HVAC Cooling Load Calculations and Principles

An Online Continuing Education Course for Engineers

Course Number: HV-6011

Credit: 6 Hours / 6 PDH / 6 CPD

HVAC Cooling Load Calculations and Principles

A. Bhatia, Mechanical Engineer

1.0 OBJECTIVE

Cooling load calculations may be used to accomplish one or more of the following objectives:

a) Provide information for equipment selection, system sizing, and system design.
b) Provide data for evaluating the optimum possibilities for load reduction.
c) Permit analysis of partial loads as required for system design, operation, and control.

This course provides a procedure for preparing a manual calculation for cooling load. A number of published methods, tables and charts from industry handbooks, manufacturer's engineering data and manufacturer's catalog data usually provide a good source of design information and criteria in the preparation of HVAC load calculation. It is not the intent of this course to duplicate this information but rather to extract appropriate data from these documents as well as provide a direction regarding the proper use or application of such data so that engineers and designers involved in preparing the calculations can make the appropriate decision and/or apply proper engineering judgment.

The course includes two example calculations for better understanding of the subject.

2.0 TERMINOLOGY

Commonly used terms relative to heat transmission and load calculations are defined below in accordance with ASHRAE Standard 12-75, Refrigeration Terms and Definitions.

Space is either a volume or a site without a partition or a partitioned room or group of rooms.

Room is an enclosed or partitioned space that is usually treated as single load.

Zone is a space or group of spaces within a building with heating and/or cooling requirements sufficiently similar so that comfort conditions can be maintained throughout by a single controlling device.

British thermal unit (Btu) is the approximate heat required to raise 1 lb. of water 1 degree Fahrenheit, from 59°F to 60°F. Air conditioners are rated by the number of British Thermal Units (Btu) of heat they can remove per hour. Another common rating term for air-conditioning size is the "ton," which is 12,000 Btu per hour and Watts. Some countries utilize one unit more than others; therefore, it is good if you can remember the relationship between *BTU/hr*, *Ton*, and *Watts*.

- 1 ton is equivalent to 12,000 BTU/hr.
- 12,000 BTU/hr is equivalent to 3,516 Watts, or 3.516 kW (kilo-Watts)

Cooling Load Temperature Difference (CLTD) is an equivalent temperature difference used for calculating the instantaneous external cooling load across a wall or roof.

Sensible Heat Gain is the energy added to space by conduction, convection, and/or radiation.

Latent Heat Gain is the energy added to space via the addition of moisture in one of the following ways: by means of vapor emitted from the occupants; generated by a process; or through air infiltration from outside or adjacent areas.

Radiant Heat Gain is the rate at which heat is absorbed by the surfaces enclosing the space and the objects within the space.

Space Heat Gain is the rate at which heat enters into and/or is generated within the conditioned space during a given time interval.

Space Cooling Load is the rate at which energy must be removed from a space to maintain a constant space air temperature.

Space Heat Extraction Rate is the rate at which heat is removed from the conditioned space and is equal to the space cooling load if the room temperature remains constant.

Temperature, Dry Bulb is the temperature of air indicated by a regular thermometer.

Temperature, Wet Bulb is the temperature measured by a thermometer that has a bulb wrapped in wet cloth. The evaporation of water from the thermometer has a cooling effect, so the temperature indicated by the wet-bulb thermometer is less than the temperature indicated by a dry-bulb (normal, unmodified) thermometer. The rate of evaporation from the wet-bulb thermometer depends on the humidity of the air. Evaporation is slower when the air is already full of water vapor. For this reason, the difference in the temperatures indicated by ordinary dry-bulb and wet-bulb thermometers gives a measure of atmospheric humidity.

Temperature, Dewpoint is the temperature to which air must be cooled in order to reach saturation or at which the condensation of water vapor in a space begins for a given state of humidity and pressure.

Relative Humidity describes how far the air is from saturation. It is a useful term for expressing the amount of water vapor when discussing the amount and rate of evaporation. One way to approach saturation, a relative humidity of 100%, is to cool the air. It is therefore useful to know how much the air needs to be cooled to reach saturation.

Thermal Transmittance or Heat Transfer Coefficient (U-factor) is the rate of heat flow through a unit area of building envelope material or assembly, including its boundary films, per unit of temperature difference between the inside and outside air. The U-factor is expressed in Btu/ (hr $^{\circ}$F ft^2).

Thermal Resistance (R) is the reciprocal of a heat transfer coefficient and is expressed in (hr $^{\circ}$F ft^2)/Btu. For example, a wall with a U-value of 0.25 would have a resistance value of R = I/U = 1/0.25 = 4.0. The value of R is also used to represent Thermal Resistivity, the reciprocal of the thermal conductivity.

3.0 SIZING YOUR AIR-CONDITIONING SYSTEM

Concepts and fundamentals of air-conditioner sizing are based on heat gain and/or losses in a building. Obviously, you will need to *remove* the amount of heat gain if it is hot outside. Similarly, you'll need to *add in* the heat loss from your space if the outside temperature is cold. In short, heat gain and heat loss must be *equally* balanced by heat removal and addition to get the desired room comfort that we want.

The heat gain or heat loss through a building depends on:

a. The temperature difference between the outside temperature and the desired temperature.

b. The type of construction and the amount of insulation in the ceiling and walls. Let's say that you have two identical buildings—one is built out of glass, and the other out of brick. Of course, the one built with glass would require much more heat addition, or removal, compared to the other—within a given day—because glass has a higher thermal conductivity (U-value) compared to brick and it is transparent, which allows direct transmission of solar heat.

c. How much shade is on your building’s windows, walls, and roof? Two nearly identical buildings with different orientations to the direction of the sunrise and sunset will also differ in air conditioner sizing.

d. How large is your room? The larger the surface area of the walls, the more heat can lose or gain through them.

e. How much air leaks into indoor space from the outside? Infiltration plays a part in determining air conditioner sizing. Door gaps, cracked windows, chimneys—these are the "doorways" for air to enter from the outside, into your living space.

f. The occupants. It takes a lot to cool a town hall full of people.

g. Activities and other equipment within a building. Cooking? Hot bath? Gymnasium?

h. Amount of lighting in the room. High efficiency lighting fixtures generate less heat.

i. How much heat the appliances generate. Power equipment such as ovens, washing machines, computers, and TVs all contribute to heat.

An air conditioner's efficiency, performance, durability, and cost depend on matching its size to the above factors. Many designers use a simple square foot method for sizing air conditioners. The most common rule of thumb is to use "1 ton for every 500 square feet of floor area." Such a method is useful in preliminary estimation of the equipment size. The main drawback of rules-of-thumb methods is the presumption that the building design will not make any difference. Thus, the rules for a badly designed building are typically the same as for a good design.

It is important to use the correct procedure for estimating heat gain or heat loss. Two groups—the Air Conditioning Contractors of America (ACCA) and the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)—publish calculation procedures for sizing central air conditioners. Reputable air-conditioning contractors will use one of these procedures, often performed with the aid of a computer, to size your new central air conditioner.

3.1 Heating Load versus Cooling Load Calculations

As the name implies, heating load calculations are carried out to estimate the heat loss from the
building in winter so as to arrive at required heating capa... ...mally during winter months
the peak heating load occurs before ... ...ns do not vary significantly
throughout the wi... ...as occupants or appliances
are beneficial as th... ..., normally, the heat load
calculations are ca... ...radiation and steady
outdoor conditions)... ...ple but conservative
approach that leads ... ...r more accurate estimation
of heating loads, one ... ...e walls and internal heat
sources, which make...

To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

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For estimating coolin... ...esses, as the peak
cooling load occurs d... ...ary significantly
throughout the day du... ...add on to the cooling
loads and neglecting t... ...cooling capacity and the
possibility of not being... ...us, cooling load
calculations are inhere...

In determining the heat... ...heat gain or internal heat gains is usually NOT included and the thermal storage effects of building structure are generally ignored. In cooling load calculations, however, 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.

We will discuss this further in succeeding sections.