



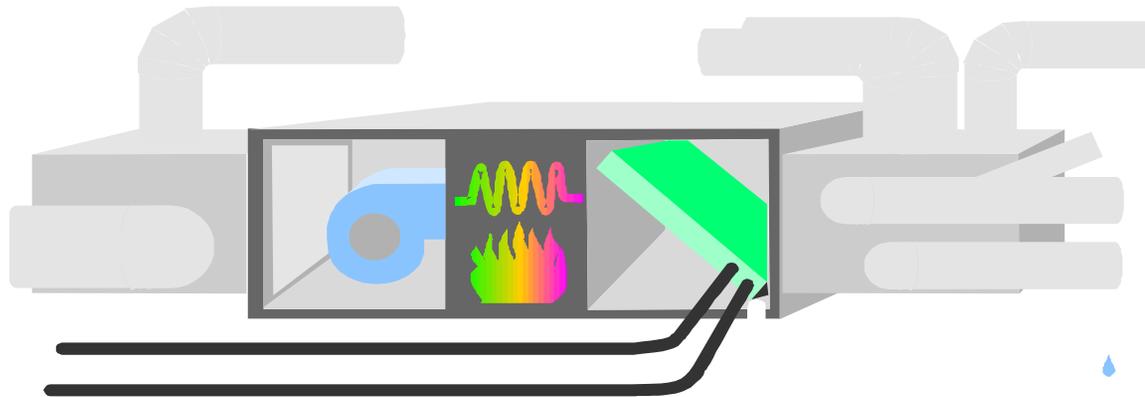
HVAC

Part 2: the details



HVAC

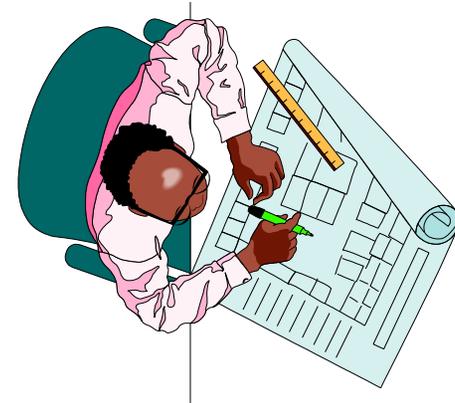
- Heating, Ventilation and Air Conditioning
- Provides comfort for people
- Allows humans to exist under adverse conditions.





Load Calculations

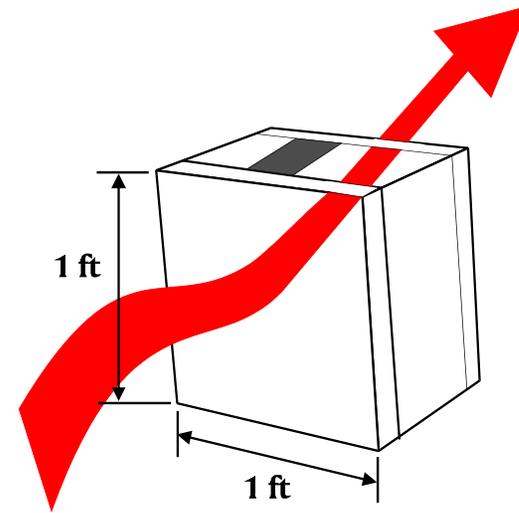
- Heating and Cooling
- *Accuracy important!*
- Design conditions
- Building shell load
- R, U value
- Internal load
- Ventilation load
- Infiltration
- Occupancy schedules





Heat Transfer

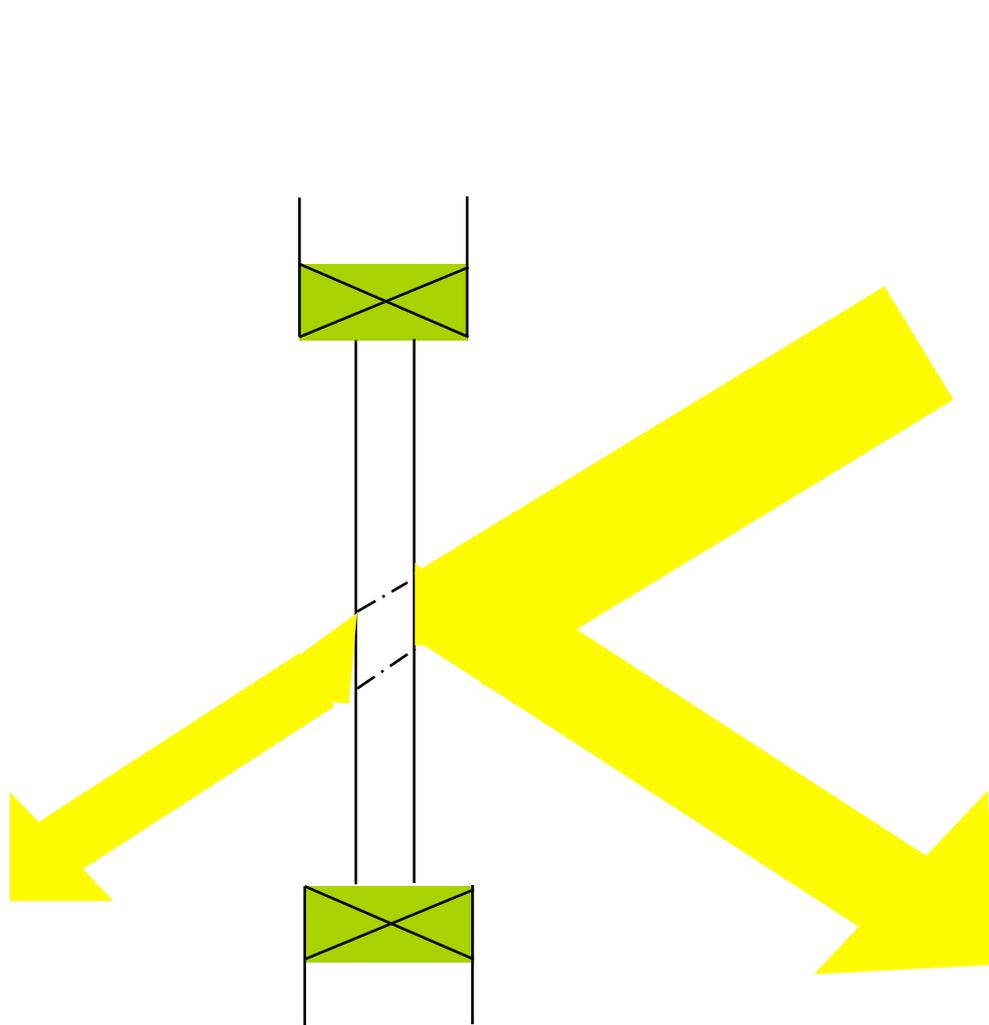
- Conduction
- Convection
- Radiation
- Resistance (R-Value)
- $U = 1 / R$
- $G_{\text{heat}} = U \times A \times \Delta T$



U-Value is the rate of heat flow in Btu/h through a one ft² area when one side is 1°F warmer



Solar Heat Gain Coefficient

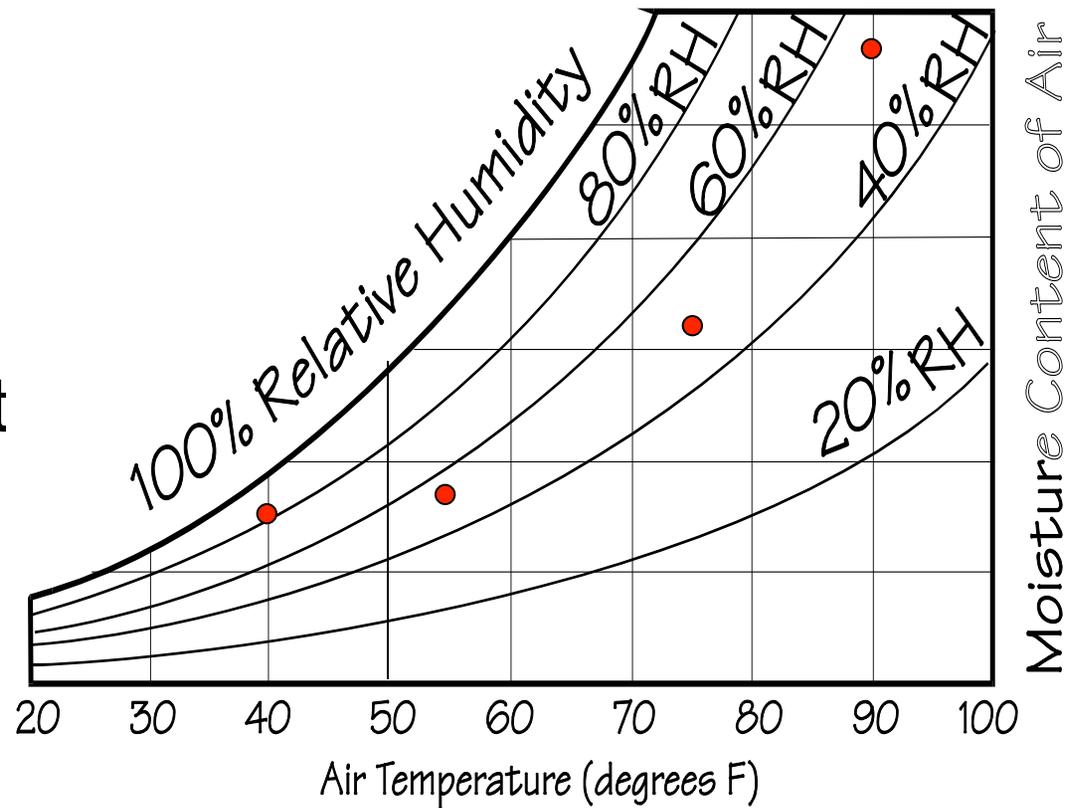


- The amount of solar heat energy allowed to pass through a window
- Example: $SHGC = 0.40$
Allows 40% through and turns 60% away



Psychrometrics

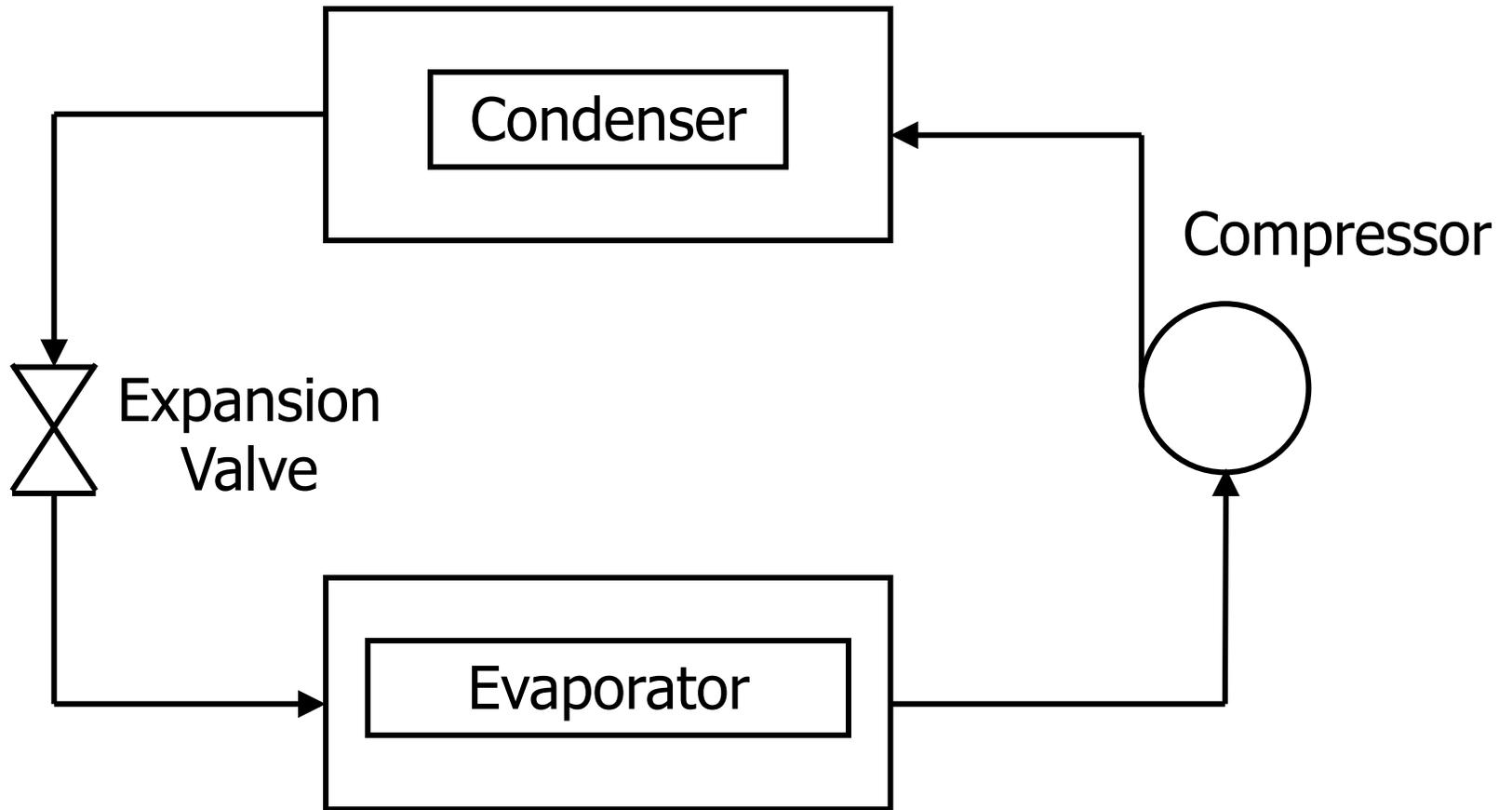
- Dry bulb temp.
- Wet bulb temp.
- Humidity
- Dew point
- Moisture content
- Heating
- Cooling
- Humidify
- De-Humidify



Psychrometric Chart



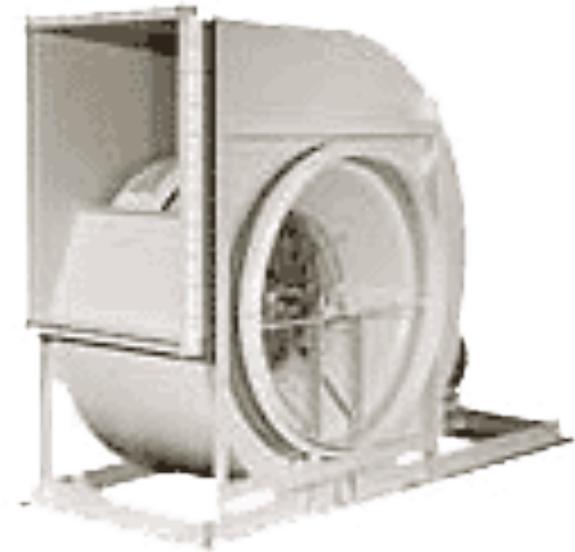
Basic Refrigeration Cycle

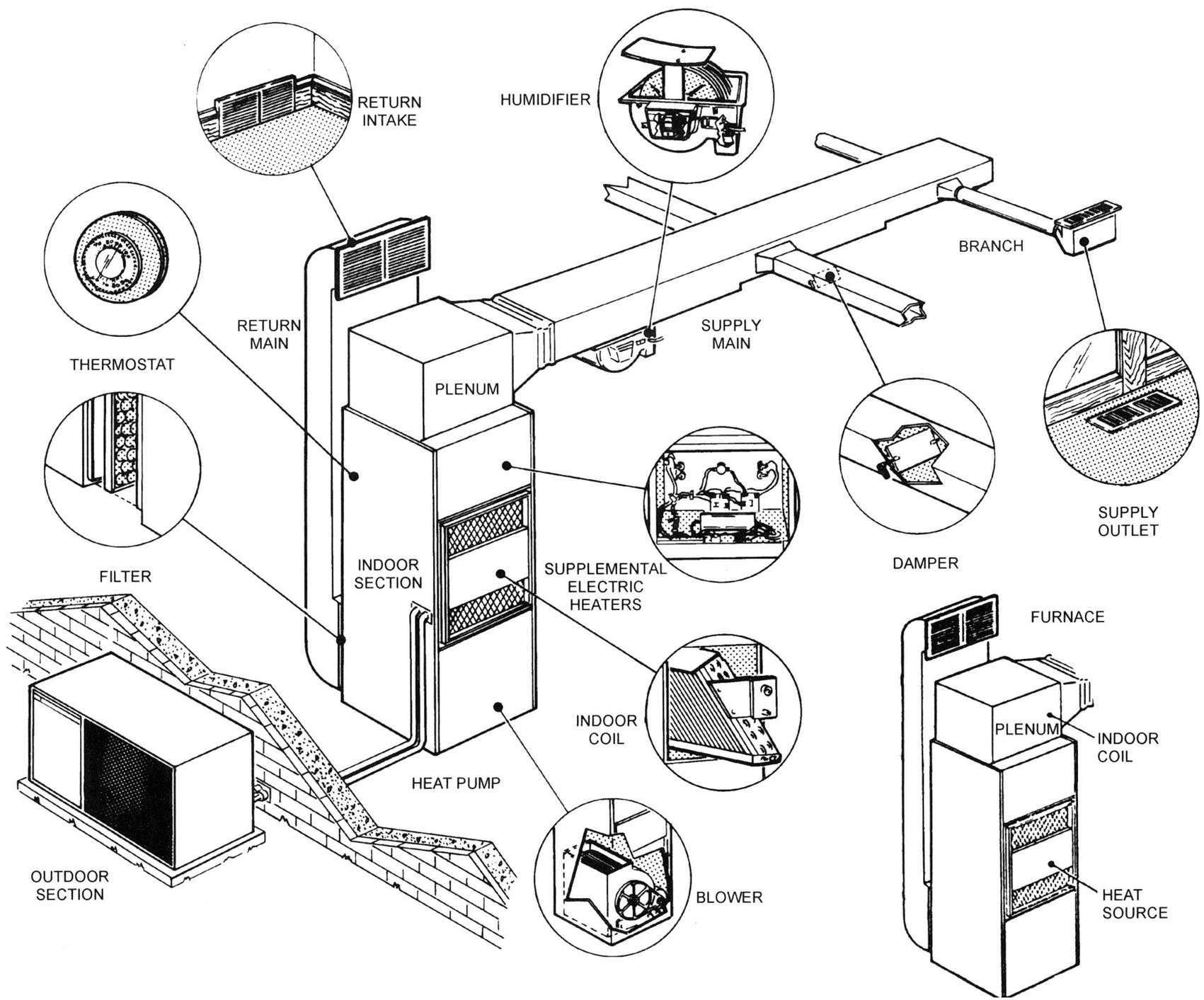




Basic HVAC Equipment

- Fans / Blowers
- Furnace / Heating unit
- Filters
- Compressor
- Condensing units
- Evaporator (cooling coil)
- Control System
- Air Distribution System







System Types and Common Terms

- Packaged Rooftop Unit
 - ◆ Constant Volume
 - ◆ Variable Volume
- Split System
 - ◆ Indoor Air Quality
 - ◆ Direct Expansion
- Heat Pump
- Geothermal
- Air to Air
- Hydronic (water)
- PTAC / PTHP



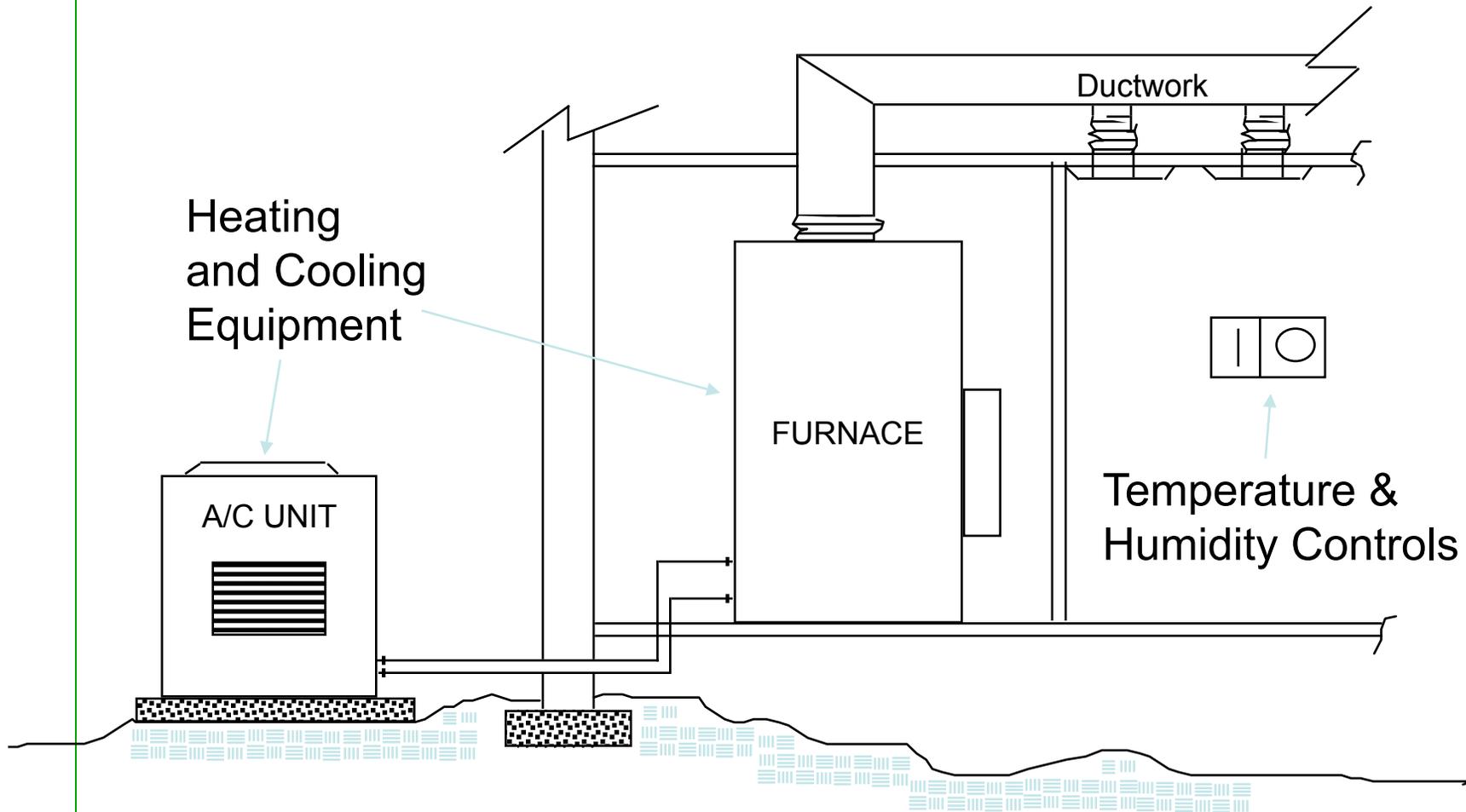


Packaged Rooftop Units





Split System





Heat Pump

- Operate on simple refrigeration cycle
- Reversing the cycle provides heating
- Temperature limitations
- Air to air
- Water source
- Geothermal
- Lake coupled

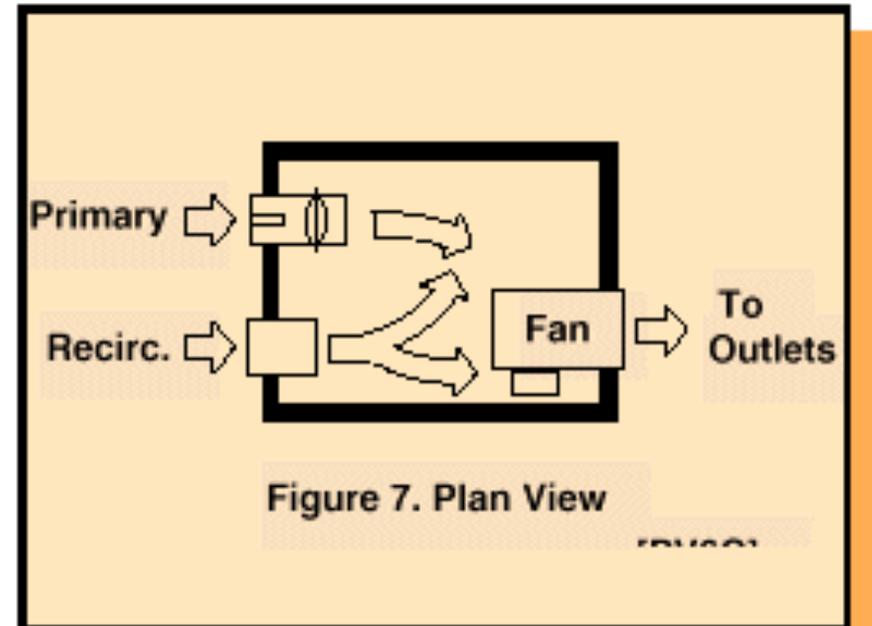
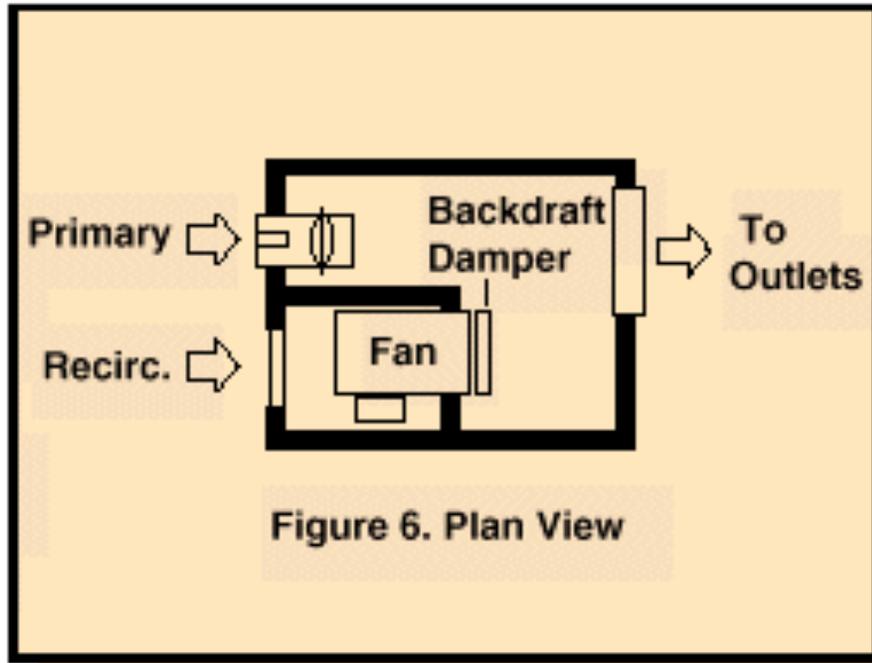




Terminal Units

Variable volume:
Parallel

Constant volume:
Series





Hydronic systems

- Pumps
- Piping
- Valves





Control Devices

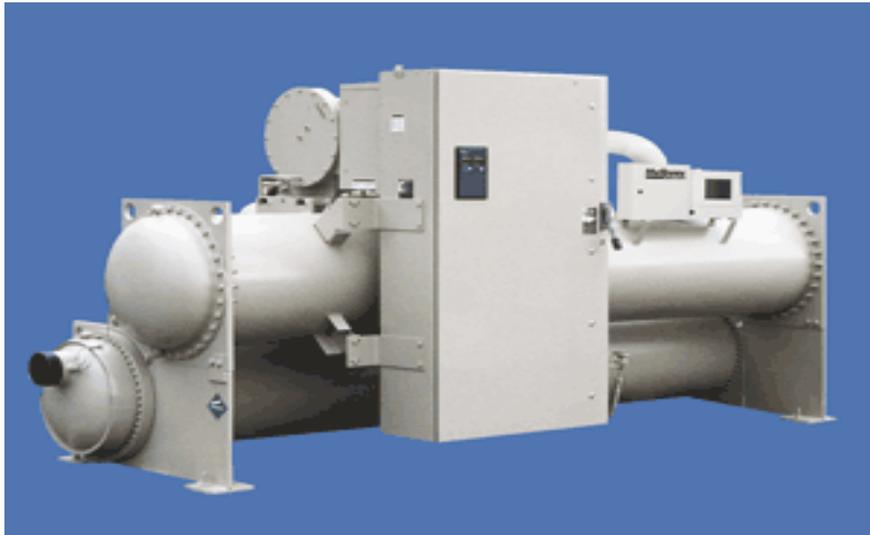
- Thermostats
 - Manual
 - Programmable
- Optimum Start
- DDC Systems
- Variable Speed Drives
- Automatic Valves and Dampers
- Outdoor Sensors





Major Equipment

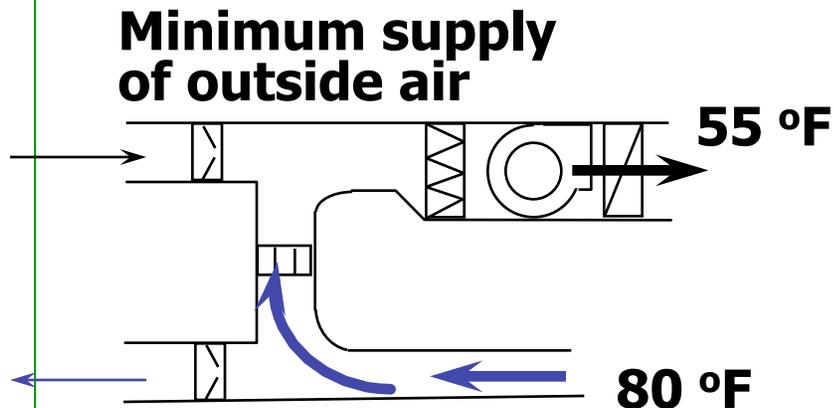
- Chillers
- Boilers
- Cooling Towers





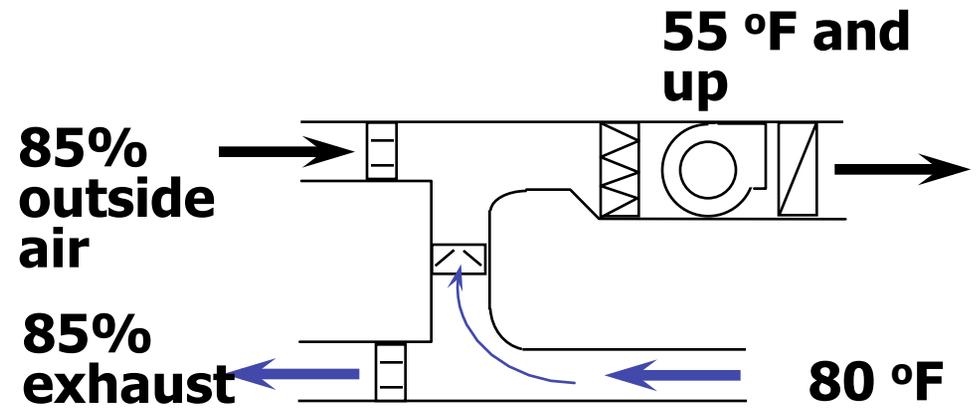
Economizers

Free cooling source: When available, use cool outdoor air instead of mechanically cooled air.



Normal Operation

Outside air dampers are positioned to provide the minimum outside air



Economizer Operation

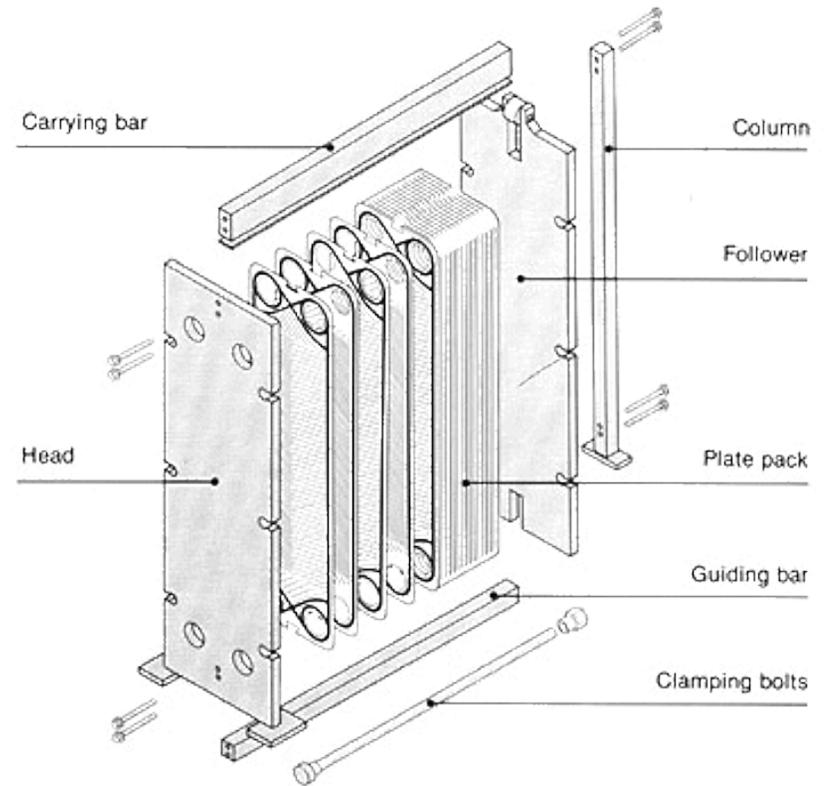
Outside air dampers are fully open. Maximum outside air is provided



Economizers



Air Side

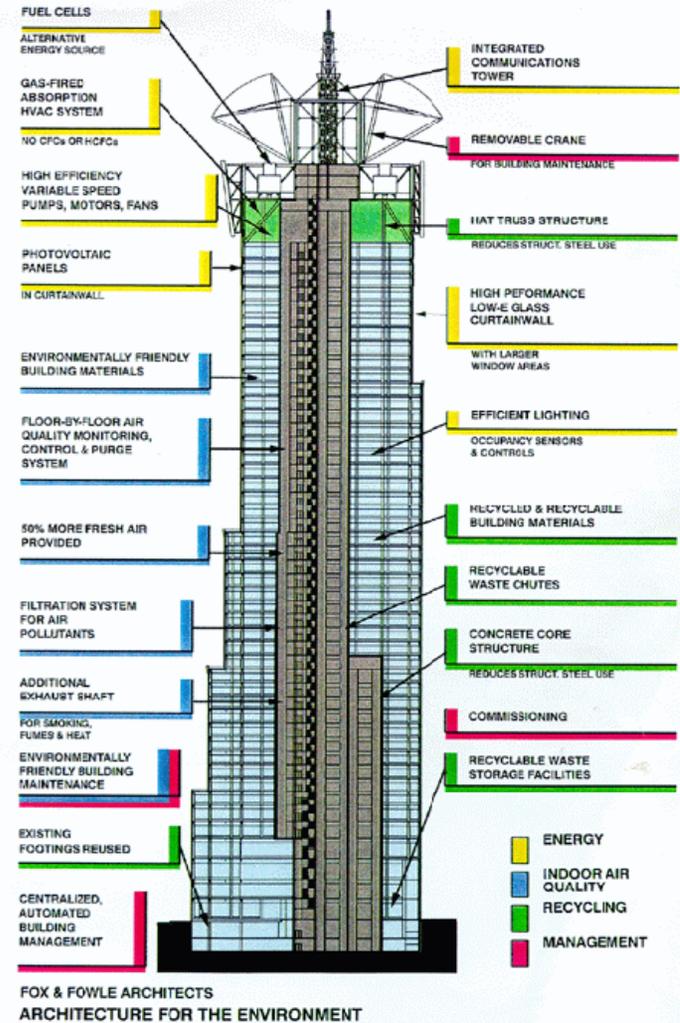
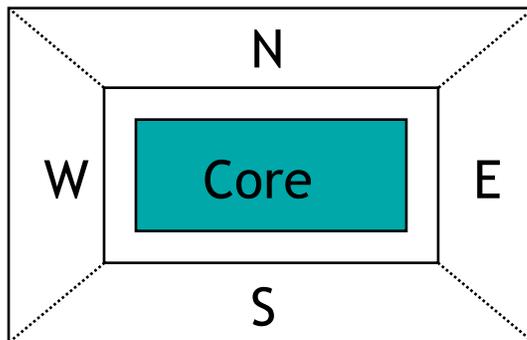


Water Side



Zoning and Economizers

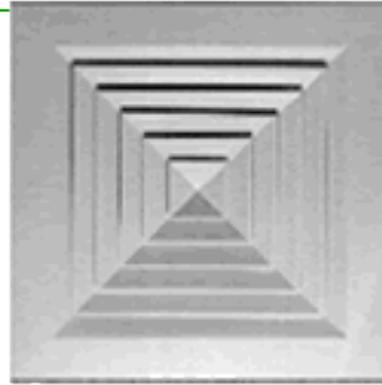
- Economizers provide “free cooling” when outdoor conditions are optimal
- Proper orientation & zoning yields comfort & efficiency





Air Distribution

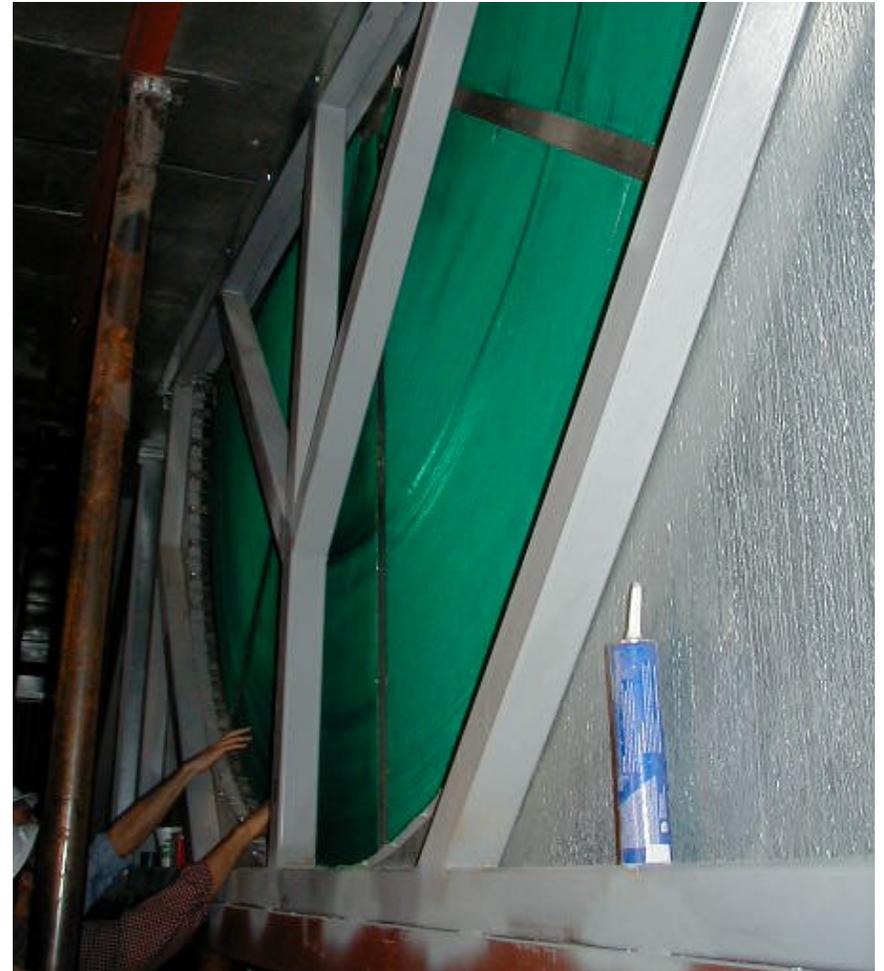
- Ductwork
 - Metal
 - Flexible
 - Ductboard
- Grilles, Louvers, & Registers
- Dampers
 - Shut off
 - Fire
 - Smoke
- Sealants
- Supports





Additional Equipment

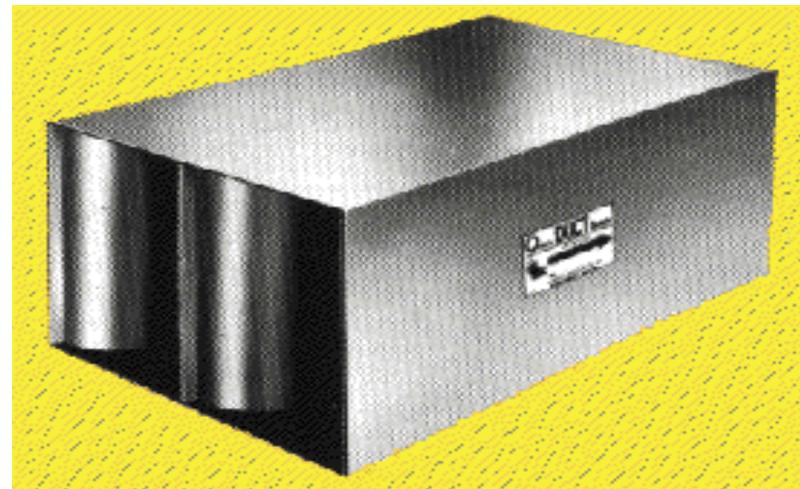
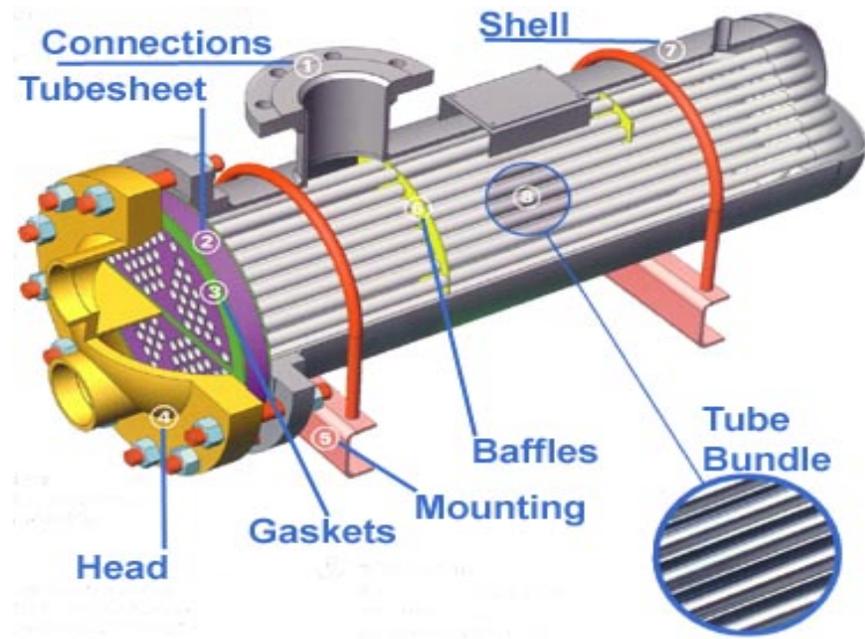
- Energy Recovery Units
- Desiccant Systems





Additional Equipment

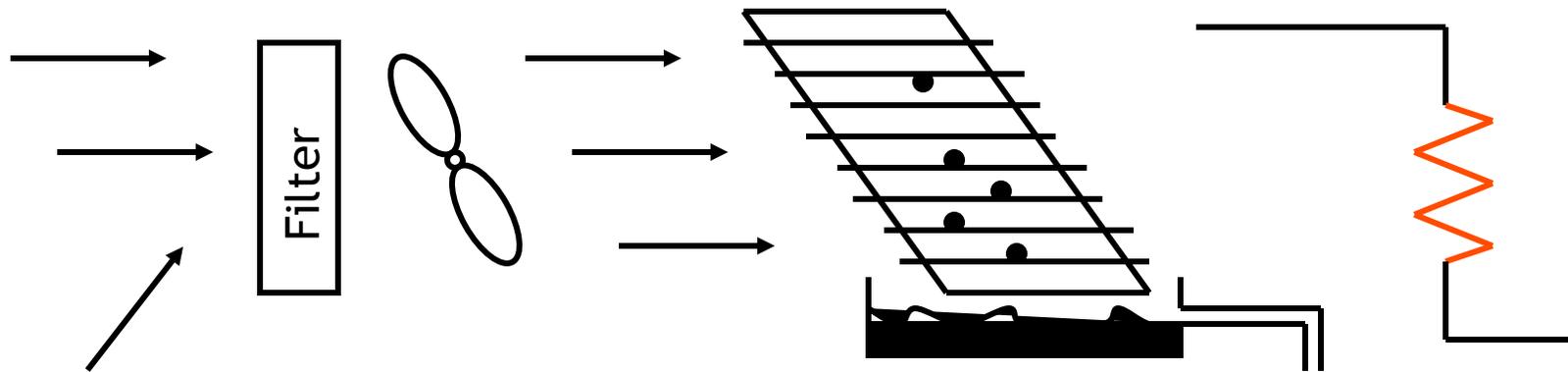
- Heat Exchangers
- Humidifiers
- Silencers





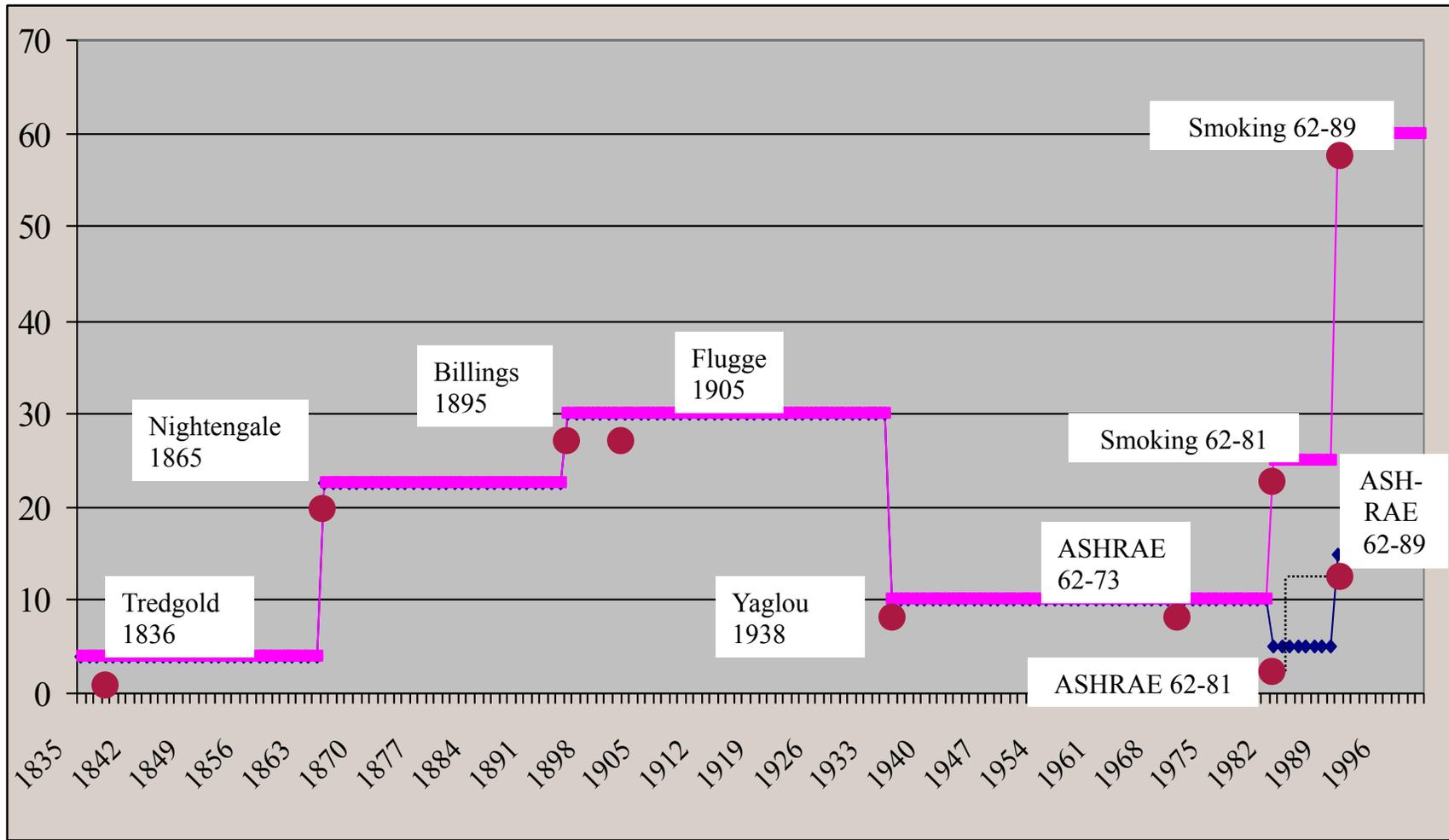
Mechanical Dehumidification

- Return air is mixed with ventilation air
- Cold coil condenses moisture
- Heat is added back (electric or gas) so that room air is not over cooled- *Reheat*





Historical Minimum Ventilation Rates (cfm/person)





Improved Ventilation Effectiveness

- Effective mixing of ventilation air within space
- Vary ventilation based on the number of occupants and process loads - changes in occupancy can be measured by CO₂ sensors
- Consider designs that separate ventilation and space conditioning
- Utilize heat recovery systems to reduce system size energy costs
- Avoid: loading docks, exhaust vents, plumbing stacks, waste collection & stagnant water

