Air Conditioning and process cooling

Energy Components at a Glance

What is it?

A means of providing cooling with mechanical refrigeration equipment.

Where is it found?

Chilled water is found in many plants, non-existent in others. Essential where it is found: clean rooms, food chilling and storage.

Why is it important?

In plants where it exists, it is usually critically important to the process and a significant portion of the electric load.

What to look for:

Use free cooling. Use all cooling towers available. Reduce loads, look at ancilliary equipment (pumps, fans) for energy savings opportunities.

Common issues and problems:

Often critically important to the process

Air Conditioning and process cooling

In most industrial plants space conditioning is restricted to heating and ventilation

In a few plants air conditioning is very important

- clean rooms
- guage test rooms
- humidity control
- temperature control
- particulate control

Things to look for

- economizer controls
- non-electric humidifiers
- non-electric dehumidifiers
- vary air flow with ventilation requirements
  - measure particulate concentration
  - measure CO_2

Air Conditioning and process cooling

Process cooling

In a few plants process cooling is very important

- food processing - chill and store food
- plastics - cool molding machines

Things to look for

- water-cooled chillers
- evaporative air-cooled chillers
- free cooling
- maximize supply temperature subject to process requirements
- use tower water in place of chilled water
- insulation
- minimize load in chilled spaces (lights, motors, etc.)

Air Conditioning and process cooling

Process cooling examples

Air ring cooling on blown film machine

- Free winter cooling
- Damper to modulate temperature

Laminating press

- cool to speed process
- cooling tower water is acceptable, chilled water is better for process
- storage reduces first cost and electric demand

Plastics injection molding machine

- hydraulic cooling by cooling tower
- mold cooling by chiller

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Process cooling examples, cont'd

Ice cream production

Multiple temperatures:

- Cream hold: 40°F
- Precooling: 30°F
- Freezing: 0°F
- Hardening: -25°F
- Warehouse: -15°F

Separate cooling systems for different temperatures

Compound systems: separate stages of compression

Cascade systems: separate refrigerant circuits

Ammonia is desirable refrigerant

- Non CFC
- Efficient selection at low temperatures
- Safety issues

Air Conditioning and process cooling
Industrial process cooling

Wide variety of processes and applications

Standard components, specially designed systems

Distribution alternatives:

- refrigerant
- air
- water
- glycol-water mixture
- secondary coolant

Air Conditioning and process cooling
Efficiency in process cooling

Insulation essential

Use “free” cooling if possible

Use all of the cooling tower capacity available

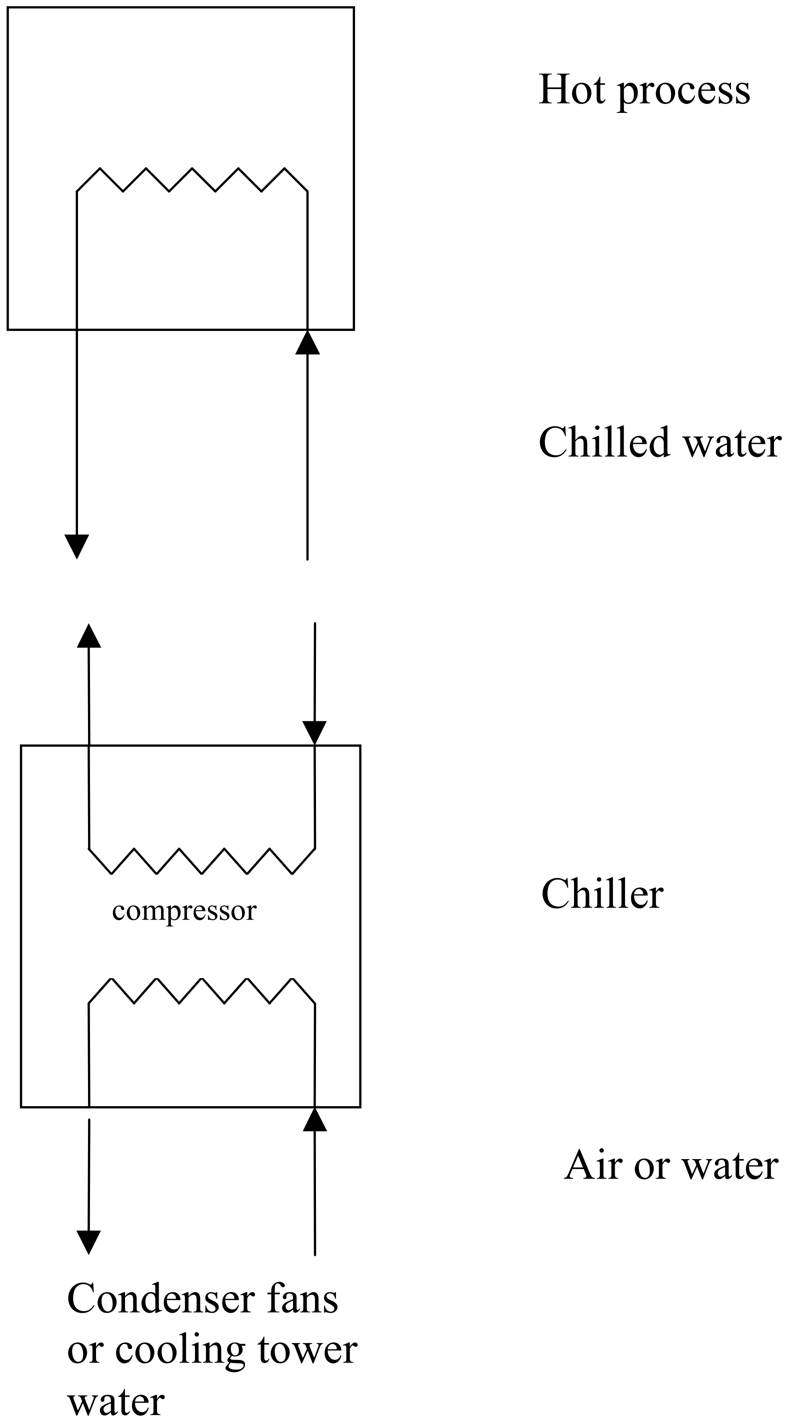
Consider part-load performance

Design controls for part-load efficiency

Use separate systems for different temperatures - the higher the temperature, the more efficient the refrigeration system

Air Conditioning and process cooling

Process cooling



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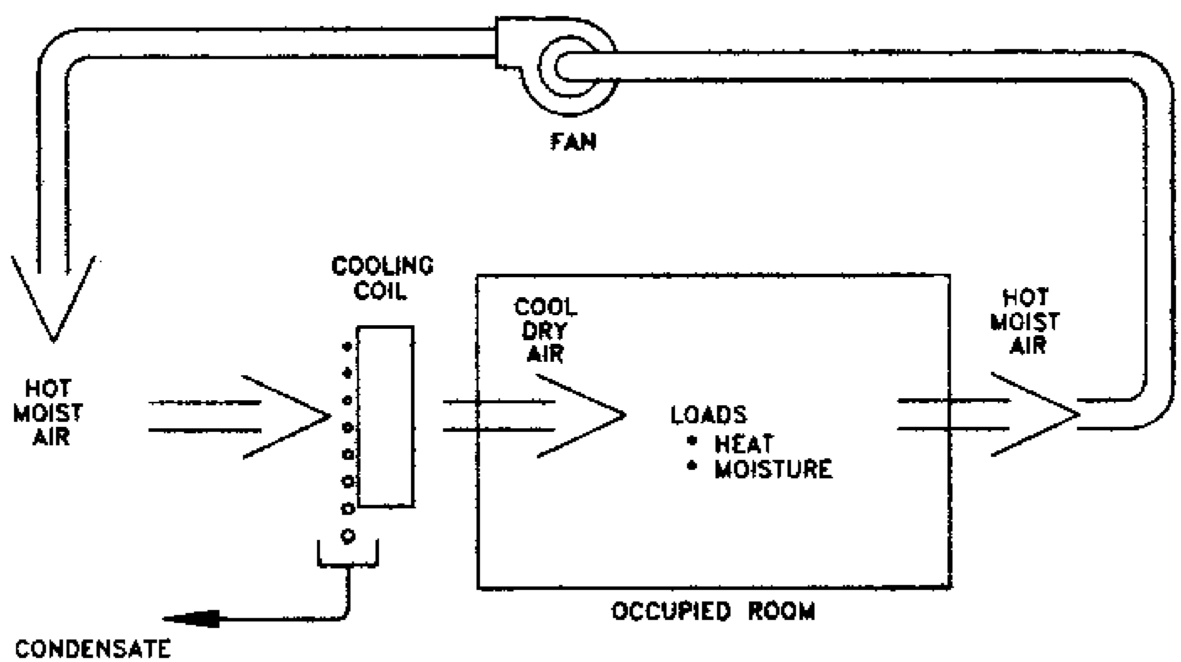
Air conditioning system



Air Conditioning and process cooling

Space cooling "Air conditioning"

Comfort

- cool air
- dry air

Remove heat from space

Sources of heat and moisture

- sun
- ventilation air
- lights
- equipment
- people

Air Conditioning and process cooling

Refrigeration vapor compression cycle

Refrigerant gas is compressed and cooled to remove heat

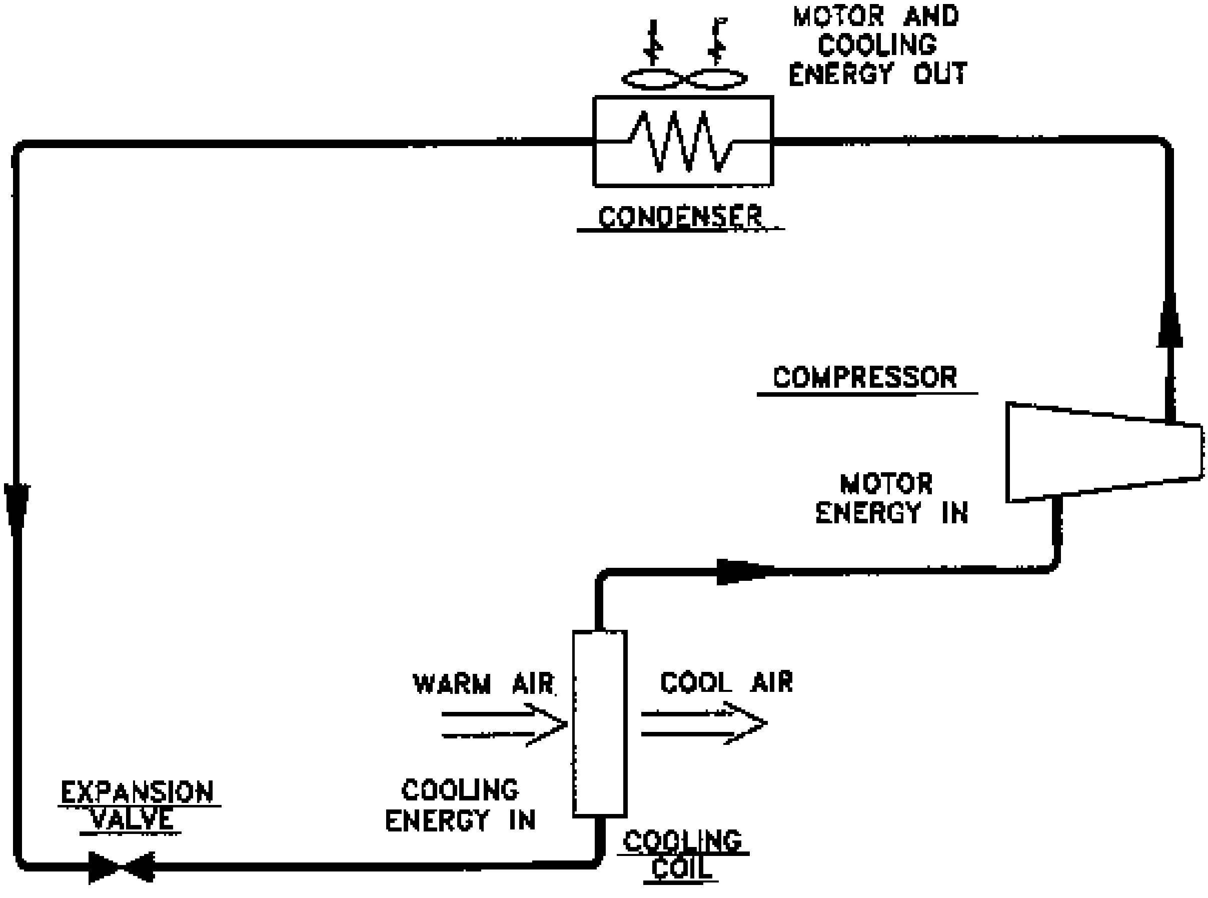
A motor (usually electric but can be steam or engine-driven) powers the compressor

Refrigerant is circulated:

- to cooling coil - gives off cooling, gains heat
- to compressor - increased temperature and pressure
- to condenser - rejects heat
- to expansion valve -reduces pressure, becomes cold gas

Air Conditioning and process cooling

Vapor compression cycle



Air Conditioning and process cooling

Vapor compression system components

Refrigeration component is composed of familiar components

Compressor

- like a bicycle pump

Condenser

- like a cold bathroom mirror

Expansion valve

- like a whistling tea kettle

Evaporator (cooling coil)

- like water or sweat evaporating off skin at the beach

Air Conditioning and process cooling

Vapor compression cycle

Refrigeration cycle moves energy around

Motor energy in: at compressor

Heat energy in: at cooling coil

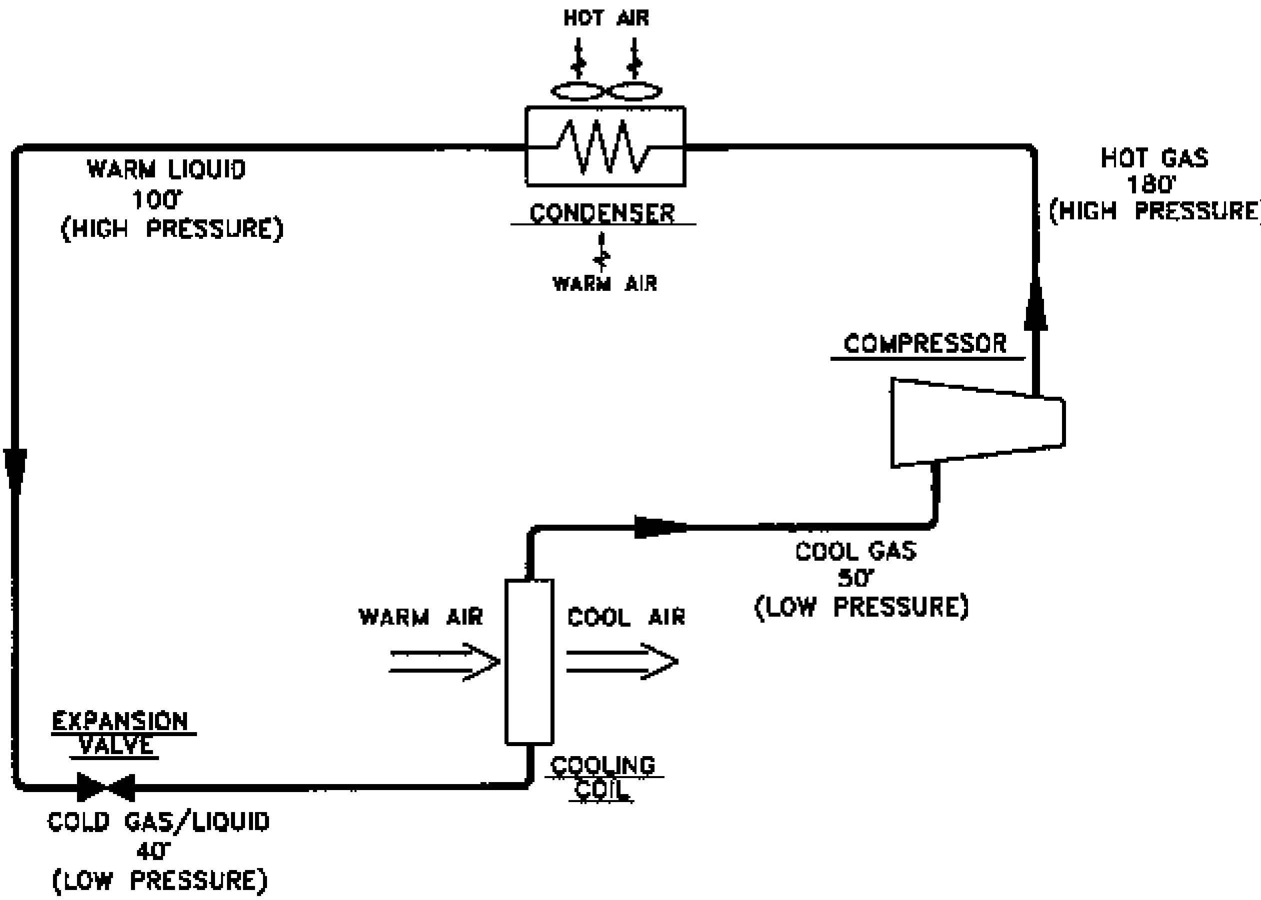
Heat and motor energy out: at condenser

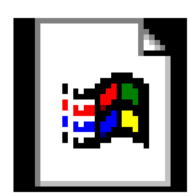
Energy balance: Energy in = energy out

Ratios of electrical energy in to heat removed (cooling produced) describe performance.

Air Conditioning and process cooling

Refrigeration cycle





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Heat pump cycle

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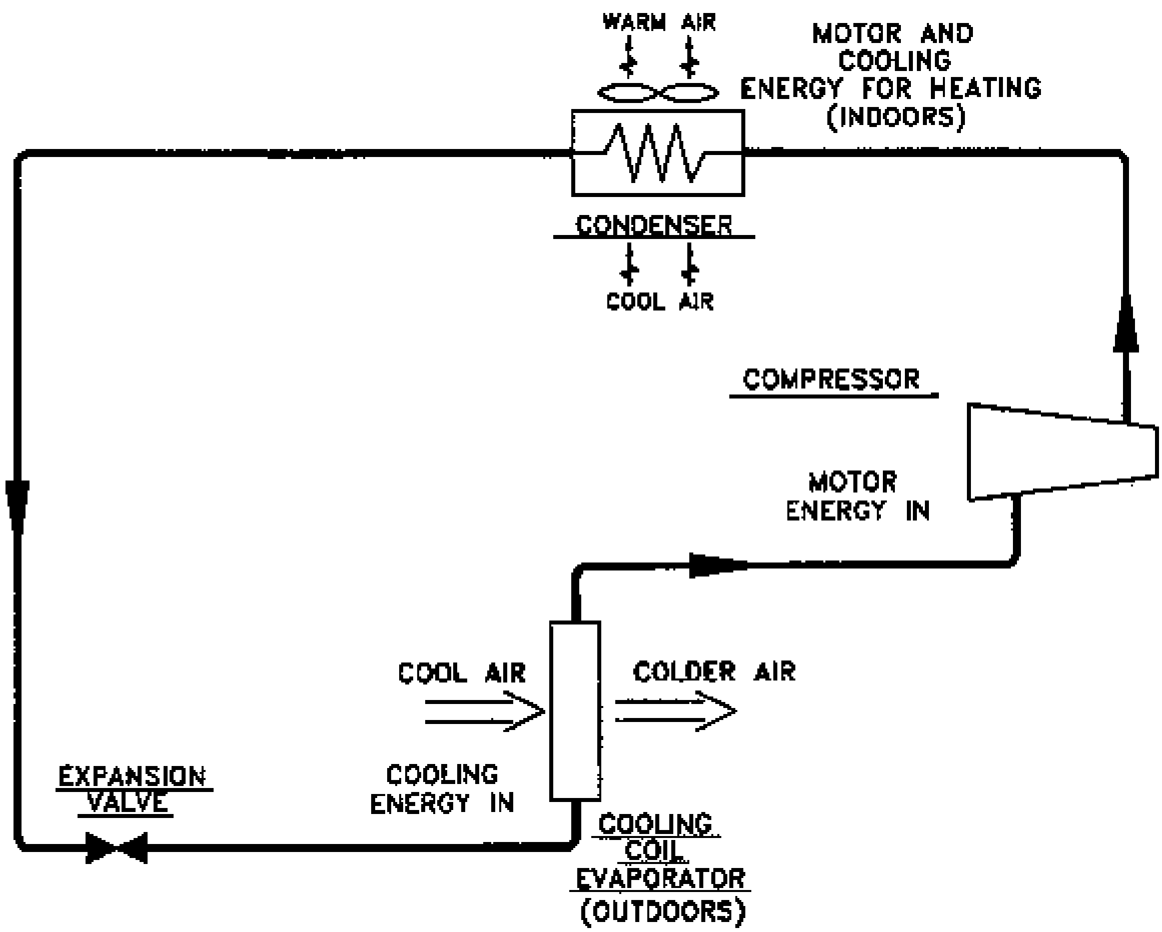


Air Conditioning and process cooling
CFCs

Chlorofluorocarbon refrigerants contribute to ozone depletion

Refrigerants being phased out

R-11	R-113	R-500
R-12	R-114	R-502

Chillers and AC units can be retrofitted with new, acceptable refrigerants

Refrigerant oil compatibility

Materials compatibility

Loss of efficiency, loss of capacity (within 10%)

- Opportunity to reduce loads with e^2
- Or replace with new equipment

Alternatives: R-22, R-123, R-134a, Ammonia, Water

Air Conditioning and process cooling
Absorption cycle

Uses heat to drive the refrigerant cycle

Refrigerant is water-salt mixture

Sources of heat

- fossil fuel
- steam: the hotter the better

Energy balance:

- heat load for cooling + heat input = heat rejected

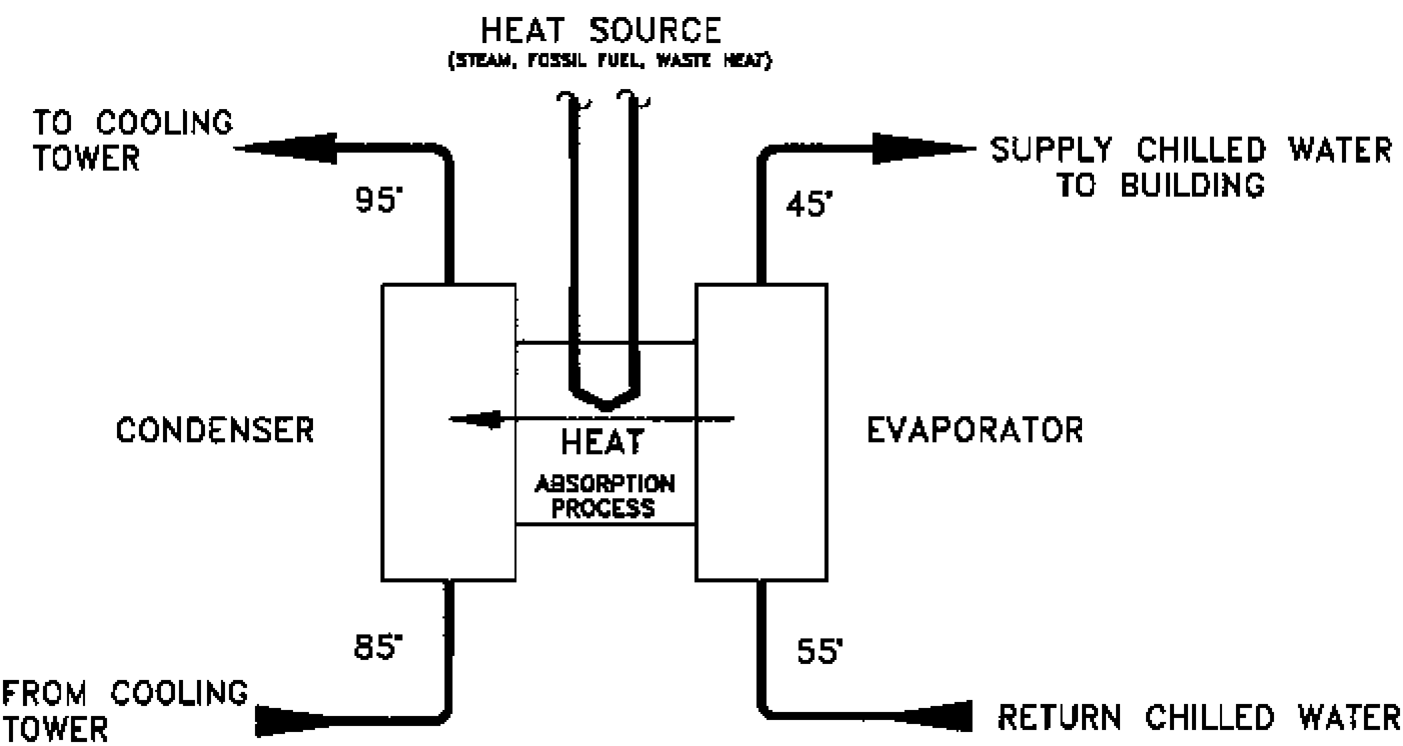
Performance:

- Single-effect absorption: COP = 0.67
- Double-effect absorption: COP = 1.0
- Triple-effect absorption: future

Fuel is often inexpensive compared to electricity which would drive a vapor-compression motor. Absorption can be competitive to electric-driven compressor cooling. Complex analysis to make comparison

Air Conditioning and process cooling

Absorption refrigeration cycle



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Evaporative cooling

Need dry air

- example: Swamp cooler

Water evaporates in hot dry air

Results in cooler, moist air

Approaches comfort

Reduce or eliminate the need for mechanical cooling

Part-load benefits especially high

Air Conditioning and process cooling

Space cooling concepts

"It's not the heat, it's the humdity"

ASHRAE Standard 55

Comfort zone:

- 67° to 82°F
- 35% to 60% rh

One ton = 1 ton of ice per day
= 12,000 Btu/hr

Window unit = 10,000 Btu/hr

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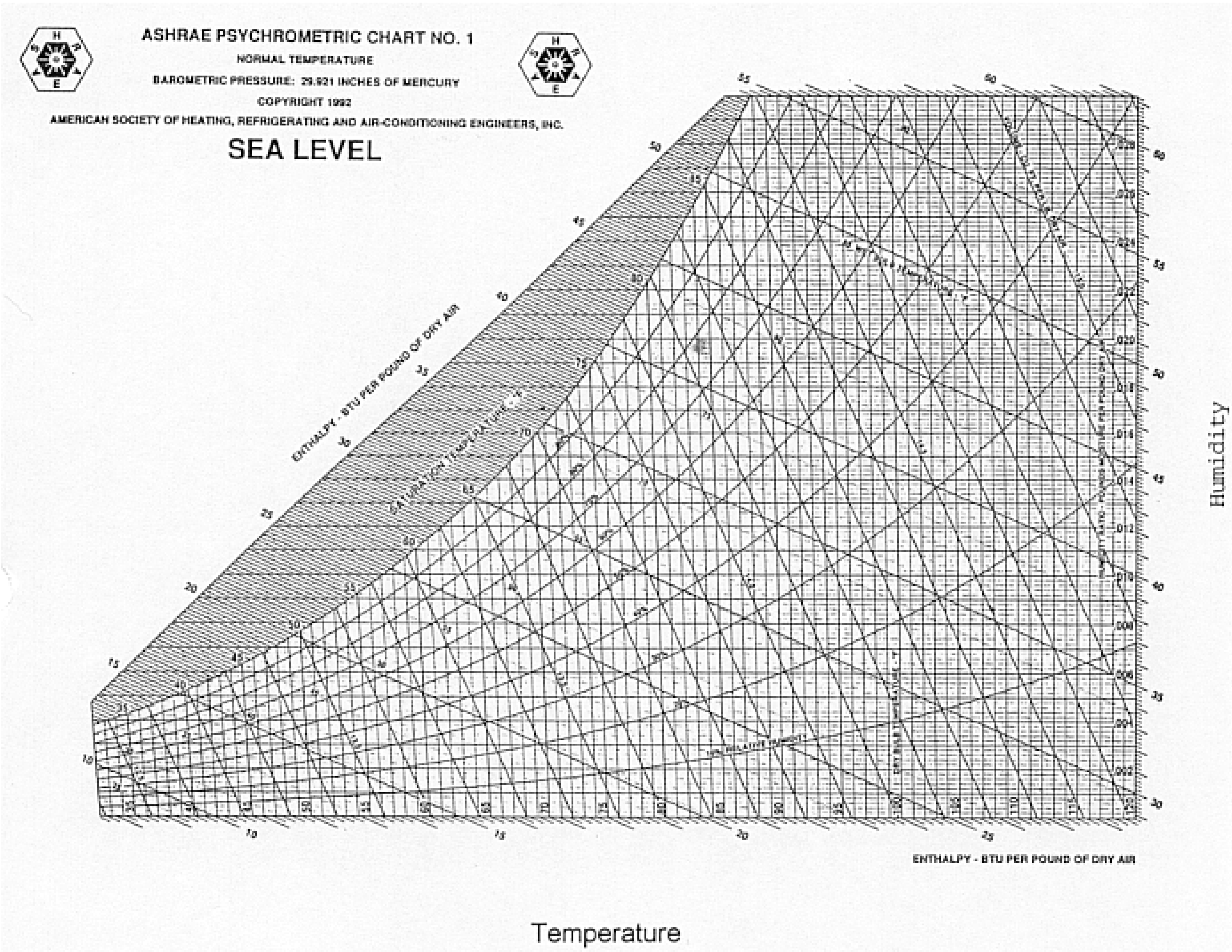
Psychrometric chart



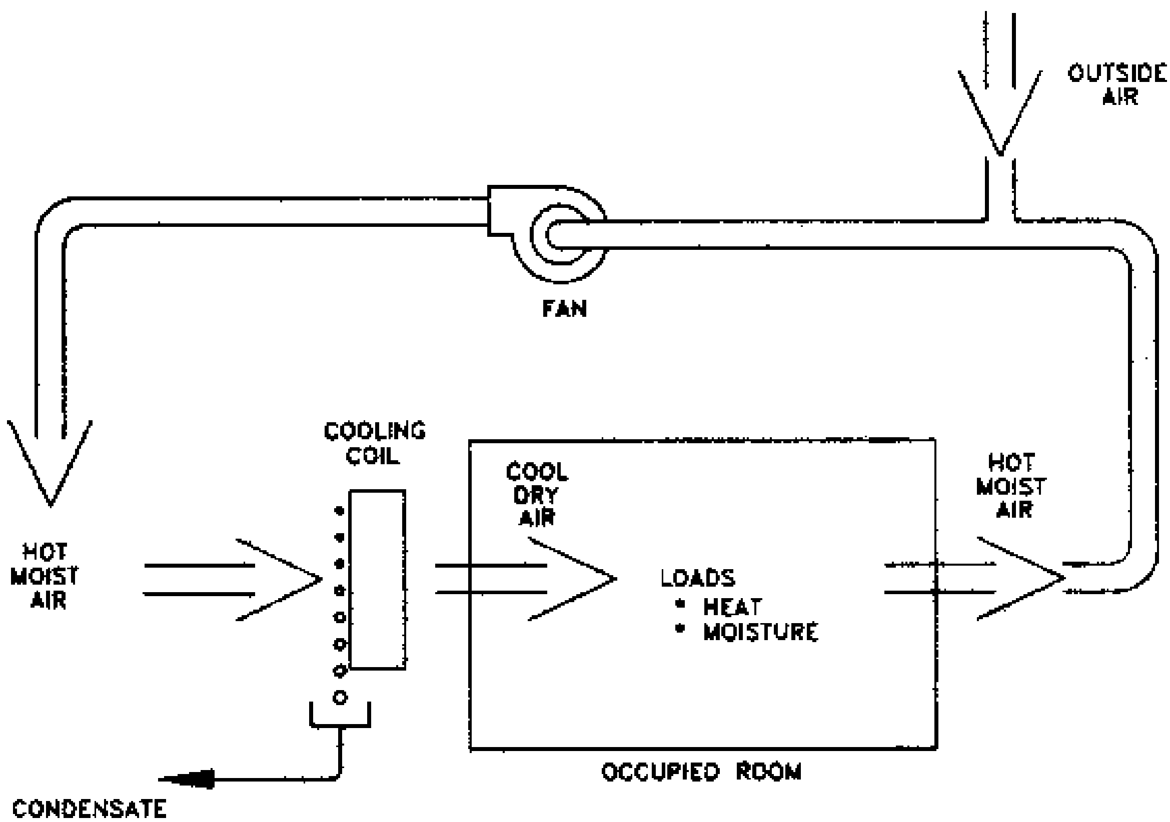
Engineering tool to calculate the energy in moist air

Heating, humidifying, cooling, dehumidifying

Comfort zone

Air Conditioning and process cooling

Air conditioning with outside air



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Humidity control

Reduce load on mechanical cooling system

Use heat (instead of cooling) to dehumidify air

Desiccant in air stream absorbs moisture

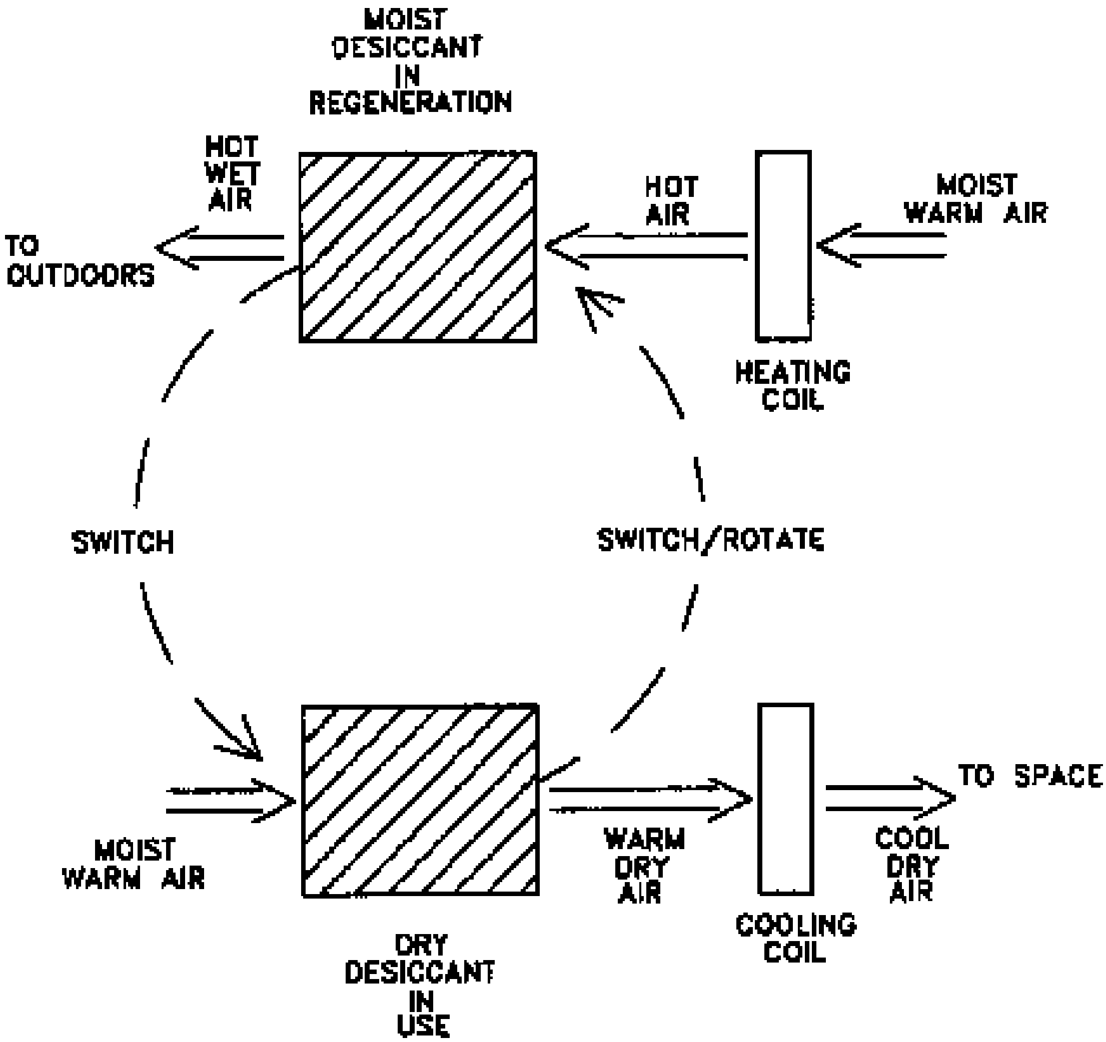
Desiccant switches or rotates to be regenerated with heat

Fossil (gas, oil) heat less expensive than electric

Waste heat is least expensive

Air Conditioning and process cooling

Desiccant dehumidification



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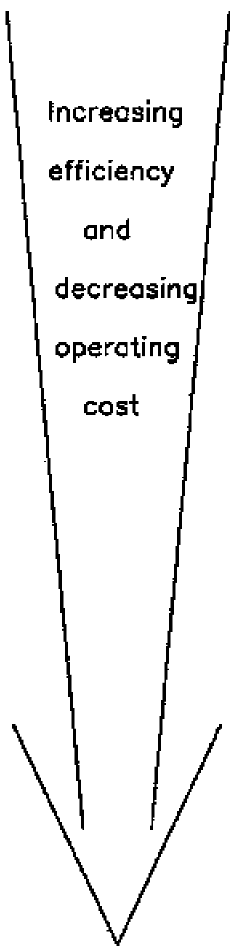
Moisture removal

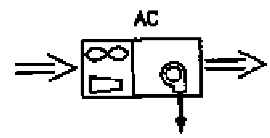


Electric technologies

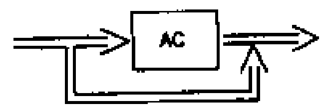
Low temperature refrigeration (freezer)

Medium temperature refrigeration (cooler)

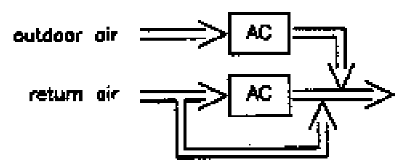
Conventional air conditioning



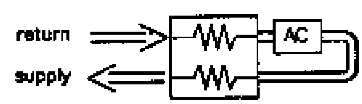
AC with bypass



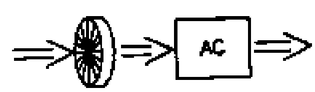
Dual path AC



Heat exchange
enhances any AC system



Gas technology



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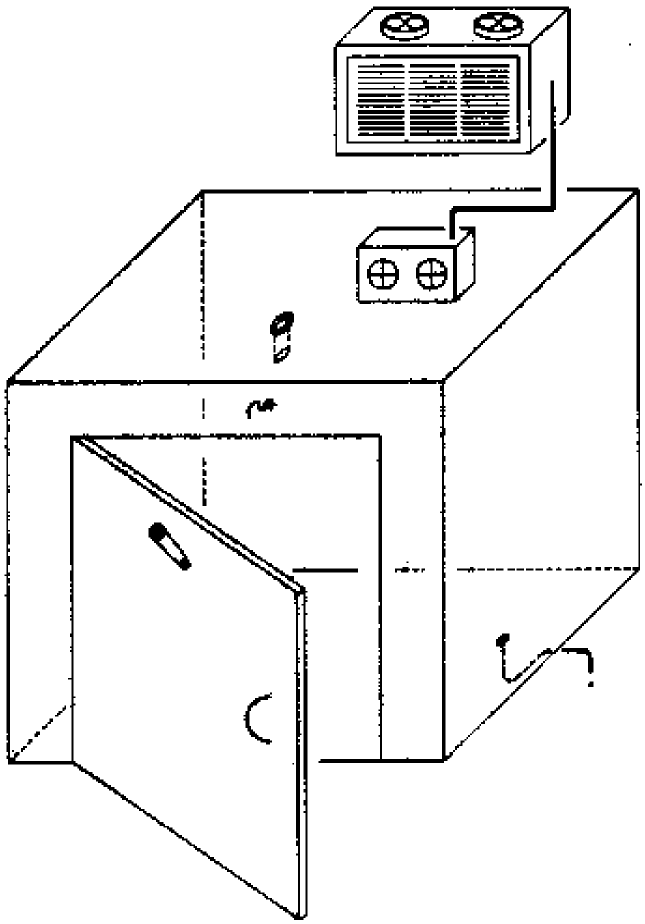
Energy use in commercial refrigeration



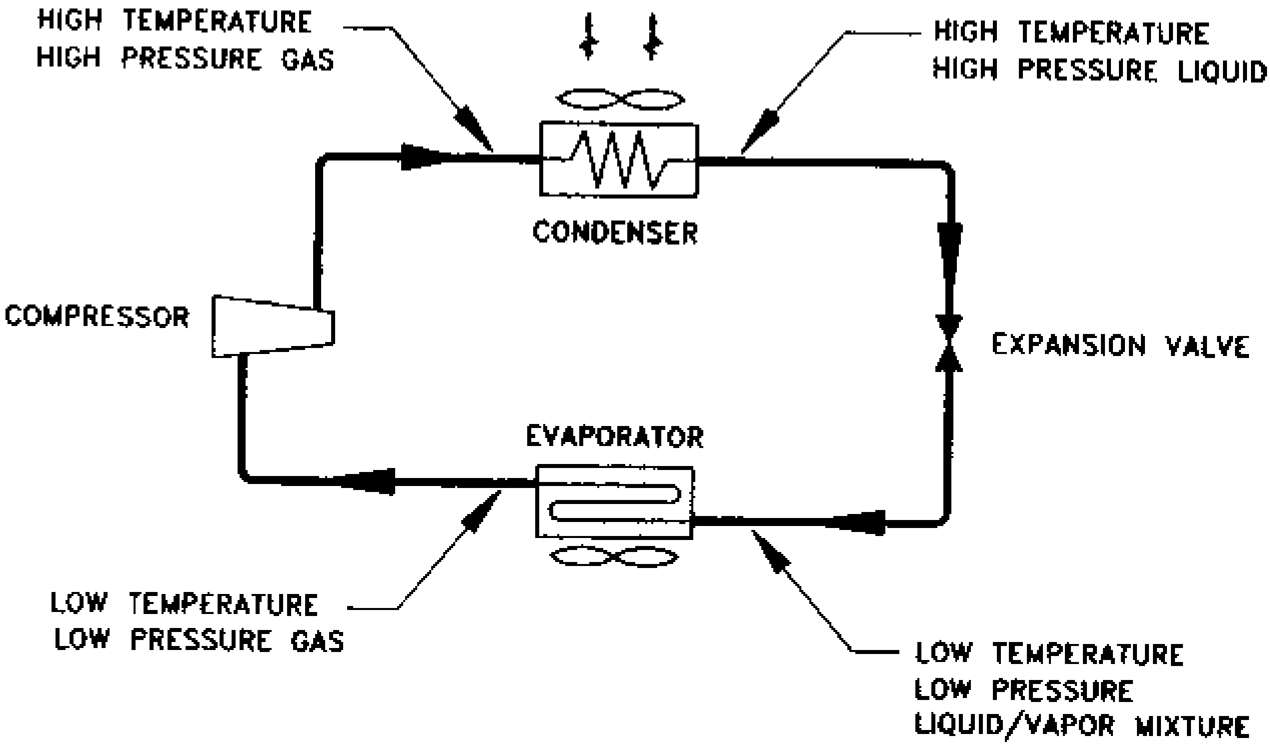
Interior

- Lights
- Evaporator Fan

Exterior

- Skin Heaters
  - –door
  - –frame
  - –perimeter
- Crankcase Heaters
- Condensate Heaters
- Compressor
- Condenser Fan

Air Conditioning and process cooling
Stand-alone Compressor



Compressor cycles to maintain suction pressure

Condenser fan cycles to maintain condensing temperature (~90° F)

Evaporator fan operates continuously

Air Conditioning and process cooling

Refrigeration load reduction

Envelope improvements - reduce load

- Insulation
- Door gaskets
- Door closer
- Vinyl strip curtains

Controls

- Occupancy sensor on light
- Cycle evaporator fan with compressor
- Control skin heaters
- Hot gas defrost in freezers
- Hot gas or controlled condensate evaporator
- Economizer operation in winter

Air Conditioning and process cooling
Refrigeration efficiency improvements

Improve efficiency and reduce load

- Fluorescent lamps
- High efficiency fans
- High efficiency motors

Compressors - improve efficiency

- high efficiency
- screw
- multiplex
- variable speed drive

Refrigeration energy re-use

- Heat recovery

Air Conditioning and process cooling

Foodservice equipment

Refrigerators

- ASHRAE 117
- NSF standard 7
- non-metallic liner
- non-electric condensate evaporator
- self-closing door
- magnetic gasket

Ice machines

- ARI standard 810
- energy use
- water use = sewer use

Air Conditioning and process cooling
Cafeteria equipment

Coffee machines

- Brew into thermal carafe
- Versatile machine
  - regular/decaf coffee
  - hot chocolate
  - hot tea
  - iced tea
- Insulated urns
- Timer to turn off urns
- Provide hot water dispenser

Griddles

- low emissivity, shiny surface
- ASTM standard F 1275
- Tilting braising pan for versatility

Air Conditioning and process cooling

Cafeteria equipment, cont'd

Fryers

- High efficiency gas
  - radiant burner
  - power burner
- Insulated electric fryer
- Electric induction fryer

Flashbake oven

- cooks with light
- faster than microwave

Air Conditioning and process cooling

Review exercise

Based on what you have just learned about air conditioning, brainstorm as many energy efficiency options as you can think of and add them to the appropriate level of the fruit tree.