



Fundamentals of HVAC

Building Loads



What you will Learn in this Lesson

- Occupants
- Ventilation and infiltration
- Lighting
- Miscellaneous electrical equipment loads
- Space conditions
- Orientation of the building
- Functional zoning
- Thermal zoning
- Envelope
- Location
- Weather
- System loads

Introduction

- Cooling load principles
 - Precise calculation is impossible
 - Even the best methods are only a good estimate of actual cooling loads
- Heat flow rates
 - Space heat gain (Instantaneous sensible and/or latent)
 - Space cooling load (to maintain space conditions)
 - Space heat extraction (actual rate of removal)
 - Cooling coil load (rate at the coil)

Introduction

- Space heat extraction
 - Equals load only when equipment is actively running
 - Equipment that cycles doesn't have a constant extraction
- Cooling coil load
 - Extraction plus system loads

Infiltration

- The science of infiltration is rich and broad
- Almost no one uses building science to determine infiltration for loads
- More often than not – a rule of thumb is used
- Infiltration comes from pressure differences
 - Stack effect

Stack Effect

$$\Delta P = C_2 (\rho_o - \rho_i) g (H - H_{NPL}) = C_2 \rho_i g (H - H_{PNL}) \left(\frac{T_i - T_o}{T_o} \right)$$

Where:

ΔP = pressure differences due to stack effect, in of water

ρ = air density , lbm/ft³ (about 0.075 for indoor conditions)

g = gravitational constant 32.2 ft/s²

H = height of observation

H_{npl} = height of neutral pressure level ft

T = average absolute temperature, R

C_2 = unit conversion factor = 0.00598

i = indoor

o = outdoor

Bernouli Equation

$$Q = C_3 C_D A \sqrt{2 \Delta P / \rho}$$

Where:

Q = airflow rate, cfm

C_D = discharge coefficient for the opening, dimensionless

A = cross-sectional area of opening, ft²

ρ = air density, lbm/ft³

ΔP = pressure difference across opening, in of water

C_3 = unit conversion factor = 776

Occupants

- People impact building loads in two ways
 - People themselves are heat sources
 - Roughly 250/200 Btu/hr sensible and latent respectively
 - For acceptable indoor air quality (IAQ) ventilation (outdoor) air is introduced into the building
- **Ventilation air is one of the largest loads in most buildings!**

Ventilation ala' Standard 62.1

- Ventilation rates are calculated to accomplish two main purposes, 1) to replace oxygen consumed by people and dilute the bio-effluents from their presence, and 2) to dilute the off-gassing from building materials.
- The amount of outdoor air which must be admitted by HVAC equipment is calculated with a series of formula found in the standard but the most important value is the amount of outdoor air which is to be introduced into the breathable zone of a space:

Ventilation

$$V_{bz} = R_p * P_z + R_a * A_z$$

Where:

V_{bz} = breathing zone outdoor airflow

R_p = outdoor airflow rate per person from the standard

P_z = the zone population

R_a = outdoor airflow rate per unit area from the standard

A_z = zone floor area: the net occupiable floor area of the ventilation zone

Lighting

- All of the electricity used for lighting ultimately ends up as heat within the space.
- Some of the light escapes through the glass, but this is a very small amount and it is usually not credited.
- Typically, the lighting load is described in Watts per ft² (W/ft²).
- The load ranges from 0.5 W/ft² for industrial lighting to 8 W/ft² for retail applications.

Lighting

- Where the light fixture is located and whether it is vented can impact the supply air requirement for a zone.
- The key issue is what percentage of the heat from the light fixture is directed into the space and what percentage is directed into the ceiling plenum.

Misc. Electrical Loads (Plug Loads)

- Similar to lighting, the electrical energy consumed by equipment within the building ultimately ends up as heat in the space.
- For most applications it is common to allow for design power consumption per area. Commonly this is described as W/ft^2 .
- Typical ranges have increased in the past 10 years due to computers and other office equipment. The common range is 0.5 W/ft^2 to 5 W/ft^2 .

Space Conditions

- Design temperature and humidity conditions are selected to provide occupant comfort or to meet the needs of the equipment (i.e. computers) located within the space
- Thermal comfort conditions can be found in ASHRAE Standard 55
- Design conditions affect the design load in two ways.
 - First, the dry bulb temperature affects the heat transfer rate through the building envelope and the sensible portion of the ventilation and infiltration loads
 - Second, the design relative humidity affects the latent load from infiltration and ventilation. The latter can be significant

Orientation

- Solar loads are a major factor in load analysis. How the building is oriented has direct impact on the calculations
- Exterior shading, whether from a feature on the building (overhangs) or another building, also affect the load calculations
- These calculations are complex since they must take into account the solar azimuth both daily and seasonally

Solar Load

- Solar load can be avoided, or stored, or extracted
- Solar load appears as thermal energy through both glass and opaque wall and roof

Orientation and Geometric Shape affect Loads

- Glass orientation has a direct effect on loads
- Shading can correct bad orientation

Radiation can be direct or indirect

- Trombe Wall: a masonry structure that stores the sun's heat from south facing windows in the winter, releasing it throughout the living space at night.
- In the summer, shading keeps the light from hitting the wall

Location and Weather

- Location impacts energy calculations directly and indirectly in several ways.
- Latitude and altitude are key parameters.
 - Latitude is used to calculate the angle of the sun against the building exterior surfaces.
 - Altitude is used to calculate the density of air.
- Indirectly, selecting the location identifies the weather files and the energy utilities

Location and Weather

- There tends to be regional differences between designers as to how loads are determined and in the available choices for system selection.
- In some regions, the water source heat pump is very common where in other regions it is not.
- Some regions favor the dual duct delivery system.
- A certain load calculation method may have started in one design firm and moved to other firms in the same region as designers tend to move to different employers.

Location and Weather

- The US government has compiled weather data from over five thousand stations around the United States, Canada and other places around the world
- The data that has been collected is available from a variety of sources including ASHRAE handbook of fundamentals and ANSI/ASHRAE Standard 169
- The choice of which weather station is the first decision for a designer

System Loads

- The actual cooling load that is presented to a cooling device such as a coil is composed of several parts
- The effect of the sum of these parts is relatively simple since the coil only knows what it sees presented to it in the form of a certain flow rate of air at a particular moist air condition
- Coils are only heat transfer devices and are not 100% efficient, which explains why air never reaches the saturation curve on the psychrometric chart but approaches to within 10% to 15% of saturation

System Loads

- The process that brings air to a specific condition with lower enthalpy at the cooling coil is known as the system cooling load
- It includes the outside air heat and humidity, the latent heat brought back from the space being conditioned, the sensible heat from the space, the sensible heat that may come from the ductwork carrying the air, and the sensible heat put into the air from compression by a fan such as a supply or return fan

End of Lesson

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Thank You!