

Advanced Psychrometric Design Examples for HVAC Systems

An Online Continuing Education Course for Engineers

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Advanced Psychrometric Design Examples for HVAC Systems

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Maintaining thermal comfort for building occupants is one of the most important goals of heating, ventilation, and air conditioning (HVAC) engineers. To properly design commission and operate the HVAC systems for environmental control, it is essential to appreciate the underlying processes that characterize the changes in the air—the psychrometric processes.

A psychrometric chart provides a convenient way to look at the air conditioning processes and is crucial in accurately computing the heat and moisture transfer rates, the required airflow rates to be pushed through the air-conditioning ducts and the sizing of the major system components. This phase, in an air-conditioning design process, follows the load calculation phase. While the load calculation phase produces quantities that represent the sensible and latent loads imposed on the conditioned space, the psychrometric analysis identifies various processes to be performed on air to satisfy the building heat (room loads). The psychrometric analysis is capable of incorporating the effects of introducing fresh outside air into the space for ventilation purposes (grand load) and the inefficiencies of the equipment (effective load). The analysis is inherently capable of distinguishing between the sensible and latent load quantities of outside and conditioned space (room) air, thus providing an insightful picture of how to handle not only the temperature but also the moisture.

There are generally four extreme climatic conditions that an air conditioning system may face. In summer operation, for example, the dry-bulb temperature of the outdoor air is always high, but the humidity ratio may either be high or low. In hot and humid climates (such as Miami, Florida), the air conditioning system is typically composed of a cooling coil whose surface temperature is below the dew point temperature. That way, both cooling and dehumidification can be achieved by the system. In hot and dry climates (such as Phoenix, Arizona), on the other hand, evaporative coolers could be the most beneficial.

Winter conditions may have similar extremes, with the dry-bulb and dew point temperatures being both low. In extremely cold conditions (such as Minneapolis, Minnesota), the

environment is typically very dry. In this case, the air conditioning system is typically composed of heating followed by a humidifying device. The humidifying device may be a spray washer or steam injector.

In cases where the outdoor air is cool but humid (such as Seattle, Washington), there may not be a need to humidify the air, and the air conditioning system is typically composed of a heating coil only. However, because of the fact that the humidity ratio at low temperatures is low even though the relative humidity may be high, some humidification may be required when the dew point is low during the winter season.

To enable you to take an active part in the design, installation or operation of HVAC services, this course provides an intensive understanding of the very essential psychrometric principles and applications to HVAC systems. The course includes numerous calculations and examples of how the psychrometric analysis may be used in the HVAC design process for different summer and winter systems.

Prerequisite: Before studying this course module, it is expected that you have the basic fundamental knowledge of air properties, psychrometric chart, and air conditioning processes. For beginners and novice engineers, it is strongly recommended to first undertake the Level-1 course “Application of Psychrometrics in Heating and Cooling Systems.”

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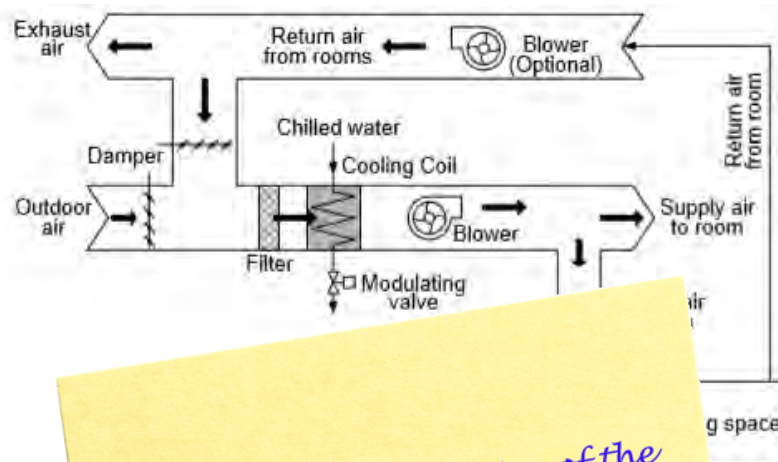
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Chapter 1: Air Conditioning System and Cooling Loads

1.0. Air Conditioning System

A typical central air conditioning process involves mixing a portion of outdoor air with return air from the room. In summer air conditioning, the mixed air flows through the air conditioning equipment where heat and moisture are removed, as required, to maintain the desired conditions. The cool and dehumidified air is then supplied to the space, where it picks up room loads generated due to: (a) heat flow through building façade - walls, roofs, and windows, (b) appliances generating heat, lighting, appliances, and occupants within the space, and (c) unintended air infiltration. The latent cooling load is due to (a) the moisture released by appliances and occupants within the space, and (b) moist air infiltration.

A typical air conditioning system is shown schematically in the Figure below.



To maintain good space conditions, the return air is exhausted to the atmosphere and replaced by outdoor air as shown. The amount of outdoor air is determined on the ventilation requirements, including the infiltration of air into the space. The outdoor air is filtered and treated (cooled and dehumidified in summer and heated in winter conditions, then the system supplies warm air to balance the heat loss through the building envelope, (b) fresh air ventilation to balance the increased cold air infiltration into the space.

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