Refrigeration &

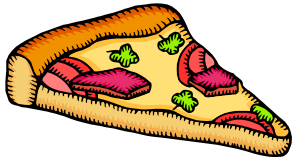
Air Conditioning

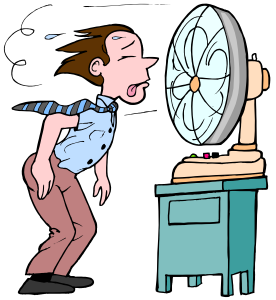
Objectives

- Basic operation of refrigeration and AC systems
- Principle components of refrigeration and AC systems
- Thermodynamic principles of refrigeration cycle
- Safety considerations

Uses of Systems

- Cooling of food stores and cargo
- Cooling of electronic spaces and equipment
  - CIC (computers and consoles)
  - Radio (communications gear)
  - Radars
  - ESGN/RLGN
  - Sonar
- Cooling of magazines
- Air conditioning for crew comfort





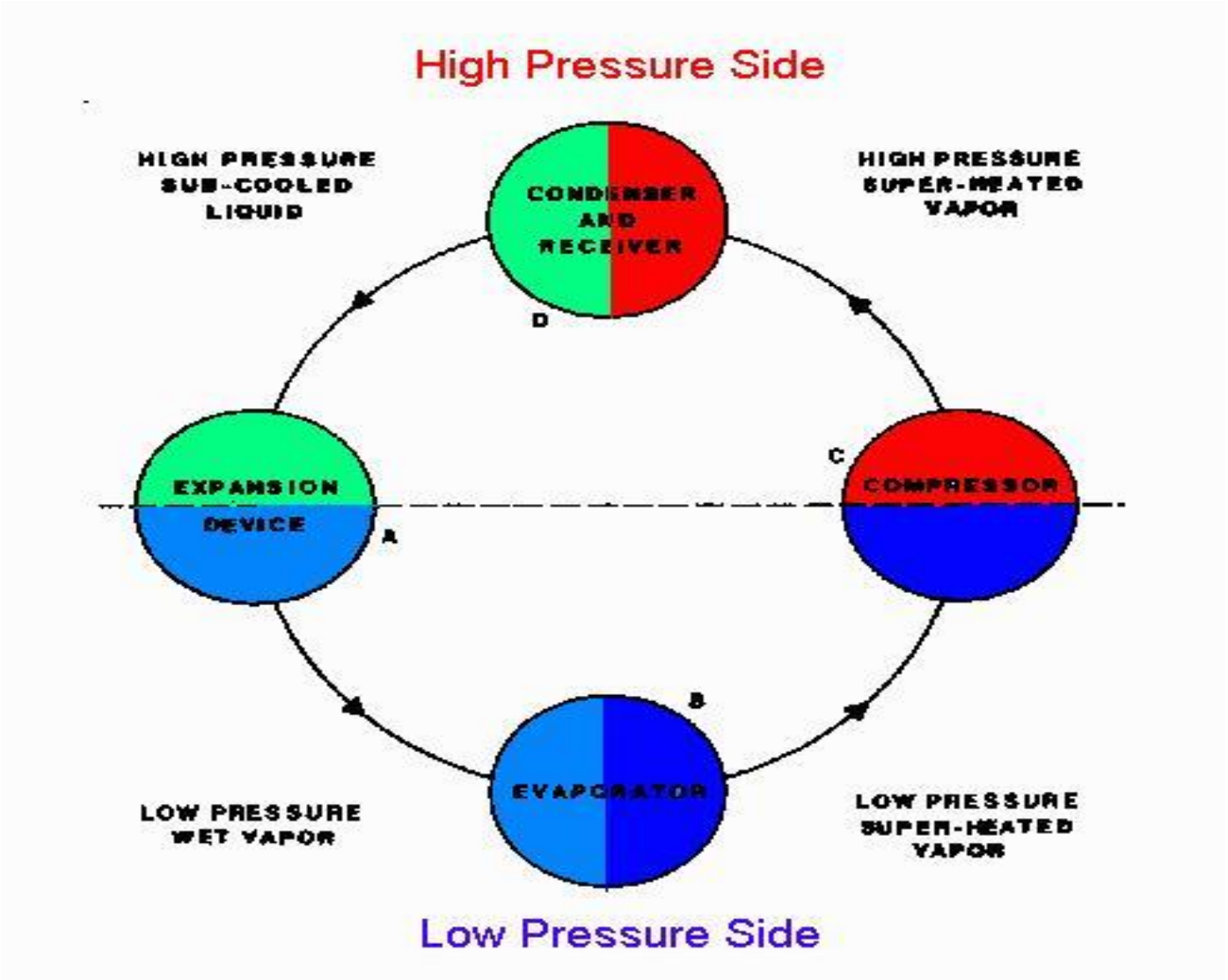
Definition Review

- Specific heat (c_p): Amount of heat required to raise the temperature of 1 lb of substance 1°F (BTU/lb) – how much for water?
- Sensible heat vs Latent heat
- LHV/LHF
- Second Law of Thermodynamics: must expend energy to get process to work

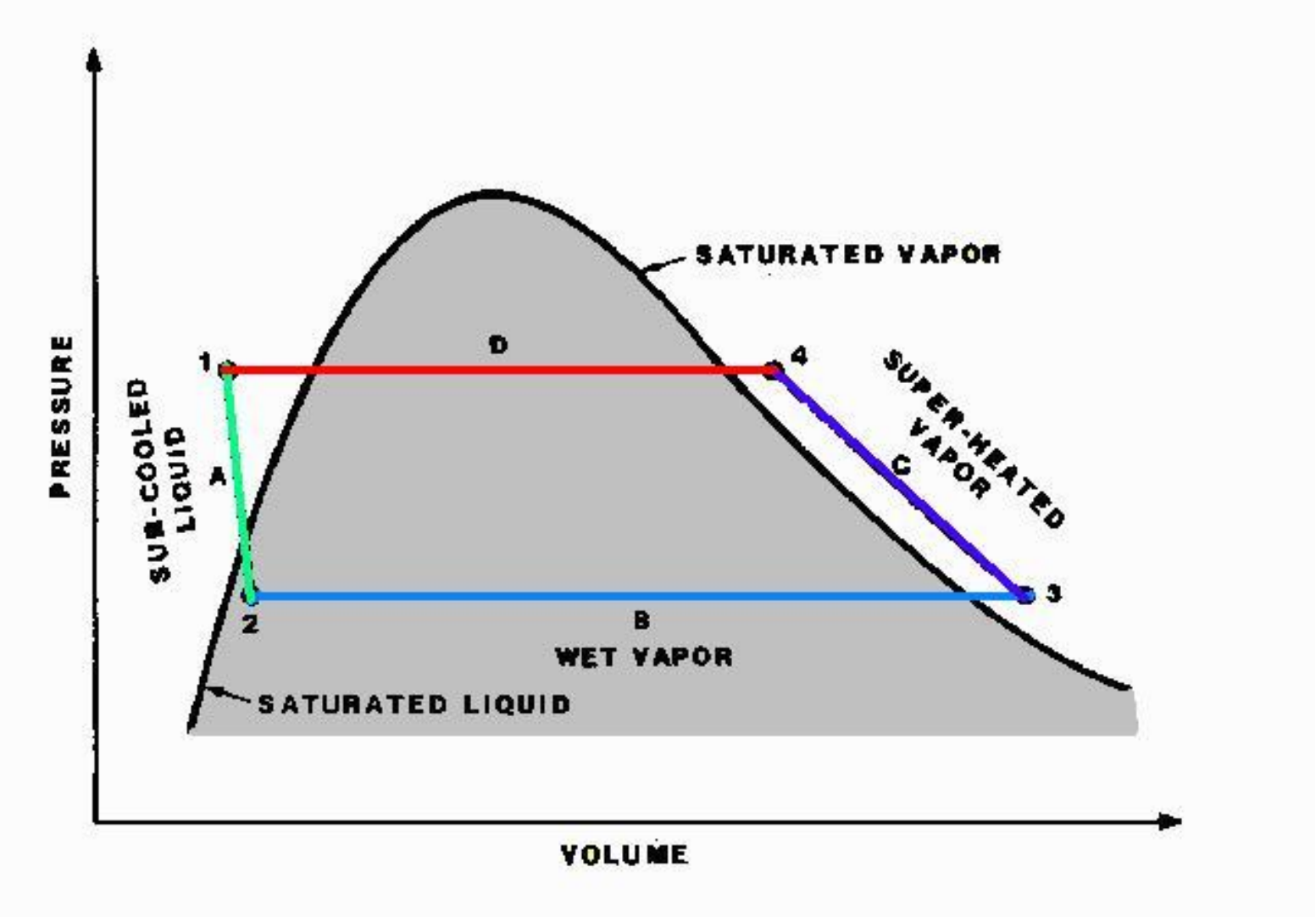
Refrigeration Cycle

- Refrigeration - Cooling of an object and maintenance of its temp below that of surroundings
- Working substance must alternate b/t colder and hotter regions
- Most common: vapor compression
  - Reverse of power cycle
  - Heat absorbed in low temp region and released in high temp region

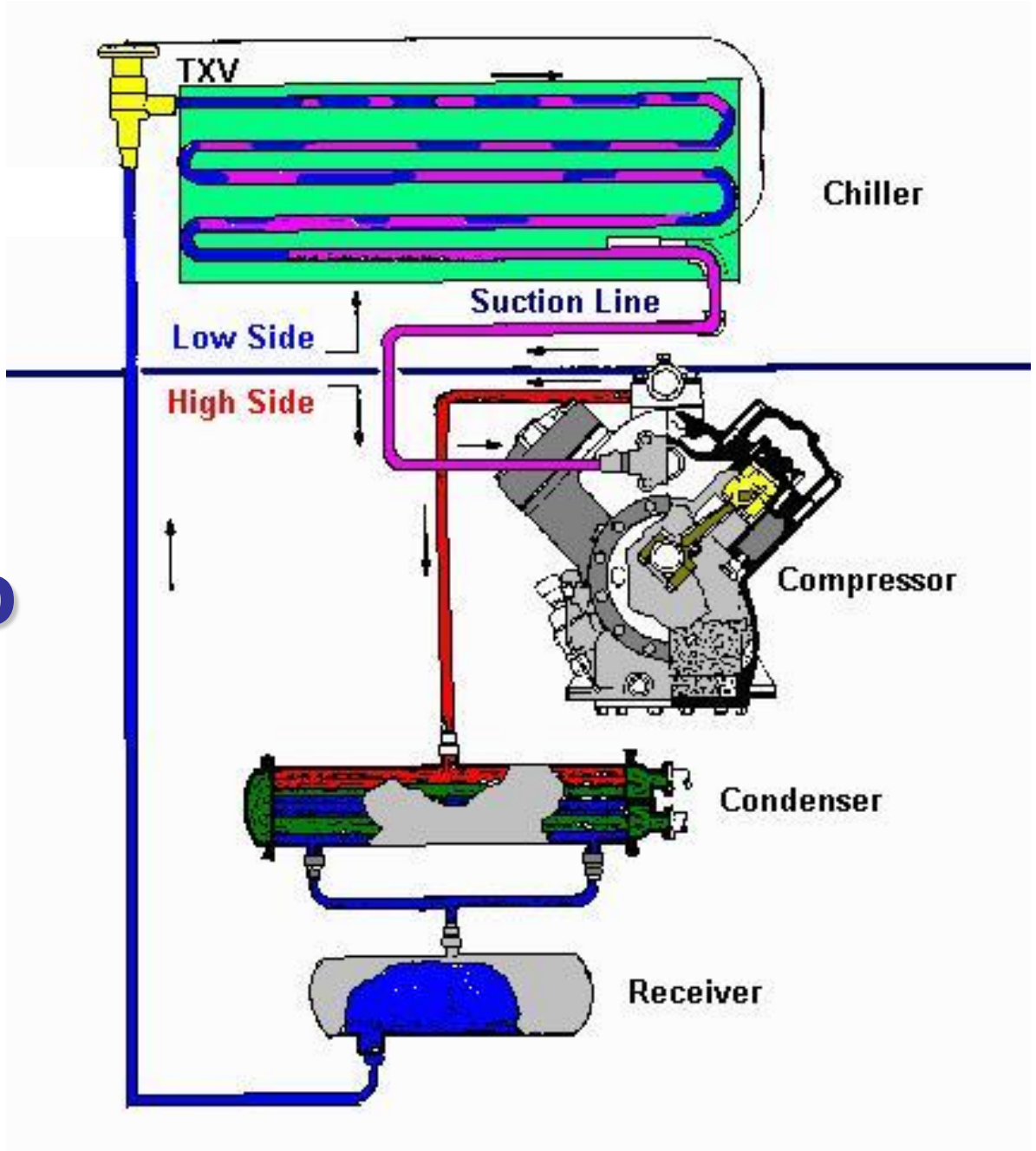
Generic Refrigeration Cycle



Thermodynamic Cycle

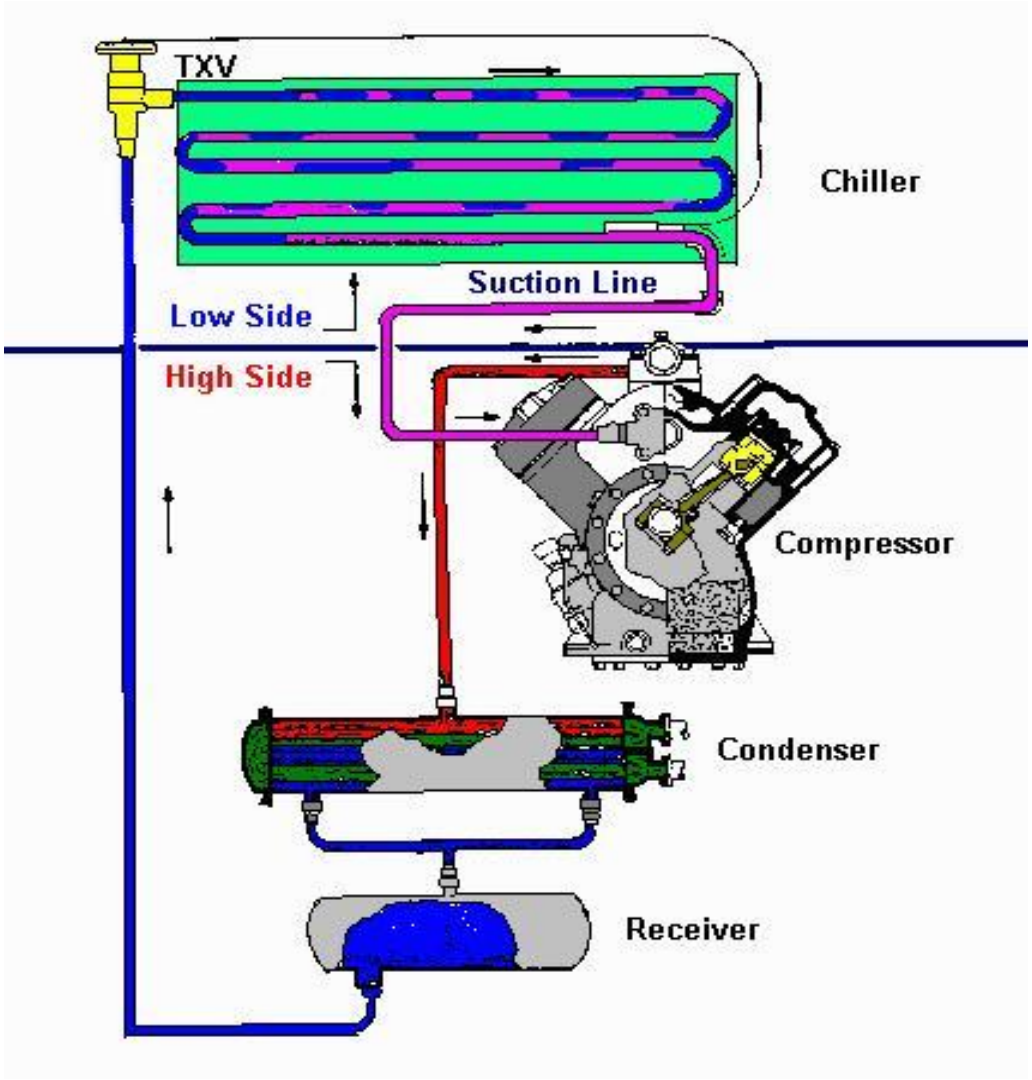


Typical Refrigeration Cycle



Components

- Refrigerant
- Evaporator/Chiller
- Compressor
- Condenser
- Receiver
- Thermostatic expansion valve (TXV)



Refrigerant

- Desirable properties:
  - High latent heat of vaporization - max cooling
  - Non-toxicity (no health hazard)
  - Desirable saturation temp (for operating pressure)
  - Chemical stability (non-flammable/non-explosive)
  - Ease of leak detection
  - Low cost
  - Readily available
- Commonly use FREON (R-12, R-114

Evaporator/Chiller

- Located in space to be refrigerated
- Cooling coil acts as an indirect heat exchanger
- Absorbs heat from surroundings and vaporizes
  - Latent Heat of Vaporization
  - Sensible Heat of surroundings
- Slightly superheated (10°F) - ensures no liquid carryover into compressor

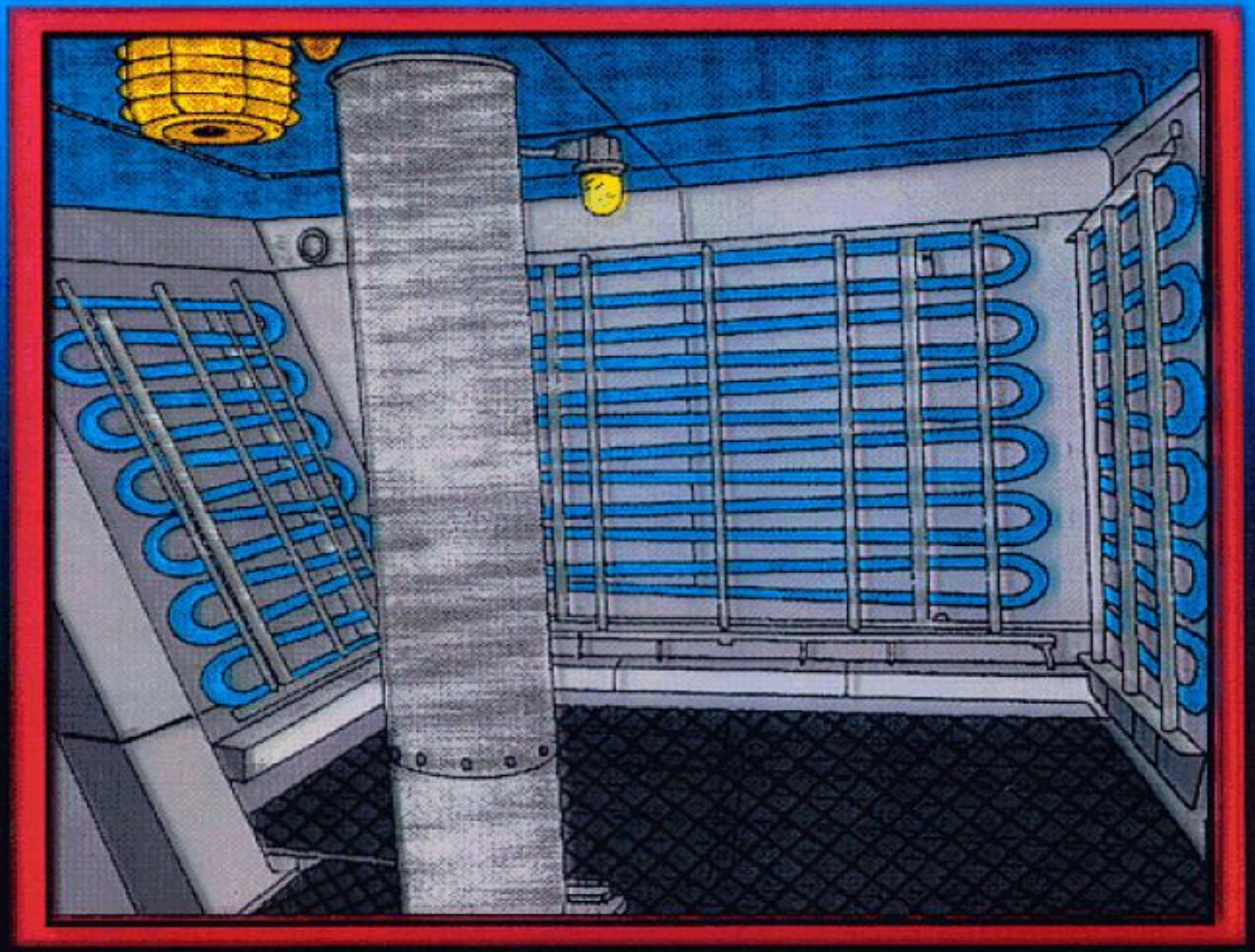


Figure 22-5

EVAPORATOR TUBING

Compressor

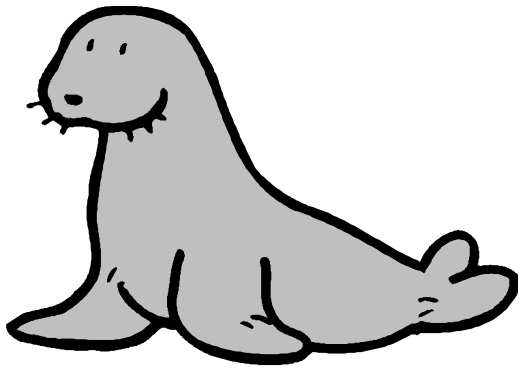
- Superheated Vapor:
  - Enters as low press, low temp vapor
  - Exits as high press, high temp vapor
- ↑ Temp: creates differential (ΔT) promotes heat transfer
- ↑ Press ↑ T_{sat} → allows for condensation at warmer temps
- Increase in energy provides the driving force to circulate refrigerant through the system

Condenser

- Refrigerant rejects latent heat to cooling medium
- Latent heat of condensation (LHC)
- Indirect heat exchanger: seawater absorbs the heat and discharges it overboard

Receiver

- Temporary storage space & surge volume for the sub-cooled refrigerant
- Serves as a vapor seal to prevent vapor from entering the expansion valve



Expansion Device

- Thermostatic Expansion Valve (TXV)
- Liquid Freon enters the expansion valve at high pressure and leaves as a low pressure wet vapor (vapor forms as refrigerant enters saturation region)
- Controls:
  - Pressure reduction
  - Amount of refrigerant entering evaporator controls capacity

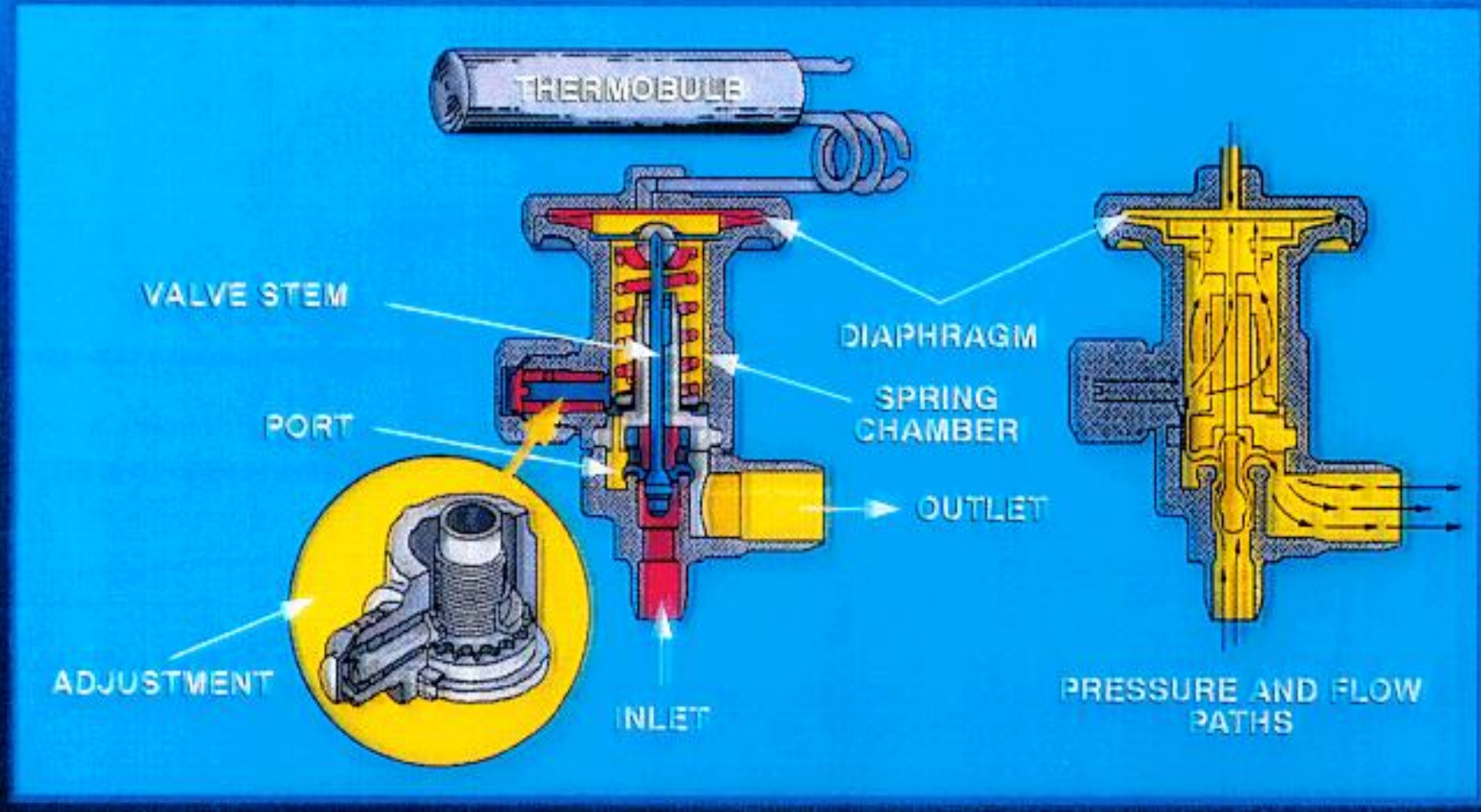


Figure 22-4

THERMOSTATIC EXPANSION VALVE

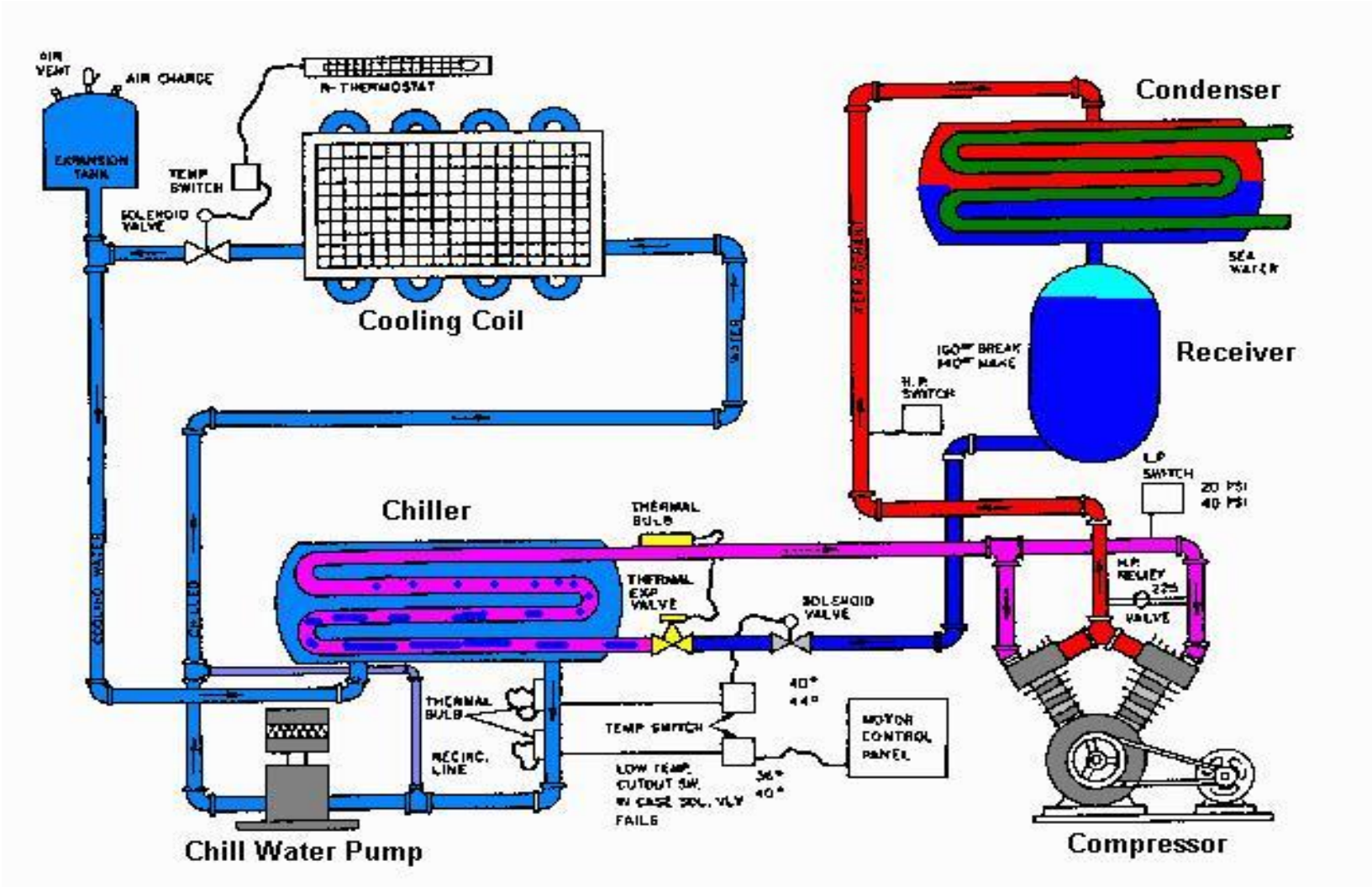
Air Conditioning

- Purpose: maintain the atmosphere of an enclosed space at a required temp, humidity and purity
- Refrigeration system is at heart of AC system
- Heaters in ventilation system
- Types Used:
  - Self-contained
  - Refrigerant circulating
  - Chill water circulating

AC System Types

- Self-Contained System
  - Add-on to ships that originally did not have AC plants
  - Not located in ventilation system (window unit)
- Refrigerant circulating system
  - Hot air passed over refrigerant cooling coils directly
- Chilled water circulating system
  - Refrigerant cools chill water
  - Hot air passes over chill water cooling coils

Basic AC System



Safety Precautions

- Phosgene gas hazard
  - Lethal
  - Created when refrigerant is exposed to high temperatures
- Handling procedures
  - Wear goggles and gloves to avoid eye irritation and frostbite
- Asphyxiation hazard in non-ventilated spa (bilges since heavier than air)
- Handling of compressed gas bottles