



# Selection of Air Handling Units

Part 1 of 2

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## Introduction

The function of an Air Handling Unit (AHU) is to maintain Indoor Air Quality (IAQ), design indoor climate condition, air treatment and the heating and cooling functions in the most efficient way.

AHU is an important equipment of an air conditioning and ventilation system. Proper design and selection of AHU is very important in view of the fact that the air distribution ducting network is directly connected to the conditioned space. An air handler or air handling unit is designed specifically to achieve the desired air circulation and distribution. To achieve this specific requirement, good engineering, right selection and sizing of equipment is necessary to ensure air mixing, air volume control, filtration, cooling, heating, humidification, de-humidification, pressurization, energy recovery, proper noise level and vibration control.

## Types of AHUs Based on Construction

### Fan Coils/ Blower Coils

These belong to the smallest and simplest category of AHUs and, as the names imply, typically consist of little more than a fan and heat transfer coil(s). To keep the coils from getting dirty too quickly, a simple filter is also included. They generally have simple controls and serve a single temperature zone. While they have their applications, they are typically less efficient than larger AHUs and have difficulty providing close control on temperature and humidity.

### Packaged AHUs

These are very common in smaller buildings and commercial applications, particularly as rooftop units. Packaged units generally contain fans, coils, filters and dampers in a single casing. Often the casing includes its own air conditioning compressors and means for heating such as gas burners, electric heating coils or heat pump coils. They often serve single temperature zones, but large variable air volume (VAV) AHUs serving multiple terminal boxes (zones) are also available. Because of their compactness and lower initial costs, packaged units have a reputation for being inefficient and maintenance intensive, but performance and reliability are improving. They are available in sizes from a few thousand cfm to more than 30,000 cfm, but their standardization can be a limitation in some applications.

### Modular AHUs

They allow users to select individual components housed in modules having consistent construction and cross sections. The user can select the type of casings, fans, filters, coils and accessories from a variety of different options. Modules are assembled at the factory or can be shipped individually and

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## About the Author

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Figure 1: Horizontal floor mounted AHU



Figure 2: Vertical floor mounted AHU



Figure 3: Ceiling suspended AHU

assembled on-site. Modular units generally allow high flexibility and can meet most air processing requirements.

### Custom AHUs

They are available in nearly any configuration that a user might require. They generally have the highest quality construction and are most commonly used in institutional or industrial applications where high flow rates, low flow-high static, multiple filtration stages, very close control and harsh conditions exist. They may also be applied in irregular spaces that would not conform to a modular line. Custom units can be configured to include virtually any combination of air processing components. They can also include walkways and service areas within them and can even accommodate space for skid-mounted equipment like pumps or heat exchangers. They are the most expensive of all of the types of AHUs discussed, but can be expected to have the longest lifespan.

### Types of AHUs Based on Configuration

- Horizontal floor mounted AHU: draw through and blow through
- Vertical floor mounted AHU
- Ceiling suspended AHU
- Thermal break AHU
- Two tier/ double decker AHU

### Types of AHUs Based on Application and Site Requirement

#### 1. Filtration Level 100,000-0.3 $\mu$ m

The component configuration for this AHU is:

- i. Mixing box with fresh air and return air damper
- ii. Coarse filter – EU-4
- iii. Coil section (heating or cooling)
- iv. Supply air fan
- v. Fine filter – EU-7
- vi. Absolute filter EU-11 (final filter)

#### 2. Filtration Level 3 $\mu$ m-5 $\mu$ m

This AHU has the following components:

- i. Mixing box with fresh air and return air damper
- ii. Coarse filter – EU-4
- iv. Supply air fan
- v. Fine filter – EU-7

#### 3. Filtration Level 20 $\mu$ m-10 $\mu$ m

This AHU comprises of following components:

- i. Mixing box with fresh air and return air damper (if return air is ducted; otherwise mixing box is not recommended, i.e. AHU room)
- ii. Coarse filter – EU-4
- iii. Coil section (heating or cooling)
- iv. Supply air fan

#### 4. Precision AHU for Data Center

These units have vertical configuration and are used floor mounted. The main components of these AHUs are:

- i. Coarse filter – EU-4
- ii. Coil section (chilled water/ DX cooling coil or dual fluid circuit)
- iii. Supply air fan

#### 5. Evaporative Units with Filtration Level 20 $\mu$ m

This unit consists of the following components:

- i. Intake louvers with birds screen
  - ii. Coarse filter – EU-2
  - iii. Cellulose cell deck pad or spray nozzle
  - iv. Supply air fan
- (Secondary filter may also be use if the application requires)

#### 6. Supply Air Ventilation

A supply air unit has the following components:

- i. Intake louvers with birds screen
- ii. Coarse filter – EU-2
- iii. Supply air fan

#### 7. Exhaust Air Ventilation Unit

The components of this unit are:

- i. Intake section
- ii. Exhaust air fan
- iii. Outlet louvers with birds screen

### Single and Double Skin AHUs

#### Single Skin AHU

Nowadays, the utilization of a single skin AHU is rare due to age detractation, shorter life span, higher noise level and higher vibration during their operation. However, these AHUs may be considered for less critical applications due to their lower cost.

For better stability and rigidity, extruded aluminum sections, stiffeners and ABS plastic corner pieces are used in the construction of this AHU.

The following options are available for the selection of skin panel:

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1. Both sides powder-coated galvanized steel sheets.
2. Galvanized steel sheet with anti-corrosive paint.
3. Galvanized steel sheet with thermal and acoustic insulation.

### Double Skin AHU

These AHUs are widely used due to sturdiness and comparatively silent operation. They are self-supporting type with modular panel section. The frame-work is made of extruded aluminum profiles fixed with polyamide corner or die-cast aluminum for compaction stability and rigidity. The unit casing comprises of self supporting panels with integrated base frame made of galvanized steel sheet.

As per user requirement and application, various combinations can be considered between the outer skin and the inner skin steel sheet material. Some of the options are as follows:

#### Outer Skin

- Zinc coated galvanized steel sheet with anti-corrosive coating.
- Pre coated aluminum or galvanized zinc coated steel, stainless steel sheet.
- Plastic coated galvanized zinc coated steel sheet.

#### Inner Skin

- Zinc coated galvanized steel sheet with anti-corrosive coating.
- Pre coated aluminum or galvanized zinc coated steel, stainless steel sheet.
- Plastic coated galvanized zinc coated steel sheet.

The standard casing metal sheet thickness is 0.7/1.0mm and industrial casing metal sheet thickness is 1.0/1.5mm. The casing is made from incombustible insulation sandwich panels filled with rigid polyurethane foam (PUF), glass fibre or mineral wool between the two sheets. Panel thickness depends upon the application and the surrounding weather condition. Sandwich panels give excellent thermal protection and meet rigorous acoustic requirements.

Thermal conducting coefficient of mineral wool core panel insulation material is  $\lambda = 0.036 \text{ W/mK}$  at density  $\delta = 60\text{to}80 \text{ kg/m}^3$ , whereas thermal conducting coefficient of PUF is  $\lambda = 0.024 \text{ W/mK}$  at density  $\delta = 35\text{to}50 \text{ kg/m}^3$ .

Double skin AHU with PUF injected sandwich panel is more popular because of the lowest 'K' value as compared to glass fibre and mineral wool. This minimizes the thickness of the unit. PUF panels are rigid, sturdy, structurally strong and dimensionally stable. They also possess higher compressive and flexural strengths, which help the unit maintain its shape or size under usage conditions.

PUF injected sandwich panel insulation material is produced by reacting polyisocyanates with polyhydroxy compound and expanded with fluorocarbon free blowing agent. If air pockets are generated during the chemical injection process, condensation will occur on the outside surface of outer skin of AHU; hence, due care is required while manufacturing PUF sandwich panels. Sandwich panels are available in two thicknesses: 25mm and 45 to 50mm.

These units have large dimensional access doors with the same thickness, adjustable hinges, door frame, door handles with



Figure 4: PUF panel

safety lockers, double rib gasket made of EPDM rubber (used in the aluminum frame groove) to ensure zero leakage.

The drain pan of the AHU is designed to facilitate positive discharge condensate water quickly and for periodic cleaning. This is fabricated from high grade stainless steel sheet with PUF sandwich having deep and dual slope.

The conventional double skin AHU is not suitable for outdoor installation as condensation is observed on the outer surface of the AHU panel and aluminum sections. This happens due to lower temperature of the outer skin than the ambient air dew point. To overcome this, aluminum thermal break profile of adequate thickness is used to construct the AHU. This thermal break profile has a built-in thermal barrier which isolates the inside and outside of the profile. The use of these thermal break sections enables the use of AHU in outdoor installations also.

## Anatomy of an AHU

### Casing and Construction

A good quality AHU can last more than 30 years with proper maintenance. Double-walled construction is now standard for all but the smallest units. Application of insulation between the walls is important. Injected PUF insulation with no through-metal contact (no thermal bridging) is available from a variety of manufacturers and generally has better thermal and acoustic performance than fiberglass insulation. If the unit is to be installed outdoors, extra insulation is recommended. For outdoor installation, corrosion resistance should be a top priority.

### Mixing Chamber

In order to maintain indoor air quality, AHUs commonly have provision to allow the introduction of outside air into, and the exhausting of air from, the building. In temperate climates, mixing the right amount of cooler outside air with warmer return air



Figure 5: Mixing section

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can be used to achieve the desired supply air temperature. A mixing chamber is therefore used, which has dampers controlling the ratio between the return, outside, and exhaust air.

### Filters

Air filters remove contaminants from the air stream and significantly improve IAQ. Rating systems for air filters, such as ASHRAE Standard 52.2-2007: *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*, define the Mean Efficiency Reporting Value (MERV) providing a comprehensive and consistent indication of a filter's capture performance within a range of particle sizes. The latest rating systems, such as the European Committee for Standardization EN779:2012, rate air filters based not only

on their ability to capture particles but also on their predicted annual energy use.

The lifecycle cost of filters should be carefully considered during the design and subsequent purchasing of the filters. Overall, the initial cost of filters can be as little as 4% of the lifecycle cost when considering energy use, change out and disposal costs. It is also extremely important not to skimp on access space. If an AHU is difficult to access and filters are difficult to reach, they will not get changed, and the unit will use excessive energy and underperform.

### Filter Selection

The filter has to remove aerosols, which comprise of solid or liquid particles suspended in air. Removal of airborne contaminant particles is done with the help of pre filters, fine filters, HEPA (High Efficiency Particulate Air) filters and ULPA (Ultra Low Penetration Air) filters.

### Filter Classification

Please see *Table 1*.

While referring *Table 1*, the following facts should be kept in mind:

*BS6540/ PN- EN 779: 2004* arrestance and efficiency test references are based on average percentage values. Primary and secondary filters are at their lowest efficiency when they are new, and at their most efficient at the end of their useful life. *PN- EN 1822 -5: 2002* tested filters offer a guarantee of minimum performance when newly installed.

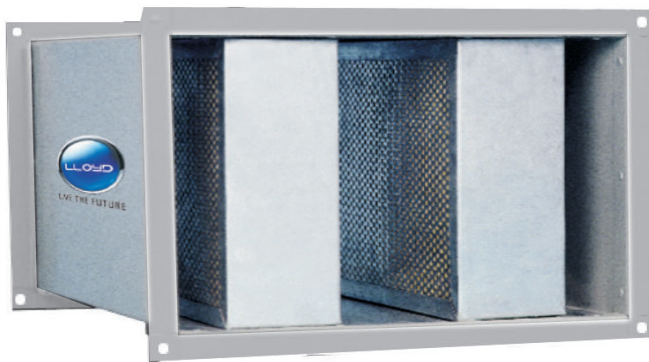


Figure 6: Filter section

Table 1: Filter classification

Type of filter	Efficiency grade Eurovent 4/5	Efficiency grade PN-EN 779: 2004	Particulate efficiency
First stage filter (coarse filter)	EU2	G2	20 microns
First stage filter (coarse filter)	EU3	G3	20 microns
First stage filter (coarse filter)	EU4	G4	10 microns
Second stage filter (fine filter)	EU5	F5	5 microns
Second stage filter (fine filter)	EU6	F6	3 microns
Second stage filter (fine filter)	EU7	F7	3 microns
Very fine filter	EU8	F8	Filter efficiency 50% down to 0.3 microns
Very fine filter	EU9	F9	Filter efficiency 75% down to 2.0 microns
Type of filter	Efficiency grade Eurovent 4/5	Efficiency grade PN-EN 1822-5:2002	Particulate efficiency
Absolute filter (Final filter)	EU10	H10	EU10 filter efficiency down to 95%for 0.3µm. H10 filter (MPPS) efficiency down to 85%for 0.3µm.
Absolute filter (Final filter)	EU11	H11	EU11 filter efficiency down to 99.97%for 0.3µm. H11 filter (MPPS) efficiency down to 95%for 0.3µm.
Absolute filter (Final filter)	EU12	H12	EU12 filter efficiency down to 99.99%for 0.3µm. H12 filter (MPPS) efficiency down to 99.5%for 0.3µm.
Absolute filter (Final filter)	EU13	H12	EU13 filter efficiency down to 99.997%for 0.3µm. H12 filter (MPPS) efficiency down to 99.5%for 0.3µm.
	--	H13	H13 filter (MPPS) efficiency down to 99.95%for 0.3µm.
Absolute filter (Final filter)	EU14	H14	EU14 filter efficiency down to 99.999%for 0.3µm. H14 filter(MPPS) efficiency down to 99.995%for 0.3µm.

MPPS – Most Penetrating Particle Size; HEPA – High Efficiency Particulate Air (filters)

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For general application, face velocity across the filter is maximum 2.54 m/s (500 fpm). The recommend air velocity for Class 100 laminar flow work surface is  $90\pm 20\%$  fpm below working area as per international and national guidelines, and applicable to operation theaters, filling of ampoules and injectable vials and the pharmaceutical industry. The filter selection also depends on clean room classification and number of air changes. Hence, while selecting the filters, the engineer should verify the following data:

- Type of filter, arrestance %, efficiency %, minimum MPPS%
- Velocity across the filter
- Overall size of filter (including filter thickness)
- Material of construction of filter frame

The AHU manufacturer should take care of the following:

- Leaks between filter frame and unit casing
- Leaks between filter frame
- Leaks at the filter sealing

### Supply and Return Fans

Fans are the heart of any AHU and can represent a significant portion of the building's total annual energy usage. The supply fan pushes or pulls the air through filters and coils and then distributes it through ductwork directly to spaces or to terminal boxes. Not all AHUs require a return fan, but units serving multiple spaces or using air-side economizers typically require a fan to return air to the AHU and to relieve air from the building.

AHUs in which the supply fan is installed after the heating and cooling coils are referred to as draw-through units, since the supply fan draws the air through the unit.

In blow-through AHUs, the supply fan is located prior to the coils. This arrangement allows fan heat, which can be significant, to be removed from the air stream without having to sub-cool the supply air – unlike for draw-through units. Although much less common than draw-through, blow-through units do have their applications, particularly in healthcare. They are also seeing increased application in low-temperature air systems.

There are many types of fans applied to air handlers; the primary differences among them relate to blade configuration and whether the fan wheel is fully housed or open. (An open wheel arrangement is referred to as a plenum fan.)

A critical part of any fan selection is acoustic performance. It is always important to know the maximum acceptable noise level on a project. Proper selection and specifying of fans and AHU casing can reduce the need for silencers and other costly noise mitigation techniques. Because the best way to reduce fan sound is to reduce the fan power, efficient fans frequently have the best acoustic performance.

### Fan Selection

Different types of fans are available; however, centrifugal fan and nowadays plug fans are widely used in AHUs.

Centrifugal fans are further classified as:

DIDW (double inlet double width): with backward or forward curved impellers.

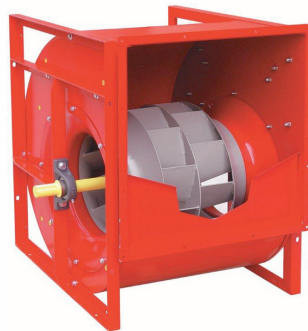


Figure 7: DIDW backward curved fan



Figure 8: Plug fan

SISW (single inlet single width): with backward or forward curved impellers.

While selecting a centrifugal fan, the designer should keep in mind the following data:

- Air flow handled by fan
- Impeller diameter
- Outlet velocity (preferable 9.2m/s)
- Quantity of fan
- Make of fan
- Static requirement
- Type of blades

Materials of construction (MOC):

- Fan casing with inlet cone: preferable GSS Grade 220 gsm minimum with skin passed, zero spangle, chromate and dry
- Impeller MOC: cold rolled sheet steel with polyester powder coating
- Hub MOC: cast aluminum
- Shaft MOC: C- 45/EN-8
- Inlet and outlet flanges: MS as per IS 1079/2062

Construction of fan should be as per AMCA class of construction 99-2408-69.

Balancing grade: impeller with hub scroll duly balanced as per ISO 1940 Grade 2.5. Fans should be dynamically trim-balanced to ISO1940 and AMCA 204/3 – Grade 2.5 after assembly.

Bearings should be self-alignment (concentric) ball bearings with adaptor sleeve, maintenance free with permanently lubricated sealed, pillow block type. (Use of eccentric grub screws is not advisable as it may damage the shaft.) Bearing support plate should be provided on fan side frame for reduction of vibration. Bearing life should be minimum L10 in excess of 1,00,000.

Fan pulley must be between 35 and 50% of impeller diameter. Both fan and motor pulley should be balanced to quality grade G.2.5.

Fan should have drain plug at the bottom of casing. Fan common base frame should be constructed from MS channels finished with anti corrosive paint.

Apart from fan construction, it is advisable to review the following characteristics of centrifugal fan:

- Operating speed (RPM)

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- Maximum RPM
- Fan efficiency at 100% load
- Brake kW
- Rotor GD2 value (kg-m<sup>2</sup>)
- Load limit factor
- Power consumed (kW)
- Recommended rating (kW) of drive motor
- Vibration level as per ISO 2372
  - Rigid structure : 4.5 mm/sec (RMS)
  - Metallic structure : 7.5 mm/sec (RMS)
  - Flexible structure : 11.2 mm/sec (RMS)
- Vibration grade of fan : 1.8mm/sec
- Spring mounted vibration isolator efficiency should be above 90%
- Noise level at 1.5m distance with inlet and outlet both duct connected at site condition
- Painting: PR 12/ epoxy coating/ equivalent on MS parts only, DFT 70 micron; shade: manufacturer's standard/ blue RAL 5009

### Fan Drive Frame

The frame is constructed from heavy gauge steel. Belt adjustment is accomplished by loosening fasteners, sliding motor plate and retightening fasteners.

### Fan Drive Motor

Drivers are sized for a minimum of 150% driven horse power. The motor should be permanently lubricated, having sealed ball bearings to provide trouble-free operation with minimal maintenance. Shaft and belt guard should be provided to avoid accidents.



Figure 9: Fan and motor module

It is necessary to verify the specifications of fan drive motor. The general specifications are:

- Make of motor
- Fan drive motor rating
- Number of poles
- Motor RPM
- Motor frame size
- Type: squirrel cage or SPDP
- Motor body protection, preferably IP-55
- Insulation type, preferably Class F
- Energy Efficiency Rating



In Part 2 of this article, which will appear in the July-August 2014 issue, we will discuss the coil section, humidifier, heat recovery and other aspects.