HVAC systems

Operating Systems

- HVAC
  - Heating
  - Cooling
  - Ventilation
- Water & Sewer
- Electrical
- Safety
- Indoor Air Quality
- Convenience

Operating Systems

- Rules for operating systems
  - Consider house as 1 large operating system, determine effect of each operating system has on each other.
  - Use high efficiency components & subsystems designed to operate properly in a new, tight house.

HVAC

- Includes
  - Furnace
  - Air conditioner
  - Ducts
  - Supply vents
  - Return vents
  - Ceiling fans

HVAC – locations

- Furnace – unfinished area
  - Basement
  - Garage
  - Closet
- At least 3’ by 6’ area

HVAC – ductwork

- Duct work should be placed in between joists.
  - Protection
  - Saving space

HVAC – ductwork

HVAC – locations

- Area requirements
  - Equipment
  - Maintenance & Service
  - Wide door

Heating systems

- Depends on
  - Climate
  - Budget
  - Specific Needs
  - Benefits & limitations
  - Fuel type & cost

Heating systems

- Main issues for system
  - System efficiency
    - Colder climates need more efficient system
    - More efficient system have higher initial cost, but could save money over long term.
  - Safety

Heating systems

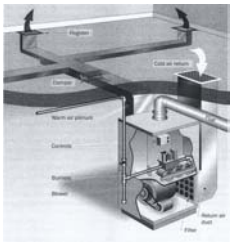
- When purchasing system
  - EnergyStar® logo
  - Good warranty
  - Reputable company

Heating systems - Types

- Forced Air Furnace
- Pumped Hot Water
- Electric Resistance
- Heat Pump
- Wood Burning Stove
- Unit Heaters
- Corn Burning Stove

Heating systems – Forced Air Furnace

- Draws in cool air into heat exchanger. Heats air then distributes throughout house by ducts.



Heating systems – Forced Air Furnace

- Fueled by
  - Natural gas
  - Propane
  - Fuel oil
  - Wood
  - Coal
  - Electric resistance elements

Heating systems – Forced Air Furnace

- All fuels cause combustion gases except electric resistance element.
- Vent combustible gases out by
  - Chimney
  - Vent system

Heating systems – Thermostat

- Turns furnace on & off at set point temperatures
- Should be placed away from
  - Direct sunlight
  - Drafts
  - Doorways
  - Skylights
  - Windows

Heating systems – air losses

- Dryer duct
- Bathroom ventilation
- Kitchen range hoods

Heating systems – air losses

- Lost air needs to be replaced with outside air via furnace.
- Backdrafting could occur

Heating systems – Sizing furnace

- Oversized
  - Cycle on & off more – causing excessive wear & tear
  - Reduced comfort
  - Excessive air noise

Heating systems – Sizing furnace

- Undersized
  - Reduce efficiency of air distribution
  - Accelerate wear on components

Heating systems – air losses

- Safety devices to eliminate backdraft
  - Sealed combustion chamber
  - Powered exhaust flow
  - Sealed combustion air and combustion exhaust flow pipe
  - Safety controls

Heating systems – Heat loss

- All systems lose heat thru chimney.
  - More efficient furnace causes cooler combustion gases and less heat escapes thru flue
- Calculate heat loss through house to determine furnace size.

Heating systems – Heat loss

- $Q = \frac{A^* \Delta T}{R}$

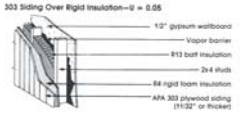
Q = heat loss BTU/hr

A = area thru heat loss, ft^2

ΔT = change in temperature, ^oF

R = Heat loss factor, ft^2*hr*^oF/BTU

Heating systems – Heat loss



- What is the heat loss from a 12' by14' by 8' room with 8 windows. The windows are double paned with dimensions of 2' by 4' each with an R value of 1.69. The inside room temperature is 70^o and the outside temperature is 10^o.

Heating systems – Heat loss

calculate areas

Walls	Windows
12'*8'*2 walls = 192 ft^2	2'*4'*8windows = 64 ft^2
14'*8'*2 walls = 224 ft^2	
416 ft^2	
- 64 ft^2	
352 ft^2	

Heating systems – Heat loss

calculate R values

Walls	R	Windows
Outside air film	0.17	1.69
11/32" plywood	0.43	
R4 rigid foam insulation	4.00	
R13 batt insulation	13.00	
½" gypsum wallboard	0.45	
Inside air film	0.68	
	18.73	

Heating systems – Heat loss

calculate change in temperature

$\Delta T = 70^o - 10^o$

$= 60^o F$

Heating systems – Heat loss

calculate heat loss

$Q = \frac{A * \Delta T}{R}$

Walls

$Q = \frac{352\ ft^2 * 60^oF}{18.73\ ft^2 * hr * ^oF/BTU}$

$Q = 1127.6\ BTU/hr$

Windows

$Q = \frac{64\ ft^2 * 60^oF}{1.69\ ft^2 * hr * ^oF/BTU}$

$Q = 2272.2\ BTU/hr$

$Q_{TOTAL} = 1127.6 + 2272.2$

$Q_{TOTAL} = 3399.8\ BTU/hr$

Heating systems – Pumped Hot Water

- Hydronic system
- Heat produced in boiler and transported thru house by hot water.
- Still produces combustable gases
- Uses water jacket instead of heat exchanger
- No ductwork, water transported to radiators
- Radiators usually placed under windows

Heating systems – Pumped Hot Water

- Radiant floor heating systems
  - Pump hot water thru plastic piping embedded in floor.
  - Heat radiates thru pipes and floor into room.

Heating systems – Electric Resistance

- Simplest & inexpensive to install
- Room to room temperature control
- No combustible gases
- Nearly 100% efficient
- Costly if electricity is expensive

Heating systems – Electric Resistance

- Baseboard units
- Individual, fan-assisted space heaters
- Furnace with a resistance element as the heat source
- Gypsum ceiling panels that contain resistance elements
- Resistance elements installed in floor systems

Heating systems – Electric Resistance

- Controlled with a thermostat
- Floor or wall mounted
- With or without fans
- Requires 200 Amp service

Heating systems – Heat Pumps

- Air to air heat pump
- Geothermal heat pump

Heating systems – Heat Pumps

- Air to air uses heat captured from the outdoor air to both heat and cool house
- Geothermal uses the earth's warmth to heat and cool house
- Uses electricity to transfer heat between outdoor and indoor coils.

Heating systems – Heat Pumps

- Not economical when weather gets cold
- May need back up system in very cold weather
- Since air temperature is lower than fuel system, more air needs to be moved thru ductwork
- No combustible gases produced

Heating systems – Heat Pumps

- Geothermal heat pump
- Uses earth's warmth to heat in winter and cool in summer
- Closed loop system placed under frost line
- Antifreeze solution runs in loop to extract heat or cool

Heating systems – Heat Pumps

- Economical to run
- High initial or set up cost
- May need backup electrical to operate system

Heating systems – Wood Burning Stoves/Unit Heaters

- Used as backup or decorative elements
- Firewood
- Messy
- Damp wood may cause moisture and insect problems
- Old not efficient, newer much better

Heating systems – Wood Burning Stoves/Unit Heaters

- Unit heaters used to heat specific areas
- Gas fired systems need to be vented outdoors

Heating systems – Comparing heating systems

- Operating costs are affected by
  - Heating system efficiency
  - Climate
  - House size
  - House structure efficiency
- Annual Fuel Utilization Efficiency (AFUE)

Heating systems – Comparing heating systems

- Minimum acceptable AFUE is 78%
- Higher efficiency furnaces may cost more

Heating systems – Fuel Cost Comparison

- Compare heating systems with different fuels
- Quantity for 1 mil BTUs * fuel price/annual efficiency
- Table 15-1

Heating systems – Fuel Cost Comparison

- Propane furnace with a cost of $1.25/gal and 80% efficiency

$$\frac{11.11 \text{ gal} * \$1.25/\text{gal}}{0.80} = \$17.36/\text{million BTU's}$$

Cooling systems - Types

- Central cooling systems
- Unitary cooling systems
- Whole-house fan

Cooling systems - Central cooling systems

- Most common
- Uses the same blower & ductwork as furnace

Cooling systems - Unitary cooling systems

- Used for a room or section of house
- No ductwork
- Window unit

Cooling systems – Whole-house fan

- Used to bring cool air into house thru windows
- Used in late evening or early morning
- Fan located in attic or roof
- Pushes hot air out of house
- Only cools house to outside temperature and does not dehumidfy

Cooling systems – Efficiency Rating

- BTU of heat removed per hour
- Central air conditioner (SEER) Seasonal Energy Efficiency Rating
  - No less than 12.0
- Unitary air conditioner (EER) Energy Efficiency Ratio
  - No less than 9.0 in mild climate
  - No less than 10.0 in hot climate

Cooling systems – Efficiency Rating

- Sizing air conditioner depends on
  - Square footage of house
  - Shading of house
  - Insulation
  - Air leakage
  - Heated generated in house

Ventilation Systems

- Used to remove
  - Moisture
  - Odors
  - Pollutants
  - Combustible gases

Ventilation Systems - Types

- Natural ventilation
  - Good for warmer, dry climates
- Mechanical ventilation
  - More reliable
  - Over ventilate – cause drafts
  - Under ventilate – cause moisture build up

Ventilation Systems –Exhaust only fan

- Used to exhaust air out of house
  - Bathroom fans
  - Oven/range hoods
- 100 cfm for kitchen
- 50 cfm for bathroom

Ventilation Systems –Heat Recovery Ventilator (HRV)

- Transfer heat between intake and exhaust depending on climate
- 2 fans used
- More efficient than exhaust only
- Higher initial cost

Ventilation Systems –Ceiling Fans

- Popular for comfort & decorative
- Moves air in room
- Moves warm air down from ceiling

Ventilation Systems – Attic

- Proper ventilation is required to control moisture
- Attic ventilation requirements
  - With vapor retarder on the ceiling
    - 0.5 ft^2 of inlet & outlet area per 300 ft^2 of floor area
  - Without vapor retarder or vent exhaust no more than 3ft above eave vent
    - 0.5 ft^2 of inlet & outlet area per 150 ft^2 of floor area

Ventilation Systems – Attic

- Mechanical ventilation can be used w/ thermostat or humidastat
- Needs to be properly sized to avoid suction

HVAC – humidifier

HVAC – dryer vent

HVAC – duct bypass