“Residential/Light Commercial HVAC Systems”

Cabrillo College
CEM 162
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Terms/Definitions:

- System Capacities
  - Btu/hour, btu/h, b/h, btuh, btu ??
  - 1 MBH = 1000 btu/hour
  - 1 KBH = 1000 btu/hour
  - 1 ton of cooling = 12,000 btu/hour
  - 1 watt = 3.414 btu/hour
  - 1 kilowatt = 1000 watts = 3,414 btu/hour
  - 1 HP = 746 watts = 2,545 btu/hour
**Terms/Definitions** (cont.)

- Airflow and water flow:
  - CFM - volume of airflow; cubic feet per minute
  - FPM - velocity/speed of airflow; feet per minute
  - AREA - duct size in **square feet**

\[
\text{CFM} = \text{FPM} \times \text{AREA}\\
\text{FPM} = \frac{\text{CFM}}{\text{AREA}}\\
\text{AREA} = \frac{\text{CFM}}{\text{FPM}}
\]
Terms/Definitions (cont.)

- Airflow and water flow (cont):
  - GPM- volume of water flow; gallons per minute
  - FPS- speed of water flow; feet per second

- Pressure:
  - airflow- inches of water; " w.g., " H₂O, Pa
    
    \[ 15 \text{ Pa} = 0.055 \text{ " H₂O} \]
  - water flow- feet of water, feet of head, ft head psi (pounds per square inch)
    
    \[ 1 \text{ ft head} = 0.433 \text{ psi} \]
    \[ 1 \text{ psi} = 2.31 \text{ ft head} \]
Ventilation- the “V” in HVAC

- Attic ventilation
- “Whole house” fans
- Restroom
- Kitchen Hoods
- Makeup air
- Outside air
- Economizers
- Demand controlled ventilation
- Energy Recovery Ventilators
Terms/Definitions (cont.)

- **Air change calculation**

  \[ \text{CFM} = \frac{(#AC/hr)(\text{Room volume})}{60} \]

  where: \( \text{CFM} = \) airflow required (ft\(^3\)/hour)
  \( \text{Room volume} = \) ft\(^3\)

  **Example**

  Room size = 25’ x 40’ x 10’ ceiling = 10,000 ft\(^3\)
  Air changes required = 4 AC/hr
  CFM required = \( \frac{(4)(10,000)}{60} = 667 \text{ CFM} \)
Ventilation Fans

Fans in HVAC Systems
- Produce CFM vs. Static Pressure (SP)
- Performance curves
- Require “Brake Horsepower” (BHP) to operate
- “Direct-drive” vs “Belt-drive” (RPM)
- Centrifugal (i.e. “squirrel-cage”) vs axial (i.e. “propeller”)
Heat transfer/capacity calculations:

\[ \text{BTU/hr} = (1.08)(\text{CFM})(\text{delta T}) \]

where:
- BTU/hour = cooling/heating capacity required
- 1.08 = constant for “standard air”
- CFM = airflow volume being heated/cooled
- deltaT = temperature difference of air

Example:
1,500 CFM system, air heated from 60°F to 120°F in furnace
\[ \text{BTU/hr} = (1.08)(1500)(120 - 60) = 97,200 \text{ btu/hr} \]
HVAC Systems Training

- **HVAC System Types/Usages**
  - Residential furnaces
  - Split system units (outdoor condensing units)
  - Refrigeration Cycle overview:
    - compressor, evaporator, condenser, expansion device
  - Package gas/electric and heat pumps
  - Geothermal heat pumps
HVAC System Applications

Residential Applications

- Gas furnaces: upflow, downflow, horizontal
- minimum 80% AFUE to meet Title 24 requirements
- AFUE (Annual Fuel Utilization Efficiency)
- condensing furnaces: 92 - 96% AFUE

NOTE: if air conditioning is required; different type furnace might be required !!
NOTE: condensing furnace cost = 1.5- 2 times cost of standard furnace; different flue venting required and condensate piping also required.
Heat transfer/capacity calculations:

Example:
“Standard efficiency” residential furnace with input heating capacity of 80 MBH (furnace nameplate). Furnace return air temp = 65°F (measured); supply air temp = 110°F (measured)

How many CFM of airflow are being delivered?

Output capacity = 80,000 (0.80 efficiency) = 64,000 Btu/hour

Btu/hour = (1.08)(CFM)(delta T)

CFM = \[ \frac{64000}{(1.08)(45)} \]

= 1,317 CFM
Residential HVAC System Applications

**Condensing units** (if house is air conditioned)

- airflow and service clearance critical to performance
- requires 208-230v single phase power to operate
- might require electrical system upgrade due to high power requirement
- SEER - seasonal energy efficiency rating
  \[
  \text{SEER} = \frac{\text{Btu/hr output}}{\text{Watts input}}
  \]
- since air conditioning operating costs are so high, recommend installing units with highest SEER available
- 5 ton unit is largest single phase unit manufactured
Refrigeration Cycle Overview
HVAC System Applications

• **Light Commercial Applications**
  - Rooftop package units (gas/electrics and heat pumps)
    - inexpensive to purchase $500 - 700 per ton
    - low installed cost $2,500 - 3,500 per ton
    - high operating cost
    - high maintenance/repair cost as units get older
    - appx 12 - 15 year useful life
    - 400 CFM per ton airflow;
      - (why 5 ton unit = 1,950 CFM ??)
    - economizers on units larger than 5.0 ton
Geothermal Heat Pumps

- All electric units; couple with solar PV
- Utilize earth ground temp as heat source in winter and heat sink in summer.
- Stable/consistent earth temperature leads to high Coefficient of Performance (COP)
- Primary source of heating/cooling is operation of high efficiency refrigeration compressors.
- Lakes/ponds can also be used as heat source/sink
  - Air/water and water/water units both available
GSHP Schematics

Fig. 9 Vertical Closed-Loop Ground-Coupled Heat Pump System (Caravagio 1982)

Fig. 10 Vertical Ground-Coupled Heat Pump Piping

Fig. 11 Horizontal Ground-Coupled Heat Pump Piping

Fig. 13 U-bend Loop Piping
HVAC System Applications:

Ducting/piping systems design:

- Sizing fundamentals based on:
  - volume flow rate (CFM, GPM)
  - acceptable design velocity (FPM, FPS)
  - acceptable friction rate
  - acceptable vibration/noise
HVAC System Applications
Duct/pipe design (cont.)

**Ducting types:**
- flex duct- “aluma-flex, wireflex”
  used for residential furnaces, package units
- rigid sheetmetal duct
  used for residential, institutional, industrial

**Piping types:**
- chilled water schedule 80 PVC, steel
- hot water Type “L” copper, steel
- refrigerant Type “ACR” copper
- Radiant floors PEX tubing
HVAC System Applications

Duct/pipe design (cont.)

- **Insulation requirements:**
  - Ducting insulation- per UMC/Title 24 requirements
    - roof ducting different than interior ducting
    - return air duct between floors; not required
    - return air duct in plenum; not required
    - supply air duct; always insulate for energy savings AND to prevent condensation
  - Piping insulation- per UMC/Title 24 requirements
    - jacketing required outdoors for weatherproofing
    - UV resistant paint to resist cracking when exposed to sun