MEBS6006 Environmental Services I

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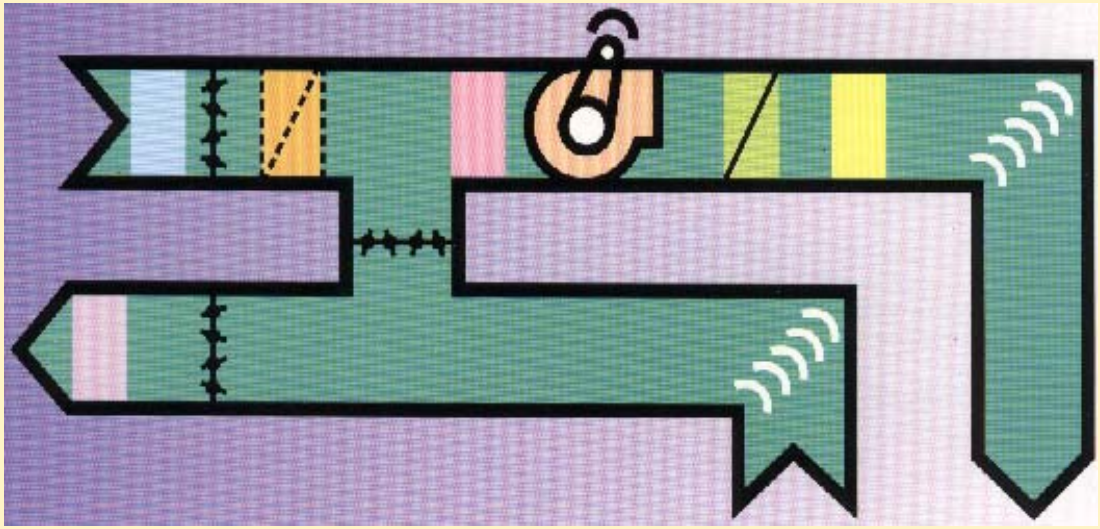

Air Side Systems

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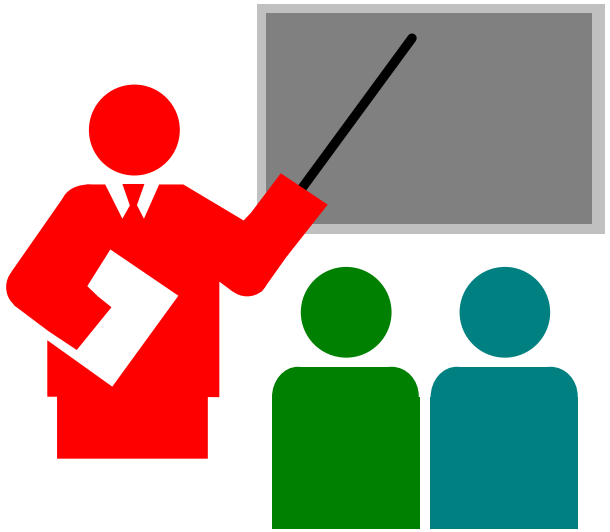
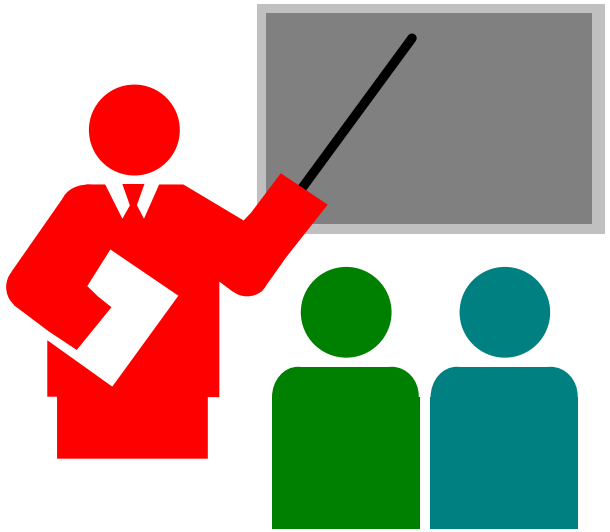
Worked Example for Last Session

- How to work out the ventilation rate based on measured CO_2 concentration?



Content

- Air Side System
  - Basics
  - Types of Air Side Systems
    - Direct Expansion Systems
    - All Air Systems
    - Air and Water Systems
    - All Water Systems
  - Components of Air Side System



Basics

Determination of Supply Air Flow Rate

$$\dot{V}_s = \frac{q_{rs}}{\rho_s c_{pa} (t_r - t_s)}$$

$\dot{V}_s$ = Volume supply flow rate

ρ_s = density of air

q_{rs} = sensible heat gain

c_{pa} = specific heat of supply air

t_r = return air temperature

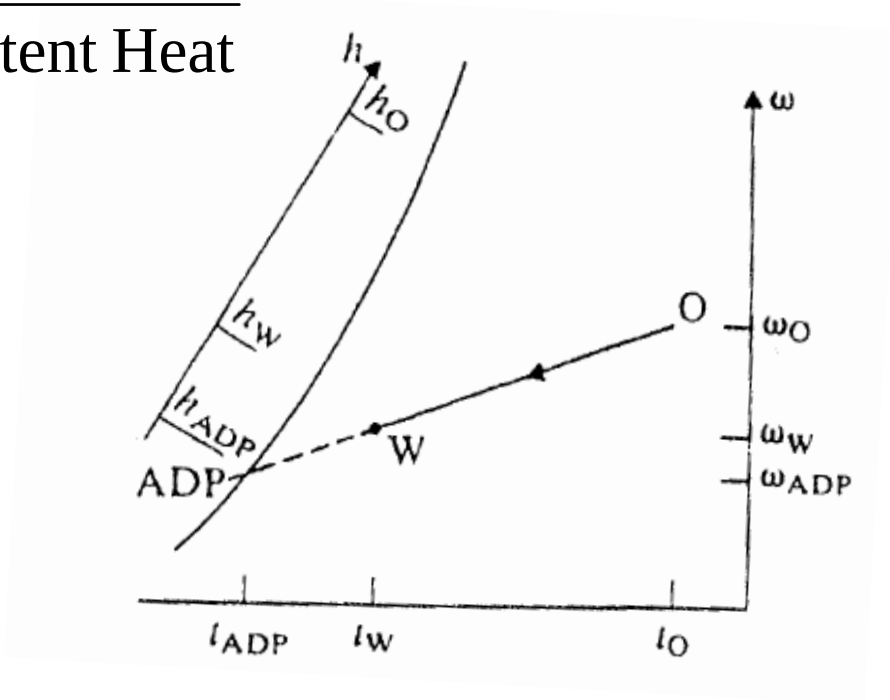
t_s = supply air temperature

Basics

$$\text{Contact Factor} = \frac{h_o - h_w}{h_o - h_{ADP}} = \frac{t_o - t_w}{t_o - t_{ADP}} = \frac{\text{Line OW}}{\text{Line OADP}}$$

$$\text{Room Ratio Line} = \frac{\text{Sensible Heat}}{\text{Sensible Heat} + \text{Latent Heat}}$$

ADP = Apparatus Dew Point



Basics

- Fan-duct systems
  - Terminology
    - Primary air (fresh air, either conditioned or unconditioned air, or makeup air)
    - Secondary air (induced space air, plenum air, or recirculating air)
    - Transfer air (indoor air that moves from an adjacent area)
  - System curve: volume flow *vs* pressure loss
  - System operating point

Basics

- Fan-duct systems
  - Flow resistance R, pressure drop Δp and volume flow rate V

$$\Delta p = R \cdot \dot{V}^2$$

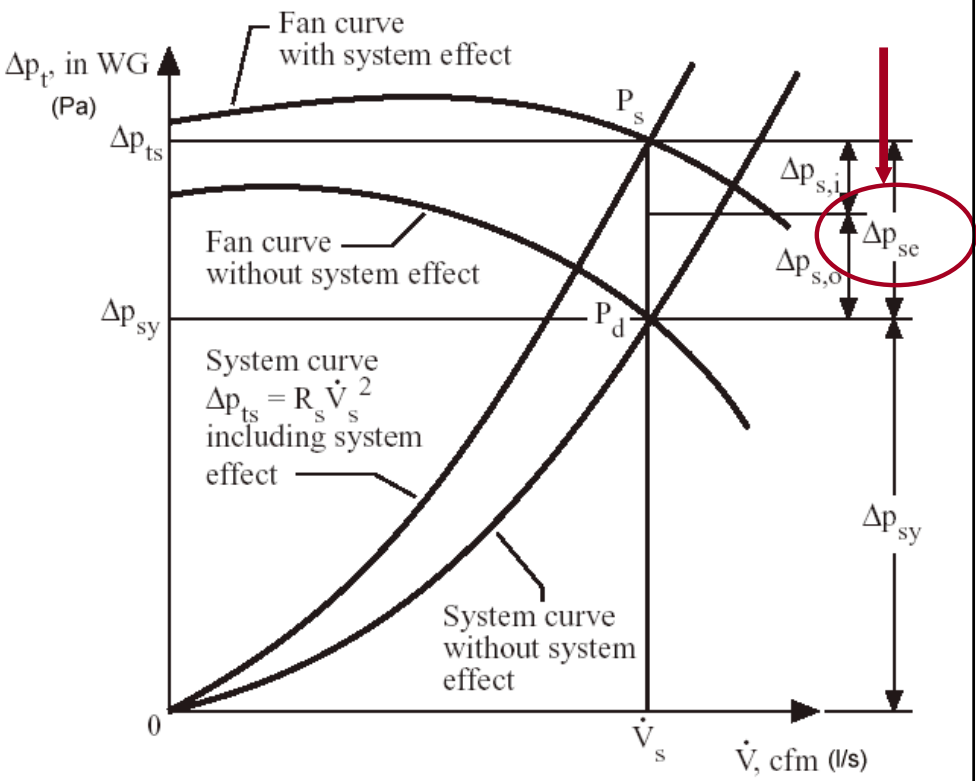
  - Duct sections in series: $R_s = R_1 + R_2 + \ldots + R_n$
  - Duct sections in parallel: $\frac{1}{\sqrt{R_p}} = \frac{1}{\sqrt{R_1}} + \frac{1}{\sqrt{R_2}} + \ldots + \frac{1}{\sqrt{R_n}}$

Basics

System effect Δp_{es}

- It is the additional total pressure loss caused by uneven or non-uniform velocity profile at the fan inlet, or at duct fittings of the fan discharge

- Due to the actual inlet and outlet connections as compared with the total pressure loss of the fan test unit during laboratory ratings



Basics

Fan Laws

- Speed (n)
- Volume flow (V)
- Total pressure loss (Δp)
- Air density (ρ)
- Power (P)

$$\dot{V}_2 / \dot{V}_1 = n_2 / n_1$$

$$\Delta p_{t2} / \Delta p_{t1} = (n_2 / n_1)^2 (\rho_2 / \rho_1)$$

$$P_2 / P_1 = (n_2 / n_1)^3 (\rho_2 / \rho_1)$$

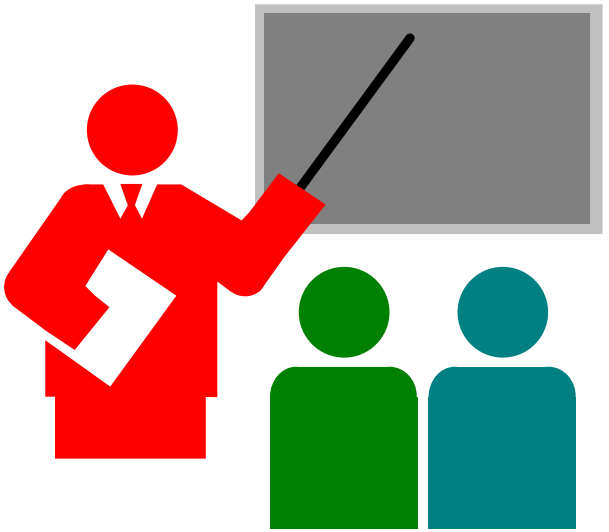
$$\text{Terminal turndown ratio} = \frac{\text{Design terminal flow rate}}{\text{Minimum flow rate}}$$

$$\text{System turndown ratio} = \frac{\text{Central Plant design flow rate}}{\text{Central Plant minimum flow rate}}$$

Types of Air Side Systems

Direct expansion Systems

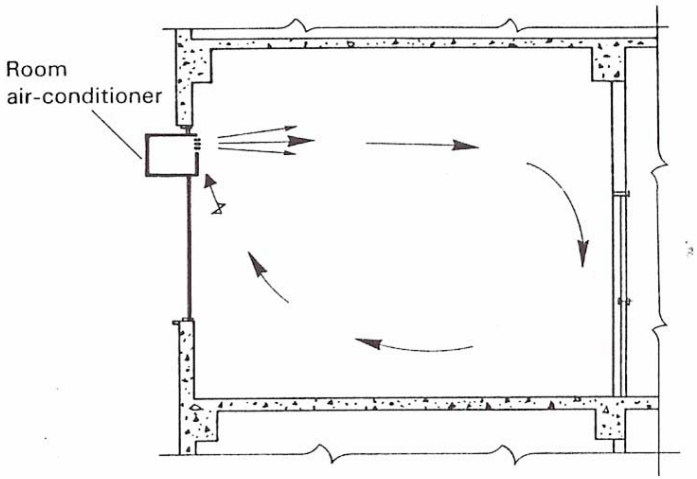
- Window air conditioners
- Unitary and Rooftop Air Conditioners
- Split type and package air conditioning systems
- Heat pumps



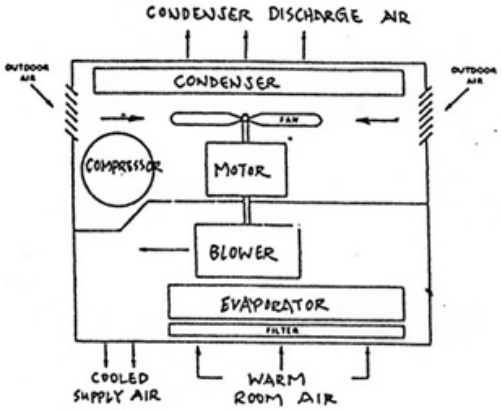
Types of Air Side Systems

Window Air Conditioners

Direct expansion of refrigerant, without chilled water as a heat transfer medium



Since the refrigerant compressor is locating inside the casing of the air conditioner, noise and vibration from the compressor can be observed.



Schematic View of Room Air Conditioner

Fresh air exchange for the room can be provided by :-

(1) setting the “ventilator” switch of the window air conditioner to “open” position

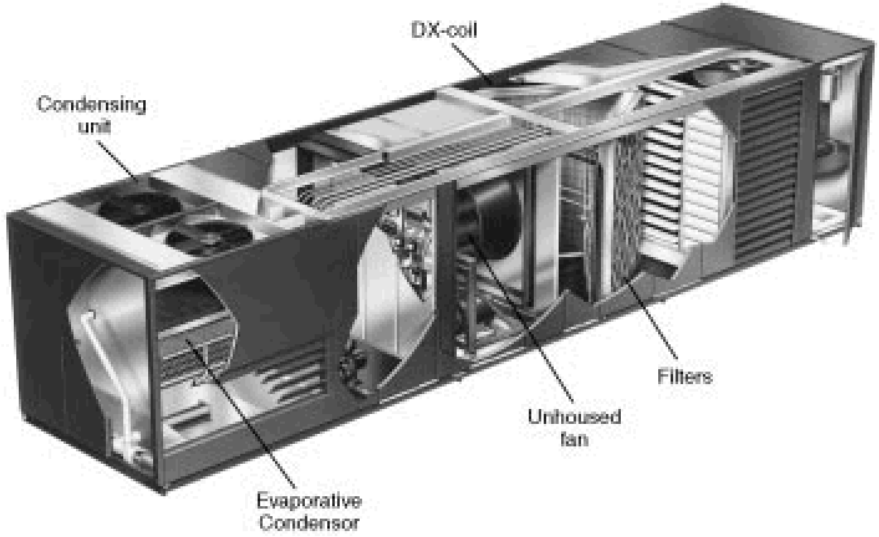
(2) installing a ventilating extract fan in the room to extract room air to outside (Caution: do not oversize the fan)

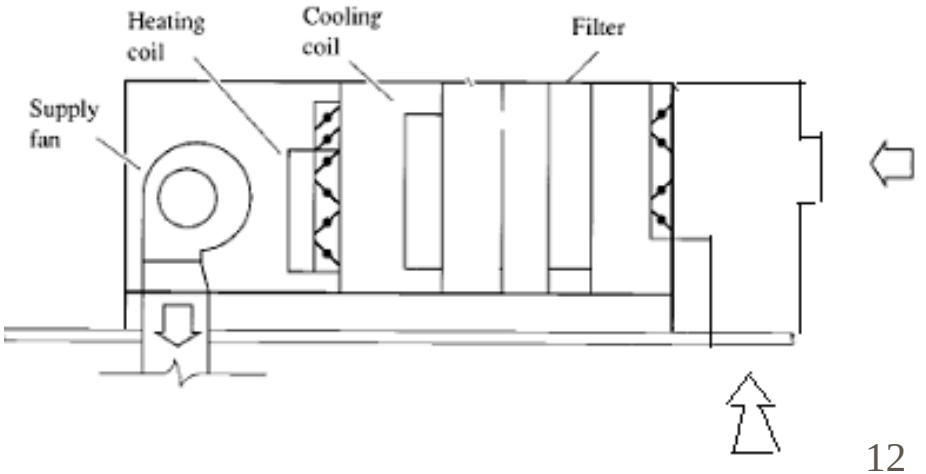
(3) naturally leaking of air in and out of the room (by opening a portion of the window)

Types of Air Side Systems

Rooftop Package Air Conditioners

- These are commonly air-cooled units.
- The units are the floor – standing type designed for installation outdoors or on the roof.
- A supply air duct and a return air duct are to be connected to the cooling unit.
- Application: For general air conditioning of stores, residences, schools, offices, etc. particularly suitable for single flat building with extensive floor areas.

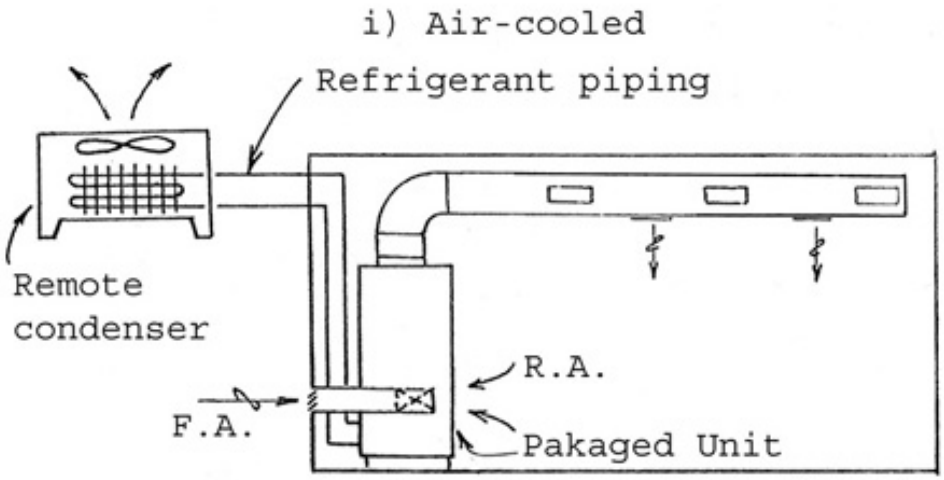


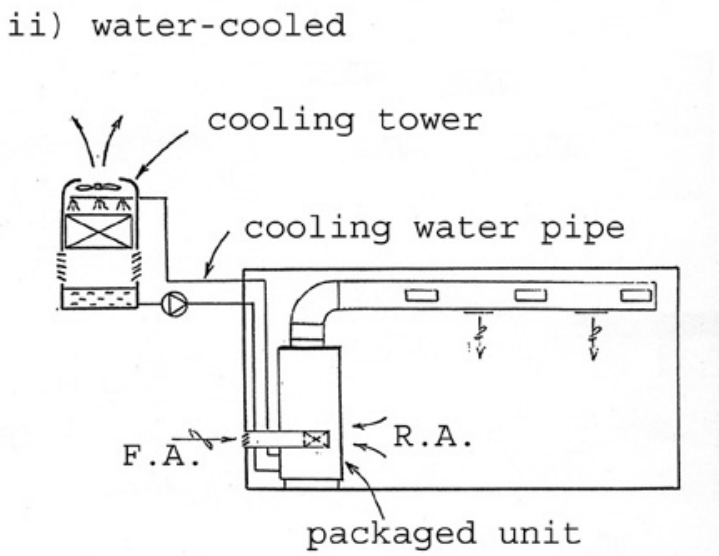


Types of Air Side Systems

Package air conditioning systems

- Factory assembled (floor mounting) package, placed indoor, containing direct expansion coil, controls, fan and compressor, with the condenser remotely placed outdoor ; commonly used in Hong Kong for restaurants, café shops, factories, etc





Refrigeration capacity

15 - 350 kW

Types of Air Side Systems

- **A packaged system-** The refrigerant compressor is installed inside the indoor unit
- The **compressor now is placed indoor**, making the machine less quiet than the split system.
- However this will allow a larger cooling capacity for the indoor unit, which then will be floor-mount usually.
- A packaged system is needed if the outdoor unit, now called the condenser only, is put on the roof top, with the indoor unit a few floors below.

Types of Air Side Systems

Split air conditioning systems –

- Factory assembled (ceiling mounting) indoor unit of fan and direct expansion coil, controls, with the condensing unit [i.e. compressor and condensing coil] remotely placed outdoor ; commonly used in Hong Kong for café shops, small offices, some domestic units, etc

Types of Air Side Systems

Single splits and multiple splits

- Multiple splits– several indoor units are connected to one outdoor unit by insulated copper refrigerant pipes

* A Multi-Split System to Fit Even the Most Luxurious of Homes

Comparing
Split Air Conditioning (SAC) System *vs* Central Air Conditioning System(CAC)

1) Split type air conditioning unit allows *flexible hours operation*. For example, for specific room in a building (e.g. server room) requiring 24 hr A/C, the running of the chiller plant will not be energy efficient;

2) SAC *does not involve a chilled water system* with a risk of water damage due to breaking or leakages;

3) SAC allow *independent control on indoor temperature* comparing with the case of adopting air handling unit serving zones;

4) It would be a *localized problem* if SAC is found out of order;

5) SAC requires *no water treatment* cost as for chilled water pipes and condenser water pipes;

6) SAC requires place for *accommodation of outdoor units* that is always a difficulty in modern building with curtain walls on all facades;

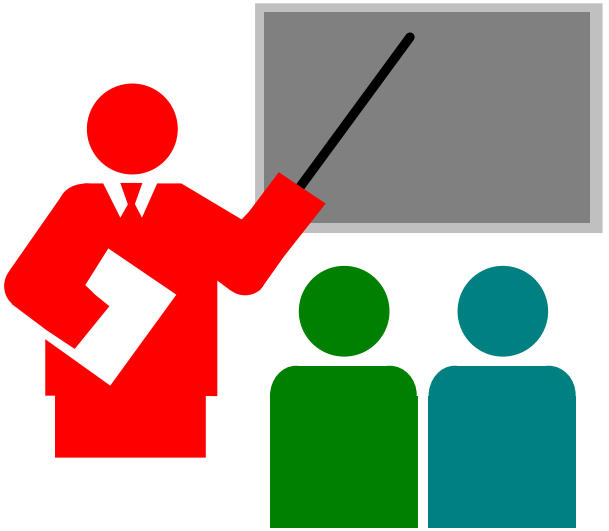
7) CAC allows the *pretreated primary air and use of thermal wheel* for recovery of energy from exhaust air.

Types of Air Side Systems

All Air Systems

- Conditioned air is delivered to the occupied space via ductwork. No refrigerant or chilled water pipe to reach the occupied area.

- Single zone
- Reheat
- Variable Air Volume
- Dual Duct
- Multi-zone



Types of Air Side Systems

Advantages of All Air Systems

- The central plant is located in unoccupied areas, hence facilitating operating and maintenance, noise control and choice of suitable equipment.
- No piping, electrical wiring and filters are located inside the conditioned space.
- Seasonal changeover is simple and readily adaptable to climatic control.
- Gives a wide choice for zoning, flexibility, and humidity control under all operating conditions.
- Allows good design flexibility for optimum air distribution, draft control, and local requirements.

Types of Air Side Systems

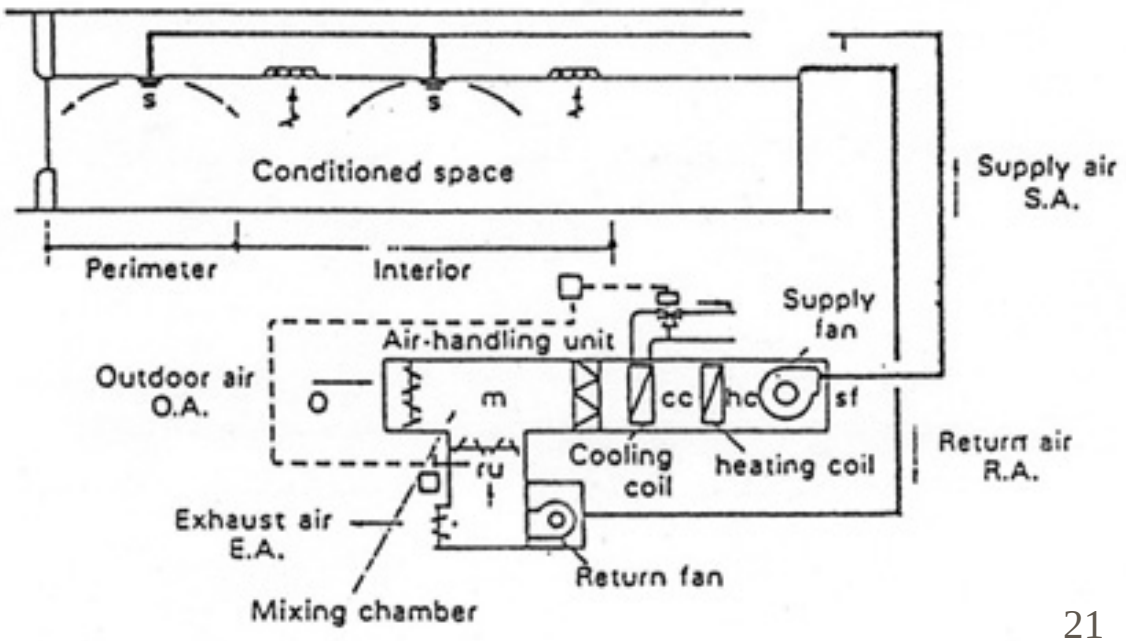
Disadvantages of All Air Systems

- Requires additional duct clearance which can reduce the usable floor space.
- Air-balancing is difficult and requires great care.
- Accessibility to terminals demands close cooperation between architectural, mechanical and structural engineers.

Types of Air Side Systems

Single-zone system

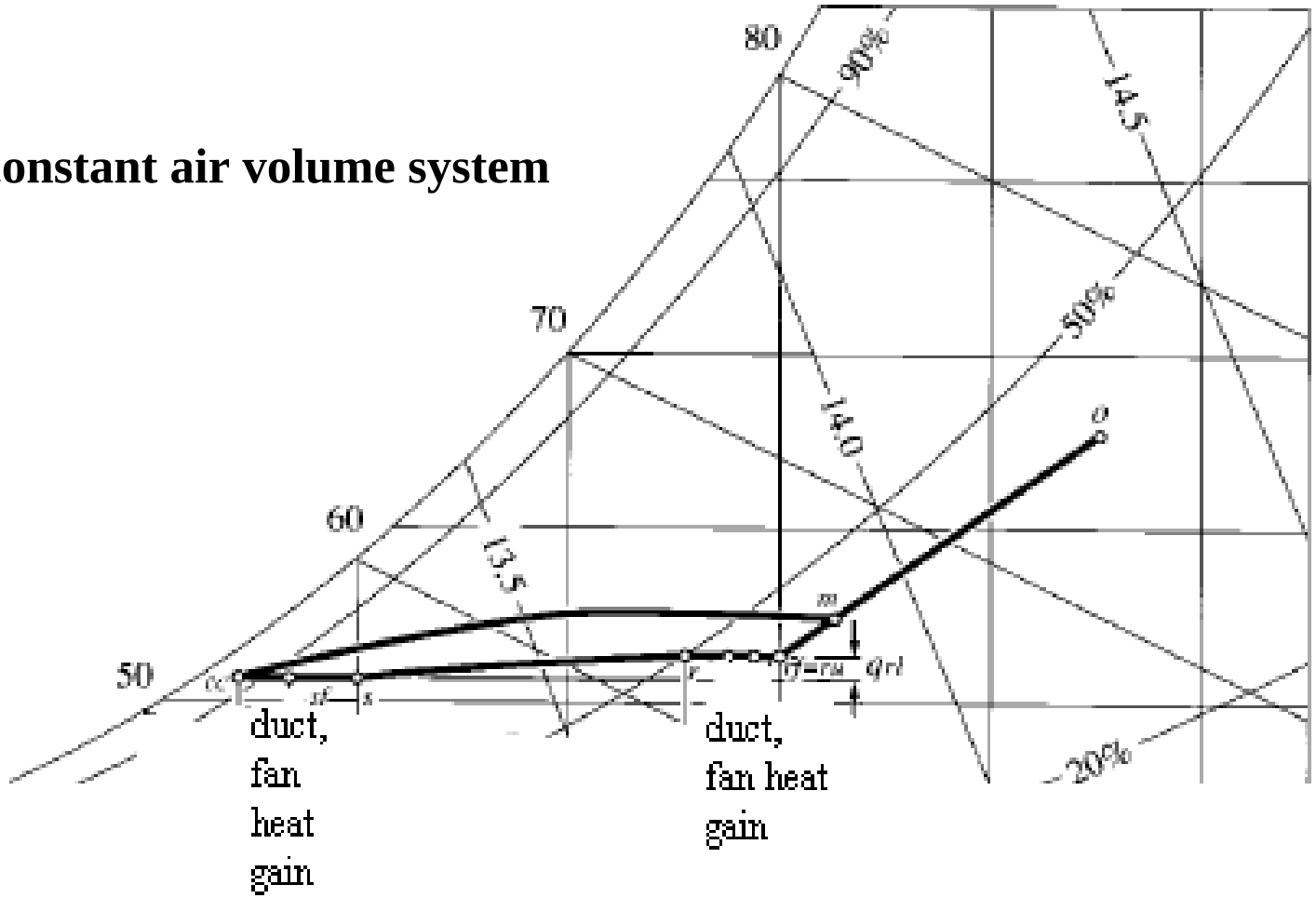
- The all-air single-zone air conditioning system is the basic central system which can supply a constant air volume or a variable air volume at low, medium or high pressure.
- Normally, the equipment is located outside the conditioned space but can also be installed within the conditioned space if conditions permit.



A Constant Air Volume System

Types of Air Side Systems

A constant air volume system



Types of Air Side Systems

Constant Air Volume(CAV) Fan System

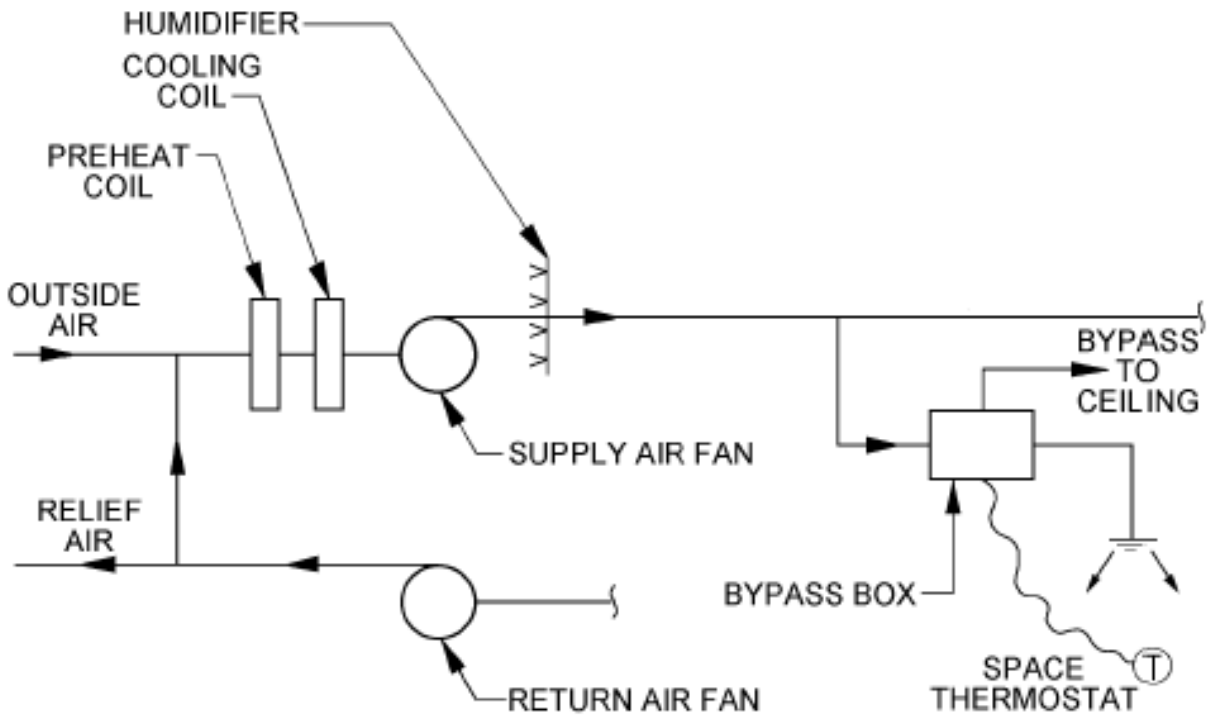
- Temperature of supply air is modulated to match the variation of space load during part-load operation. Volume flow rate remains constant; return temperature (as an indicator of room temperature) as set point temperature; supply temperature is raised during part load.

- The total fan motor power required for a CAV fan system supplying constant air volume at design conditions shall not exceed 1.6 W per L/s of supply air quantity.

- The requirement will be considered as having complied with if the total fan motor power has to exceed 1.6 W per L/s of supply air quantity in order to meet special design needs, such as statutory, safety and health requirements.

Types of Air Side Systems

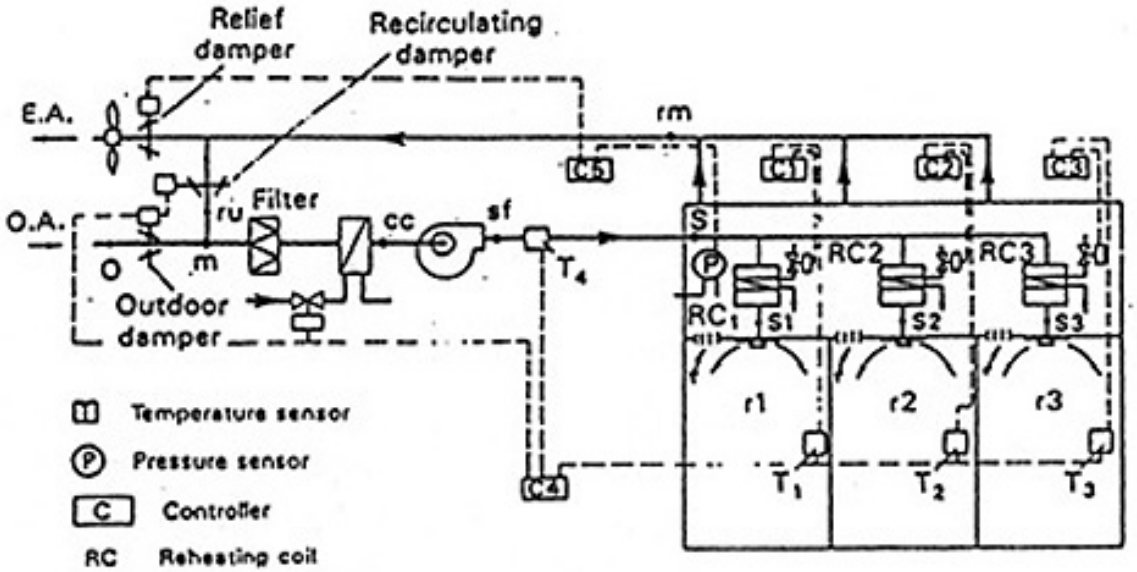
All-air, Single Duct, Constant Air Volume with BYPASS



Types of Air Side Systems

Reheat System

- The reheat system is a modification of the single-zone system. It provides:-
  - Zone or space control for areas of unequal loading.
  - Heating or cooling of perimeter areas with different exposures.
  - Close control for process or comfort applications. In the reheat system, heat is added as a secondary process to either preconditioned primary air or recirculated room air. The heating medium can be hot water, steam or electricity.



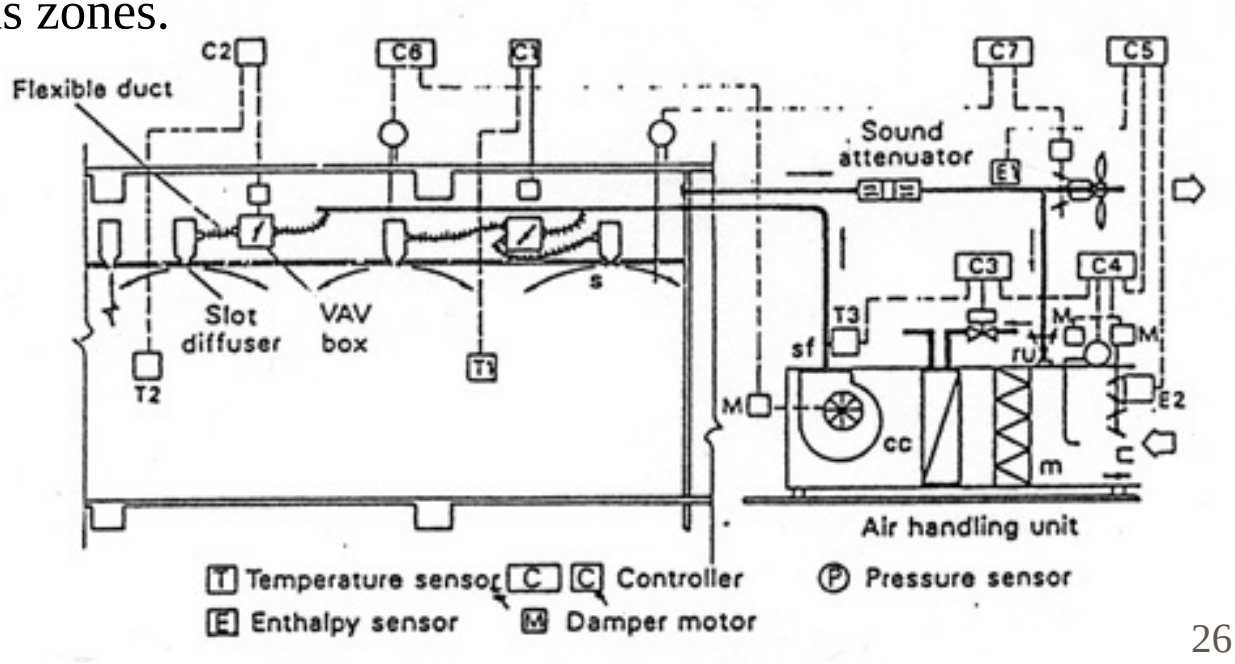
Types of Air Side Systems

Variable Air Volume System

The variable air volume system compensates for varying cooling loads by regulating the volume of cooling air supplied through a single duct.

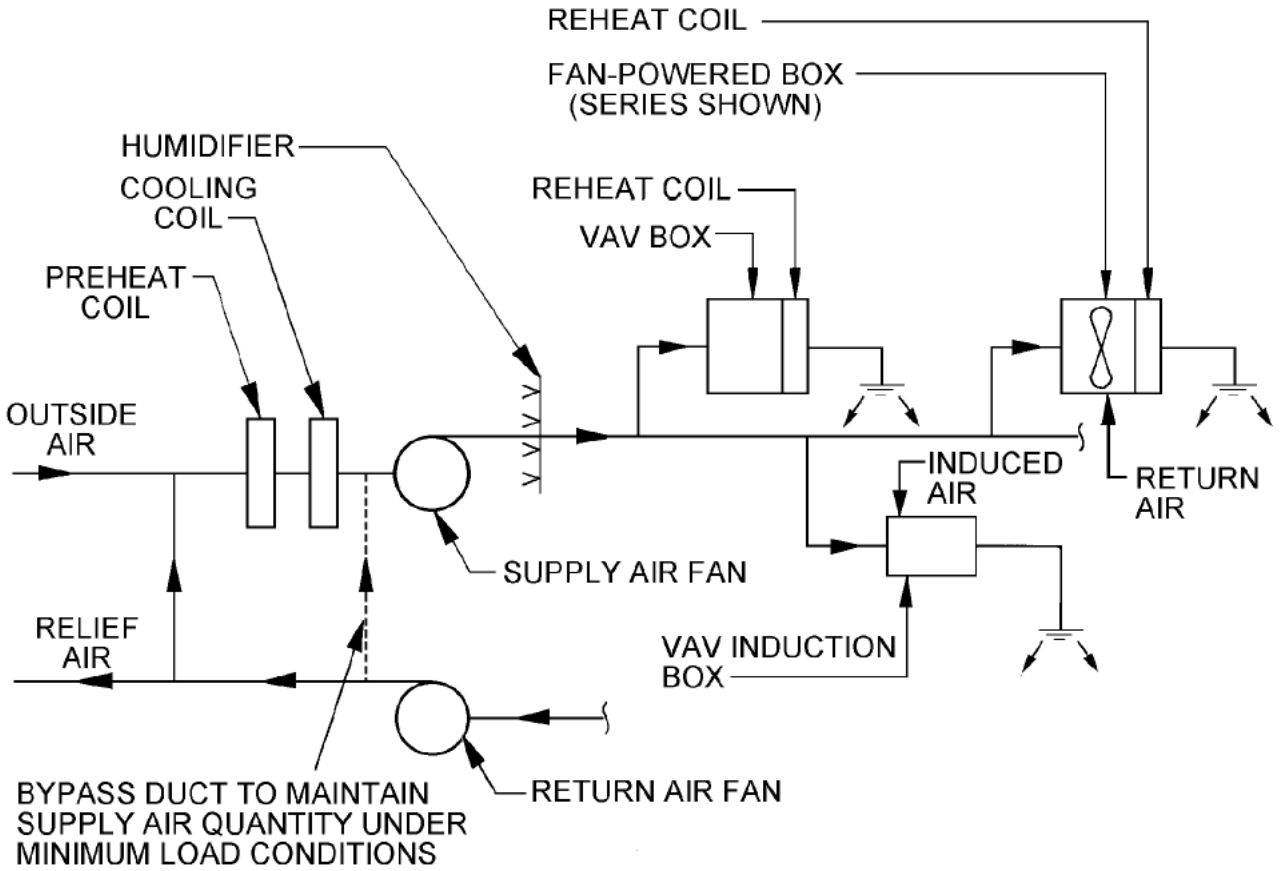
Simple Variable Air Volume (VAV)

Simple VAV systems typically cools only and have no requirement for simultaneous heating and cooling in various zones.



Types of Air Side Systems

Variable Air Volume System

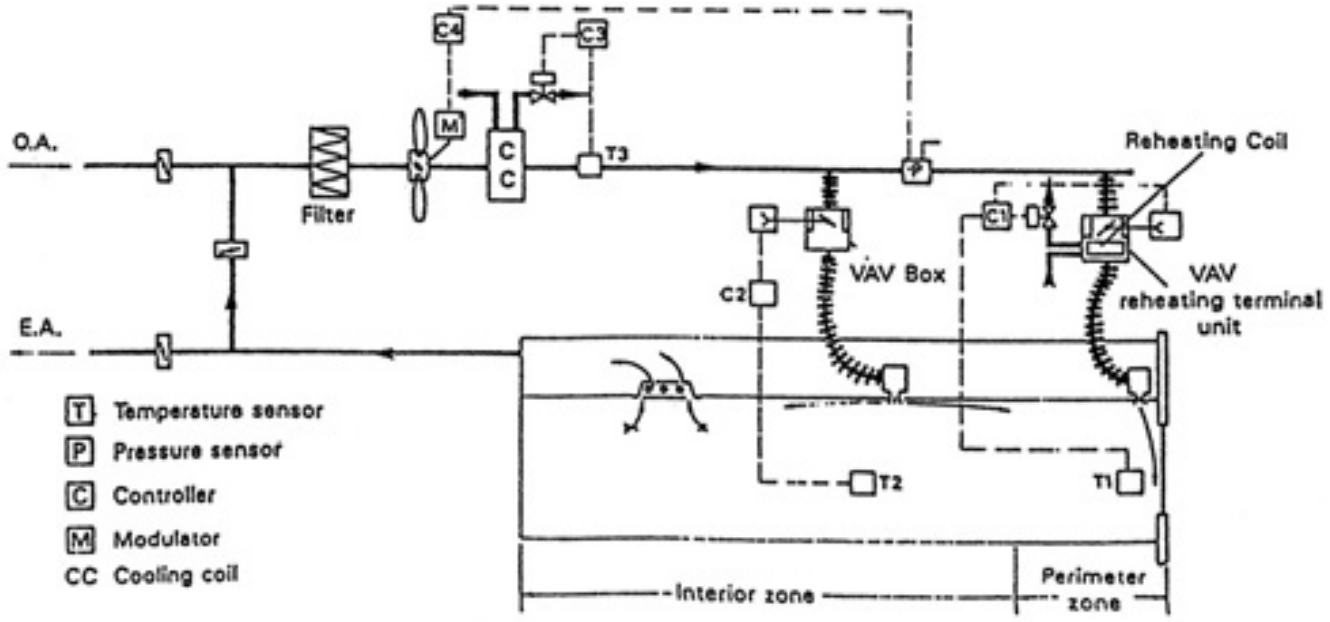


Variable Air Volume with Reheat, Induction and Fan-Powered Devices

Types of Air Side Systems

- Variable Air Volume – Reheat

- It integrates heating at or near the terminal units. It is applied to systems requiring full heating and cooling flexibility in interior and exterior zones. Heating is turned on when the air flow reaches a predetermined minimum.



Types of Air Side Systems

Advantages of VAV systems

- When combined with a perimeter heating system, it offers inexpensive temperature control for multiple zoning and a high degree of simultaneous heating-cooling flexibility.
- Capital cost is lower since diversities of loads from lights, occupancy, solar and equipment of as much as 30% are permitted.
- Virtually self-balancing.
- Lower operating cost because fans run long hours at reduced volume
- Lower operating cost because unoccupied areas may be fully cut-off
- Reduced noise level when the system is running at off-peak loads.
- Allows simultaneous heating and cooling without seasonal changeover.

Types of Air Side Systems

Variable Air Volume (VAV) System (EMSD- COP)

- The total fan motor power required for a VAV fan system of being able to vary system air volume automatically as a function of load at design conditions shall not exceed 2.1 W per L/s of supply air quantity.

- The requirement will be considered as having complied with if the total fan motor power has to exceed 2.1 W per L/s of supply air quantity in order to meet special design needs, such as statutory, safety and health requirements.

- Any individual supply fan with a fan motor power of 5 kW or greater shall incorporate controls and devices such that the fan motor demands no more than 55 % of design wattage at 50% of design air volume.

Types of Air Side Systems

Duct Static Pressure.

Pressure-dependent VAV box

- In a pressure-dependent VAV box, the variation of the duct static pressure at the inlet of the VAV box caused by the opening and closing of the dampers connected to the same main supply duct influences the modulation of its supply volume flow rate.
- When the pressure at the inlet varies, the airflow often oscillates. Pressure-dependent VAV boxes are least expensive. They are used when the duct static pressure is more stable and in places where there is no need for maximum and minimum limit control.

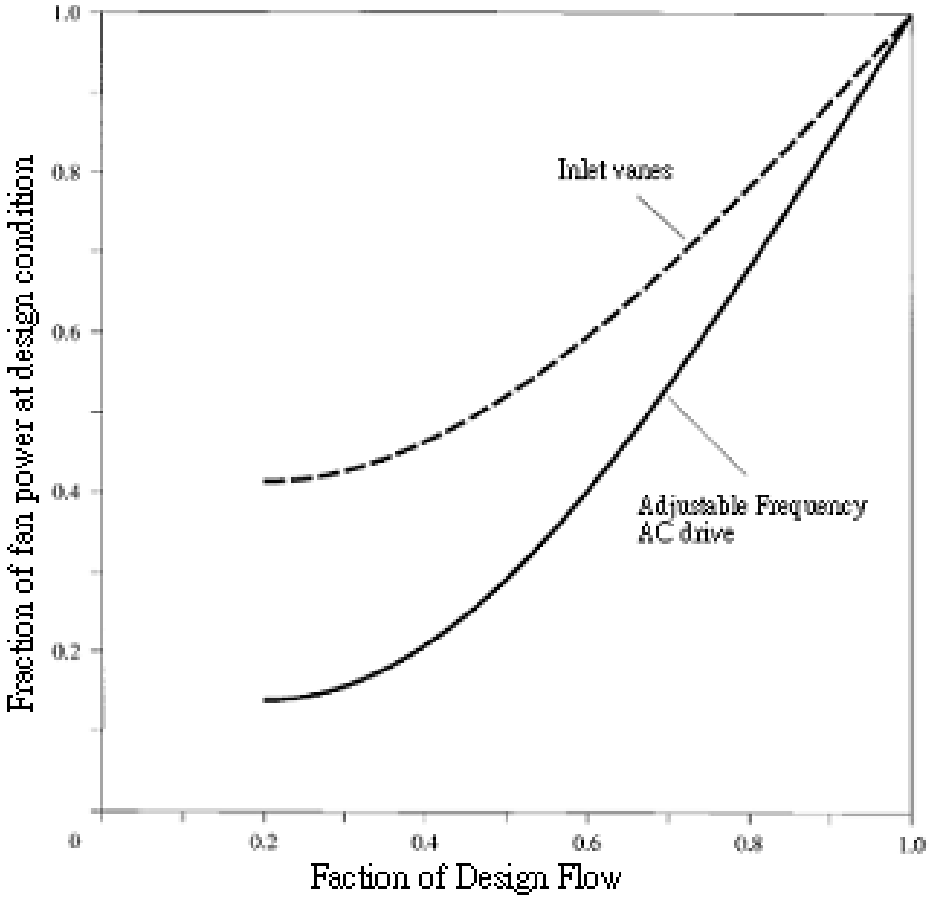
Pressure-independent VAV box

- A pressure-independent VAV box modulates its supply volume flow rate regardless of the variation of duct static pressure at its inlet. An air flow sensor adjusts the volume control damper of the box according to actual demand.

Types of Air Side Systems

VAV system – Flow rate control

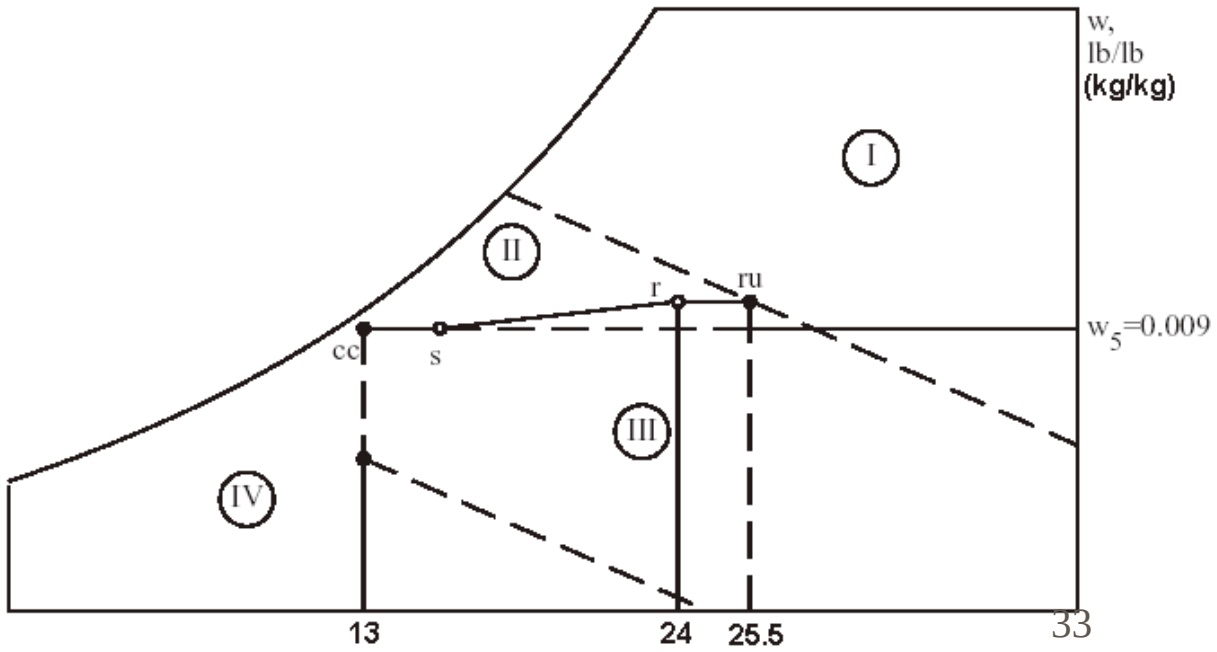
- Either Inlet guide vane or frequency drive would control the flow rate of supply air
- A pressure sensor to be mounted at duct for feeding signal for the controller to control the flow rate of the VAV system
- A word of precaution – At reduced flow condition, the reduced air may also cause increase in carbon dioxide concentration.
- The minimum of supply air rate (against the standard value) should be considered, say 30% of the design flow rate.



Types of Air Side Systems

Year-round operation of a VAV system

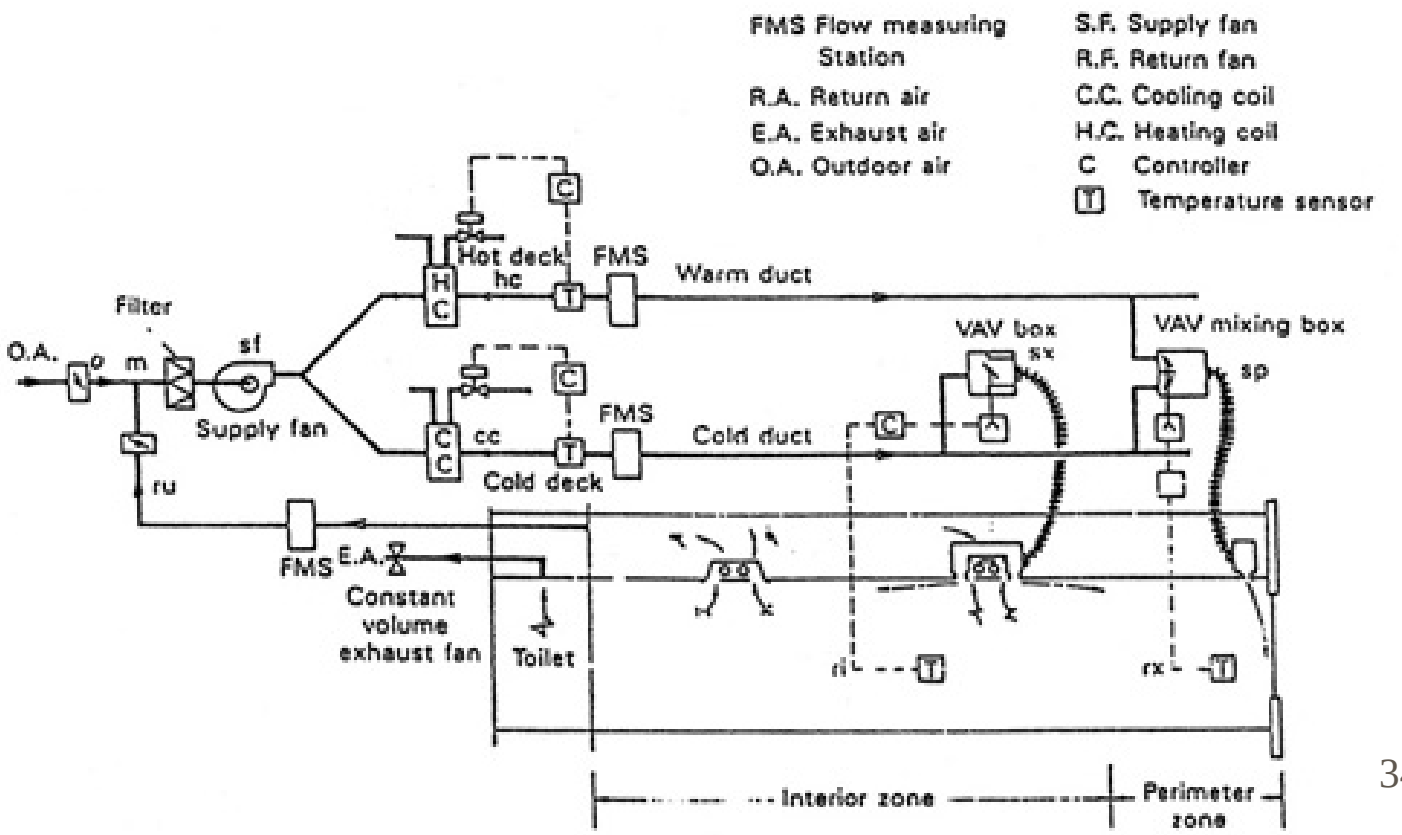
- Region I: Refrigeration/evaporative cooling
  - Enthalpy of outdoor > that of recirculating air
- Region II: Free cooling & refrigeration
  - Enthalpy of outdoor ⩽ that of recirculating air
- Region III: Free cooling, evaporative cooling & refrigeration
  - Enthalpy of outdoor ⩽ that of recirculating air
- Region VI: Winter heating



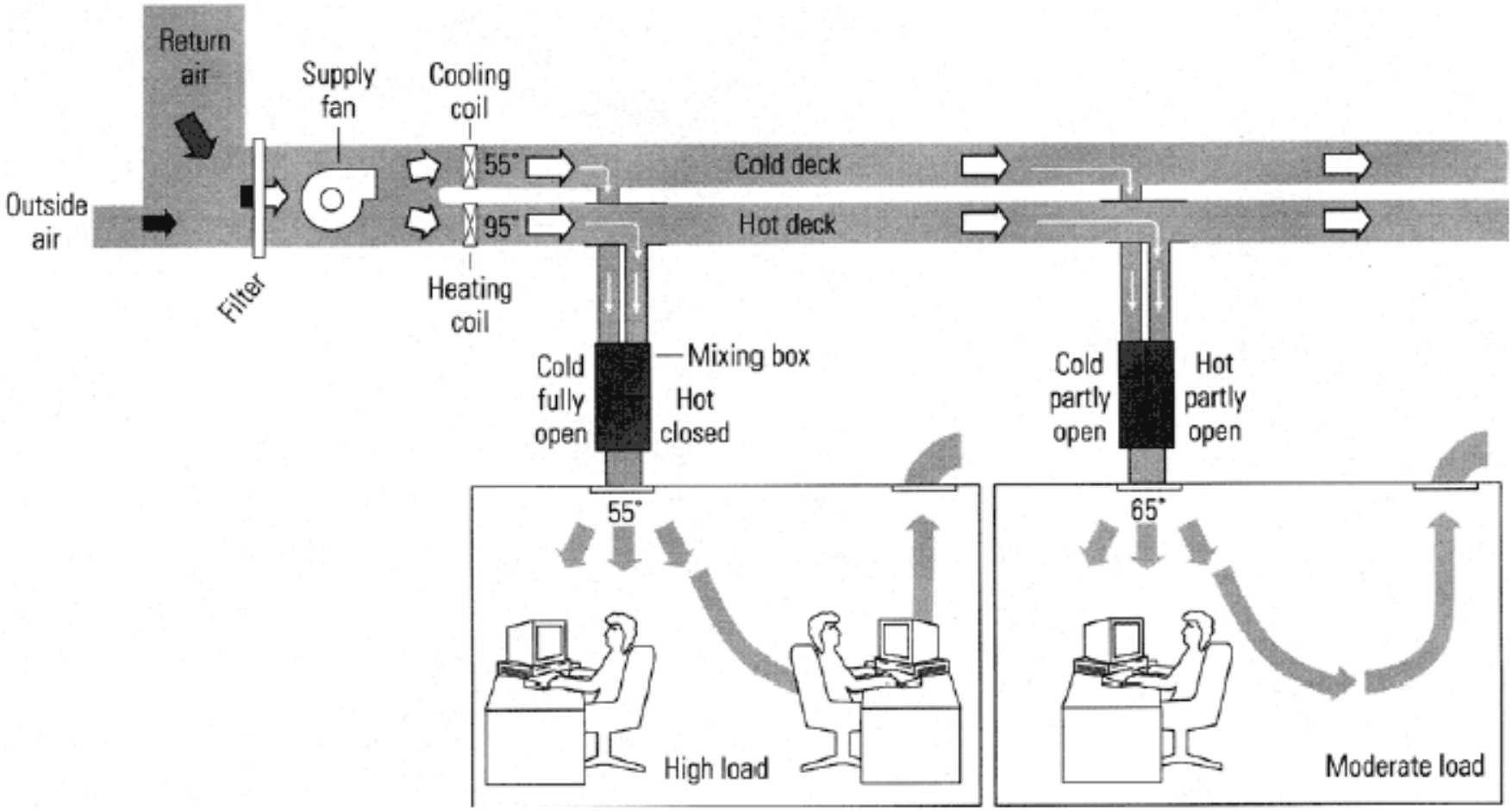
Types of Air Side Systems

Dual Duct System

- The dual-duct system employs two air ducts to supply cold air and warm air to a mixing terminal unit which proportions the cold and warm air in response to a thermostat located in the conditioned space.



Types of Air Side Systems

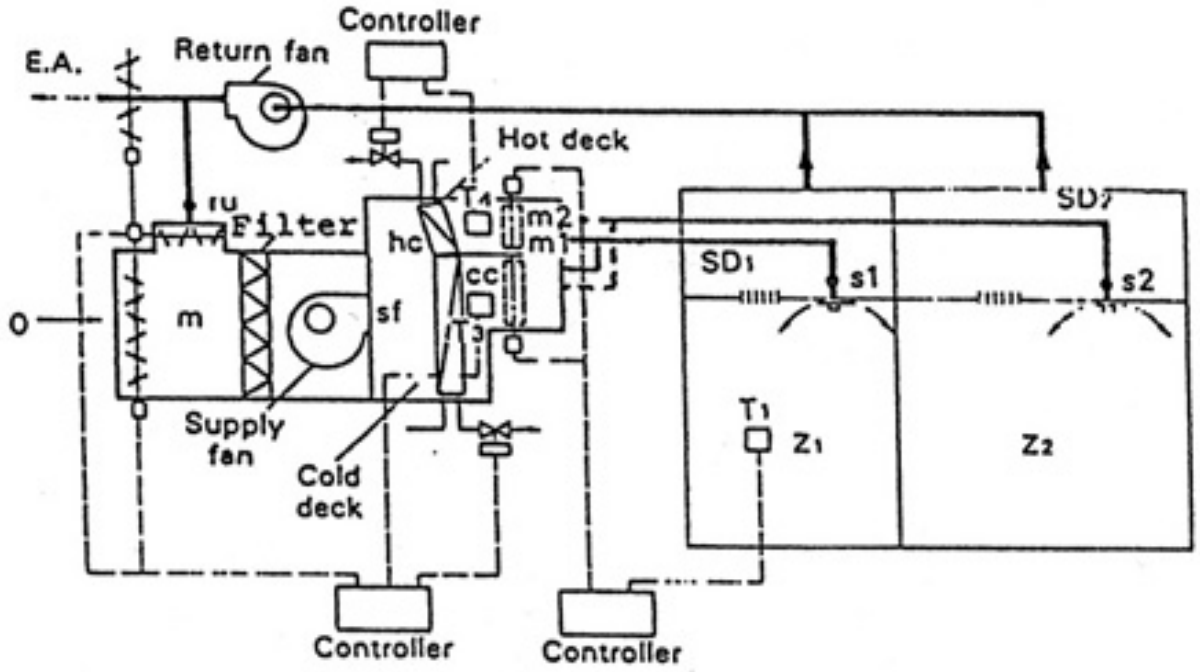


Dual duct system

Types of Air Side Systems

Multi-zone System

- The multi-zone system applies to a relatively small number of zones served by a single, central air-handling unit. Different zone requirements are met by mixing cold and warm air through zone dampers at the central air handler in response to zone thermostats.



Types of Air Side Systems

Multi-zone, Constant Volume System with Reheat

- During summer mode, outdoor air is mixed with recirculating air.
- The mixture flows through the filter and is then cooled and humidified at the cooling coil and discharged from the AHU at supply fan outlet.
- After absorbing the duct heat gain, the conditioned air enters the reheating coil.
- Assume only one heating coil is energized so as to maintain the air temperature while the other is not.
- Return air from both spaces is mixed together and returned to AHU with some exhausts out to outside

Types of Air Side Systems

Multizone, Constant Volume System

$$T_{rm} = \frac{\dot{m}_{a1}T_{r1} + \dot{m}_{a2}T_{r2} + \cdots + \dot{m}_{an}T_{rn}}{\dot{m}_{a1} + \dot{m}_{a2} + \cdots + \dot{m}_{an}}$$

tr is replaced by T_{rm}

Where $\dot{m}_{a1}$ = mass flow rate at zone a1

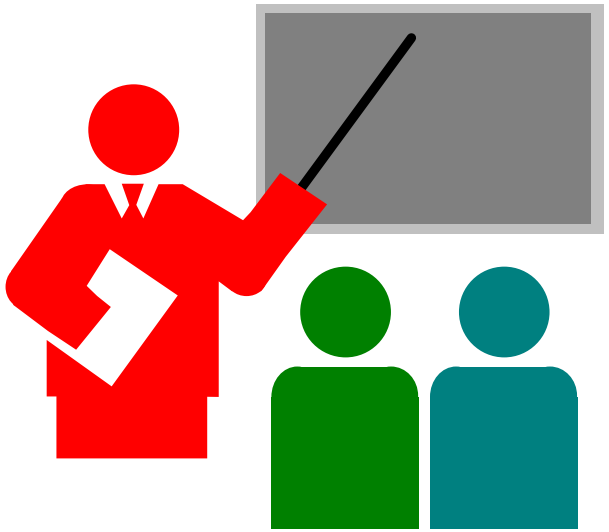
T_{r1} = Temperature at zone 1

Supply flow rate equals summation of the flow to all the zones

Types of Air Side Systems

Air and Water Systems

- Induction Systems
- Fan Coil Systems
- Two-pipe Systems
- Four-pipe Systems



Types of Air Side Systems

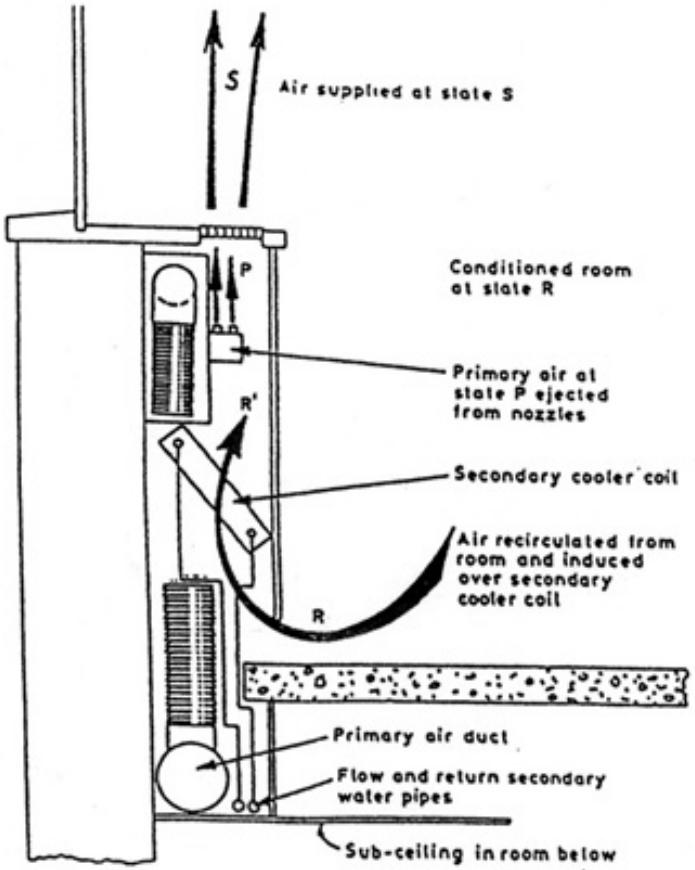
Air-and Water System

- An air-and-water system is one in which both air and water (cooled or heated in central plant room) are distributed to room terminals to perform cooling or heating function.

- The air side is comprised of central air conditioning equipment, a duct distributing primary air and a room terminal.

- The water side consists of a pump and piping to convey water to heat transfer surfaces within each conditioned space. The water is commonly cooled by the introduction of chilled water from the primary cooling system.

Types of Air Side Systems



Section of perimeter induction unit installation

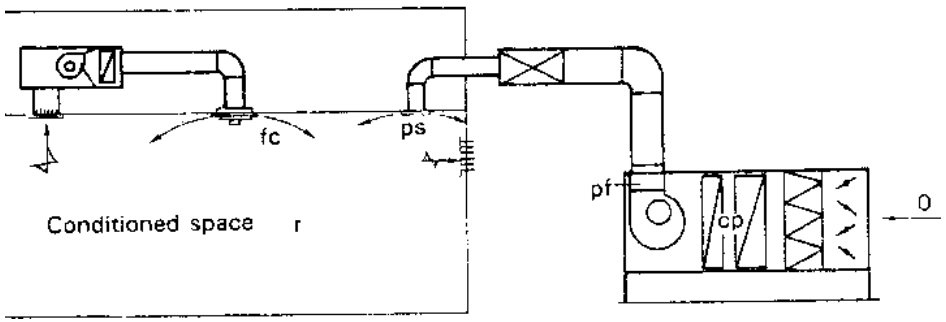
Induction System

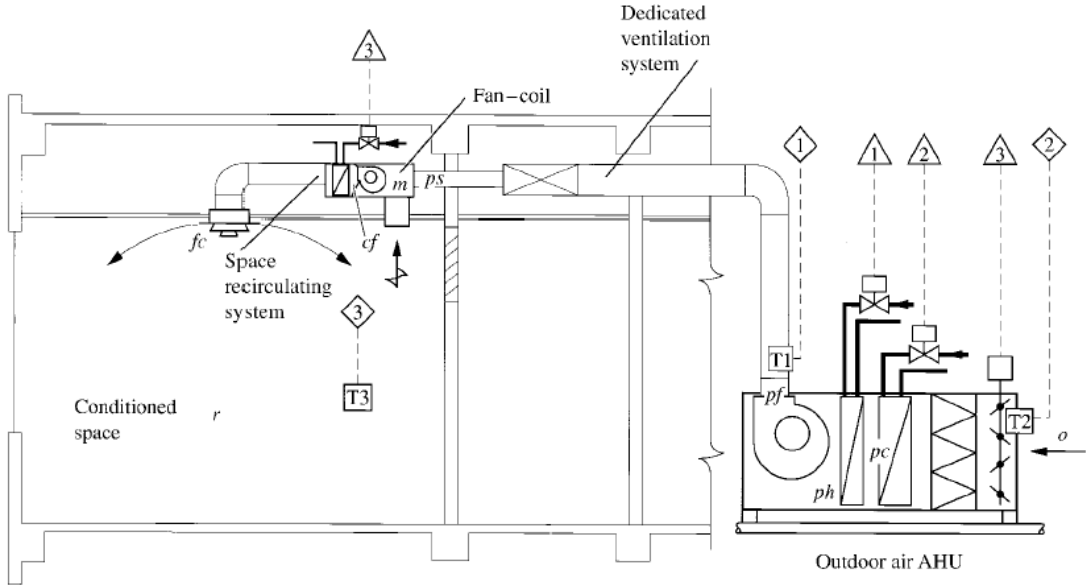
- The inducting system is designed for use in perimeter rooms of multi-storey, multi-room building.
- In the induction system, ducted primary air is fed into a small plenum chamber where its pressure is reduced by means of a suitable damper to the level required at the nozzles.
- The plenum is acoustically treated to attenuate part of the noise generated in the duct system and in the unit. The primary air is then delivered through nozzles as high velocity jets which induce secondary air from the room and over the secondary coil.

Types of Air Side Systems

Fan-Coil System

- The basic elements of the fan-coil units are a finned-tube coil and a fan section.
- The fan section recirculates air continuously from within the perimeter space through the coil which is supplied with either hot or chilled water.
- Auxiliary air may be delivered to the conditioned space for dehumidification and ventilation purposes.

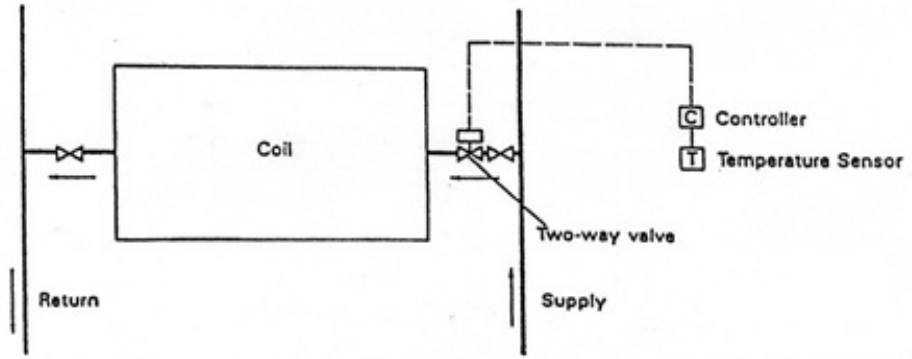


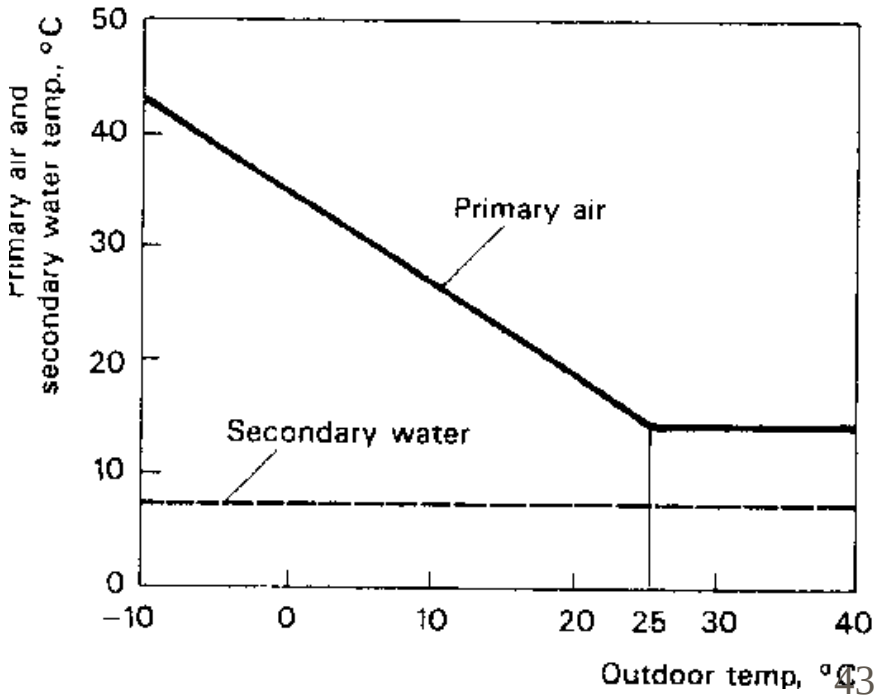


Types of Air Side Systems

Two-pipe Systems

- The secondary water is cold in summer and intermediate seasons and warm in winter.
- The primary air quantity is fixed and the primary air temperature is varied in reverse proportion to outside temperature to provide the necessary amount of heating during summer and intermediate seasons.
- During winter cycle operation, the primary air is preheated and supplied at about 10˚C to provide a source of cooling.

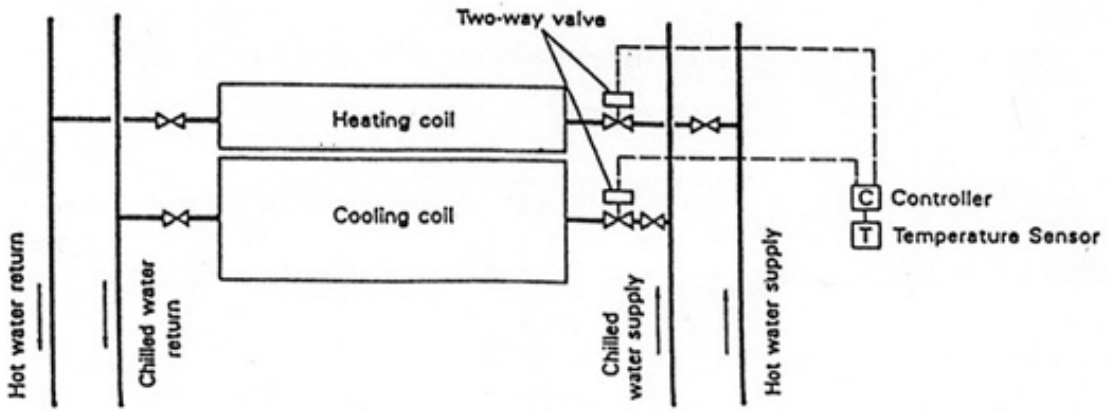




Types of Air Side Systems

Four pipe Systems

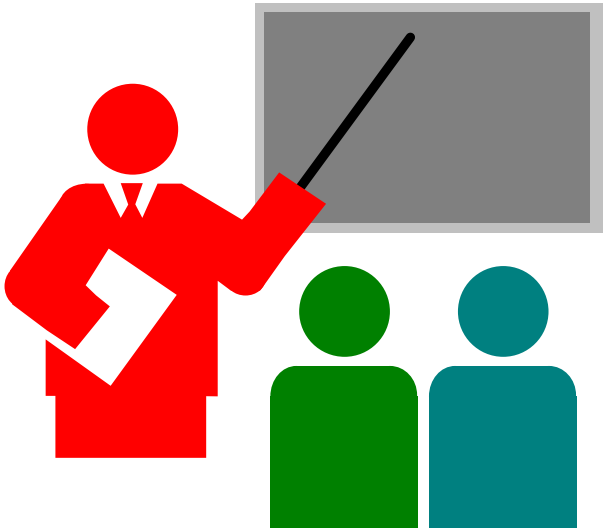
- Four-pipe systems have a cold water supply, cold water return, warm water supply and warm water return.
- The terminal unit usually has two independent secondary water coils, one served by hot water, the other by cold water.
- The primary air is cold and remains at the same temperature year-round.



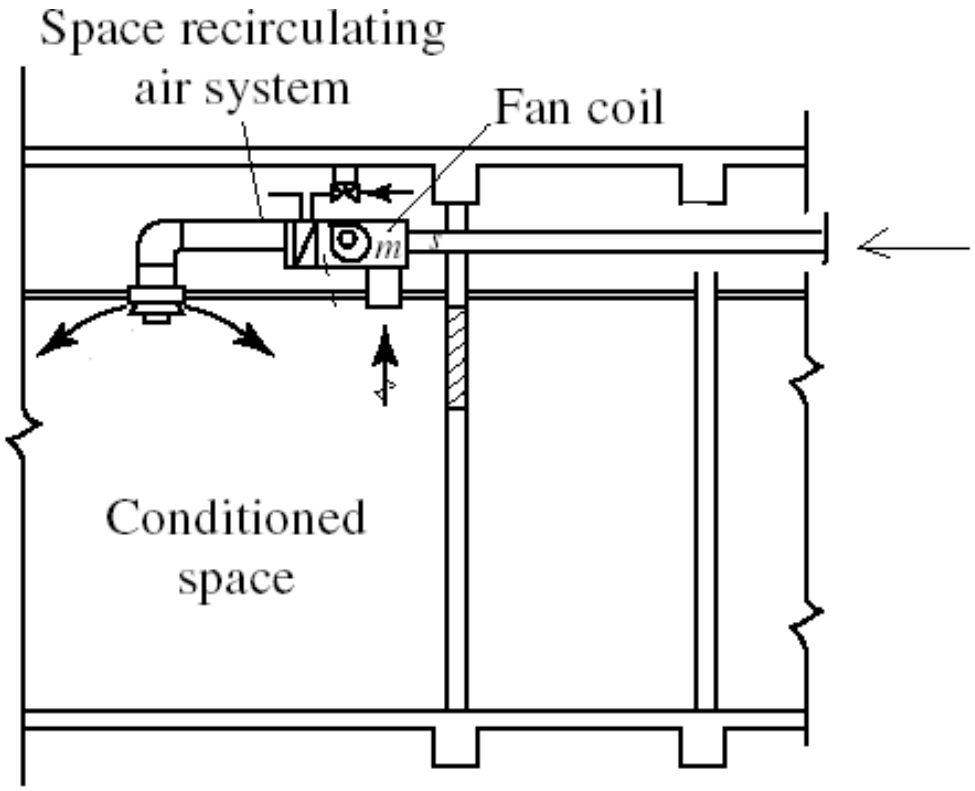
Types of Air Side Systems

All Water Systems

- Fan-coil units



Types of Air Side Systems



All –water system: Fan Coil Unit only

- All-water systems are those with fan-coil, unit ventilator, or valance type room terminals with unconditioned ventilation air supplied by an opening through the wall or by infiltration.
- Cooling and dehumidification is provided by circulating chilled water through a finned coil in the unit.
- Heating is provided by supplying hot water through the same or a separate coil.

Types of Air Side Systems

All-water Systems

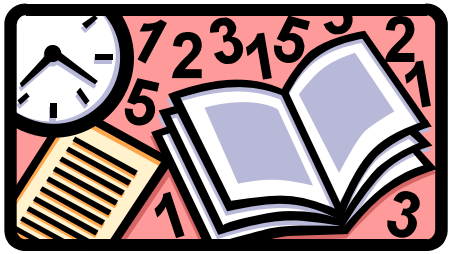
System Advantages

- Flexible and readily adaptable to many building module requirements.
- Provides individual room control.

System Disadvantages

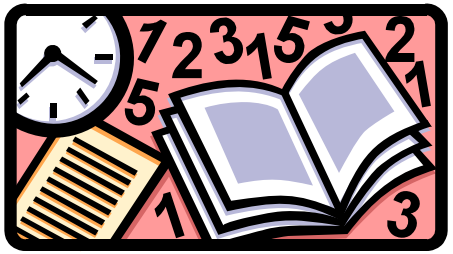
- No positive ventilation is provided unless wall openings are used.
- No humidification is provided.
- Maintenance and service work has to be done in the occupied areas.

Components of Air Side Systems



- Duct work Sizing and Insulation
- Fan
- Slot Diffuser, Ceiling Diffuser, Jet Nozzle Diffuser
- VAV Boxes
- Air Filters
- Fan Coil Units
- Air Handling Units and Primary Air Units

Components of Air Side Systems

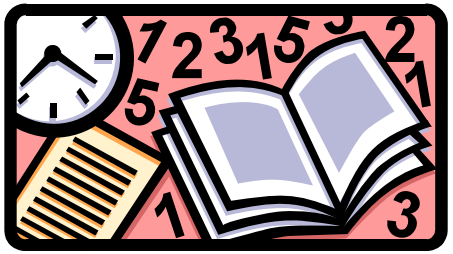


Duct work Sizing

Velocity method

- This method is based on the selection of duct velocities by the designer using limiting noise generation and/or pressure drop.
- The velocity at the fan connection is chosen, and this is progressively reduced in the duct run from the fan to the terminals.
- For simple layouts or sections of system.
- Also industrial systems which need a minimum transport velocities.

Components of Air Side Systems



Duct work Sizing

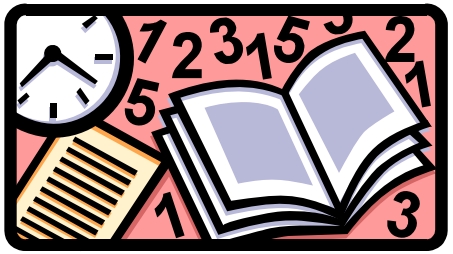
Equal friction method

- The basis for this method is to select a constant pressure loss per unit length for the duct runs and then to size the ducts at this rate.

- The method is used for the sizing of very simple low pressure supply and extract systems, some medium pressure systems and also for variable air volume (VAV) systems.

- For low pressure systems, typical values used for the constant pressure loss rate are in the range 0.8-1.2 Pa/m with duct velocities not exceeding 10 m/s.

Components of Air Side Systems



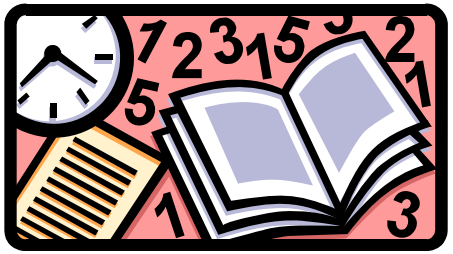
Duct work Sizing

Static Regain method

- To size ducts between branch take-offs so that the recovery in static pressure after one branch take-off due to reduction in velocity is equal to the static pressure loss due to friction and fitting in the subsequent duct run.

- It is used in those parts of a high pressure system where the initial duct velocity pressure is sufficient to give static pressure regain without unnecessarily low duct velocities at the end of the run.

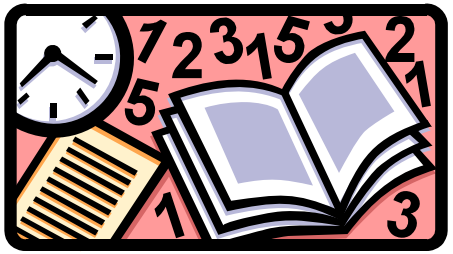
Components of Air Side Systems



Duct Insulation

- Duct insulation is mounted or inner-lined to reduce heat loss and heat gain as well as to prevent the condensation on the outer surface of the duct.
- It is usually in the form of duct wrap (outer surface), duct inner liner ??, or fiberglass duct boards.
- Duct liner provides both thermal insulation and sound attenuation.
- The thickness of an insulation layer is based on economical analysis.

Components of Air Side Systems



Minimum Insulation Thickness for Ductworks and AHU Casings

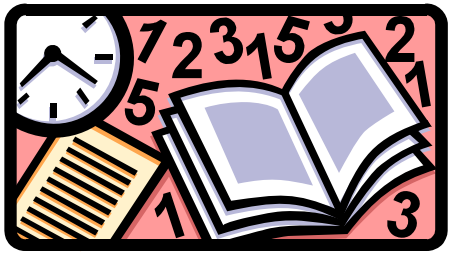
Minimum Insulation Thickness (mm)				
Maximum temp. difference[1]	Thermal conductivity[2] - λ - W/(m ·°C)			
	0.024	0.04	0.055	0.07
15°C max. for indoor condition at 80%RH; still air; h[3]=5.7	13	21	29	37
15°C max. for indoor condition at 95%RH; still air; h[3]=10	43	72	99	126
20°C max. for outdoor condition at 95%RH; wind speed = 1m/s; h[3]=13.5	38	63	87	110

Notes : (1) The maximum temperature difference at design conditions is the greatest temperature difference between the space within which the duct is located and the design temperature of the air carried by the duct. Where the duct is used for both heating and cooling purposes, the larger temperature difference should be used.

(2) The insulation thickness in above table is based on thermal conductivity rated at 20°C mean.

(3) The surface coefficient h=5.7 is assumed for bright metal surfaces at indoor still air condition; h=10 for cement or black matt surfaces at indoor still air condition and h=13.5 for cement or black matt surfaces at outdoor condition with a wind speed of 1m/s.

Components of Air Side Systems



Air Leakage Limit on Ductwork

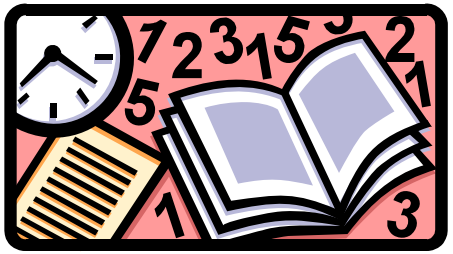
- At least 25% in area of ductwork which is designed to operate at operating static pressure in excess of 750 Pa shall be leakage tested in accordance with the air leakage limit set (EMSD- COP)

Table(5.1) : Air Leakage Limit On Ductwork

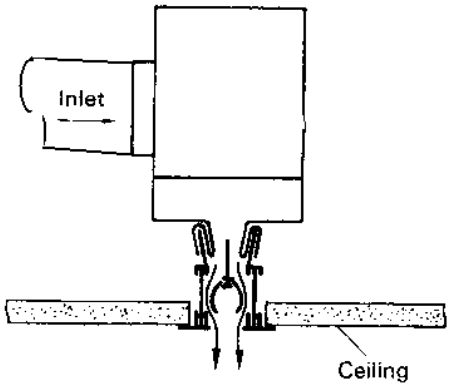
Leakage Class	Operating Static Pressure (Pa)	Air Leakage Limit (L/s per m^2 of duct surface)
I	above 750 to 1000	$0.009 \times p^{0.65}$
II	above 1000 to 2000	$0.003 \times p^{0.65}$
III	above 2000	$0.001 \times p^{0.65}$

Note : where p is the operating static pressure in Pascal

Components of Air Side Systems

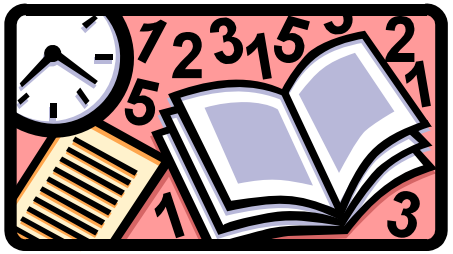


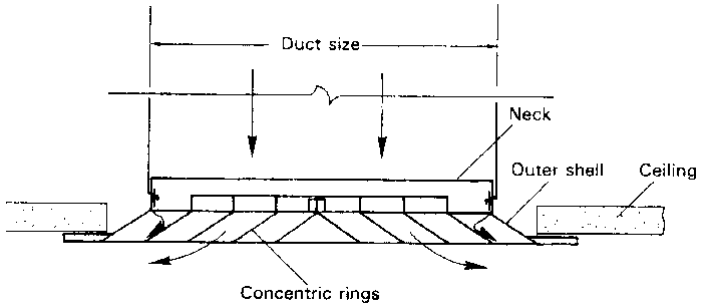
- Slot Diffuser

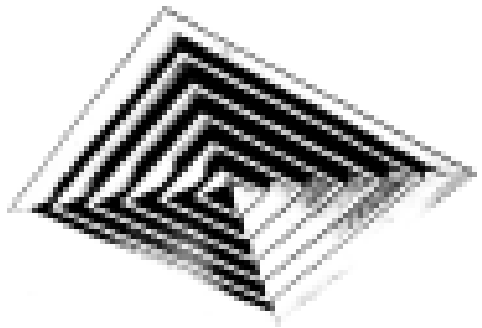


- A slot diffuser consists of a plenum box with single or multiple slots and air deflecting vanes.
- Air discharged from a slot diffuser can be projected horizontally or vertically.
- With multiple slots, air can be horizontally discharged either left or right, or a combination of both, or one slot can discharge vertically while another discharges horizontally.
- The function of the plenum box is to distribute the air more evenly at the slot.
- The plenum box is insulated internally.

Components of Air Side Systems



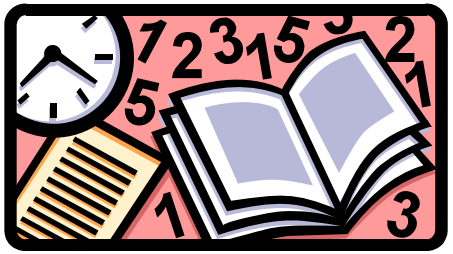




Ceiling Diffusers

- A ceiling diffuser consists of a series of concentric rings or inner cones made up of vanes arranged in fixed directions and an outer shell or frame
- Ceiling diffusers can be round, square, or rectangular.
- Square diffusers are most widely used.
- Supply air is discharged through the concentric air passages or directional passages in one, two, three, or in all directions by using different types of inner cone and vanes.

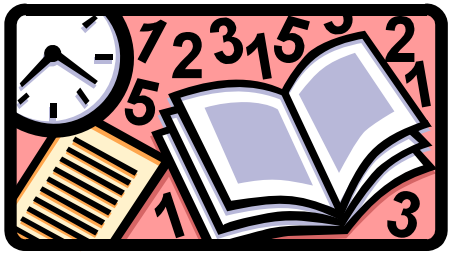
Components of Air Side Systems



Jet Nozzle Diffuser

- Ideally suited for predictable directional control of conditioned air within large spaces such as malls, exhibit halls, sports arenas, industrial and manufacturing facilities, atrium areas, and large office building entrances.
- Small nozzle sizes provide shorter throws for smaller spaces
- Spot air distribution ideal for industrial heating,ventilating, or cooling
- Side wall, ceiling, or duct mounted applications at any orientation
- Rapid temperature equalization eliminates stratification

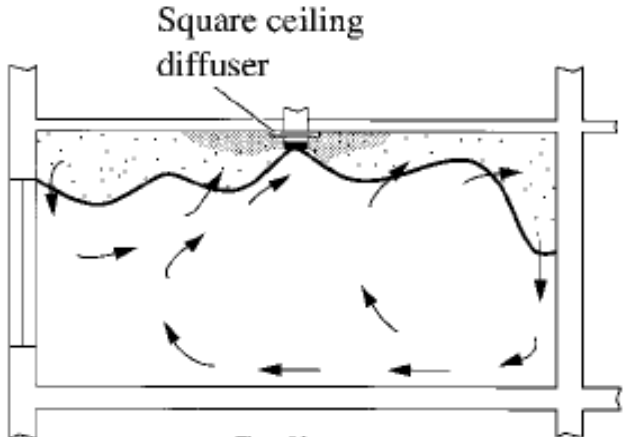
Components of Air Side Systems



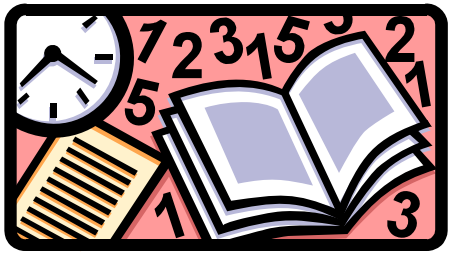
Coanda effect

When a jet is discharged from a terminal device adjacent and parallel to an unobstructed flat surface, the jet entrains air from one side only resulting in deflection of the axis of the jet towards the surface.

This is due to frictional losses between the jet and the surface.



Components of Air Side Systems

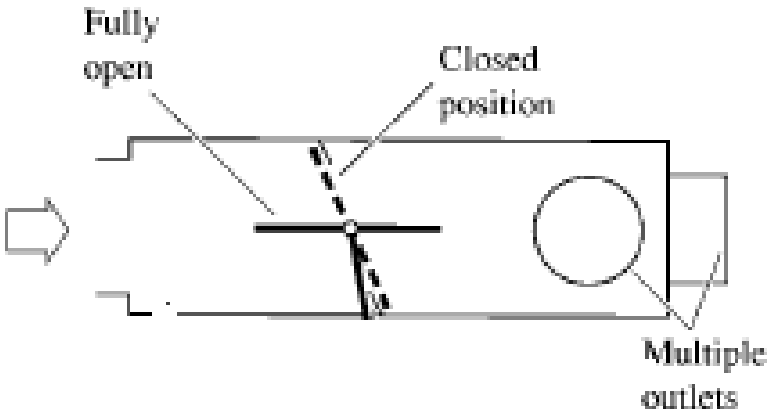


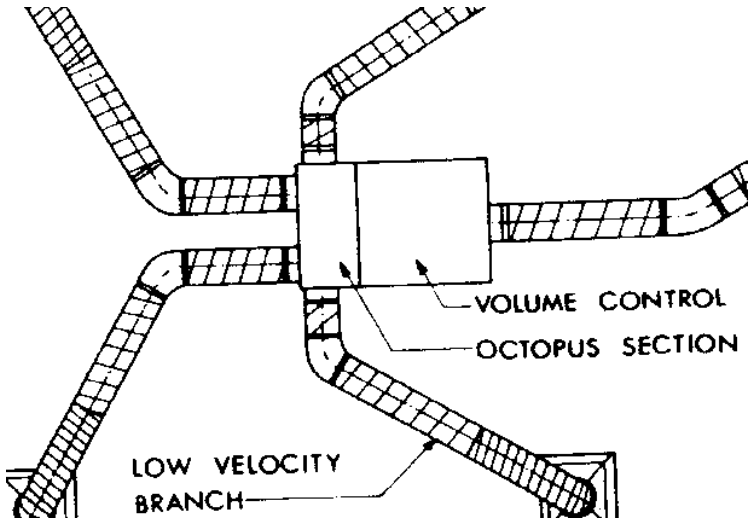
- The air diffusion performance index (ADPI), in percent, which evaluates the performance of space air diffusion, is calculated as

$$\text{ADPI} = \frac{N_\theta \times 100}{N}$$

where N_θ = number of points measured in occupied zone in which $-1.7°\text{C} < \theta < +1.1°\text{C}$
N = total number of points measured in occupied zone

Components of Air Side Systems

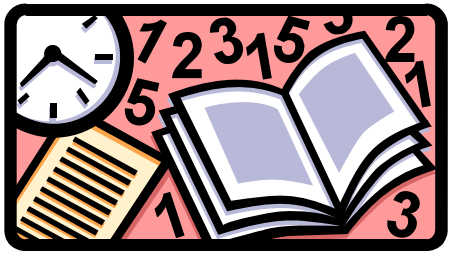




VAV Box

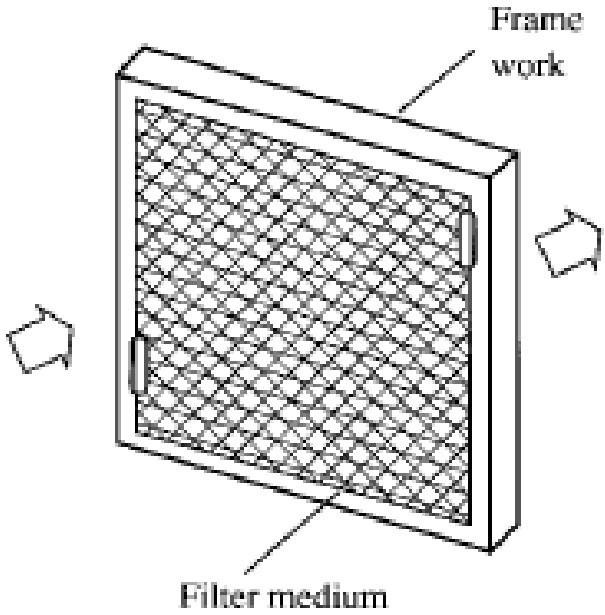
- A variable-air-volume box is a terminal device in which the supply volume flow rate is modulated by varying the opening of the air passage by means of a single-blade butter-fly damper
- Pneumatic or direct digital control
- Pneumatic control VAV box is fading out and replaced by DDC VAV box.

Components of Air Side Systems

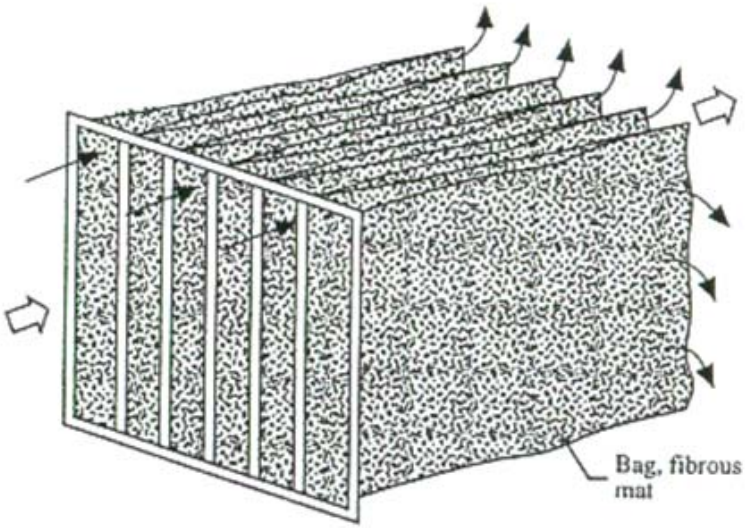


Air Filters

- **Low Efficiency Filter**
  - Dust spot efficiency lower than 30%
  - Panel type
  - Dimension 500mm x 500mm
  - Filter media
    - Corrugated metal wire mesh
    - Dry and reusable-nylon



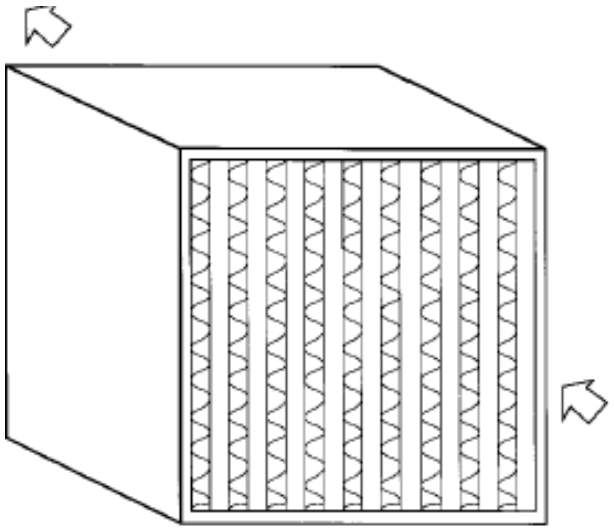
Components of Air Side Systems

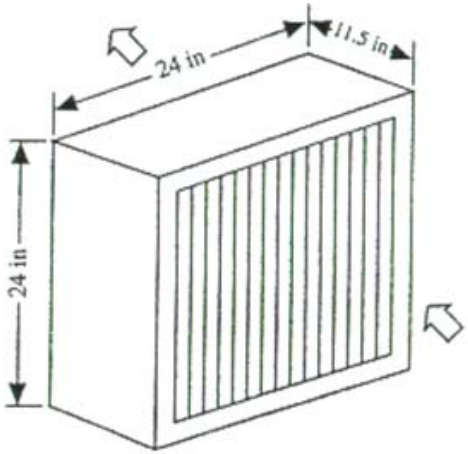


Medium Efficiency Filter

- Filter efficiency between 30% to 95%
- Extended surfaces such as pleated mats or bags are used to
  - Increase surface area of the filter media
  - Increase air velocity flowing through the filter media

Components of Air Side Systems





High Efficiency Particulate Air Filter

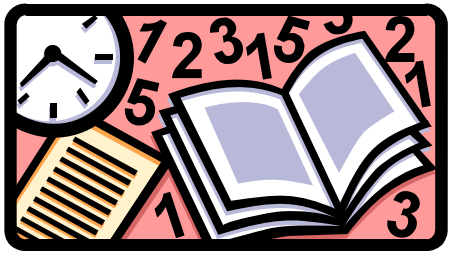
Principle of operation

- It remove dust particle by filtration of the passing air;

Construction:

- The filter media is glass fibre of submicrometer diameter that is formed into pleated paper mats (dry and disposable).
- The performance of filter media is measured by alpha value which is a function of penetration in % and pressure drop (mm).
- Typical size of filter is 600mm x 600mm x 300mm
- Surface filter media area may be 50 times of the face area

Components of Air Side Systems

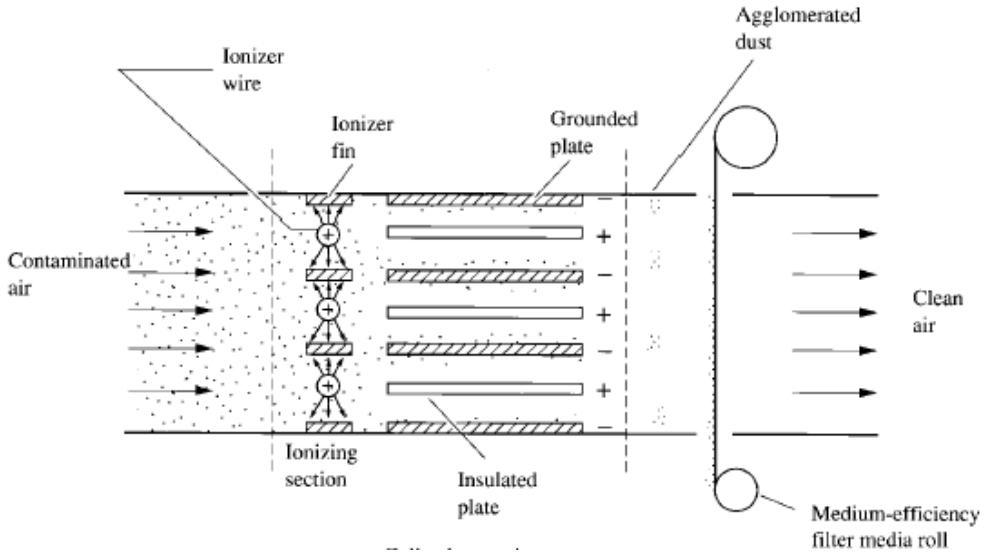


High Efficiency Particulate Air Filter *(Cont'd)*

Application: meet the requirement of dioctyl phthalate (DOP) 99.97% efficiency for dust particle $\geqq 0.3\,\mu\mathrm{m}$

- Clean room
- Clean space for microelectronic industry
- Pharmaceutical industry
- Precision manufacturing industry
- Operating theatre in hospital

Components of Air Side Systems



Electronic air cleaner

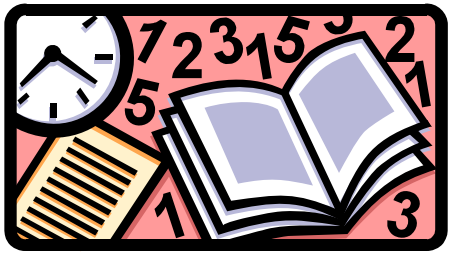
Principles of operation

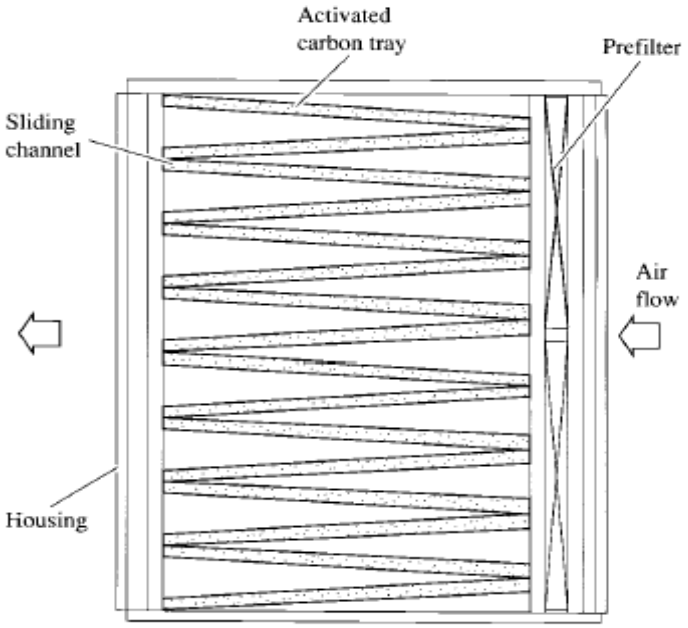
- A high DC potential of 1.2kV is applied to the ionizing field.
- Positive ions generated from the ionizer wire charge the dust particles.
- When traveling in the air stream of the ionizing field, positively charged dust particles are attached to the ground plates.

Application

Atmospheric dust and cigarettes smoke

Components of Air Side Systems





Activated carbon filter

Principles of operation:

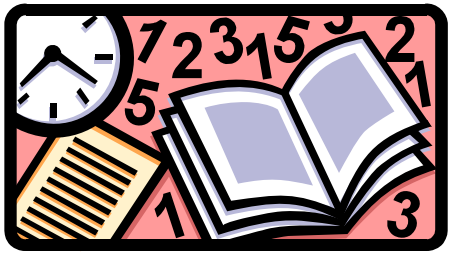
- Removal by absorption.
- Gas molecules diffuse into the microspores or macrospores of activated carbon, bond to these surfaces
- Reactivation or regeneration required at the end of its life

Construction

- Activated carbon is placed in special tray
- Low efficiency filter is placed as pre-filter

- *Application:*
- Refuse storage room ventilation: removal of objectionable odour and irritating vapour of gaseous airborne particles 3nm to 6nm in size

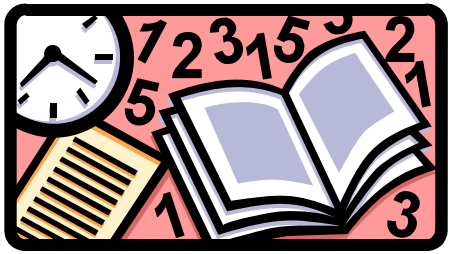
Components of Air Side Systems



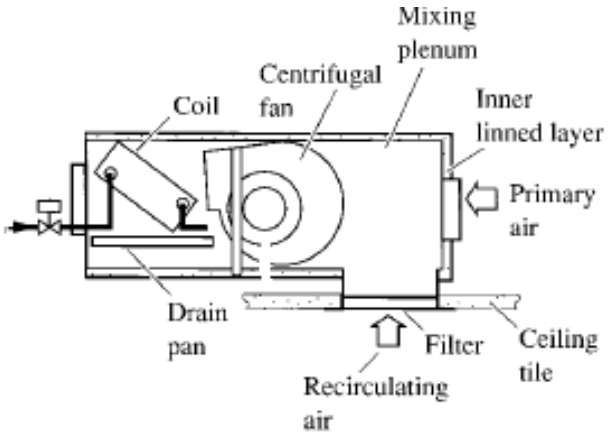
Test Method for Filters with different efficiency

	Weight arrestance	Dust Spot	Di-Otyl Phthalate DOP
Particle size of test dust	Large particles in atmospheric dust	Atmospheric dust	0.3 μm particles
Means to determine dust concentration	Precision Balance	Change in light transmission	Particle count
Application	Low efficiency filter	Medium efficiency filter	High efficiency filter

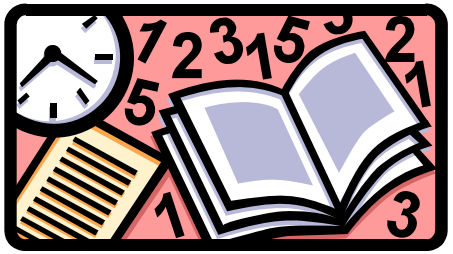
Components of Air Side Systems



- Fan Coil Units
- A fan-coil unit, is a terminal unit installed directly inside the conditioned space
- It includes
  - A small motor driven centrifugal fan
  - A finned coil,
  - A filter,
  - An outer casing, and
  - Controls.



Components of Air Side Systems

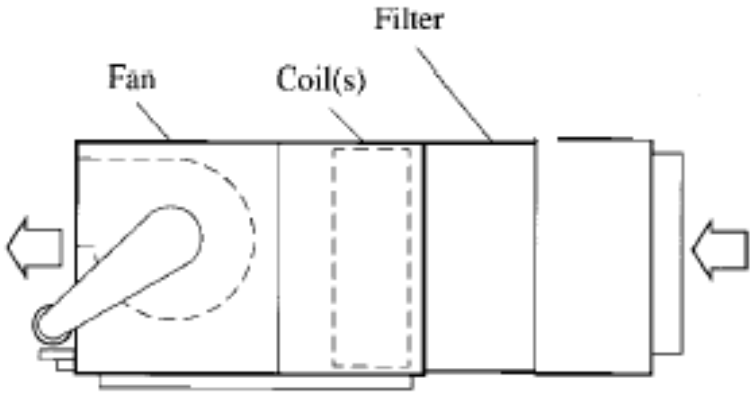


Air Handling Unit(AHU)/ Primary Air Unit(PAU)

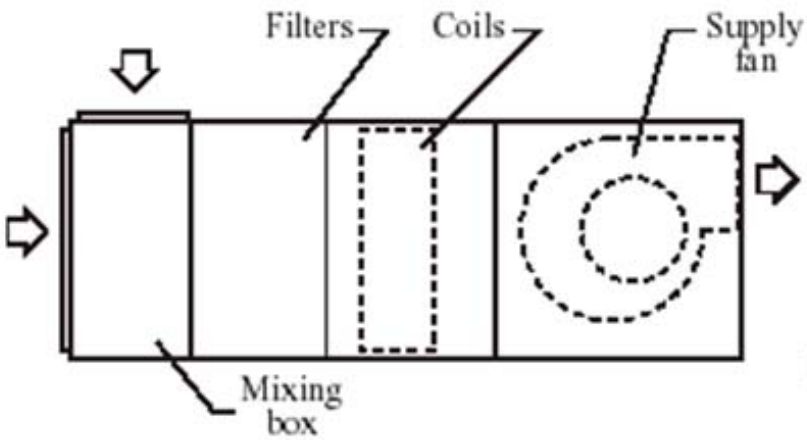
- Double-wall sheet-metal casing in which the insulation material is sandwiched between two sheet-metal panels

- Single sheet-metal panel with inner insulation layer and perforated metal liners: attenuate the fan noise but with problem of exposing insulating materials (:wet and collect dirt, microbial growth and erosion over time).

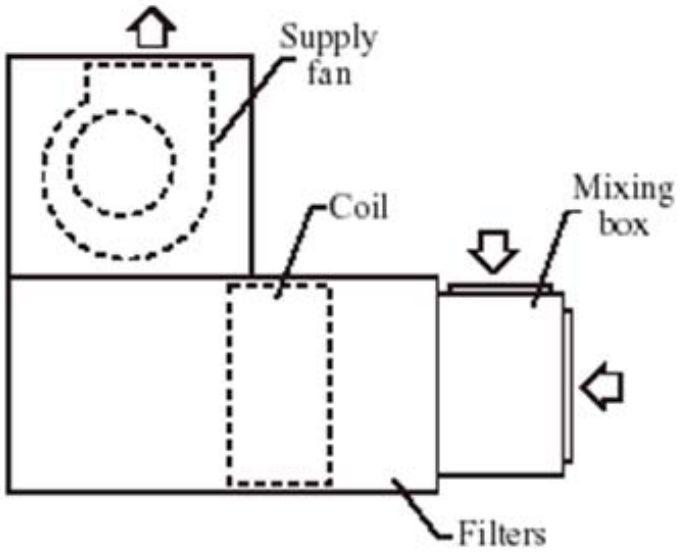
PAU



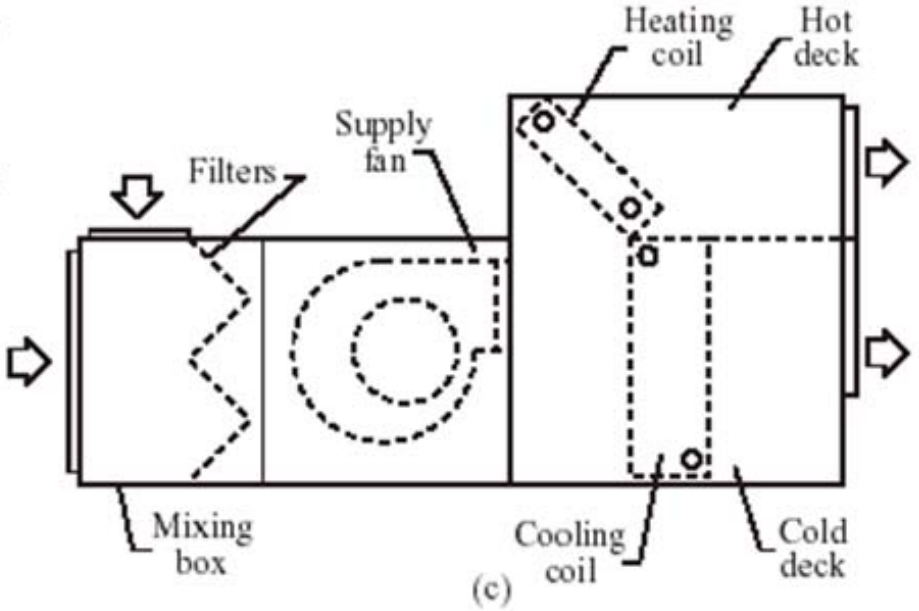
Components of Air Side Systems



(a)



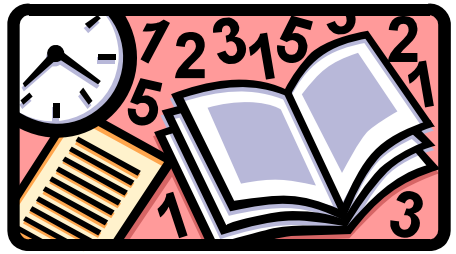
(b)

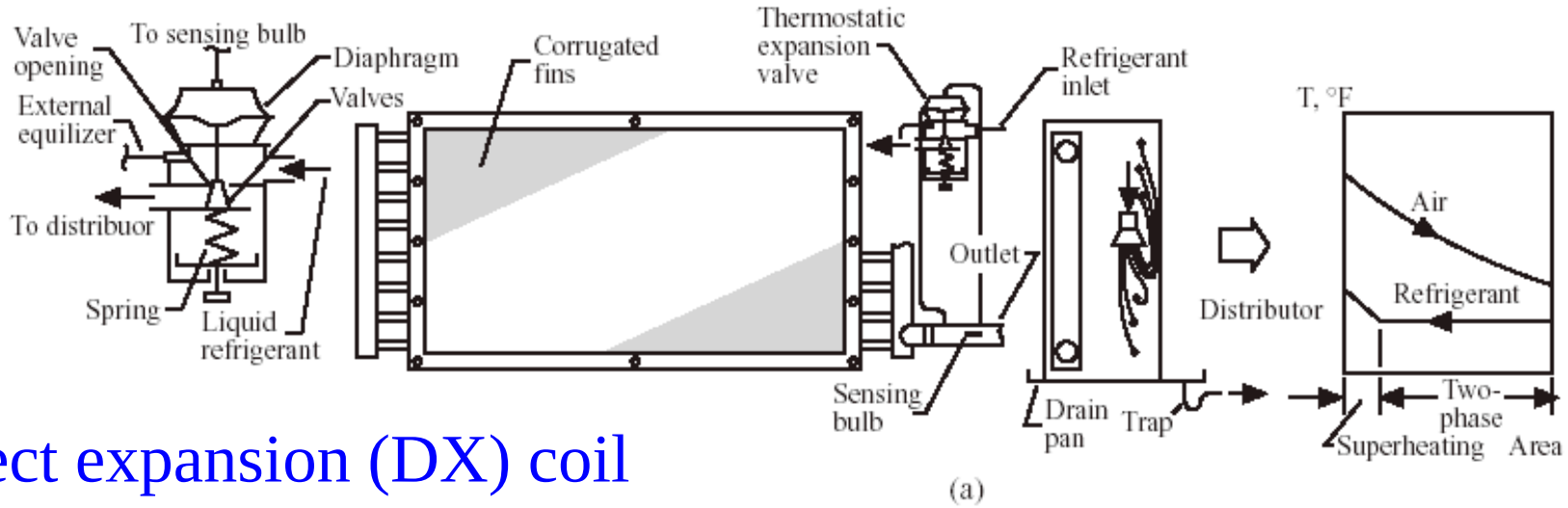


(c)

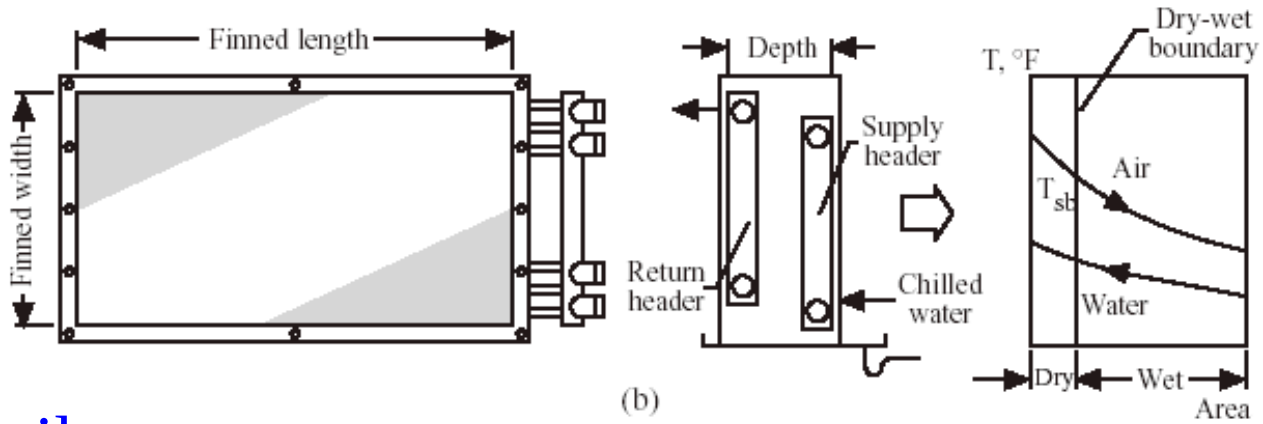
Type of air handling units: (a) horizontal draw-through unit, (b) vertical draw-through unit, and (c) multizone blow-through unit.

Components of Air Side Systems



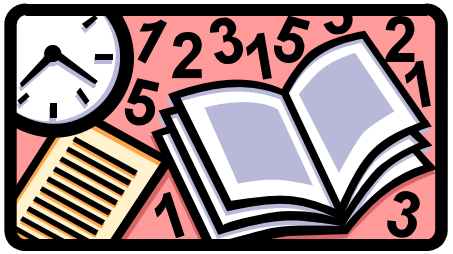


Direct expansion (DX) coil



Water cooling coil

Components of Air Side Systems



AHU/PAU Fan

- A double-inlet airfoil, backward-inclined centrifugal fan
- Centrifugal fan has higher fan total pressure for its higher efficiency and lower noise.

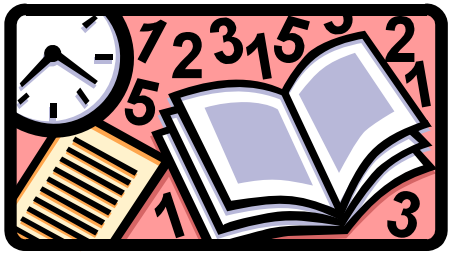
AHU/PAU-Filters

- Air filtration is an important component to achieve an acceptable indoor air quality.
- Low-efficiency filters of the panel type as pre-filter
- Medium- and high-efficiency bag type for filtering the air
- Carbon-activated gaseous absorption filters for removal of objectionable odors

AHU- Outdoor Air and Mixing Plenum

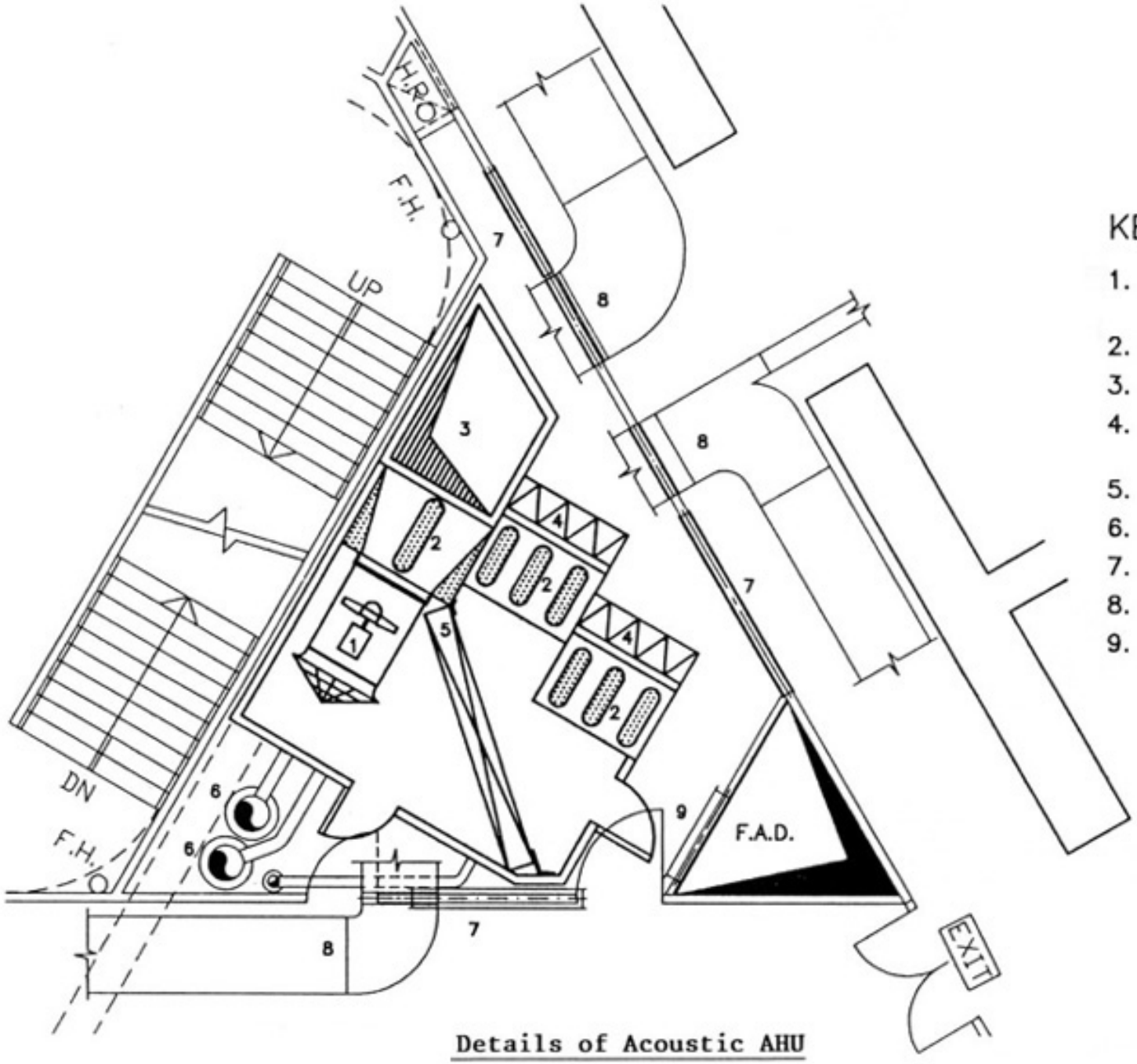
- An outdoor air intake and mixing plenum includes an outdoor air intake, a mixing plenum and connection with return air duct.

Components of Air Side Systems



- **AHU/ PAU Coils**
  - Indirect contact heat exchangers
  - Heat transfer between air flowing over the coil and water, refrigerant, steam or brine insider the coil
  - Fins: extended (secondary) surfaces

- **AHU/ PAU Direct expansion (DX) coil**
  - Refrigerant is fed
  - Air and refrigerant flow:
    - Usually counterflow and cross flow
  - Typical evaporating temperature = 3-10 ^{o}C
  - Condensate drain pan (to collect condensation)
  - Face velocity, heat transfer coefficients, air-side pressure drop, physical size



Details of Acoustic AHU

Q & A