



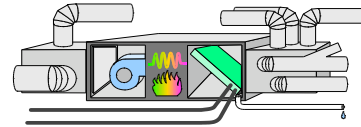
## HVAC

### Part 2: the details



## HVAC

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



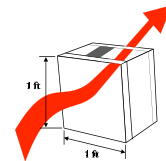
## Load Calculations

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



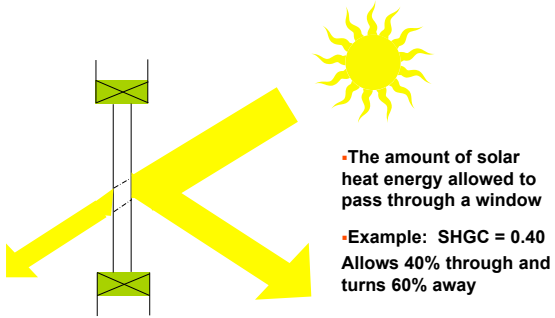
## Heat Transfer

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



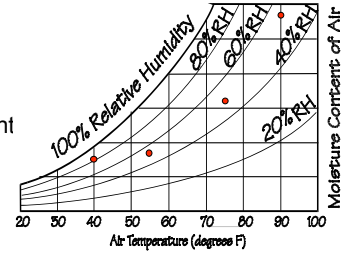
U-Value is the rate of heat flow in Btu/h through a one ft<sup>2</sup> area when one side is 1°F warmer

## Solar Heat Gain Coefficient



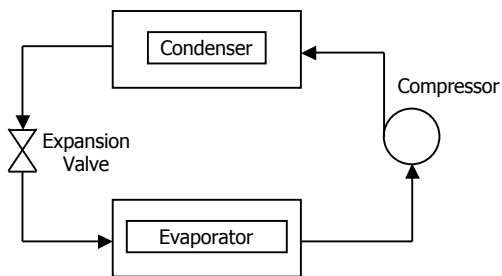
## Psychrometrics

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



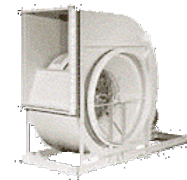
Psychrometric Chart

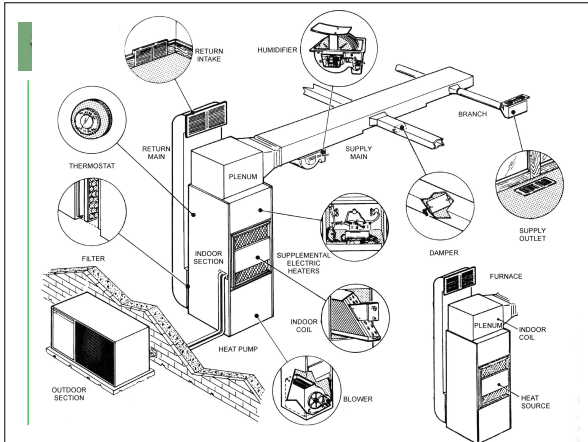
## Basic Refrigeration Cycle



## Basic HVAC Equipment

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

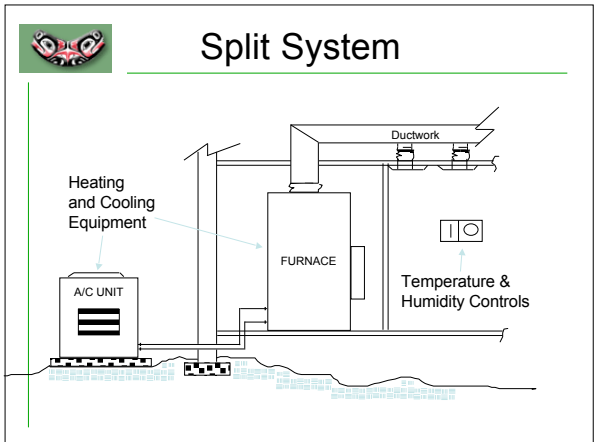




## System Types and Common Terms

- 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





## Heat Pump

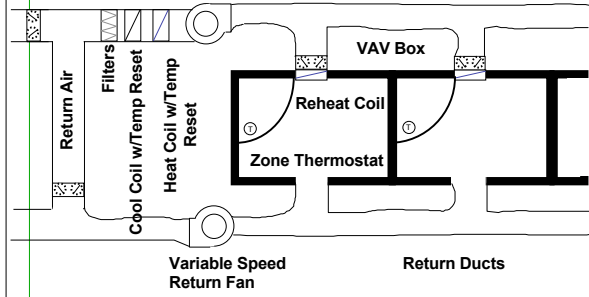
- Operate on simple refrigeration cycle
- Reversing the cycle provides heating
- Temperature limitations
- Air to air
- Water source
- Geothermal
- Lake coupled



## Variable Air Volume

Variable Speed Supply Fan

Supply Ducts

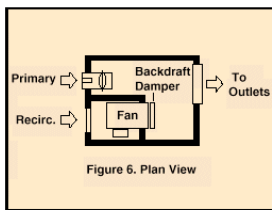


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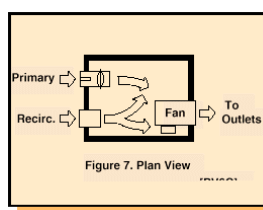


## Terminal Units

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

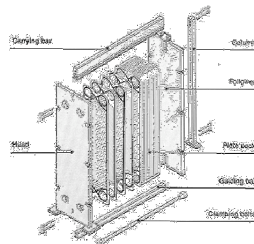
- Chillers
- Boilers
- Cooling Towers



## Economizers



Air Side

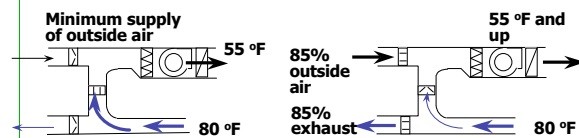


Water Side



## 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

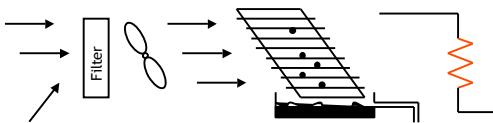
HVAC-20



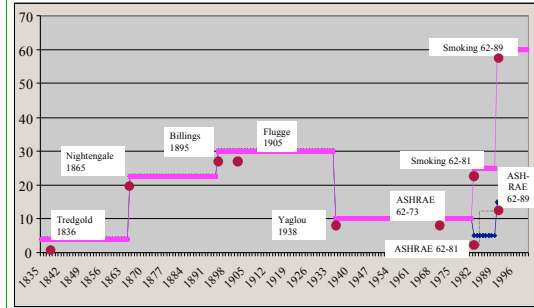


## Mechanical Dehumidification

- 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 CO<sub>2</sub> 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

