

“Residential/Light Commercial HVAC Systems”

Cabrillo College

CEM 162

Spring 2009

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

$$\mathbf{CFM = FPM \times AREA}$$

$$\mathbf{FPM = CFM/AREA}$$

$$\mathbf{AREA= CFM/FPM}$$

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
 $15 \text{ Pa} = 0.055 \text{ " H}_2\text{O}$
 - 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: CFM = airflow required (ft³/hour)

Room volume = ft³

Example

Room size = 25' x 40' x 10' ceiling = 10,000 ft³

Air changes required = 4 AC/hr

$$\text{CFM required} = \frac{(4)(10,000)}{60} = \mathbf{667 \text{ CFM}}$$

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 60F to 120 F in furnace

$$\text{Btu/hr} = (1.08)(1500)(120 - 60) = \quad \quad \quad \mathbf{97,200 \text{ btu/hr}}$$

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 = 65F (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)

$$\begin{aligned} \text{CFM} &= \frac{\text{Btu/hr}}{(1.08)(\text{delta T})} = \frac{64000}{(1.08)(110-65)} = \frac{64000}{(1.08)(45)} \\ &= \mathbf{1,317 \text{ CFM}} \end{aligned}$$

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

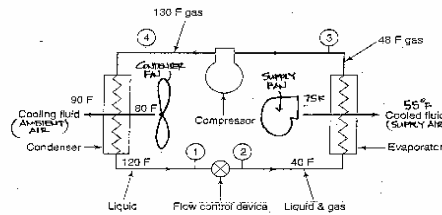
PROCESS 1-2. At point (1), the refrigerant is in the liquid state at a relatively high pressure and high temperature. It flows to (2) through a restriction, called the flow control device or expansion device. The refrigerant loses pressure as it flows through the restriction. The pressure at (2) is so low that a small portion of the refrigerant flashes (evaporates) into gas. But in order to evaporate, it must gain heat (which it takes from the portion of the refrigerant that did not evaporate), thus cooling the mixture and resulting in a low temperature at (2).

PROCESS 2-3. The refrigerant flows through a heat exchanger called the evaporator. The heat exchanger has two circuits. The refrigerant circulates in one, and in the other, the fluid to be cooled (usually air or water) flows. The fluid to be cooled is at a slightly higher temperature than the refrigerant, therefore heat is transferred from it to the refrigerant, producing the cooling effect desired. The refrigerant boils because of the heat it receives in the evaporator. By the time it leaves the evaporator (3), it is completely vaporized.

PROCESS 3-4. Leaving the evaporator the refrigerant is a gas at a low temperature and low pressure. In order to be able to use it again to achieve the refrigerating effect continuously, it must be brought back to the condition at (1)—a liquid at a high pressure. The first step in this process is to increase the pressure of the refrigerant gas by using a compressor. Compressing the gas also results in increasing its temperature.

PROCESS 4-1. The refrigerant leaves the compressor as a gas at high temperature and pressure. In order to change it to a liquid, heat must be removed from it. This is accomplished in a heat exchanger called the condenser. The refrigerant flows through one circuit in the condenser. In the other circuit, a cooling fluid flows (air or water) at a temperature lower than the refrigerant. Heat therefore transfers from the refrigerant to the cooling fluid, and as a result, the refrigerant condenses to a liquid (1).

The refrigerant has returned to its initial state and it now ready to repeat the cycle. Of course the process is actually continuous as the refrigerant circulates through the system.



The Vapor-Compression Refrigeration Cycle

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

Residential Heating/Cooling

- **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

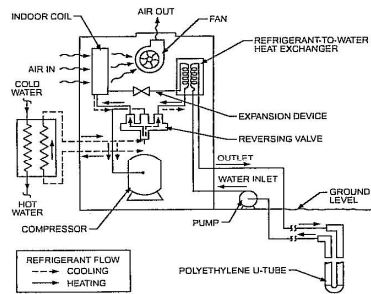


Fig. 9 Vertical Closed-Loop Ground-Coupled Heat Pump System (Kavanaugh 1985)

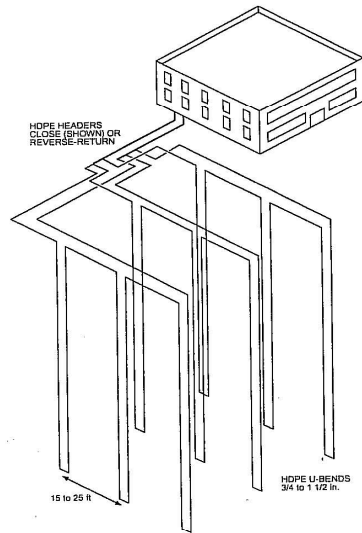


Fig. 10 Vertical Ground-Coupled Heat Pump Piping

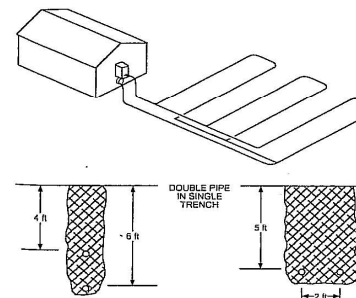


Fig. 11 Horizontal Ground-Coupled Heat Pump Piping

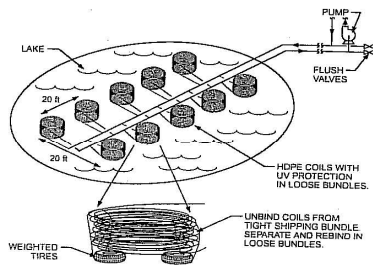


Fig. 13 Lake Loop Piping

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