HEATING VENTILATION AND AIR CONDITIONING

**HVAC:** A simple definition of air conditioning is the simultaneous control of Temperature, humidity, cleanliness and motion of air.

**Applications of HVAC Systems:** HVAC Systems are used for either human comfort or for process control and it is also used to provide some conditions that some process requires. For examples, Textiles, Printing, Photographic processing facilities as well as Computer rooms and Medical facilities.

**TYPES OF HVAC SYSTEM**
1. Portable / Window A/c system
2. Split A/c system  
   a. Ducted system  
   b. Non-Ducted System
3. Package A/c system
4. Central air conditioning system  
   a. Summer air conditioning system  
   b. Winter air conditioning system  
   c. Year round air conditioning system

**Basic Design of Air Conditioning System:**

![Diagram of Air Conditioning System](image1)

**Portable/window Air Conditioning System**

![Diagram of Room Air Conditioner](image2)
1. **Window air conditioner**
   - Capacity (1Ton - 3Ton).
   - Applications: Small rooms, Shops and offices.
   - Many traditional air conditioners in use are single rectangular units (window mounted).
   - These are compressor based refrigerant system that uses air to exchange heat, with this type of System the air is dehumidified as it is cooled.
   - Normally outside air is used to cool the condenser section, For this reason these units are placed in windows or through openings in a wall.
   - These units are available up to 2.5 tons capacity.

2. **Split Air Conditioning System**
   - **Ducted split (DX system)**
   - **Non-Ducted**

   - **Non-Ducted Split A/c**
     - Capacity (1Ton - 5 Ton)
     - In ducted split system the condenser and compressor are located in an outdoor unit and the evaporator is mounted in the indoor unit.
     - When air conditioner is turned on, room air is drawn from various parts of the room through return air outlets. This air is pulled through a filter where airborne particles such as dust and lint are removed. The filtered air routed to supply duct through FCU back to the room.
     - Condenser unit is connected to the indoor unit through refrigerant pipes.

   **Fan Coil Unit (FCU):**
   A fan coil unit is, just as the name implies, a small unit with a fan and a chilled and/or heating water coil enclosed in a common cabinet. Fan coil units are usually small enough to be located in the space that they serve. Fan coil units typically have a small fan, fan motor, filters, a single water coil, and controls mounted inside a decorative cabinet. Fan coil units are usually located in bathrooms, toilets are in kitchens.
FILTERS:
One inch throwaway filters are tight fitting to prevent air bypass. Filters are easily removable from the bottom without the need for tools. The filter rack is convertible from rear to bottom return without the need for additional parts. Optional 1" and 2" pleated filters are available for use with the HPP unit.

DRAIN PAN:
Standard drain pans are externally insulated, single wall galvanized steel with an option for stainless steel. Drain pans are available with secondary drain connection. On concealed models, the HP Series drain pan is easily removable for cleaning or reversing connections.

3. Package Unit System

- Package A/C or DX direct expansion system (single package unit) Capacity (5 Ton -100 Ton)
- Applications: (Restaurants Villas Hospitals and Corporate Offices)
- Package units system: All components (condenser, compressor and the evaporator) are located in a single outdoor unit that may be located on the ground floor or on the roof floor.
- Package unit system doesn’t need chilled or refrigerant pipe connections they act as independent cooling system

4. Central Air Conditioning System

- Supply Duct
- Fan Compartment
- Vibration Isolator (‘flex joint)
- Heating and/or Cooling Coil
- Filter Compartment
- Mixed (re-circulated+outside) Air Duct.

Air Handling Unit
**Air Handling Unit (AHU):**

Air handling unit is a devise used as part of a HVAC system. usually, an air handler is a large metal box Containing a blower, heating and or cooling elements, filter racks or chambers, sound attenuators, and Dampers. Air handling units usually connected to ductwork that distributes the conditioned air through the building, and returns to the unit. AHU are mounted on anti vibration pads. While placing AHU, maintenance place should be taken into consideration to the left or to the right side of the unit.

**AHU Details**

**Chillers:**

A chiller is a machine that removes heat from a liquid via a vapor-compressor or absorption refrigeration cycle. Most often water is chilled, this chilled water is used to cool and dehumidify air in mid-to large commercial, industrial, and institutional facilities. Most chillers are weatherproof. Chilled water is distributed to heat exchangers, FCU’s, AHU’s, FAHU’s and used water is returned to the chiller. Chiller is a huge machine and makes lot of noise, so these are mounted on concrete foundations with inertia base system.

**Water Cooled Chiller**

**Air Cooled Chiller**
**Variable Air Volume (VAV)**

VAV is an all air HVAC system that has relatively fixed supply air temperature, but the volumetric flow rate of air varies to meet the thermal load.

![Variable Air Volume (VAV) Image](image)

**Thermostat**

Thermostats control the operation of HVAC systems. It turns on and off, or modulating, the heating or cooling systems to bring the building to the set temperature. Usually thermostat location is as shown in the design drawing (input drawing). Otherwise it has to shown near to the return grill area and near to the door.

**Fire Damper:**

Fire damper is used to stop the flow of air when there is any fire hazard. These dampers are used when a duct passes through the kitchen area. Sometimes FD’s are used when the duct crosses the wall.

![Fire Damper Image](image)

**Volume Control Damper (VCD):**

This damper is used to control the flow of air in the branches. The representation of the VCD is shown in fig. output drawing.

**Motorised Damper:**

Ducting systems must provide a method of adjusting the volume of air flow to various parts of the system. Balancing, flow-control, and fire/smoke dampers provide this function. Besides the regulation provided at the registers or diffusers that spread air into individual rooms, dampers can be fitted within the ducts themselves. These dampers may be manual or automatic.

![Motorised Damper Image](image)
**Access doors:**
Access doors are provided for fire dampers, as they need inspection and testing. These access doors are fitted to the duct vertically down on either side of the duct.

**Supply Air Diffuser:**
This is a air distribution medium used to supply air. It is connected to ducts and Available in standard sizes of 150x150, 225x225, 300x300, 375x375, 450x450 etc. Factors to be considered while designing SAD sizes are CFM, Noise level, Type of false ceiling.

**Return or Exhaust Air Diffuser**
Return/Exhaust air diffusers are used for extracting air from the conditioned area. Return air diffusers (RAD) or Exhaust air diffusers (EAD) are available in standard sizes of 150x150, 225x225, 300x300, 375x375, 450x450, etc. Factors to be considered while designing RAD or EAD sizes are CFM, Noise level, Type of false ceiling.

**Grills and Registers**
Grilles are louvered or perforated covering for an opening in an air passage, which can be located in a sidewall, ceiling, or floor. 
Registers are the combination of grille and damper assembly over an air opening.
Flexible Ducts:
Flexible duct are the medium used for the connection of diffusers from Main duct/Branch duct and it is also used for connect two ducts at different levels, It is made up of Fiber Glass wool and available in different standard sizes.

DEFINITIONS:

AXIAL FAN: Type of fan where pressure is produced due to an increase in air velocity thorough the rotating impeller. The air flow through the fan is parallel to the impeller axis.

CENTRIFUGAL FAN: Type of fan where pressure and velocity are produced by the centrifugal action of the rotating impeller and the velocity of air leaving the tip of the impeller.

COMPRESSOR: A refrigerant compressor converts input electricity into mechanical energy in order to remove heat from air.

CONDENSER: The heat exchanger in a mechanical refrigeration cycle. it removes heat from the hot, high pressure refrigerant vapor. the removal of heat converts the vapor into a liquid.

CHILLER: A machine which uses mechanical shaft energy to chill water through the vapor compression refrigeration cycle. Chillers can be air or water cooled, and typically have centrifugal, reciprocating or screw compressors.

CONDENSATION: Condensation occurs when water vapor is converted to liquid.

COOLING COIL: A coil which is used to lower the temperature of an air stream. heat is transferred from the air stream to chilled water or refrigerant circulating through the coil tubes.

DUCT: A passageway made of galvanized sheet metal or other suitable material that is used to distribute the air needed to heat, ventilate, or cool the conditioned spaces.

DAMPER: A devise used to control the flow of air within a duct.

DEHUMIDIFICATION: Process where moisture is removed from the air.

DEHUMIDIFIER: A devise which removes moisture from the air.

DIFFUSER: A devise which evenly distributes high velocity supply air into the conditioned space.

DISTRIBUTION: The transport of conditioned air or water throughout a facility. Also refers to the equipment which performs this function.

DUCT: A passageway made of galvanized sheet metal or other suitable

EXHAUST AIR: Building air which is expelled of “exhausted” from the building to balance the incoming fresh outside air. Exhaust air removes airborne contaminants.

FAN COIL UNITS: Fan coil units (FCU) are typically mounted in the ceiling at each zone and contain a blower, air filter, and water coil or coils.

FILTER: A devise which removes particulate contaminants from an air stream.

HEATING COIL: A coil used to increase the temperature of an air stream. heat is transferred to the air stream from hot water circulating through the coil tubes.
**PACKAGED UNITS:** HVAC units that contain all components for a complete air cooled refrigeration cycle in one unit.

**PLENUM:** An enclosure that is part of the air distribution system and is distinguished by having almost uniform air pressure.

**BOTTOM OF PIPE:** BOP is the distance between the finished floor level to the bottom of the pipe.

**BOTTOM OF DUCT:** BOD is the distance between the finished floor level to the bottom of the duct.

**Types of Ducts:**
Ducts are mainly two types. One is rectangular duct and the other one is round duct.

**RECTANGULAR DUCT:**
The rectangular duct has three dimensions, which are length, width and height. Here we represent only width and height. The first dimension represents the width of the duct and the other dimension is height, which is on the other side of the duct. So we can not see that dimension in drawing and it is written as Width x Height. The units we use for the representation of the duct are mm/inches. The calculation of the duct size depends upon the flow rate of the air. The sizes of the duct should be even numbers only. It is not suggested to take odd numbers. If we get odd numbers while calculating the duct size, it should be rounded to next even number.

For example:

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450x250
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450 – is the width of the duct
250 – is the height of the duct

**ROUND DUCT:**
Round duct which is in circular shape. It has low rate of friction when compared to rectangular duct. These are used according to the client requirement.

**TYPES OF ELBOWS:**
These are used when duct takes a diversion. There are two types of elbows, they are concentric elbows, eccentric elbow.

**Concentric Elbow:**
Concentric elbow is used to connect the duct of same size during diversion. Generally we take the inner radius as 150mm(6") or half of the width of duct and similarly the outer radius of the elbow will be the width of the duct.

**Eccentric Elbow:**
Eccentric elbow is used to connect two ducts having different width and height and it is taking a diversion. The inner radius of the duct is taken 150mm(6"). The outer radius of the duct is calculated as follows

\[ (6" + \text{Width1} + \text{Width2})/2 \]

Where Width1 – it is the width of the first duct.
Width2 – it is the width of the second duct for which the elbow is going to connect.
The example for the eccentric elbow is shown below.
Here width of the first duct is 12", width of the second duct is 14". Add 12"+14"+6” and divide the value by 2. The value, which we got after the calculation will be the outer radius of the elbow.
Reducer:

is used to connect two different sizes of duct. Reducer should be placed after every branch. The length of the reducer should be in increments of feet i.e. \( \frac{1}{2}' , 1' , 1\frac{1}{2}' , \text{etc.} \)

It is advisable that the length of the reducer is taken \( 1\frac{1}{2}' (450\text{mm}) \). There are two types of reducers; they are eccentric reducer and concentric reducer.

Types of reducers

The angle (\( \theta \)) between the two faces of Concentric reducer at diverging is \( 45^\circ \) (Max.) , at converging is \( 60^\circ \) (Max.) and the maximum length (L) of reducer is 1500mm.

**Concentric Reducer:**

The total reduction of Duct width is 200. Since this is the concentric reducer the size reduction is \( 200 + 200 \) (on both the sides). So, the given values are

Process 1:

\[
\tan \theta = \frac{1}{7} = 0.143 = \frac{\text{Opposite side}}{\text{Adjacent side}}
\]

Opposite side = 100

Adjacent side = L (this is the length of reducer we need to find out)

\[
L = \frac{200}{\tan \theta} = \frac{200}{0.25} = 800 \text{ (700 Approx.) is the Length of reducer.}
\]

The Slope of Reducer is 1:7. Allowable Slope is 1:4 The Maximum and minimum length of reducer are 1500mm and 150mm

Process 2:

We know the slope angle \( \tan \theta = \frac{1}{7} = 0.143 \),

From above we can calculate the angle \( \theta = \tan^{-1} (0.143) = 8.138^\circ \).

**Eccentric Reducer:**

The total reduction of Duct width is 200. Since this is the eccentric reducer the size reduction 200 is on only one side. And the remaining process is same as above.
Duct splitter (yee):

Follow the given method while splitting the duct. For example the Supply duct dimensions are AxB with an airflow (a l/s), and the two branches information is CxD with an airflow (b l/s), ExF with an airflow (c l/s). These two branch ducts, divides the main duct at X, Y distance. To find the X distance follow the method given below:

- \[ X = \frac{(A \times b)}{a} \]
- \[ Y = \frac{(A \times c)}{a} \]

For better understanding refer the example given below:

The Supply duct information:
- Dimensions AxB = 1000x800
- Airflow a l/s = 2550 l/s

The branches information:
- Dimensions CxD = 800x650
- Airflow b l/s = 2000 l/s
- Dimensions ExF = 300x250
- Airflow c l/s = 550 l/s

To get the “x” value:

\[ \frac{(1000 \times 2000)}{2550} \]

(Nearly consider it as 785mm)

It means that the duct 800x650 (CxD) splits the main supply duct at a distance 785mm

Duct:

Duct is used to carry medium with respect to the direction of flow.

In HVAC (Heating Ventilation and Air Conditioning) the main ducts used are:
- Supply Air Duct
- Return Air Duct
- Fresh Air Duct
- Exhaust Air Duct

Supply Air Duct:

This duct is used to supply air, which is coming from the FCU/AHU. It is always covered with insulation. Insulation to be provided as per the client Specification. Normally the material for the insulation is fiber glass wool. If the supply duct is using for FCU, sound linear must be provided at least 3m. From the machine mouth and this sound linear should be represented as hidden line. Supply duct is represented with different color and layer as per the client standard. Fig. Shown below show return air duct with an abbreviation of RAD.

Fresh Air Duct:

This duct is used to supply unconditioned air. Air is directly taken from the atmosphere without any foreign particles. This Air is supplied to the return air Plenum box where it get mixed with return air. Fig. Shown below show fresh air duct with an abbreviation of FAD.

Exhaust Air Duct:

This duct is used for the extraction of air from the conditioned area. The air which is extracted from the conditioned area will be thrown into atmosphere. Usually Exhaust ducts will be provided in kitchen, toilets and washing areas. Fig. Shown below show exhaust air duct with an abbreviation of EAD.

Return Air Duct:

This duct is used to return air from the room wherever supply air provided except toilets, washing area and kitchen etc. This duct is represented by different color and layer as per the client specification. The line type is continuous. A sound linear is also provide to this duct. Fig. Shown below show return air duct with an abbreviation of RAD.
Sand Trap Louver (STL)

Turning vanes in rectangular duct elbow reduce pressure drop and turbulence

Abbreviations:

AHU : Air Handling Unit  
FCU : Fan Coil Unit  
FAHU : Fresh Air Handling Unit  
SEF : Smoke Exhaust Fan  
SF : Supply Fan  
FF : Fresh Air Fan  
SPF : Staircase Pressurization Fan  
CU : Condensing Unit  
WRAC : Window Room Air Conditioner  
PCH : Chilled Water Primary pump  
PSCH : Chilled Water Secondary pump  
CH : Liquid Water Chiller  
AAV : Automatic Air Vent  
VAV : Variable Air Volume box  
CAV : Constant Air Volume box  
F : Filter  
OU : Out Door Unit  
IU : Indoor Unit  
JF : Jet Fan  
EXF : Exhaust Fan  
SCD : Supply Ceiling Diffuser  
RCD : Return Ceiling Diffuser  
SR : Supply Register  
RR : Return Register  
ER : Exhaust Register
SG : Supply Grill
RG : Return Grill
EG : Exhaust Grill
DR : Door Louver
DG : Door Grill
AD : Access Door
TG : Transfer Grill
FAL : Fresh Air Louver
SLBG : Supply Linear Bar Grill
RLBG : Return Linear Bar Grill
PTCD : Perforated Transfer Ceiling Diffuser
PECD : Perforated Exhaust Ceiling Diffuser
TCD : Transfer Ceiling Diffuser
TFBD : Transfer Flow Bar Diffuser
SFBD : Supply Flow Bar Diffuser
RFBD : Return Flow Bar Diffuser
SLD : Supply Linear Diffuser
RLD : Return Linear Diffuser
JN : Jet Nozzle
FAO : Fresh Air Duct Opening
RDO : Return Air Duct Opening
STL : Sand Trap Louvers
EF : Exhaust Fan
FAD : Fresh Air Duct
SAD : Supply Air Duct
RAD : Return Air Duct
EAD : Exhaust Air Duct
KED : Kitchen Hood Exhaust Duct
DED : Dish Washer Exhaust Duct
SED : Smoke Exhaust Duct
TED : Toilet Exhaust Duct
FLEX. : Flexible Duct
CHWS : Chilled Water Supply
CHWR : Chilled Water Return
VD : Volume Damper
FD : Fire Damper
NRD : Non-return Damper
L/S : Liters per Second
T : Thermostat
SAT : Sound Attenuator
BDD : Back Draft Damper
FSD : Fire and Smoke Damper
FCL : False Ceiling Level
NTS : Not To Scale
BOU : Bottom Of Unit
BOD : Bottom Of Duct
BOP : Bottom Of Pipe
COP : Centre Of Pipe
T/A : To Above
CL : Concrete Level / Center Line
FFL : Finish Floor Level
Procedure for preparing HVAC shop drawings

- Refer Latest Architectural, Structural, Tender drawings and other standard.
- Deleted Tender Architectural data, keeping all other service.
- Inserted Architectural Shop Drawing.
- X-Ref Structural Shop Drawing.
- Delete unwanted architectural data.
- Clear Duct Interference with other applicable service. (Structural, CHW, Chiller, Fan, etc.)
- Clear CHW Interference with other applicable service. (Structural, AC, Chiller, Fan, etc.)
- Check False ceiling level at each area.
- Prepare Sections and Details at all critical areas.
- Prepare Schedule for FCU’s, AHU’s, Grills, Diffusers, damper, Louvers, Registers etc.
- Provide dimensions from ducts to walls/grids, pipes to walls/grids.
- Check Bottom of pipe, Bottom of Duct & Levels.
- Detached Structural X-Ref.
- Incorporate all Reference drawing.
- Incorporated Notes.
- Incorporated Abbreviation and Legend.
- Check LTS Scale.
- Check Title Block Drawn by, Checked by, Approved by, Date, Revision, Title Text & Drawing Number in the Title Block.
- Checked for CAD standards.
- Raised any doubts, discrepancy & other detail.

Assigning Levels
1. While assigning the Elevations of the Ducts or Pipes, normally we have to follow the order of priority from the soffit slab as below.

If the sprinklers are upright
- Drainage
- Fire Protection
- Plumbing
- HVAC
- Electrical

If the sprinklers are Pendent
- Drainage
- HVAC
- Plumbing
- Fire Protection
- Electrical

2. The maximum length of any Flexible duct is 1500mm.
3. The minimum gap between the Sofit Slab and FCU is 150mm.
Sections, Views and Details:

A section is a selected area or region of the drawing, which enable to understand for the laymen also. It gives us a view of the ducts, pipes and other air condition’s components. Generally sections has to be made at difficult or critical region. We can take any number of sections.

Need for sections:

Some of the areas in the drawing duct may foul or interfere with the other duct or with the chilled water or any other components. So sections are needed to understand the areas properly without occurrence of fouling or interference. So duct has to be run according to the conditions of the false ceiling.

See to that there should not be interference or foul in the drawing.

Procedure for making sections

1. While doing sections we have to find out the levels of the current/working floor and the upper roof ‘s finished floor levels and structure slab levels (FFL and SSL). Bottom of the duct (BOD) and bottom of the pipe (BOP) and all the levels have to be taken from the finished floor level (FFL) only.
2. The levels of the FFL and SSL may get from the structure layouts of the respected floors. For example: If we are working the 2nd floor then we have to check out the SSL and FFL values of the 2nd floor and 3rd floor of the structure/ architectural layout. The values of the slab sizes are also taken in to account.
3. We have to check out the levels before making the sections, so that there should not be any fouling in between the ducts and/or Pipes. All the pipes and ducts distance are kept as in the drawing. If any fouling occur in the sections we can move duct or pipe according to the conditions (upwards or downwards).
4. If the levels of the two ducts or pipe are same, we can change levels of ducts or pipe by considering the false ceiling conditions.
5. If duct has to be taken up or down it has to be shown in the section only. So that fouling can be easily observed or manipulated.
6. The structure layout and false ceiling level taken as X (the values of the false ceiling may change according the client requirement are taking the SSL and FFL levels. It is not constant value but generally it should be more than 2m. So that it should be sufficient to walk for a man) from the FFL. The slab level also made in the section and the value of that should be taken from the structure only.
7. Bottom of the Duct and pipe (BOD and BOP) values has been calculated before, and it has to be shown in the sections.
8. Duct should not be come below the false ceiling. All the duct and pipes should be within the false ceiling only.
9. The support for the duct and pipe are shown in the drawing. The dimension of the duct and type (supply/return) of the duct is marked in the drawing.
10. If the duct is crossing or interfere with any other duct of the same BOD then at interfere point we can take duct route up and down to avoid the interference. This has to be done by checking false ceiling conditions and other duct, which may interfere.
11. The beam are also very important to be considered in the false ceiling if any beam is coming in the false ceiling then BOD or BOP values to be altered according the size of the beam. The dimension of the beam, locations and other values of the beam given in structure or architectural layouts.
12. Generally the duct should not pierce the beam.