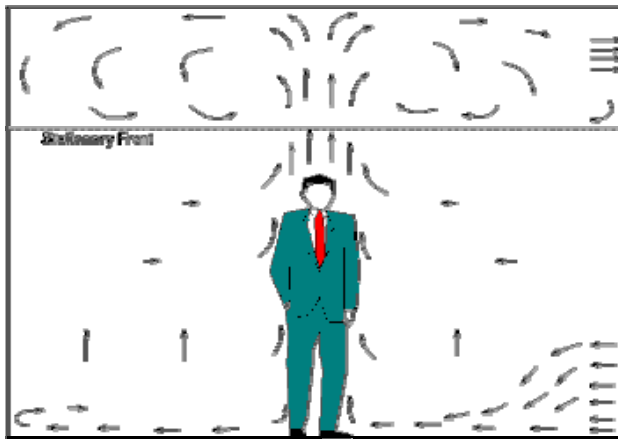
Main advantages of cold air distribution:

- Reduce design supply volume flow (larger ΔT)
- Air-side components can be downsized
- Fan energy use can be reduced
- Reduced fan sound levels

Drawbacks: dumping of cold air jet & IAQ issues

5. Draw a simplified diagram to show the typical air flow patterns of a room installed with a displacement ventilation system. You may assume low-level supply outlet is being used. Give two characteristics of stratified displacement flow.

Answer: (* Outline of the solution only)



Two characteristics of stratified displacement flow: (* any two of them)

- Cold air supply of usually 100% outdoor air
- Air must be supplied at low velocity (< 0.3 m/s) & at a height less than 0.54 m above floor
- Cold air supplied at 2.8 to 5 °C lower than occupied zone
- Height of lower zone shall be higher than a seated occupant (1.4 m); all air is supply air in lower zone
- Smaller cooling load density (max. 41 W/m²)
- Return or exhaust inlets located near ceiling level