

Refrigeration Cycle Overview

- **Compressor:** (provides "work"/energy use: appx 1 HP/ton)
 - Centrifugal, screw, scroll or reciprocating
- **Condenser:** (provides "heat rejection")
 - Air-cooled vs. water cooled
- **Expansion/metering device:** (controls flow of refrigerant)
 - Orifice vs. "TXV"
- **Evaporator:** (delivers cooling to conditioned space)
 - DX Cooling coil
- **Refrigerants:** (environmental/global warming issues)
 - HCFC vs. CFC

HVAC System Types

- **All-Air systems- (package units !):**
 - constant volume, rooftop package gas-electric units
 - constant volume, rooftop package heat pumps
 - variable volume, rooftop package cooling/only units
 - constant volume, classroom heating/cooling units

HVAC System Types

- **Air/Water systems:**
 - central plant chilled water systems
 - central plant hot water systems
 - central plant steam heating systems
 - water-source heat pumps
 - air-cooled chilled water systems

HVAC System Types

****Rooftop Package Units****

- Why are these so Common ?
 - Low first cost
 - Easy to obtain
 - Simple to use/install
 - Excellent ventilation via air-side economizers
- What are their shortcomings ?
 - High operating/maintenance cost
 - 12-15 year lifespan
 - Pre-packaged individual components

HVAC System Types

****Rooftop Package Units****

- Gas/Electric; Cooling/only; Heat Pumps
 - Cooling capacities:
 - 1 ton = 400 CFM (+/- 20% flexibility)
 - unit capacity = total capacity NOT sensible capacity
 - ARI ratings: 95F ambient, 80F edb, 67F ewb)
 - sensible cooling capacity 70-80% of total
 - EER (Energy Efficiency Ratio)= $\frac{\text{btu/hr output}}{\text{KW input}}$

HVAC System Types

****Rooftop Package Units****

- Heating Capacities:
 - 1) **Gas/electric units-**
 - Input capacity (1 MBH = 1000 btu/hr)
 - Output capacity (1 MBH = 1000 btu/hr)
 - Efficiency = $\frac{\text{output MBH}}{\text{input MBH}}$
 - Title 24 minimum efficiency = 80%
 - Typically "low heat" models used in California
 - "Aluminized steel" heat exchangers (SS as option)

HVAC System Types

Rooftop Package Units

2) Package Heat Pumps-

- heat is generated by refrigeration compressors
- reversing valve changes function of evaporator and condenser
- heat output is a function of OSA temperature
- ARI ratings @ 47 F ambient
- COP (Coefficient Of Performance) = $\frac{\text{output btu/hr}}{\text{input btu/hr}}$
- auxiliary electric heaters needed for cold winter A.M. and "defrost cycle"

Rooftop VAV Systems

■ VAV- Variable Air Volume

- 1) Room temperature control by modulating quantity of "constant temperature" supply air
- 2) Supply air reset actually varies temperature of supply air to keep minimum airflow's up
- 3) Minimum supply of ventilation air critical !!
15 CFM/person recommended @ all times
- 4) VAV boxes should be "pressure independent" so that they compensate for changes in upstream pressure.
"velocity controls/sensors" required

Rooftop VAV Systems

■ Control Systems:

DDC, electric, pneumatic zone controls
Refrigeration controls- multiple compressors/staging
(discharge temp sensor) cylinder unloaders
hot gas bypass
Fan controls- NONE--"ride the curve" (note effect
(static pressure sensor) on ducting system design)
Discharge dampers
Inlet vanes
Variable Frequency Drive (VFD)

Rooftop VAV Systems

■ Control Systems (cont.):

- Morning warmup-** return air sensor w/ 70 F setpt.
- Night set back-** building sensor w/ 60 F setpt.
- Pilot zones-** building sensor (1 per heating system) located @ north zone to control heating system serving that area of building
- VAV boxes-** pressure dependent vs. independent
- DDC controls-** higher initial cost
more diagnostics
better troubleshooting (remote)

VAV Systems

■ Energy Savings:

- "Part-load" performance on refrigeration system
Cooling systems are designed to run at partial load in order to better match building load characteristic.
- Fan BHP energy savings
"CUBE LAW"- BHP energy savings varies to the cube of CFM reduction.

EXAMPLE:

CFM value is reduced to 50% of original CFM
BHP value is reduced to 12.5% of original BHP

HVAC System Types

Central Plant

■ Central Plant Systems:

- Why are these systems installed ?
 - Lower ongoing operation/maintenance costs offset higher initial cost
 - Life Cycle Cost/Present Worth Analysis
 - Longer lifespan of equipment--> 25-30 years
 - Greater flexibility in designing/selecting "engineered" components
 - Increased reliability of system

Central Plant HVAC Systems

- **Air-cooled vs. Water-cooled chillers**
 - air-cooled: least expensive initial cost
higher operating cost (1.2-1.6 kw/ton)
rated capacity based on T dry bulb
(i.e. San Jose--> 95 F minimum)
 - water-cooled: higher initial cost
lowest operating cost (0.5-0.8 kw/ton)
rated capacity based on T wet bulb
(i.e. San Jose--> 70 F)
higher maintenance cost (cooling towers)

HVAC Control Strategies

- **Economizers:**
 - utilize “free cooling” when it is available.
 - Package units- advisable for systems 5 tons and larger for cost-effectiveness
 - enthalpy vs. dry bulb control
- **Indoor Air Quality:**
 - very controversial topic in ASHRAE
 - CO2 monitors in workplace ?
 - What about hydrocarbon outgassing ?

HVAC Control Strategies

- **Variable Frequency Drives:**
 - increased reliability/efficiency
 - PG & E rebates still exist
- **DDC Controls:**
 - increased monitoring capabilities for user
 - “smart” controls
 - optimum start/stop; morning warm-up; night setback
 - remote contractor/technician access for troubleshooting
