HVAC - Guide to Air Handling Systems Design

An Online Continuing Education Course for Engineers

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HVAC – Guide to Air Handling Systems Design

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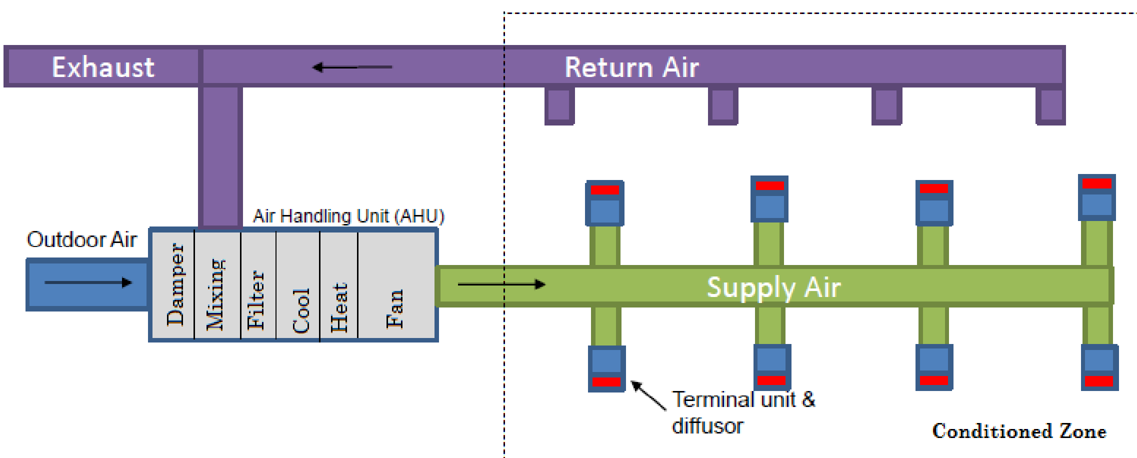
An Air Handling Unit (AHU) is a device used to condition and circulate air as part of a heating, ventilating, and air-conditioning (HVAC) system. The supply of air for most air-conditioning systems is a mixture of outdoor air and recirculated air. These are called recirculation type AHU, where the required amounts of outdoor air and return air are mixed in the mixing chamber and passes through heating or cooling coils. The temperature of the discharge air is altered and maintained within predetermined limits by means of control systems. The conditioned supply air is than discharged into the space through ductwork and supply air diffusers located on the drop ceiling.

The diagram below shows the logical flow of air through an AHU:



Sometimes AHUs discharge (supply) and admit (return) air directly to and from the space served, without ductwork. They can be used in many other applications, for example, they can be used for providing smoke control, maintaining pressure relationships between spaces, and providing fresh air for occupants.

This 7-hr course provides general information and guidance on the selection of air handling systems. While much of the discussion in the remainder of the course relates primarily to large AHUs, the general considerations can be applied to any size.

CHAPTER 1
Air Handling Unit Sizing Factors

An Air-Handling Unit (AHU) is a factory made encased assembly consisting of a fan or fans and other necessary sections like coil, filters etc. to perform one or more of the functions of circulating, cleaning, heating, cooling, humidifying, dehumidifying and mixing of air. A central Air Handling Unit is more likely to be tailor made for a given project although they are available as standard units which comprise of a number of modules, each module providing a particular function.

The thermal load of the occupied zones determine the capacity of the heating/cooling coil (in BTUH or Tonnage) and the air flow calculation determines the fan capacity (in cubic feet per minute or CFM). Standard small and modular AHU's are typically designed to deliver 400 CFM air flow rate per ton of refrigeration (12000 BTUH).

Heating and Cooling Load

The function of the AHU is to provide conditioned air in sufficient quantity to offset the heat gains to the space (in the cooling mode) and the heat losses (in the heating mode), while maintaining the required temperature and humidity in the space.
The heat gains or heat losses in a building are the result of heat transfer through:

1. The building envelope (solar heat gain through windows and skylights, and infiltration through openings);
2. Internal sources originating within the building envelop (for example, heat gain through lighting, people, and equipment).
3. Outdoor airflow for ventilation and building pressurization.

Normally, the heat loss calculations are carried out assuming steady state conditions (no solar radiation and steady outdoor conditions). Credit for internal heat gains is usually NOT included and the thermal storage effects of building structure are generally ignored. This is a simple and conservative approach.

For estimating cooling loads, one has to consider the unsteady state processes, as the peak cooling load occurs during the day time and the outside conditions also vary significantly throughout the day due to solar radiation. The thermal storage characteristics of the building play a vital role because the time at which the space may realize the heat gain as a cooling load will be considerably offset from the time the heat started to flow. The cooling load calculations are therefore inherently more complicated and we will focus more on the cooling applications in this course.

Airflow

Air flow calculation determines the fan capacity of the air handling unit. This is single most important factor that affects the physical size (foot print) of air handling unit and is important factor while conceptualizing the space requirements for mechanical rooms and also the air-distribution ducts.

HVAC engineers use "Psychrometric" analysis for sizing the coils and for estimating the air flow rates required to be pushed into the ducting system. We will learn how to solve air conditioning problems through psychrometrics but before let's refresh some basic thermodynamic properties of moist air.

Basic Properties of Air

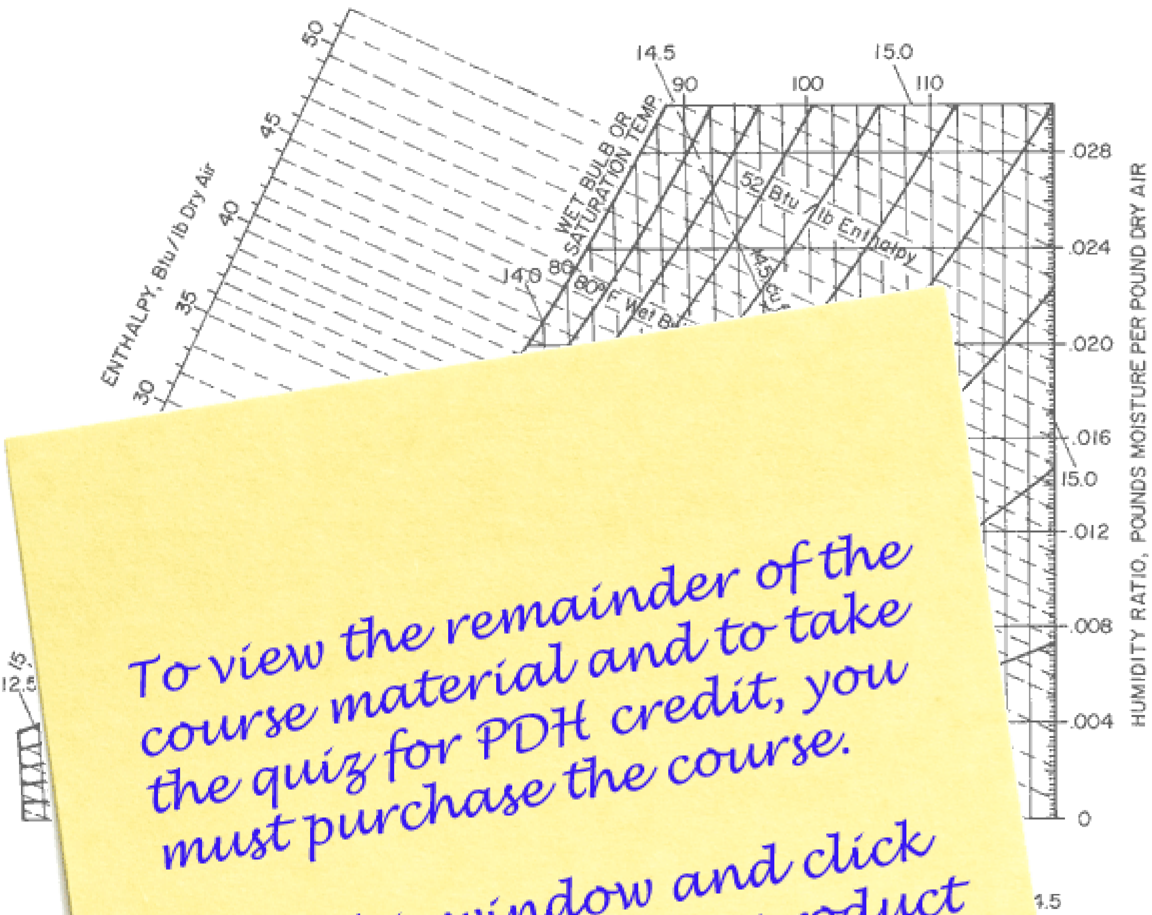
1. Dry air is comprised of 78.1% nitrogen, 21% oxygen, and has trace amounts of ten additional elements totalling 0.9%. The air around us is a mixture of dry air and water vapour. When this moist air reaches a level at which it cannot hold any more moisture, it is said to be - saturated. The colder the air, the less moisture which can be held in the air while warmer air can hold larger quantities of moisture in the air.
2. The moisture in dry air (its specific humidity) is measured in grains of moisture per pound of air (7,000 grains equal 1 pound). Air at 75°F and 60% RH has an absolute humidity of 78 grains of water per pound (7000 grains) of dry air.
3. Sensible heat is the heat associated with a temperature change of a substance at a constant moisture level. Sensible heat can be — sensed or felt and quantified by measurement with a dry bulb thermometer. Sensible heat shows on the psychrometric chart as a horizontal line; there is no resulting change in the amount of water vapour in the air.
4. Latent Heat is the heat associated with the phase change of the substance. For example, if sufficient latent heat is added to water in the liquid state, it will change state into a vapour or steam. The change of state from a liquid to steam is called the —latent heat of vaporization and from a steam to a liquid is called —the latent heat of condensation. The change of state from a liquid to a solid is called —the latent heat of fusion and from a solid to liquid the - latent heat of melting. Latent heat appears on the psychrometric chart as a vertical line.
5. Enthalpy is a measure of total heat content of a substance including sensible and latent heat. It is a true measure of energy required to change state. Can be used to determine actual cooling loads including latent heat removal.

Psychrometric Chart

Atmospheric air is a mixture of air and water vapour. The psychrometric chart is a graph showing the various concentrations of water vapour in the air and the associated temperatures, densities and energy contents. It provides an interrelation of 7 thermodynamic properties of air-water mixtures at different conditions.

1. **Dry Bulb Temperature:** The Dry Bulb Temperature is the temperature of the air and water vapor mixture as measured by a simple thermometer. (Measured in Celsius or Fahrenheit).
2. **Wet Bulb (or Saturation) Temperature:** When discussing a mixture of water vapor and air, the Wet Bulb Temperature is the lowest air temperature achievable by evaporative water into the air to bring the air to saturation. This property is usually measured using a wet bulb thermometer or psychrometer (Measured in Celsius or Fahrenheit).
3. **Relative Humidity:** A quantity used to describe the ratio of water vapor to air in a humid air sample. Thermodynamically, this quantity is defined as the ratio of the partial pressure of water vapor in the air-water mixture to the saturated vapor pressure of water at the same conditions (pressure and temperature of the mixture). (Usually stated as a percentage).
4. **Dew Point:** Dew Point (DP, DPT) is the temperature at which water vapor in moist air starts condensing when it is cooled. When air is at 100% relative humidity, it is at dew point and water vapor will begin to condense if it is cooled any further.
5. **Humidity Ratio:** The Humidity Ratio is defined as the mass ratio of liquid water to dry air in a gas and vapor mixture. This quantity is usually expressed in pounds of moisture per pound of dry air.
6. **Enthalpy:** Enthalpy is the heat energy content of moist air. It is usually expressed in Btu/lb of dry air or KJ/kg of dry air and represents the heat energy due to temperature and moisture in the air.
7. **Specific Volume:** The volume of an air and water vapor mixture that contains one unit mass of dry air. Usually expressed in cubic meters per kilogram of dry air, or cubic feet per pound of dry air.

The psychrometric chart is a very useful tool to unlock the mystery surrounding the seven properties of air. If any two properties of the air mixture are known, the other five thermodynamic properties can be determined



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Processes N

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- Heating …
- Humidification and dehumidification
- Heating and humidification
- Cooling and dehumidification
- Evaporative cooling
- Chemical dehydration