

Lectures 4 (Air Handling Unit)

Functions of Air-Handling Units

An air-handling unit (AHU) is the primary equipment in an air system of a central hydronic system; it handles and conditions the air and distributes it to various conditioned spaces. In an AHU, the required amounts of outdoor air and recirculating air are often mixed and conditioned. The temperature of the discharge air is then maintained within predetermined limits by means of control systems. After that, the conditioned supply air is provided with motive force and is distributed to various conditioned spaces through ductwork and space diffusion devices. Many air-handling units are modular so that they have the flexibility to add components as required. An AHU basically consists of an outdoor air intake and mixing box section, a fan section including a supply fan and a fan motor, a coil section with a water cooling coil, a filter section, and a control section. A return or relief fan, a heating coil, a precooling coil, and a humidifier may also be included depending on the application. Supply volume flow rates of AHUs vary from 2000 to 63,000 cfm (945 to 29,730 L/ s). Whether a return fan or a relief fan should be added to an air system depends on the construction and operating characteristics of the air system and the total pressure loss of the return system. A heating coil is mainly used in the air-handling unit that serves the perimeter zone, or for morning warm-up in the heating season. The use of a precooling coil, to draw cooling water from the cooling tower as a water economizer. Humidifiers are employed for processing air conditioning and health care facilities where space humidity must be controlled.

Classifications of Air-Handling Units

Air-handling units may be classified according to their structure, location, and conditioning characteristics. ***Horizontal or Vertical Unit.*** In a horizontal unit, the supply fan, coils, and filters are all installed at the same level, as shown in Fig.1a. Horizontal units need more floor space for installation, and they are mainly used as large AHUs. Most horizontal units are installed inside the fan room.

Occasionally, small horizontal units may be hung from the ceiling inside the ceiling plenum. In such a circumstance, fan noise and vibration must be carefully controlled if the unit is adjacent to the conditioned space. In a vertical unit, the supply fan is not installed at the same level as the coils and filters but is often at a higher level, as shown in Fig.1b. Vertical units require less floor space. They are usually smaller, so that the height of the coil section plus the fan section, and the height of the ductwork that crosses over the AHU under the ceiling, is less than the head room (the height from the floor to the ceiling or the beam of the fan room). The fan room is the room used to house AHUs and other mechanical equipment.

Draw-Through Unit or Blow-Through Unit. In a draw-through unit, the supply fan is located downstream from the cooling coil section, and the air is drawn through the coil section, as shown in Fig.1a and b. In a draw-through unit, conditioned air is evenly distributed over the entire surface of the coil section. Also the discharge air from the AHU can be easily connected to a supply duct of similar higher velocity. Draw-through units are the most widely used AHUs.

In a blow-through unit, the supply fan is located upstream from the coil section, and the air blows through the coil section, as shown in Fig.1c. Usually, a multizone air-handling unit adopts a blow-through unit. In a multizone AHU, the

coil section is divided into the hot deck and the cold deck. The heating coil is installed in the hot deck just above the cold deck, where the cooling coil is located. The hot deck is connected to ductwork that supplies warm air to the perimeter zone through the warm duct. The cold deck is connected to a cold duct that supplies cold air to both the perimeter and interior zones. A blow-through unit also has the advantage of treating the supply fan heat gain as part of the coil load and thus reduces the supply system heat gain.

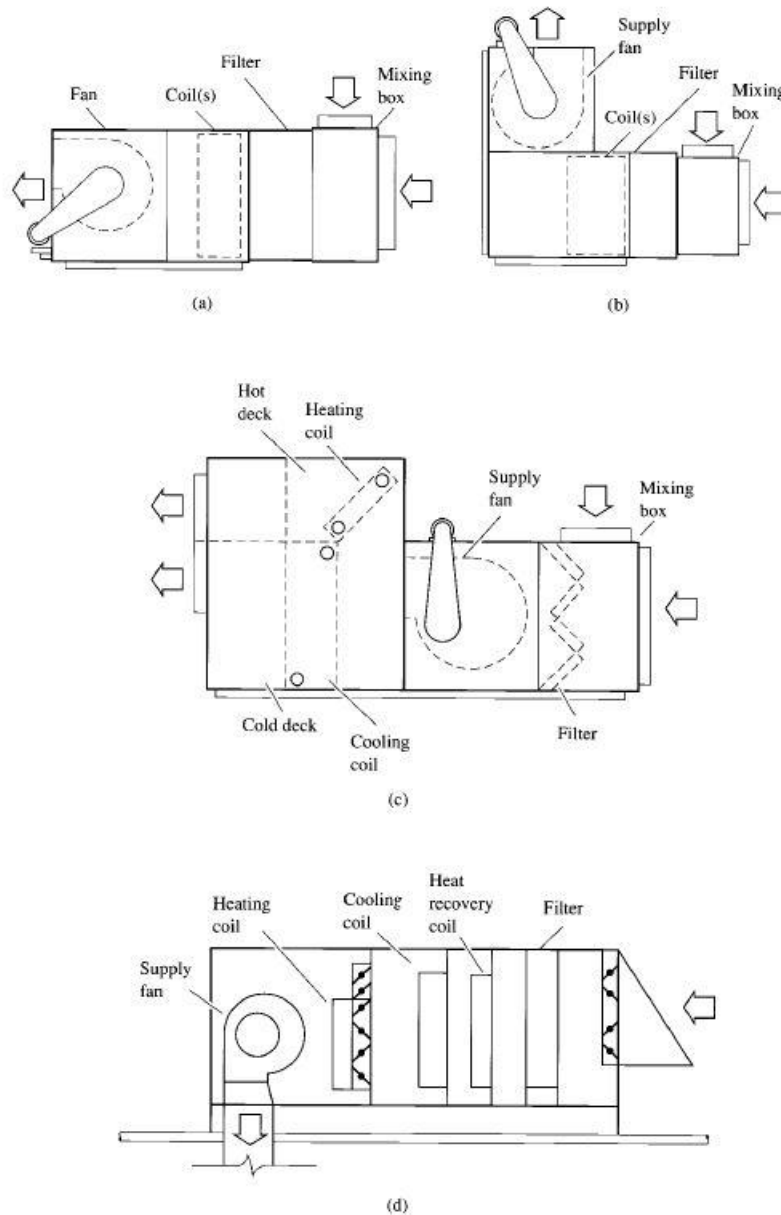
Outdoor Air (or Makeup Air) AHU or Mixing AHU. Most mixing AHUs can be used to condition either outdoor air only or a mixture of outdoor air and recirculating air, whereas an outdoor air AHU is used only to condition 100 percent outdoor air, as shown in Fig.1d. An outdoor air, or makeup air, AHU is a once-through unit; there is no return air and mixing box. It may be a constant-volume system or a variable-air-volume (VAV) system if the number of occupants varies. In an outdoor-air AHU, the cooling coil is usually a six- to eight-row depth coil because of the greater enthalpy difference during cooling and dehumidification in summer. Freeze protections for water coils are necessary in locations where the outdoor temperature may be below 32°F (0°C) in winter. A heat recovery coil or a water economizer precooling coil is often installed in makeup air AHUs for energy savings.

Single-Zone AHU or Multizone AHU. A single-zone AHU serves only a single zone. A multizone AHU serves two or more zones, as shown in Fig.1c. A zone can be a large perimeter or an interior zone or one of the many control zones which connect to a multizone AHU through ducts and terminals. A multizone AHU with a hot and cold deck is now often used for a dual-duct VAV system. Another kind of multizone unit which has many separate warm air ducts and cold air ducts with associated warm and cold air dampers for each of the zones became

obsolete because this kind of multizone unit wastes energy, needs complicated control, and is expensive.

Factory-Fabricated AHU or Field-Built AHU, Custom-Built or Standard Fabrication. One important reason to use factory-fabricated AHUs or standard fabrications is their lower cost and higher quality. Factory labor and controlled manufacturing techniques provide more efficient and better quality construction than field labor and assembly. Custom-built and field-built AHUs provide more flexibility in structure, system component arrangements, dimensions, and specialized functions than standard fabricated products. Custombuilt and field-built AHUs also need more comprehensive, detailed specifications. Standard fabricating products are usually less expensive and can be delivered in a shorter time.

Rooftop AHU or Indoor AHU. A rooftop AHU is an outdoor penthouse, as shown in Fig. 1d. It is usually curb-mounted on the roof and should be completely weathertight. The outside casing is usually made of heavy-gauge galvanized steel or aluminum sheets with corrosion-resistant coating and sealant at the joints, both inside and outside. The fan motor, water valves, damper actuator linkages, and controls are all installed inside the casing. Access doors are necessary for service and maintenance of fans, coils, and filters. An indoor AHU is usually located in the fan room. Small AHUs are sometimes ceiling-hung.



FI 1 Type of air-handling units (AHUs): (a) horizontal, draw-through unit; (b) vertical draw-through unit; (c) blow-through unit, multizone AHU; (d) makeup air AHU, custom-built, rooftop unit.

MAIN COMPONENTS

Because of the impact of the indoor air quality (IAQ), the design and the construction of the AHU have been affected in many ways, as discussed in Gill (1996).

Casing

Two kinds of casings are more widely used for new AHUs today: (1) a double-wall sheet-metal casing in which the insulation material is sandwiched between two sheet-metal panels of 1- to 2-in. (25- to 50-mm) thickness with a U value from 0.12 to 0.25 Btu /h ft² °F (0.68 to 1.42 W/m² °C) and (2) single sheet-metal panel with inner insulation layer and perforated metal liners. Although insulating materials such as glass fibers and mineral wool are inert, when they become wet and collect dirt, both the glass fiber and the glass fiber liner provide the site and source of microbial growth. In addition, glass fiber liner is susceptible to deterioration and erosion over time. With a double-wall sheet-metal casing, glass fibers are not exposed to the moisture of the ambient air. Its inner surface can also be cleaned easily. Perforated metal liners cannot isolate the insulating material from the ambient moisture, but they are helpful to attenuate the fan noise. The outside surface of the casing is often coated with an ultraviolet-resistant epoxy paint. The interior surface is better coated with a light color paint which increases the ability to spot the debris and microbial growth. Hinged access panels to the fan, coils, and filter sections must be provided for inspection and maintenance. Thermal break construction employs a resin bridge between the exterior and interior panels to interrupt the through-metal path heat transfer. A well-sealed doublewall metal panel should have an air leakage of only 1 cfm / ft² (5.078 L / s m²) panel at a 4 in. WC (1000 Pa) of outer and inner static pressure difference.

Fans

A double-inlet airfoil, backward-inclined centrifugal fan is often used in large AHUs with greater cfm (L / s) and higher fan total pressure for its higher efficiency and lower noise. Vane-axial fans with carefully designed sound-absorptive housings, sound attenuators at inlet and outlet, and other attenuations can now provide a sound rating of NC 55 in the fan room. Although the forwardcurved centrifugal fan has a lower efficiency at full load, it is more compact and its part-load operating characteristics are better than those of a backward-inclined centrifugal fan. It is often used in small AHUs and where cfm (L/ s) and fan total pressure are lower. For VAV systems, a dedicated outdoor air injection fan is sometimes used to provide outdoor ventilation air according to demand at both full and part load. An axial relief fan or an unhooded centrifugal return fan may be added as an optional system component. A return fan is used when the total pressure loss of the return system is considerable. Large fans are usually belt-driven. Only small fans are sometimes direct-driven. As mentioned in Sec. 15.4, an adjustable-frequency variable-speed drive saves more energy than inlet vanes for VAV systems during part-load operation. It is often cost-effective for large centrifugal fans although a variable-speed drive is expensive. Inlet vanes are not suitable for small airfoil or backward-inclined centrifugal fans because they block the air passage at the fan inlet. Generally, a centrifugal fan has a higher efficiency and at the same time a lower noise. Given two fans of the same model, both with the same cfm (L / s) and fan total pressure, a centrifugal fan that is greater in size and slower in speed creates less noise.

Coils

In AHUs, the following types of coil are often used: water cooling coils, water heating coils, electric heating coils, and water precooling coils.. Electric

heating coils are made with nickel-chromium wire as the heating element. Ceramic bushes float the heating elements, and vertical brackets prevent the elements from sagging. In a finned tubular element sheathed construction, the electric heating coil is usually made with a spiral fin brazed to a steel sheath. An electric heating coil is usually divided into several stages for capacity control. When an electric heating coil is installed inside an AHU, the manufacturer should have the assembly tested by the Underwriters' Laboratory (UL) to ensure that its requirements are met. Otherwise, the heater may only be installed outside the AHU as a duct heater, with a minimum distance of 4 ft (1.2 m) from the AHU. Various safety cutoffs and controls must be provided according to the National Electrical Codes and other related codes. Cooling and heating coils need periodic cleaning and freeze-up protection in locations where the outdoor air temperature may drop below 32°F (0°C) in winter. Condensate pan and condensate drain line must be properly designed and installed.

Filters

Air filtration is an important component to achieve an acceptable indoor air quality. In AHUs, earlier low-efficiency filters of the panel type are giving way to the medium- and high-efficiency bag type and cartridge type of filters. Carbon-activated gaseous absorption filters are also used to remove objectionable odors or volatile organic compounds (VOCs) in buildings. Newly developed air filters are more efficient at removing air contaminants of particle size between 0.3 and 5 μ m which are lung-damaging dust.

Humidifiers

Usually, there is no humidifier installed in the AHU for comfort air conditioning systems; but the outdoor climate is very cold in winter so that if a humidifier is not employed, the winter indoor relative humidity may be too low.

Humidifiers are necessary for health care facilities and processing systems in pharmaceutical, semiconductor, textile, communication centers, and computer rooms. Steam grid or electric heating element humidifiers are widely used in AHUs where a warm air supply and humidity control are needed in winter. Ultrasonic humidifiers are often used for buildings in which a cold air supply and humidity control are required. For industrial applications such as textile mills where humidity control, air washing, and cold air supply are needed all year round, an air washer is often used for these purposes.

Outdoor Air Intake, Mixing, and Exhaust Section

An outdoor air intake, mixing, and exhaust section includes an outdoor air intake, an exhaust outlet, dampers, a mixing box, and a return fan or a relief fan. The location of outdoor air intake has a direct impact on space IAQ.

- The outdoor air intake for each AHU should install with wind shield and louvers to prevent rain and birds. If the AHU is located on the roof, the bottom of the outdoor intake louvers should be at least 3 ft above the the roof.
- The outdoor air intake must be located as far away from the exhaust outlets and plumbing vent stacks (horizontally and vertically) as possible, to prevent the intake of exhaust contaminants, condensation, and freezing which may provide a means of growth of microorganisms. Codes and local regulations should be followed.
- The outdoor air intake should reflect the influence of the prevailing winds.
- An outdoor intake system should be provided with air filters or even air cleaners in locations where outdoor air contaminants exceed the National Primary Air Quality Standard. For better outdoor ventilation air control, an outdoor damper should split into two dampers: a minimum outdoor

ventilation damper and an economizer damper of 100 percent outdoor air free cooling except in small AHUs. Both should provide a short ducted outside path for air balancing and install with airflow measuring station, or a minimum outdoor ventilation air injection fan and control if necessary. Poor mixing, such as parallel outdoor and recirculating airstreams in the mixing box, causes stratification of the mixture. This is one of the important causes of coil freezing in locations where the outdoor air temperature drops below 32°F (0°C). For good mixing, airstreams should meet at a 90° angle or opposite each other, as shown in Fig. 2. Recently, there is a trend to use an unhooded plug / plenum fan as a return fan in many AHUs and PUs. Usually, a return fan is located nearly in the center of an exhaust compartment, as shown in Fig.3. The exhaust and recirculating dampers form two sides of the exhaust compartment. A plug / plenum fan has the advantage of discharging from both exhaust and recirculating dampers and is quieter. After the recirculating damper, the mixture enters the coil section.

Controls

AHU controls include generic, specific, safety, and diagnostic controls. The economizer control, discharge air temperature control, duct static pressure control, outdoor ventilation air control, humidity, and warm-up or cool-down controls.

Component Layout

In a typical horizontal, drawn-through AHU, the layout of the components in serial order is usually as follows:

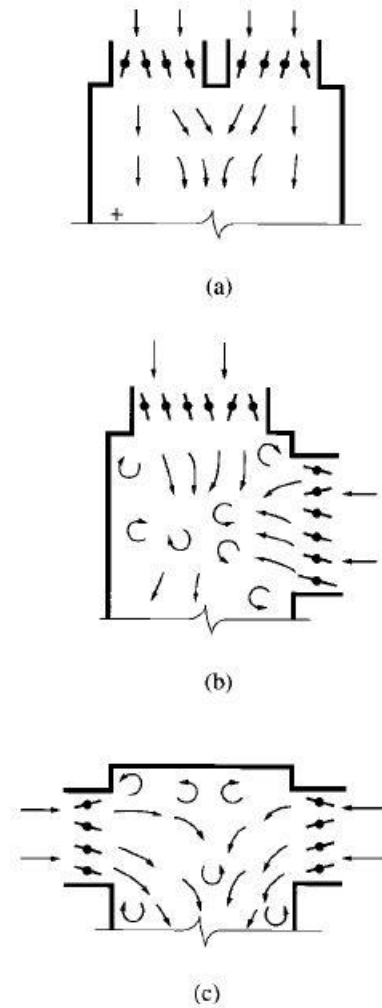


Fig. 2 Mixing of outdoor and recirculating airstreams: (a) parallel airstreams (poor mixing); (b) airstreams at 90° (good mixing); (c) opposite airstreams (good mixing).

1. Return or relief fan, exhaust air passage and damper (optional)
2. Mixing box with outdoor air and recirculating air dampers
3. Filters: (prefilter, optional) medium-efficiency filters
4. Preheating coil (optional)
5. Precooling coil (optional)
6. Cooling coil
7. Heating coil (optional)
8. Supply fan
9. Humidifier (optional)
10. High- or ultrahigh-efficiency filters (optional)

If there is a relief fan, it should be located on one side of the exhausting compartment or in the relief or exhaust passage. If there is an unhoused return fan, it should be located nearly in the center of the exhaust compartment. The volume flow and fan total pressure of the return fan should be carefully determined so that the pressure inside the exhaust compartment is positive; and the pressure inside the mixing box must be negative in order to extract outdoor air, except an outdoor air projected fan is installed in the outdoor air passage .

In an AHU, to condition a mixture of outdoor and recirculating air is often simpler and less expensive than to condition the outdoor air and recirculating air separately. Therefore, the mixing box is usually located before the filters and the coils. A preheating coil is always located before the water heating and cooling coils for the sake of freeze-up protection. A always located before a cooling coil for a greater temperature difference between the air and water. A steam grid humidifier is usually located after a heating coil because humidification is more effective at a higher air temperature. If there are ultrahigh-efficiency filters, they should be located as near to the clean room or clean space as possible to prevent

pollution from the ductwork or elsewhere. Low- or medium-efficiency prefilters must be installed ahead of the coils.

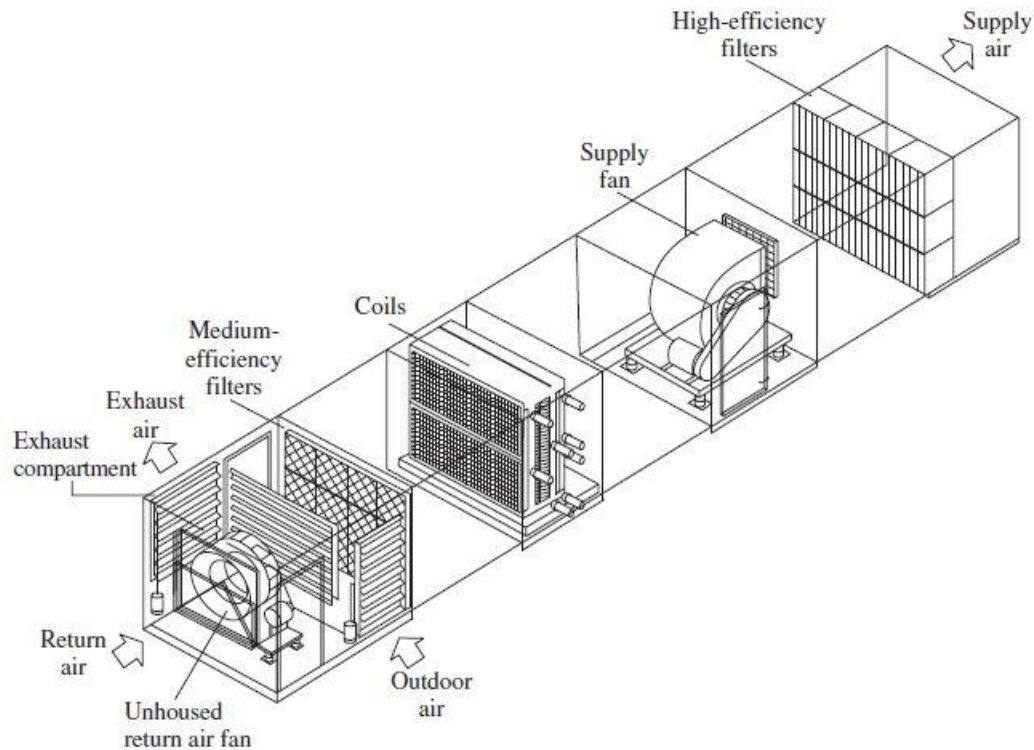


Fig.3 A typical AHU with unboxed plug/plenum return fan.

Coil Face Velocity

The size, or more accurately, the width and height of a horizontal AHU, is mainly determined by the face velocity of the coil. A higher coil face velocity results in a smaller coil, a higher heat transfer coefficient, a greater pressure drop across the coil and filter, and a smaller fan room, which directly affects the space required. On the contrary, a lower coil face velocity has a larger coil, a lower heat-transfer coefficient, and a smaller pressure drop and fan energy use. The maximum face velocity is usually determined according to the value required to

prevent carryover of water droplets due to condensate from a cooling coil. As mentioned in Secs. 10.2 and 15.10, the cooling coil face velocity should not exceed 500 fpm (2.5 m / s) for a smooth fin coil and 550 fpm (2.75 m / s) for corrugated fins. The lower limit of the coil face velocity depends mainly on the initial and energy cost analysis, including cost of the AHU, fan room size, the total number of annual operating hours, and the unit rate of electric power. A lower limit of face velocities between 400 and 450 fpm (2 and 2.25 m / s) at design conditions may be considered appropriate under many specific circumstances. For a fan room of adequate head room, it is preferable to use a high coil to reduce the face velocity and the pressure drop of coils and filters. Use of a high coil has little influence on the floor area of the fan room except that when a coil is higher than 42 in. (1070 mm), a cooling coil should split into two coils vertically and use two separate condensate pans vertically to prevent condensate carryover.

References:

- 1- HANDBOOK OF AIR CONDITIONING AND REFRIGERATION,
Shan K. Wang, Second Edition McGraw-Hill, 2000.**