CHAPTER - 1: HEATING AND COOLING LOADS

Heating and cooling loads pertain to the amount of energy required to add heat (heating) or extract heat (cooling) to achieve and sustain the desired temperature and humidity levels within an indoor space.

1.1 Cooling and Heating Load Calculations

Determination of cooling and heating loads is a first critical step for designing an air conditioning system for summer and winter operations. HVAC equipment selection, ductwork sizing, and the HVAC system's control approach are all influenced by the heating and cooling loads.

Cooling and heating load calculations consider multiple factors that affects the cooling and heating requirements of a building, including:

a. **Climate:** The climate of the region where the building is located will have a significant impact on the cooling and heating loads.
b. **Insulation levels:** The insulation levels in the building's walls, roof, and windows will affect how much heat is lost or gained through the building envelope.
c. **Occupancy:** The number of people in the building and their activities will generate heat, which will need to be removed by the HVAC system.
d. **Lighting:** The amount of lighting and appliances in the building will also generate heat, which will need to be removed by the HVAC system.
e. **Equipment and Appliances:** There are other sources of heat in a building, such as equipment and appliances. These heat gains will also need to be removed by the HVAC system.
f. **Ventilation and Infiltration:** ASHRAE Standard 62.1 requires certain outside air typically 20 cubic feet per minute (CFM) per person to be introduced in space for maintaining indoor air quality (IAQ). This treatment and conditioning of fresh air adds to heating or cooling loads.

Why HVAC Load Calculations are Important!

Here are some key reasons why cooling and heating load calculations are important:

Benefits of Proper Heating and Cooling Load Calculations		
	Right-sizing equipment	*The HVAC system's size and capacity are determined by the building's cooling and heating needs. If it's undersized, it won't be effective, and if it's oversized, it will waste energy and be inefficient.*
	Reduced Energy Consumption	*Properly sized equipment will use less energy, which will save money on utility bills.*
	Optimal comfort conditions	*When HVAC equipment is oversized, the building may become too cold, and when it's undersized, it may become uncomfortable.*
	Indoor air quality	*Accurate load calculations ensure the ventilation system is the right size for the building, meeting occupancy needs without wasting energy and following codes. ASHRAE Standard 62.1 sets minimum ventilation rates for different buildings, and accurate calculations help meet these requirements.*
	Cost-effectiveness	*Accurate load calculations make HVAC systems cost-effective. They help avoid oversized equipment, saving on upfront costs. Right sizing the system improves energy efficiency, leading to long-term savings on energy consumption and utility bills.*
	Equipment longevity	*Accurate load calculations are essential for efficient and durable HVAC equipment. If the equipment is too big or too small, it can wear out quickly, work inefficiently, and have a shorter lifespan. Load calculations help designers ensure the system operates as intended, lasting longer with fewer breakdowns and maintenance issues.*

1.2 HVAC Capacity

The cooling or refrigeration capacity is measured in "tons of refrigeration (TR)" in USA.

The term "ton" in this context is not a measure of weight but rather a historical reference to the amount of cooling power required to melt one short ton (2,000 pounds or approximately 907 kilograms) of ice in 24 hours.

	Refrigeration Load (Tons and KW)
	A ton of refrigeration (nominal) is defined as the ability of air conditioning equipment to remove 12,000 British Thermal Units (BTUs) of heat per hour. *"Nominal" is used for air conditioning equipment because achieving the exact 12,000 BTUs/hr. per ton is difficult due to derating of equipment capacity at high outdoor air temperatures.*
	In countries where the metric system is more prevalent, the cooling capacities are often measured in kilowatts (kW, thermal). *A ton of refrigeration is equivalent to approximately 3.516 kilowatts (kW).*

1.3 Heating Load

Heating load refers to the heat rate necessary to sustain desired indoor temperatures during winter. The key factors affecting heating loads are:

a. **Outside air temperature:** The cooler the outdoor air temperature, the higher will be the heat loss. Buildings need to be well insulated to reduce the heat loss.
b. **Building envelope construction:** Heat losses through the walls, roof, floor, and windows: The amount of heat lost through these components depends on their overall thermal transmittance or U-value. The U-value is a measure of how well a material conducts heat.
c. **Ventilation and infiltration:** Ventilation and infiltration heat loss through the building: Ventilation is the intentional introduction of outside air into a building. Infiltration is the unintentional introduction of outside air into a building. Both ventilation and infiltration can cause heat loss, as the outside air must be heated to the desired indoor temperature.

1.3.1 Heating Load Exemptions – Factors to Exclude!

Certain contributors to heat gain should be excluded from heat load calculations owing to their inherent unpredictability.

	Solar	*Credit for solar gains should not be taken unless building is specifically designed for solar heating. Solar gain is not a factor at night when design temperatures generally reach their lowest point.*

	People	*Credit for people should not be taken. People gain is not a factor at night when design temperatures generally reach their lowest point because buildings are generally unoccupied at night.*
	Lighting	*Credit for lighting should not be taken. Lighting is an inefficient means to heat a building and lights are generally off at night when design temperatures generally reach their lowest point.*
	Equipment	*Credit for equipment should not be taken unless a reliable source of heat is generated 24 hours a day (i.e., Computer Facility, Industrial Process).*

1.4 Cooling Load

The cooling load refers to the rate at which heat must be extracted from conditioned areas to achieve the desired comfort conditions. Although heat gain and cooling load should ideally align, variations often arise due to heat retention in objects and the subsequent time lag in releasing the stored heat.

	The total cooling load of a building comprises heat transferred through the building envelope (walls, roof, floor, windows, doors, etc.) and heat generated by occupants, equipment, and lighting.

1.4.1 External and Internal Loads

Buildings can be classified as externally loaded or internally loaded depending on their primary cooling load source. The heat transfer occurring through the building's envelope (walls, roof, and glass) and ventilation air is referred as the external load, whereas other loads such as heat gain from lights, equipment and people fall under the category of internal loads.

The total cooling load includes two kinds of loads – sensible load and latent load.

1.4.2 Sensible Loads

Sensible loads impact the dry bulb temperature.

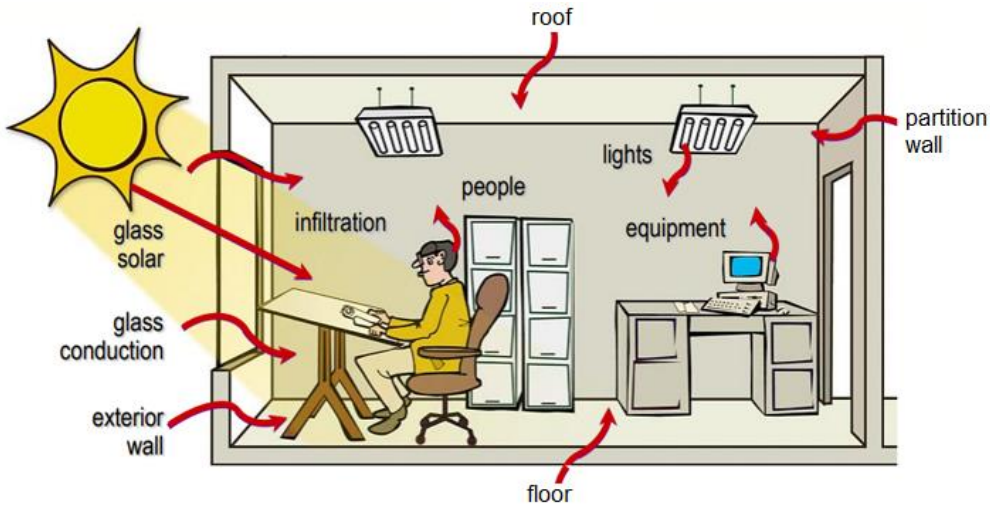

Figure 1. Various Heat Gain in a building

Sensible loads impact the temperature of the conditioned space. It originates from sources such as:

a. Heat transmission through building structures (walls, roofs, windows, etc.) exposed to solar radiation.
b. Direct heat transmission through glass surfaces.
c. Heat brought in by outdoor ventilation air.
d. Heat carried in by outdoor leaking air.
e. Internal heat loads from lighting, appliances, office equipment, human occupants, and other motor loads.
f. Miscellaneous heat gains through duct walls, supply duct leakages, and fan motor heat gains.

The summation of all these elements will provide the total sensible heat loads.

1.4.3 Latent Loads

Latent loads impact the moisture content of the conditioned space. It originates from sources such as:

a. Ventilation and infiltration.
b. Respiration, and perspiration.

c. Cooking, hot baths, and vaporization processes.

The summation of all these elements will provide the total latent gain.

1.4.4 Total Cooling Load

The total cooling load is sum of sensible and latent loads.

> *Sensible load maintains indoor temperature, while the latent load manages moisture content.*

Sizing the cooling system for the total cooling load is essential for achieving optimal performance. An improperly sized system, whether too small or too large, can lead to discomfort, humidity problems, and increased energy consumption.

1.4.5 Space Heat Gain

The space heat gain depends on:

a. Temperature difference between outside and desired temperature
b. Type of construction and insulation
c. Amount of shade on windows, walls, and roof
d. Room size and wall surface area
e. Air leaks from outside and infiltration
f. Number of occupants
g. Activities and equipment within the building
h. Amount of lighting
i. Heat generated by appliances.

The size of the air conditioning system should be matched to these factors to ensure efficiency, performance, durability, and cost-effectiveness.

1.4.6 Cooling Load vs. Heat Gain

> *Cooling load is usually less than building heat gain because cooling load calculation factors in heat storage capacity of the building shell and internal furnishings, which reduce the impact of short-term heat gains.*

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