HVAC Fundamentals & Concepts

B. Load Calculations

1.Heating Loads

a. Building net heating load
b. System heat losses
c. Heating coil load

2. Cooling Loads

a. Room and building peak cooling load
b. Infiltration and ventilation
c. Cooling coil load

3. Use of psychrometric tables and various software packages for heating and cooling load estimates

Load Calculations

1. Heating Loads

a. Building net and gross heating load

Net heating load is the amount of heat needed for all rooms in the building, or the building net heating load is the amount of heat required for the building at outdoor design conditions. This includes:

i. Building heat transfer losses
ii. Infiltration losses
iii. Ventilation load

b. System heat losses

Heat loss that comes from the loads on the boiler or furnace. This includes:

i. Duct heat transfer loss
ii. Duct leakage
iii. Piping losses (Pickup Factor or Allowance)

***Gross heating load* is the sum of building net heating load and system heat losses.**

Load Calculations Cont'd

b. System Heat Losses

i. Duct Heat Transfer Loss

- In a warm air heating system, if the ducts pass through unheated spaces (attics, basements, shafts, crawl spaces) there is heat transfer from warm air in the duct to the cooler surrounding spaces.
- Duct heat transfer loss is estimated to be approximately 2 – 5% of the building sensible heat loss.
- Factors in estimating duct heat loss include length & insulation of the ductwork, and surrounding temperatures.

ii. Duct Leakage

- In warm air supply, some heat loss will occur when warm air leaks through supply duct seams into surrounding unconditioned spaces.
- Duct leakage is usually estimated at about 5 – 10%, depending on the quality of the sheet meet installation

iii. Pickup Losses

- Heat loss through piping and heat loss during system start-up (pickup factor)
- Heat losses through piping are negligible because the pipes used are small and insulated. However, system start-up is estimated at 10% loss for intermittently heated buildings, and up to 40% for a 10^{o}F temperature setback

Load Calculations Cont'd

1. Heating loads

c. Heating Coil Load

- Reheat also called heating coil load (Dry Expansion or DX coils) is the process where, after the warm air is cooled by the cooling coil, it is partially reheated before being supplied to the air-conditioned space.
- The reheat process may be accomplished with a reheat coil or by using return air or mixed air.
- See the diagram

Load Calculations Cont'd

2. Cooling Loads:

a. Room and building peak cooling load

- Room cooling load is the sum of each of the cooling load components (roof, walls, glass, solar, people, equipment, and infiltration) in the room.
- Cooling load is calculated by using a prepared form below:
  - Insert the table from APPENDIX 511
- Room peak cooling load calculations are the maximum value of the room cooling load calculations. This is because the air-conditioning system must be sized to handle the peak loads.

Load Calculations Cont'd

General guidelines to simplify calculation for Cooling Load Temperature Difference (CLTD), Solar Heat Gain Factor (SHGF) and Cooling Load Factor (CLF) for glass are:

1. *For west-facing glass, maximum load is in mid-summer in the afternoon.*
2. *For east-facing glass, maximum solar load is in early or mid-summer in the morning.*
3. *For southwest-facing glass, maximum solar load is in the fall or winter in early afternoon.*
4. *For southwest-facing glass, maximum solar load is in the fall in the afternoon.*
5. *For roofs, maximum load is in the summer in the afternoon or evening.*
6. *For walls, maximum load is in the summer in the afternoon or evening.*

These generalizations can be used to localize approximate times of room peak loads.

Load Calculations Cont'd

4. a. Building Peak Cooling Load

- The **building cooling load** is the rate at which heat is removed from all air-conditioned rooms in the building at the time the building cooling load is at its peak value.
- Since the peaks do not occur at the same time, the auditor must determine the time of year and time of day at which the building cooling load is at a peak and then calculate it.

Load Calculations Cont'd

Typical building peak cooling loads:

- For buildings that are approximately square shaped in plan with similar construction on all four walls, the peak load is usually in late afternoon in summer. This is because temperature is highest then, and there is no differential influence of solar radiation on the side of a building.
- For buildings with a long south or southwest exposure having large glass area, the peak load may occur in the fall, around mid-day, because radiation is highest then. Careful analysis is required.
- For one-story buildings with very large roof area, the peak load usually occurs in the afternoon in summer.

These suggestions must be verified in each case because there are so many variations in building orientation and construction.

Once the peak load time is determined, the total building heat gains can be calculated.

Load Calculations Cont'd

- Put in example of calculating room and building peak cooling loads

Load Calculations Cont'd

b. Cooling load calculations for lighting, people, equipment & appliances

The equation for determining cooling load due to heat gain from lighting is

$$Q = 3.4 \times W \times BF \times CLF$$

Where

Q = cooling load from lighting, Btu/hr

W = lighting capacity, watts

BF = ballast factor (1.25 for fluorescent lighting, 1.0 for incandescent lighting)

CLF = cooling load factor for lighting

Load Calculations Cont'd

- The factor **CLF** accounts for storage of part of the lighting heat gain. The storage effect depends on how long the lights and cooling system are operating, as well as the construction, type of lighting fixture, and ventilating rate.
- No storage effect can be allowed for any of the following conditions:
  a. Cooling system operates only during occupied hours
  b. Cooling system operates more than 16 hours
  c. Temperature of the space is allowed to rise during non-occupied hours (temperature swing)
- For those cases where they are applicable, they may be found in the *ASHRAE Fundamentals Volume,* otherwise use a value of CFL = 1.0.

Load Calculations Cont'd

- The heat gain from people consists of sensible heat and latent heat resulting from perspiration. Some of the sensible heat may be absorbed by the heat storage effect, but this does not apply to the latent heat.

$$Q_s = q_s \times n \times CLF \rightarrow (1)$$

$$Q_l = q_l \times n \rightarrow (2)$$

Where

Q_s, Q_l = sensible and latent heat gains (loads)

q_s, q_l = sensible and latent heat gains per person

n = number of people

CLF = cooling load factor for people

Load Calculations Cont'd

Equipment and Appliances:

- The heat gain from equipment & appliances may sometimes be found directly from the manufacturer or the nameplate data, with allowance for intermittent use.
- Some equipment & appliances produce both sensible and latent heat.
- See the sample table and example:
- add a sample/table here

Load Calculations Cont'd

c. Infiltration & Ventilation

Infiltration of air through cracks around windows or doors in results in both a sensible and latent heat gain to the rooms.

- ***Sensible Heat Loss Effect*** of Infiltration or Ventilation Air

$$Q_s = 1.1 \times CFM \times (T_{indoor} - T_{outdoor}) \rightarrow (1)$$

Where

Q_s = sensible heat loss from infiltration or ventilation air, Btu/hr

CFM = air infiltration (or ventilation) flow rate, ft^3/min

$T_{indoor}, T_{outdoor}$ = temperature change between indoor and outdoor air, ^oF

- ***Latent Heat Loss Effect*** of Infiltration or Ventilation Air

$$Q_l = 0.68 \times CFM \times (W_i - W_o) \rightarrow (2)$$

Where

Q_l = latent heat required for infiltration or ventilation air, Btu/hr

CFM = air infiltration or ventilation rate, ft^3/min

W_i, W_o = higher (indoor) and lower (outdoor) humidity ratio in grains water/lbm dry (gr w/lb_m d.a)

Load Calculations Cont'd

Finding the Infiltration or Ventilation Rate:

There are two methods used of calculating the CFM of infiltration air:

1. Crack Method

2. Air Change Method

Load Calculations Cont'd

- **Crack Method**
- The crack method assumes that a reasonably accurate estimate of the rate of air infiltration per foot of crack opening can be measured or established.
- Table 3.4 lists typical allowable infiltration rates, based on a 25 mph wind
  1. Corner Room Infiltration
  2. Door Usage
- Insert tables:

Load Calculations Cont'd

- **Air Change Method**
- This method is based on the number of air changes per hour (ACH) in a room caused by the infiltration.
- One air change is defined as being equal to the room air volume
- Air changes range between (0.5 to 1.5 ACH)
- For buildings ranging from "Tight" to "Loose" construction, the following equation can used.

Load Calculations Cont'd

- For "Tight" or "Loose" construction buildings the Air Change is calculated as follows:

$$CFM = ACH \times \frac{V}{60} \rightarrow (1)$$

Where;

CFM = air infiltration rate to room, CFM

ACH = number of air changes per hour for room

V = room volume, ft^3

- Examples:

Load Calculations Cont'd

2. Cooling loads

d. Cooling Coil Load

- The cooling coil load is the rate at which heat must be removed by the air-conditioning equipment cooling coils. The cooling coil load is greater than the building load because there are heat gains to the air-conditioning system itself. These heat gains include:
- Ventilation (outside air);
- Heat gains to ducts;
- Heat produced by the air-conditioning system's fans and pumps;
- Air leakage from ducts.
- Example of cooling coil load

Load Calculations Cont'd

- Use of psychrometric charts and various software packages for heating and cooling estimates:
- Trace 700 & Psychrometric Charts to Perform the following:
  1. Heating process for air
  2. Cooling and dehumidifying process for air
  3. Outside and return air mixing process
  4. Air handler model
  5. Mixing more than two air steams (collection process)
  6. Humidification process
  7. Zone process
- Trace 700
  - Create Room Screen
  - Single Sheet Worksheet
  - Rooms Worksheet
  - Walls Worksheet
  - Internal Load Worksheet
  - Airflows Worksheet
  - Partition/Floor Worksheet
  - Spreadsheet Worksheet

Load Calculations Cont’d

- Psychrometric charts Analysis of HVAC Systems
- Psychrometrics for supply ducts and return air
- Psychrometrics for reheat systems
- Variables volume systems
- Multi-zone and dual duct systems
- Evaporative cooling

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