# WELLCOME TO MY CLASS

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**Mymensingh Polytechnic institute**

# AUTOMOBILE AIR-CONDITIONING

**SUBJECT CODE : 66253**

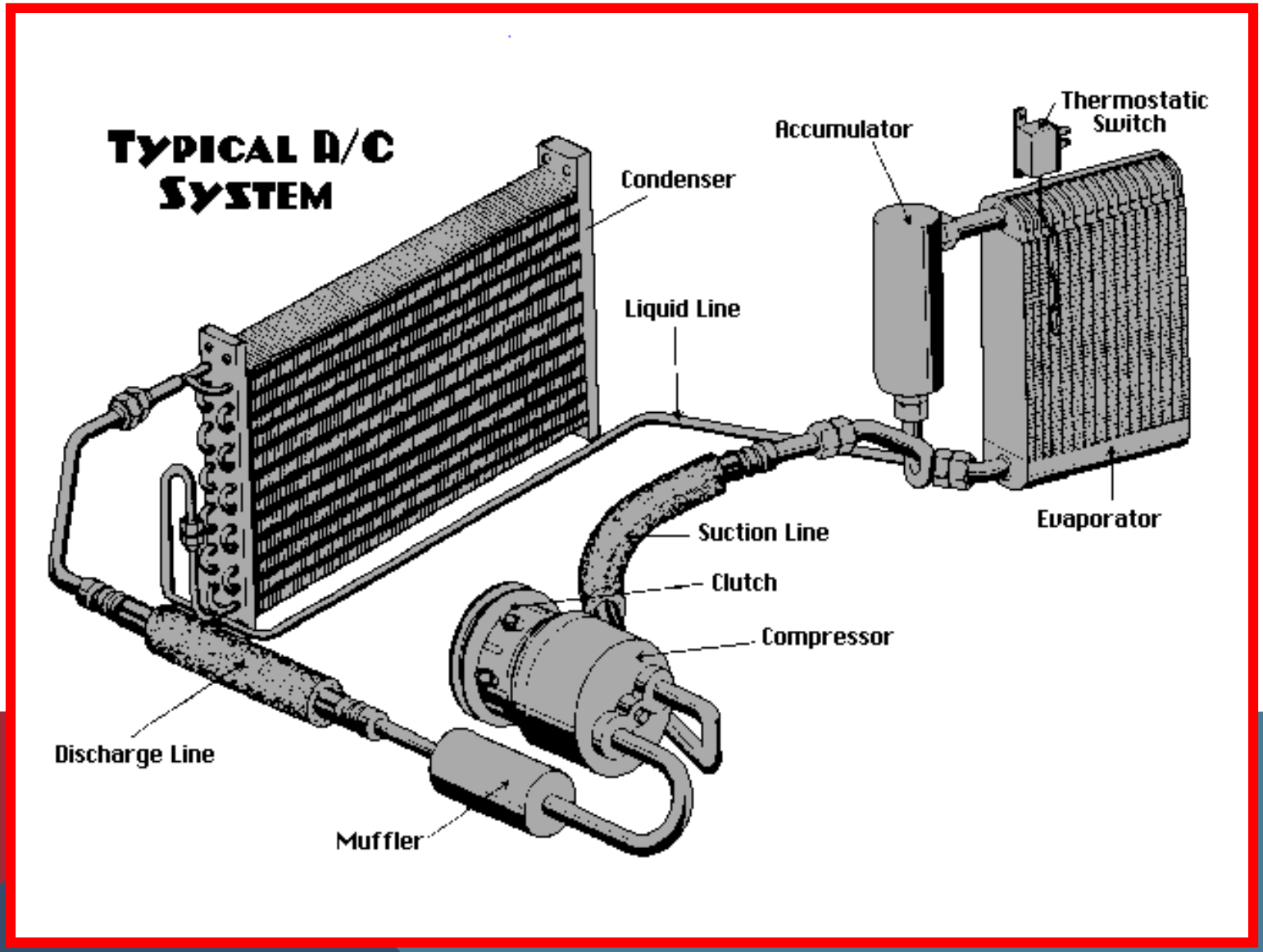
| Period per Week | | Credit |
|---|---|---|
| T | p | C |
| 2 | 3 | 3 |

# AIMS

**To provide the students with an opportunity to acquire knowledge, skill and attitude in the area of basic refrigeration and auto air-conditioning with special emphasis on:**

- **Refrigeration science.**
- **Different methods of refrigeration.**
- **Components and accessories of refrigeration cycle.**
- **Refrigerants.**
- **Air-conditioning fundamentals**
- **Automobile bus air conditioning system**
- **Van & Trailer refrigeration system**
- **Automobile air-conditioning system and servicing.**

# BASIC AIR CONDITIONING SYSTEM



# RATIONALE

**Refrigeration science; Different methods of refrigeration; Vapor compression cycle components and**

**accessories; Refrigerants; Air-conditioning fundamentals; Automobile air conditioner; Automobile air**

**conditioner control system; Automobile bus air conditioning system; Van & Trailer refrigeration system,**

**Automobile air conditioner servicing.**

# Topics

**After Completing the subject, students will be able to:**

- **Understand the science of refrigeration.**
- **Understand different methods of refrigeration.**
- **Understand the features of vapor compression system components.**
- **Understand the features of the accessories used in auto air-conditioner refrigeration cycle.**
- **Understand the features of automobile air-conditioner control system.**
- **Understand the features of coupling & safety devices of automobile air-conditioner.**
- **Understand the concept of transport refrigeration.**
- **Understand features of refrigerated Covered Van and trailers.**
- **Understand the concept of bus air-conditioning system.**
- **Understand the automobile air-conditioning system servicing.**

# *Describe operating principle of* Refrigeration

**Out line :**

- **Basic Refrigeration Cycle**
- **Refrigeration “Rules of Thumb” and Definition**
- **Common Units of Measure**
- **Common Terms**
- **Common Acronyms**
- **Refrigeration System Components**
- **Refrigeration Cycles**
- **Superheat and Subcooling**
- **Scotsman Refrigeration 201**

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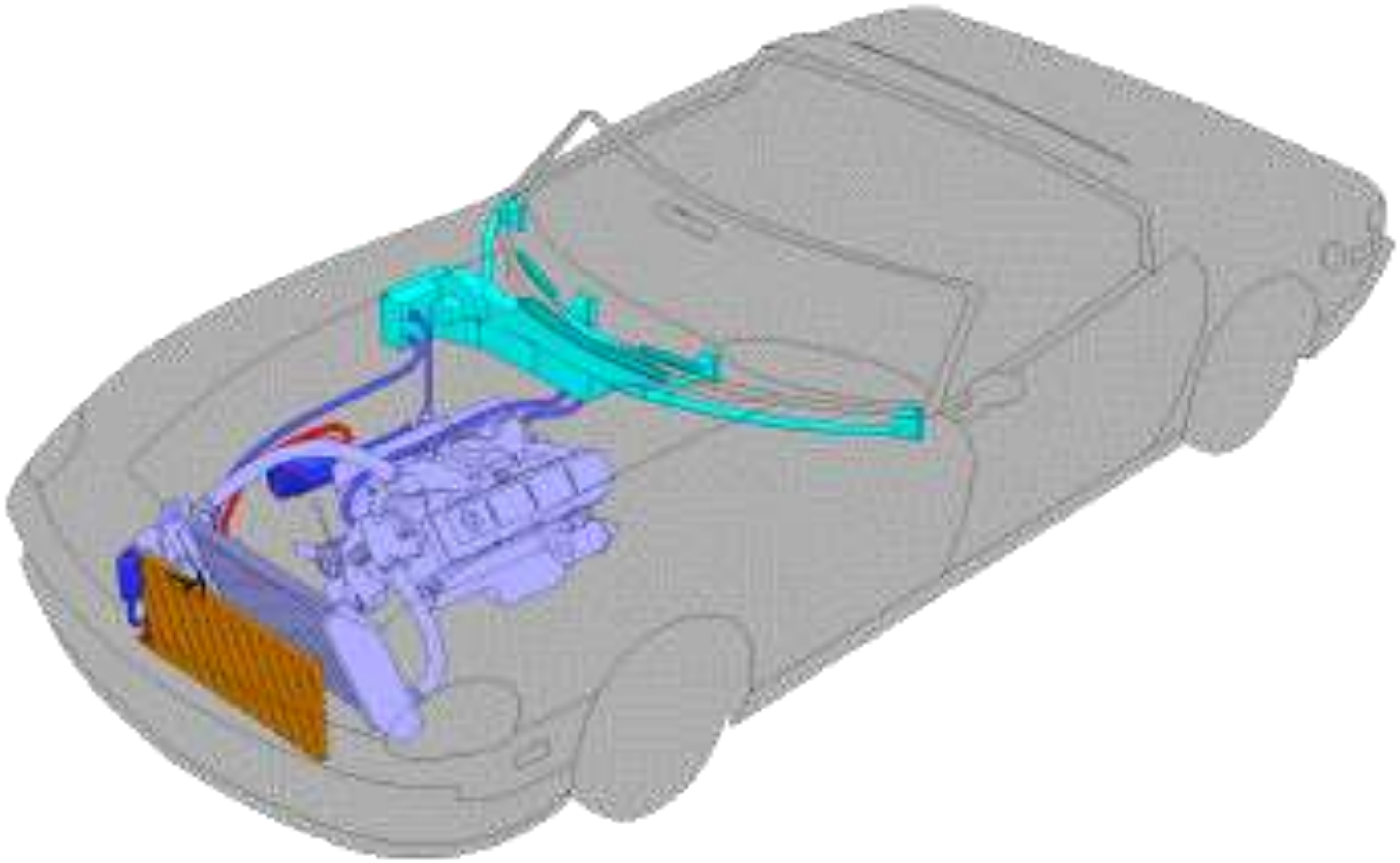
# A/C SYSTEM COMPONENTS



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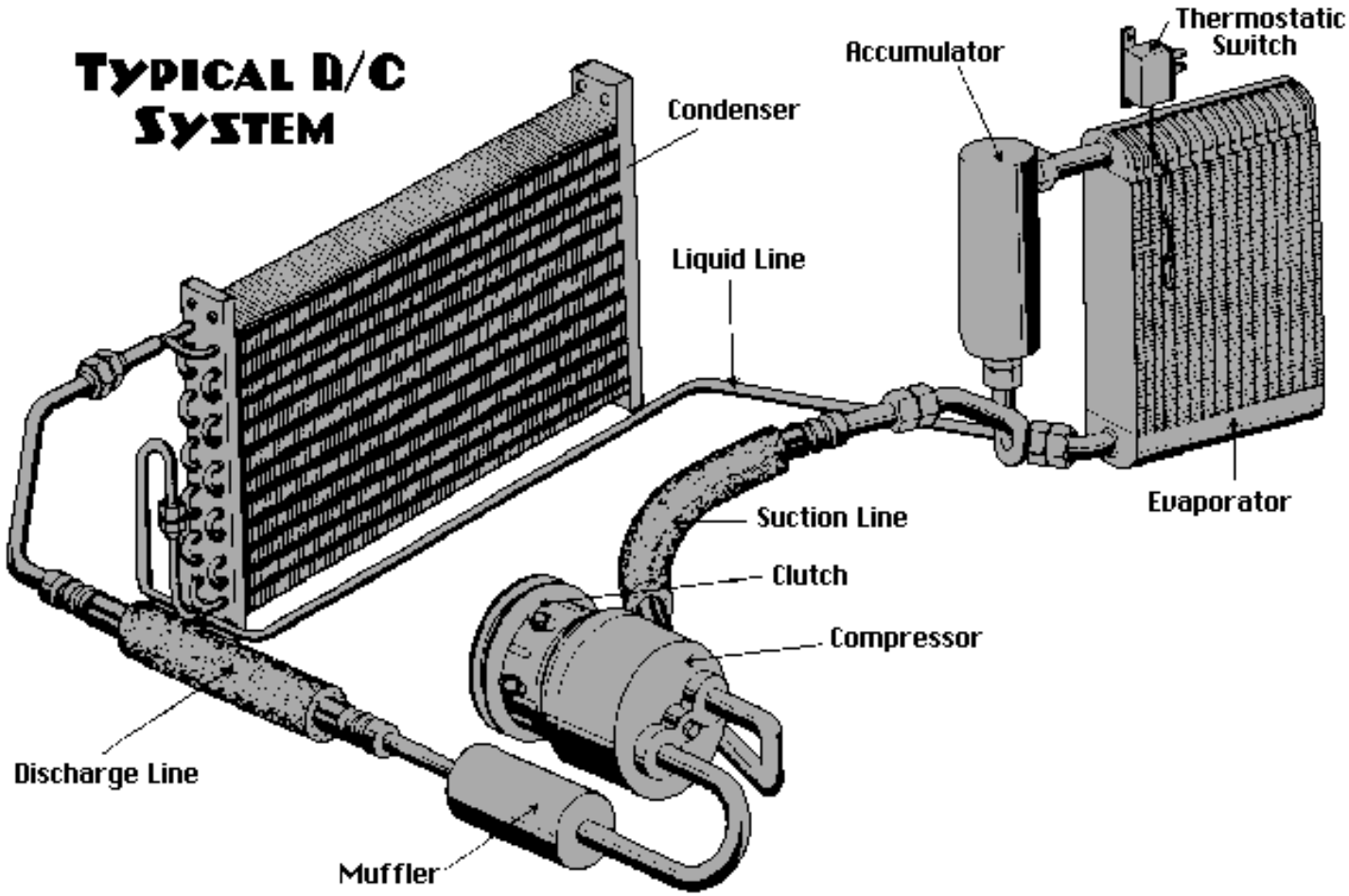
# The Refrigeration Cycle

- **Refrigeration – To remove heat by mechanical means**
- **Refrigerant – Chemical compound used in a refrigeration system to carry heat**
- **Refrigeration Cycle – Repeatedly changing refrigerant from a liquid to a vapor & vapor to liquid to remove heat**

# DESCRIBE THE PARTS A/C/S

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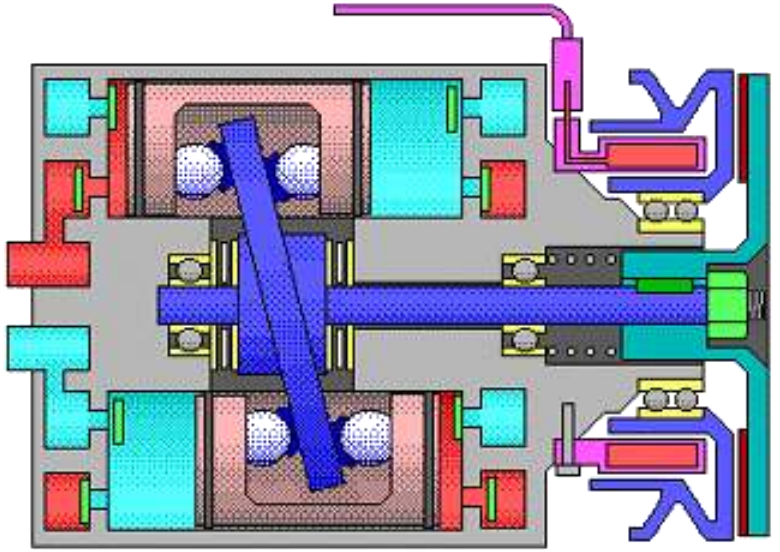
# Compressor

- **Refrigerant pump**
- **Increases Pressure & Temperature**
- **Separates High & Low sides of system**
- **Oil stored in Crankcase (sump)**



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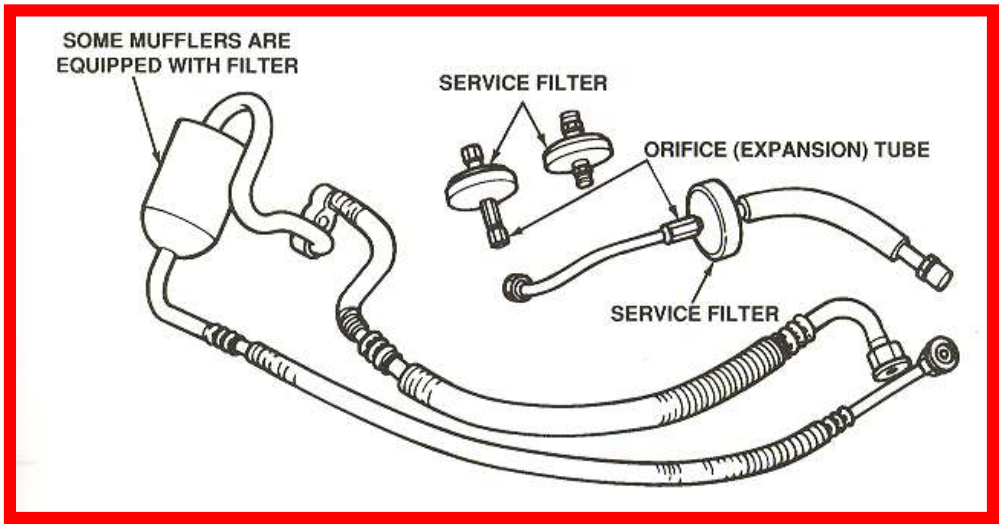
# Compressor Malfunctions

- **Malfunctions evident in following ways:**
  - **Noise**
  - **Seizure**
  - **Leaks**
  - **High inlet & low discharge pressures**

# Discharge Hose




- **CONTAINS HIGH PRESSURE.**
- **SYNTHETIC RUBBER WITH NYLON BARRIER LINING.**
- **13/32 ID.**
- **PREFORMED METAL ENDS WITH FITTINGS.**

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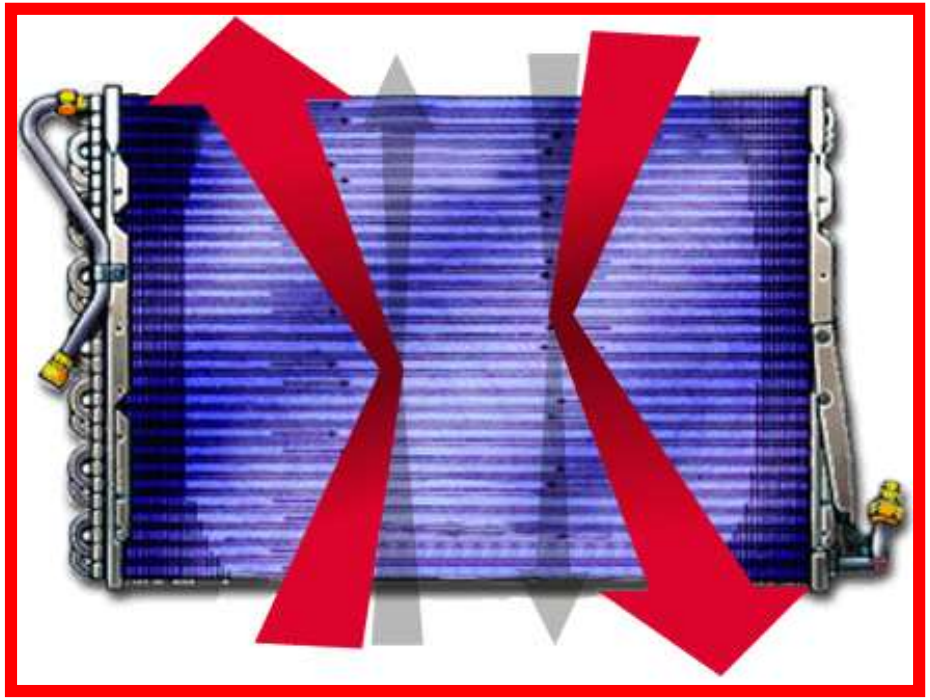
# Condenser

- **Heat exchanger.**
- **Liquefies heat laden vapor**
- **Hot vapor enters at top of condenser**
- **Hot liquid leaves at bottom**



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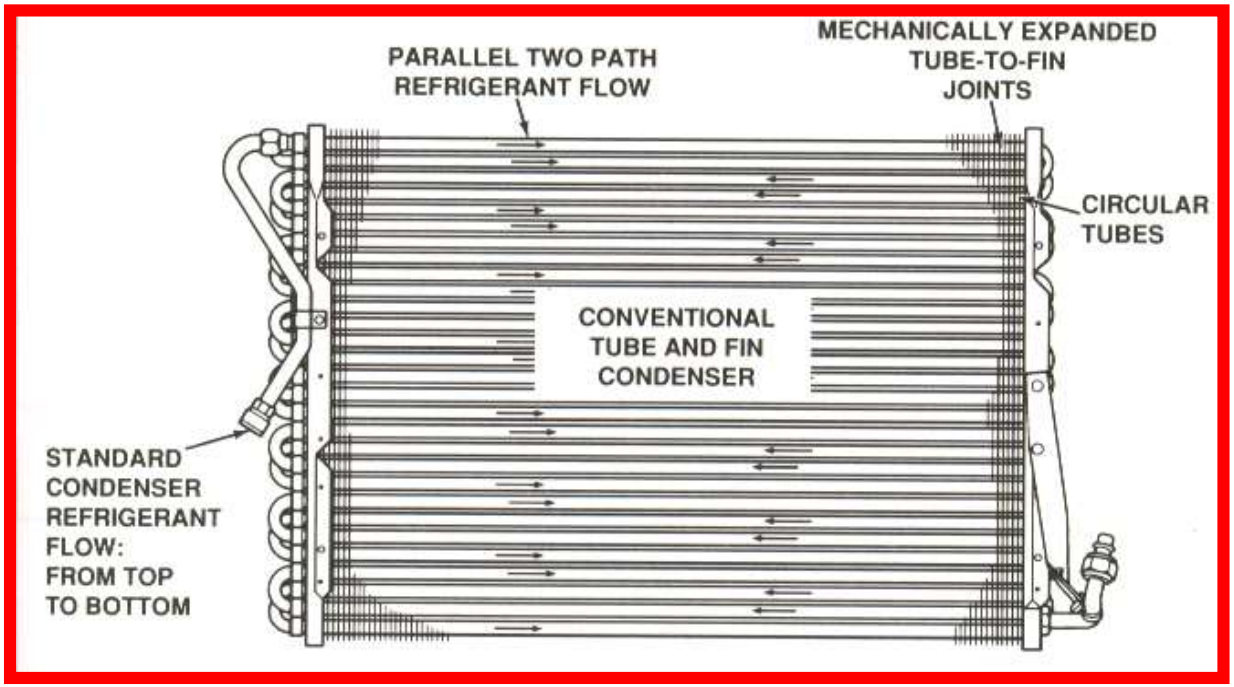
# Conventional Tube and Fin




- **Parallel Two Path.**
- **Mechanically expanded tube to fin joints.**
- **Circular Tubes.**

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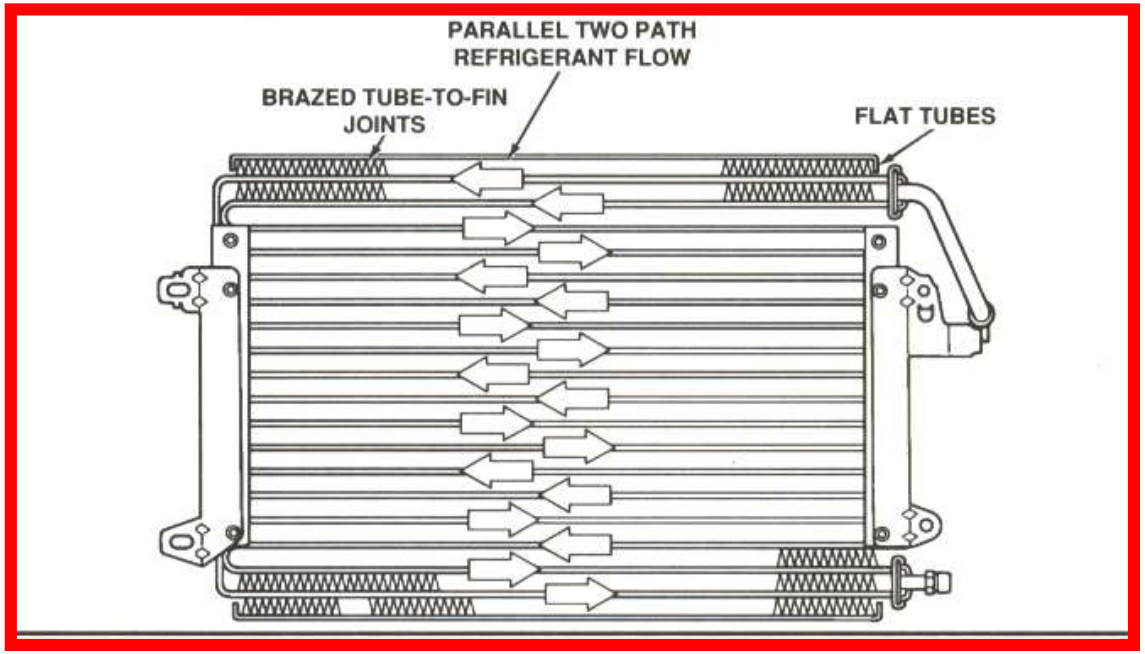
# Serpentine Tube and Centre Condenser




- **Brazed tube to fin joints.**
- **Flat Tubes.**
- **Parallel two path flow.**

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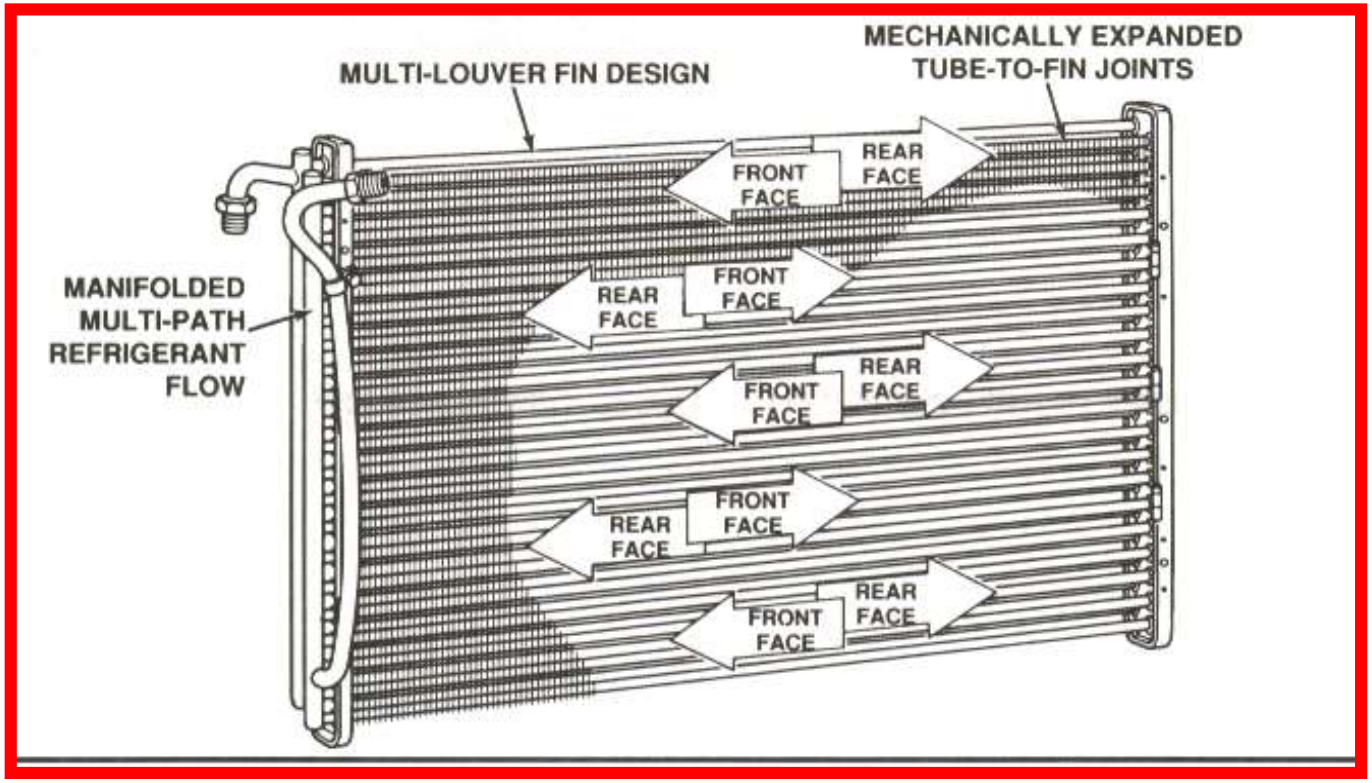
# Multi-Louver Fin Design




- **Manifolded Multi-path refrigerant flow.**

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# Evaporator

- **Dehumidifies the airstream.**
- **Under ideal conditions, refrigerant boils to complete saturation 3/4 of the way through Evaporator.**
- **Flooded evaporator means is full of liquid refrigerant with no room for expansion.**
- **Starved evaporator means all refrigerant is boiled in the first quarter of the evaporator.**

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# Receiver -Drier

- Stores reserve liquid refrigerant
- Ensures vapor-free liquid to the thermostatic expansion valve (TXV).
- Located on the high side of the system.
- Contains a desiccant that absorbs moisture.

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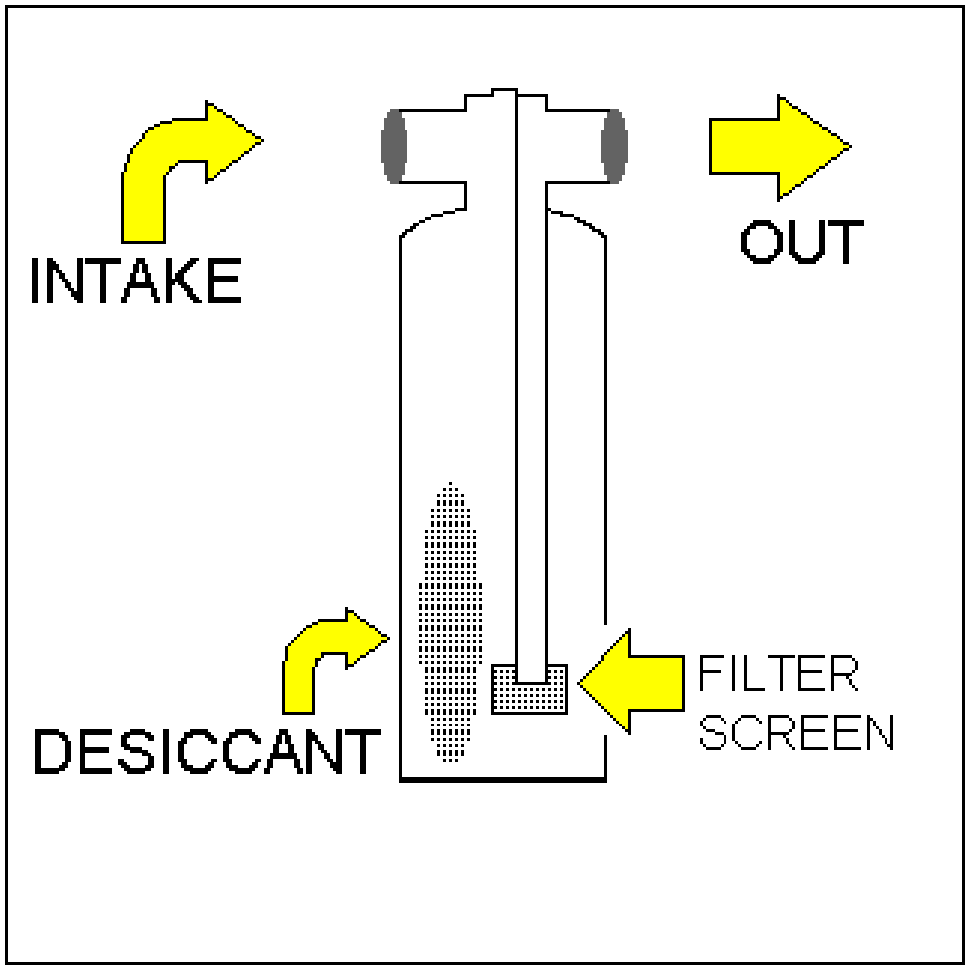
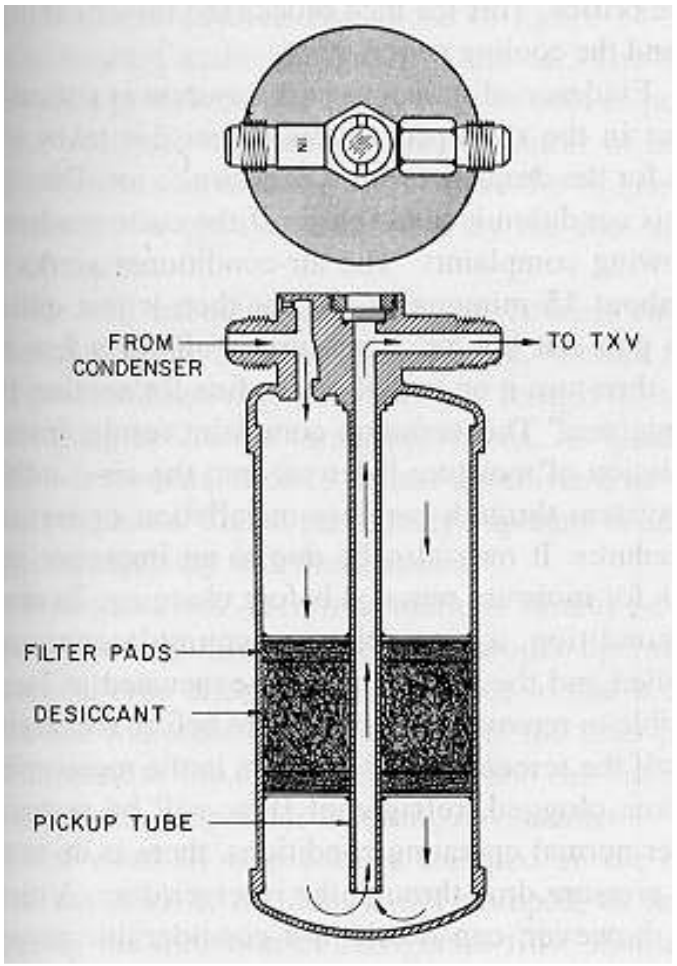
# Receiver -Drier

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# Thermostatic Expansion Valve

- Located on inlet side of evaporator.
- Used to control evaporator temp.
- Variable orifice can vary on pressure, temperature or both.
- Can malfunction in open or closed position.

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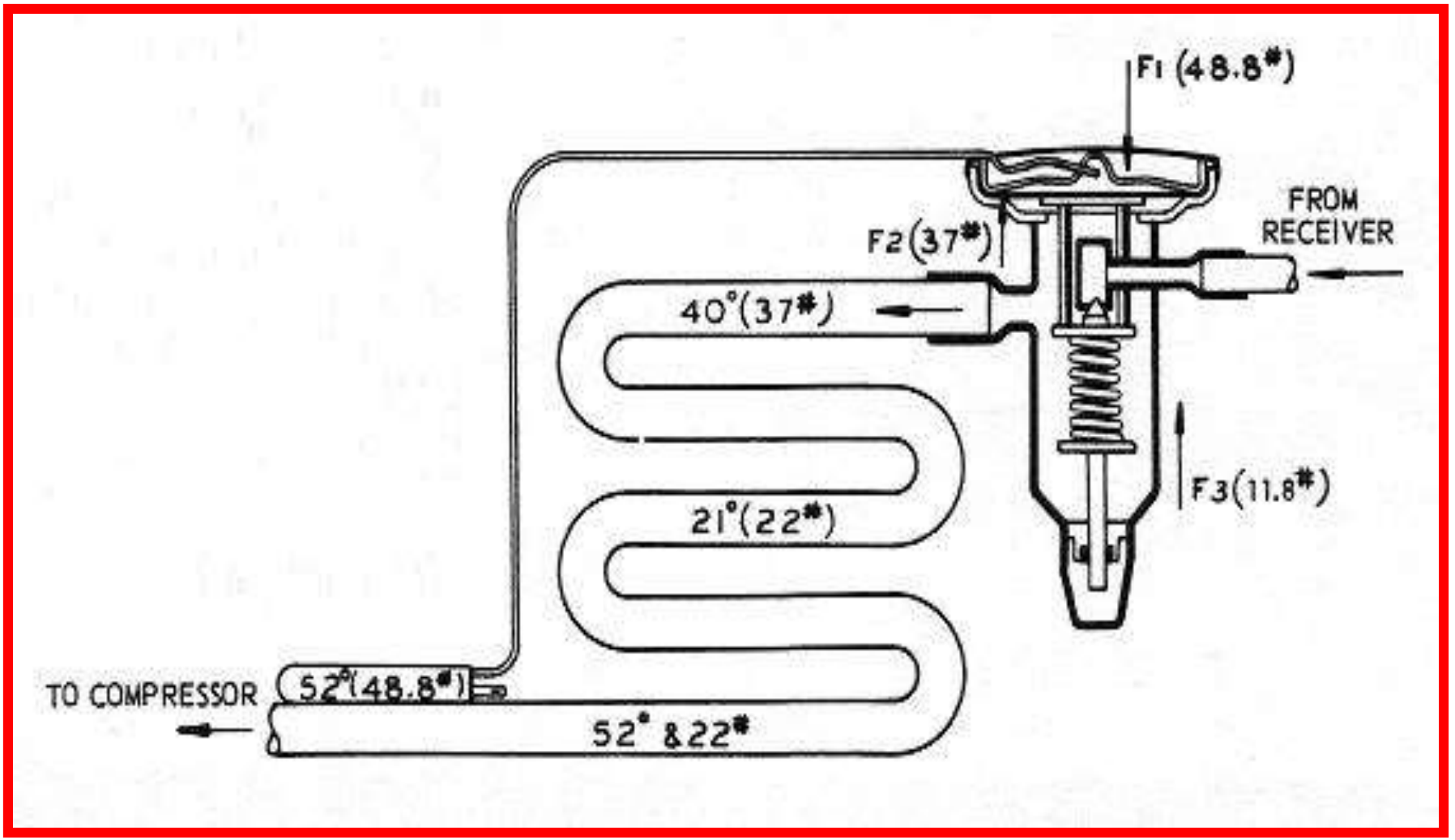
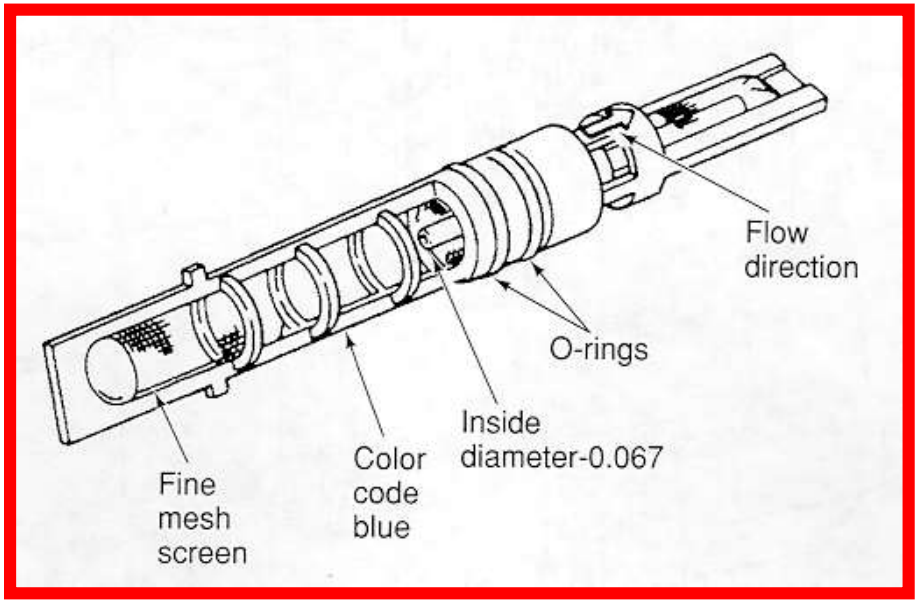
# TXV Operation



# Orifice Tube

- **Calibrated Restrictor**
- **Different color = different Orifice size.**
- **Mesh Filter Screen.**
- **Meters refrigerant into evaporator as low pressure liquid.**

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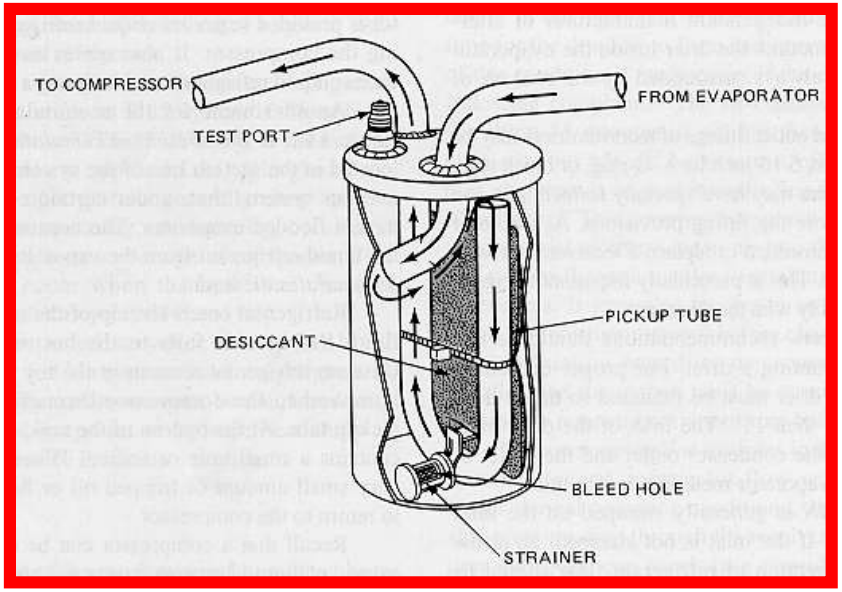
# Accumulator

- **Located between evaporator and compressor (low side)**
- **Primary function is to separate the vapour from the liquid and oil.**
- **Location for desiccant.**

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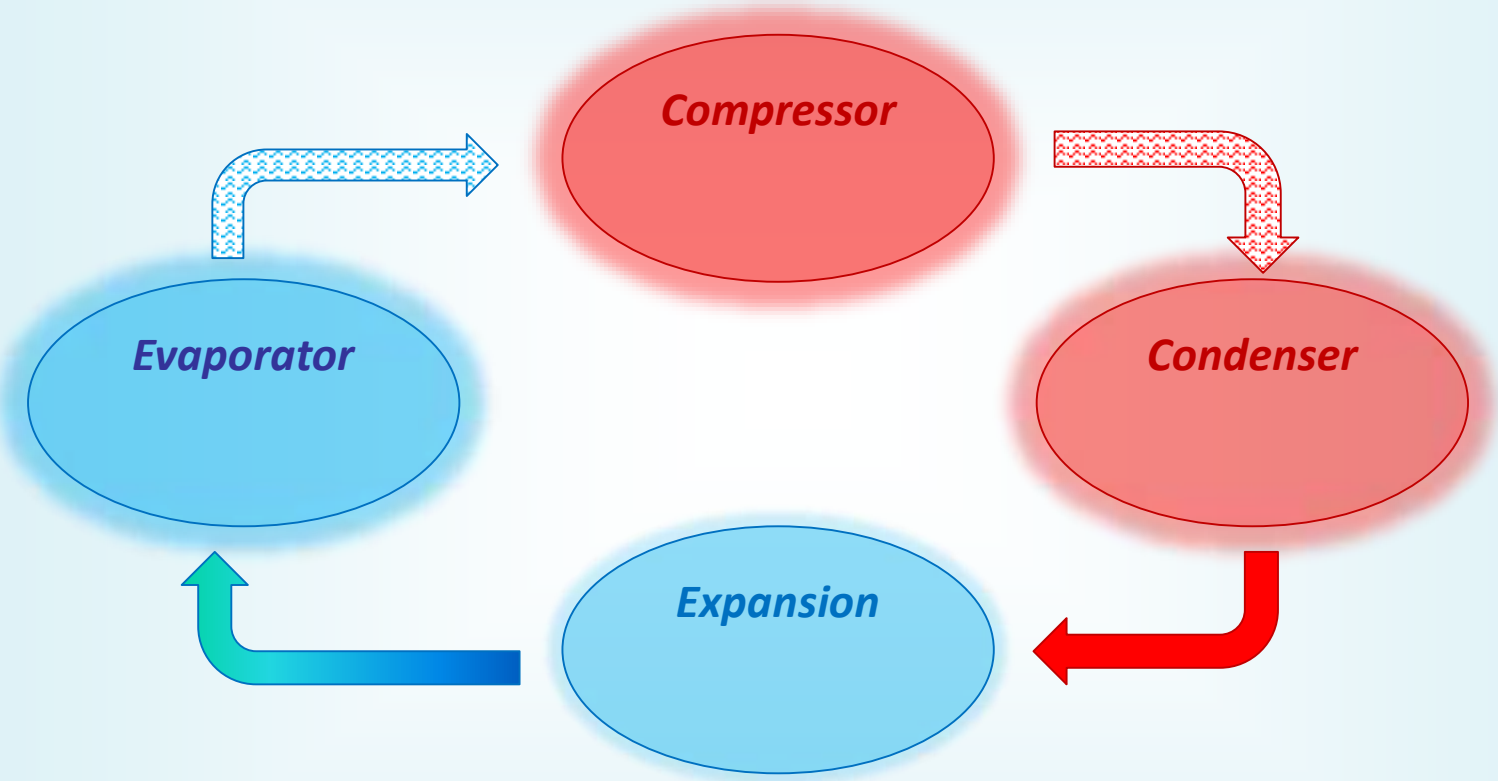
# Basic Refrigeration Cycle

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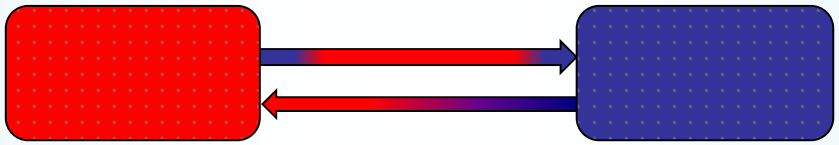
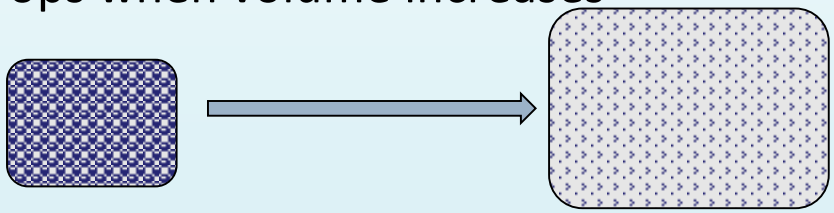
# *Refrigeration "Rules of Thumb"*

- Heat transfer
  - heat transfer always occurs from a region of high energy to another region of lower energy.
  - The greater the temperature difference, the faster energy will flow attempting to reach equilibrium.



- Temperature
  - Indicates the velocity of molecules of a substance. As heat energy in a substance increases, its molecules vibrate faster
- Pressure
  - pressure drops when volume increases



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# Refrigeration Definition

The removal of heat from one place (water) and depositing it to another (air/water) using an intermediate medium (vapor compression refrigeration system). This transfer of heat from one place to another is done through the evaporation and condensing of refrigerant.

# Common Units of Measure

- Units of Heat
  - BTU (British Thermal Unit): heat required to raise 1 pound of water 1 degree Fahrenheit.

| Substance | Temp Rise from addition of 1 BTU |
|---|---|
| Water | 1 deg. F |
| Ice | 2 deg. F |
| Steam | 2.08 deg. F |
| Aluminum | 4.54 deg. F |
| Copper | 11.11 deg. F |

- **Units of Power (energy/time)**
  - **BTU/Hr: unit of measure for rate of heat transfer**
  - **1 Watt = 3.41 BTU/Hr**
  - **Ton (heat required to melt a ton of ice in 24 hours):**

    **1 Ton = 12,000 BTU/Hr**

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# Common Units of Measure

- Units of Pressure
  - **PSIA** (absolute pressure) – actual pressure at a given position. Pressure at sea level: 14.696 psia.
  - **PSIG** (gauge pressure) – different between absolute pressure and local atmospheric pressure. Pressure gauge open to atmosphere will read 0 psig. Gauge pressure below zero is called vacuum pressure.
  - **Microns of Hg** (unit to measure vacuum, millitorr):
    - 1 psi = 51,700 microns of Hg

# ACRONYMS

- TXV – thermal expansion valve
- SH – super heat
- SC – sub cooling
- CCD – crankcase differential
- BW – batch weight
- AHRI – Air-Conditioning, Heating, and Refrigeration Institute
- DOE – Department of Energy
- EPA – Environmental Protection Agency
- UL – Underwriter's Laboratory
- ETL – Electrical Testing Laboratories
- NSF – National Sanitation Foundation

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# Vapor Compression System Components

- Compressor
- Condenser
- Drier
- Expansion Device
  - TXV
  - Capillary Tube
- Evaporator
- Hot Gas Valve

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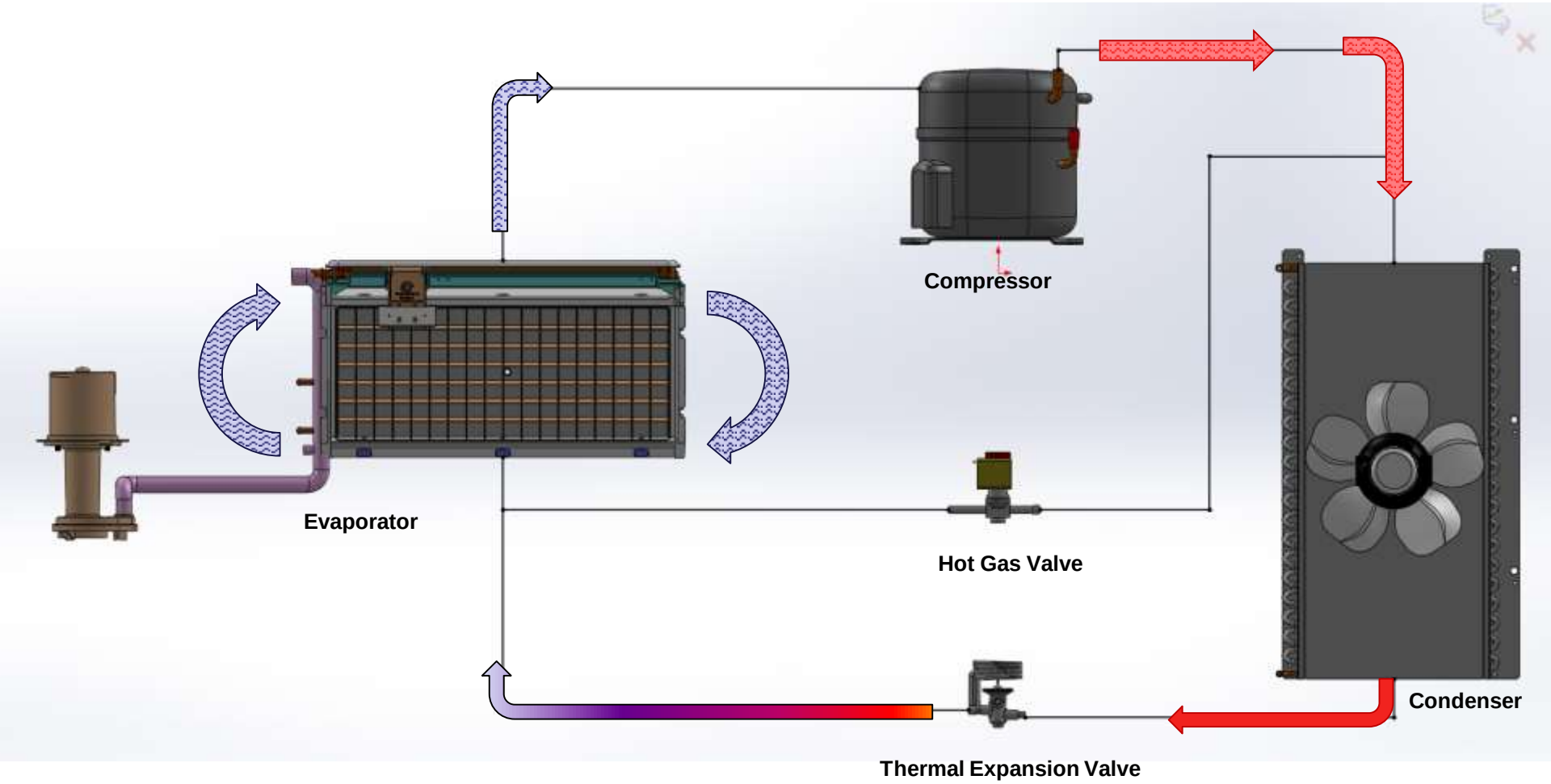
# Vapor Compression System Components

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# Vapor Compression System Components

**Compressor**

- **Emerson; Copeland**
- **Tecumseh**
- **Embraco**
- **Bristol**
- **Danfoss**

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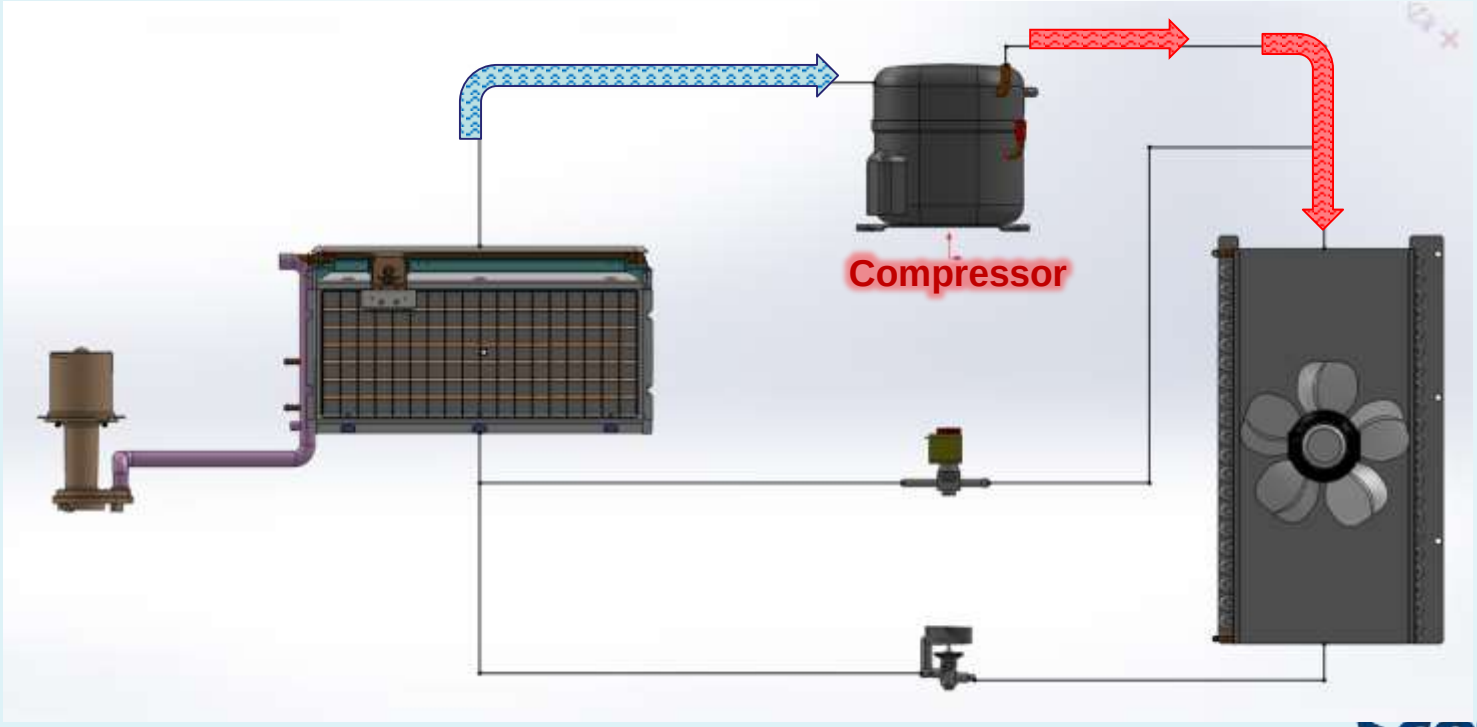
# Vapor Compression System Components

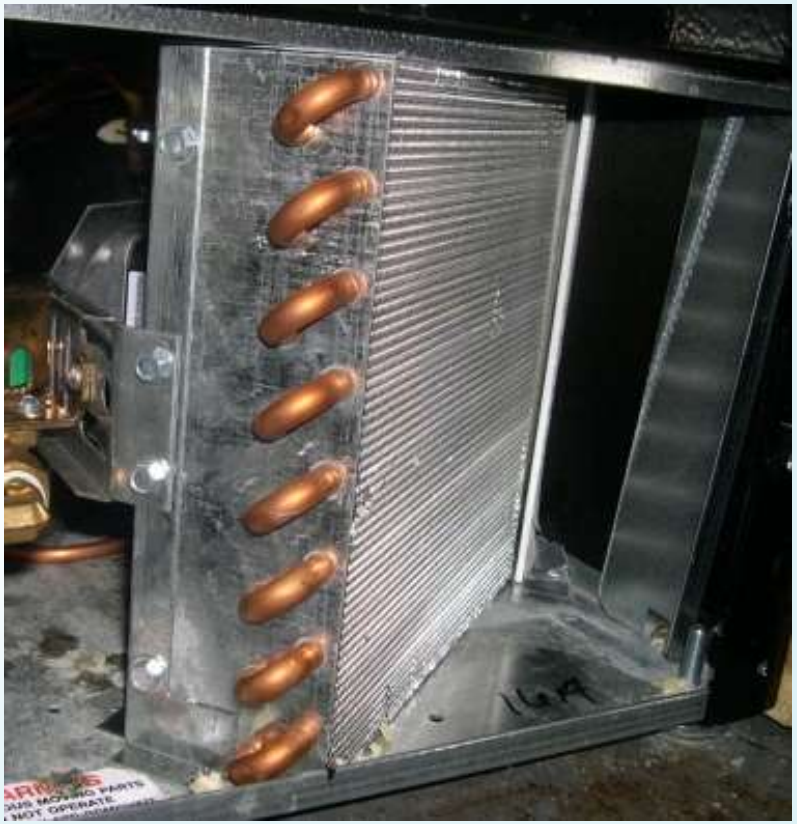
- **Compressor – performs two primary functions:**
  - **pulls low pressure vapor from the evaporator**
  - **compresses this vapor into a high temperature, high pressure gas so that it may be condensed**



# Vapor Compression System Components

## Condenser

- Modine (air cooled)
- Packles (water cooled)



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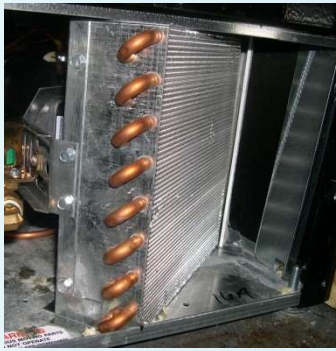
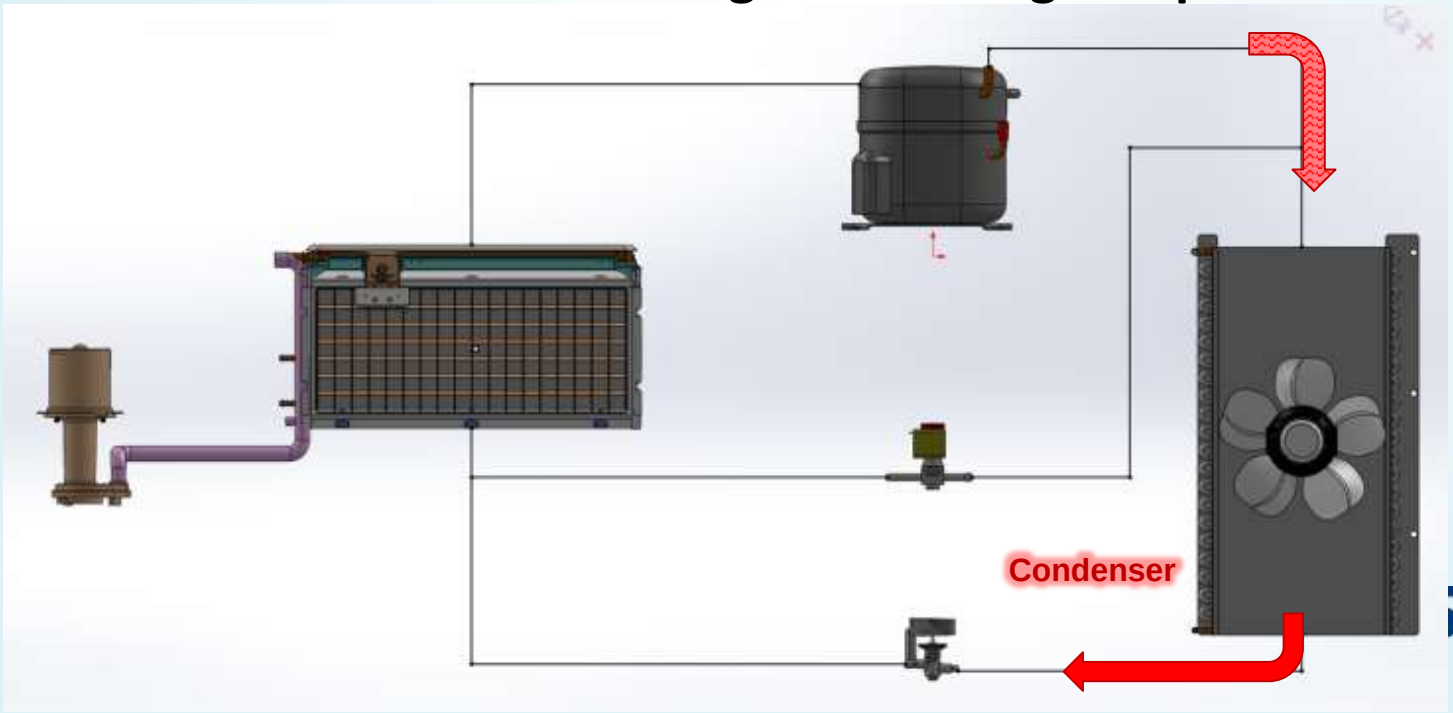
# Vapor Compression System Components

- **Condenser – removes heat from refrigerant by providing a medium at a lower temperature to which the heat may flow and be dissipated. Superheated gas is converted to a subcooled liquid. Two sources of this heat:**
  - **heat absorbed by the evaporator**
  - **heat added to the refrigerant during compression**



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# Vapor Compression System Components

- **TXV (Thermal Expansion Valve)**
  - **Emerson; Flow Controls**
  - **Danfoss**

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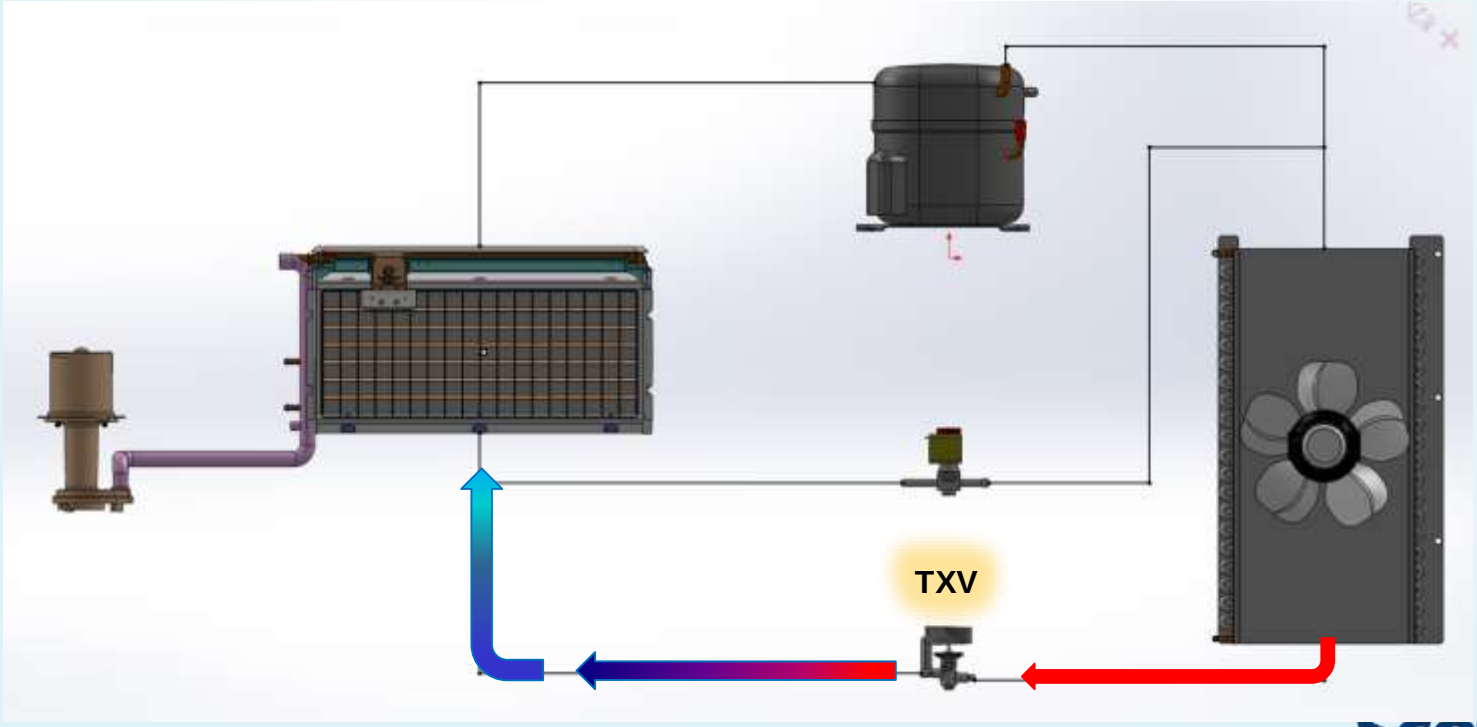
# Vapor Compression System Components

- **TXV – an expansion device which “throttles” high pressure liquid to low pressure liquid (expands during this process). Meters refrigerant into the evaporator based on temperature measured at the evaporator outlet.**

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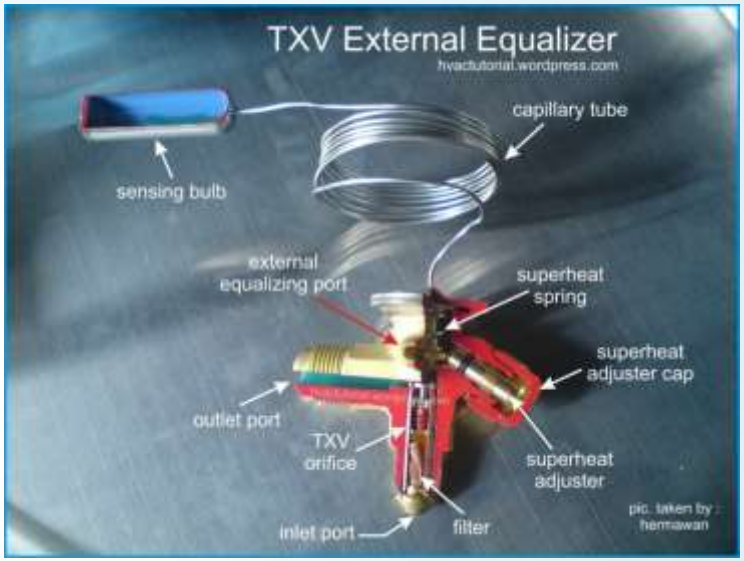
# Vapor Compression System Components

- **The TXV has only one function. It meters the flow of liquid refrigerant into the evaporator in exact proportion to the evaporation rate of the refrigerant in the evaporator. By responding to the temperature of the refrigerant gas leaving the evaporator and the pressure of the evaporator, the TXV can control the gas leaving the evaporator at a predetermined superheat.**

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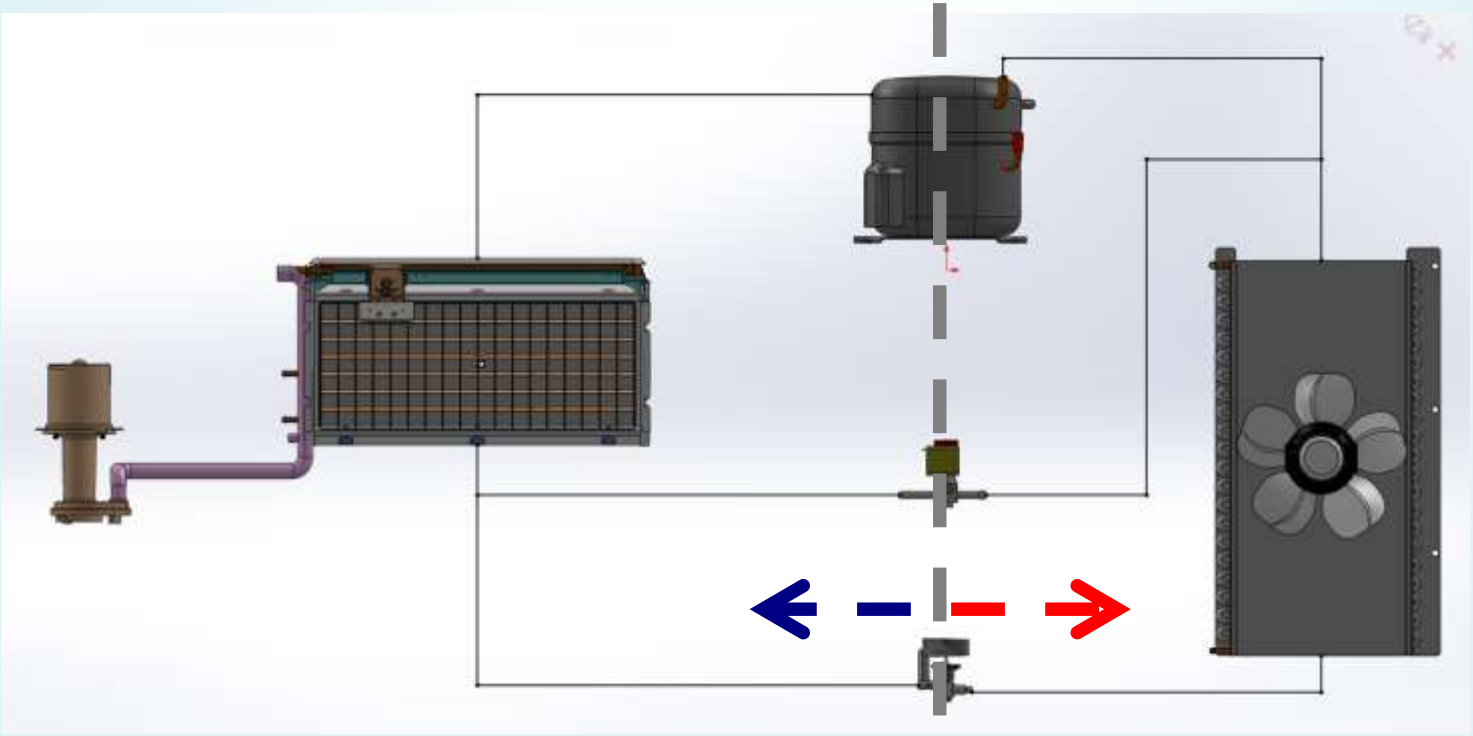
# Refrigeration System Components

**High** *(pressure)* **Side**



**Low** *(pressure)* **side**

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# Vapor Compression System Components

- **Filter Drier**
- **Emerson, Flow Controls**


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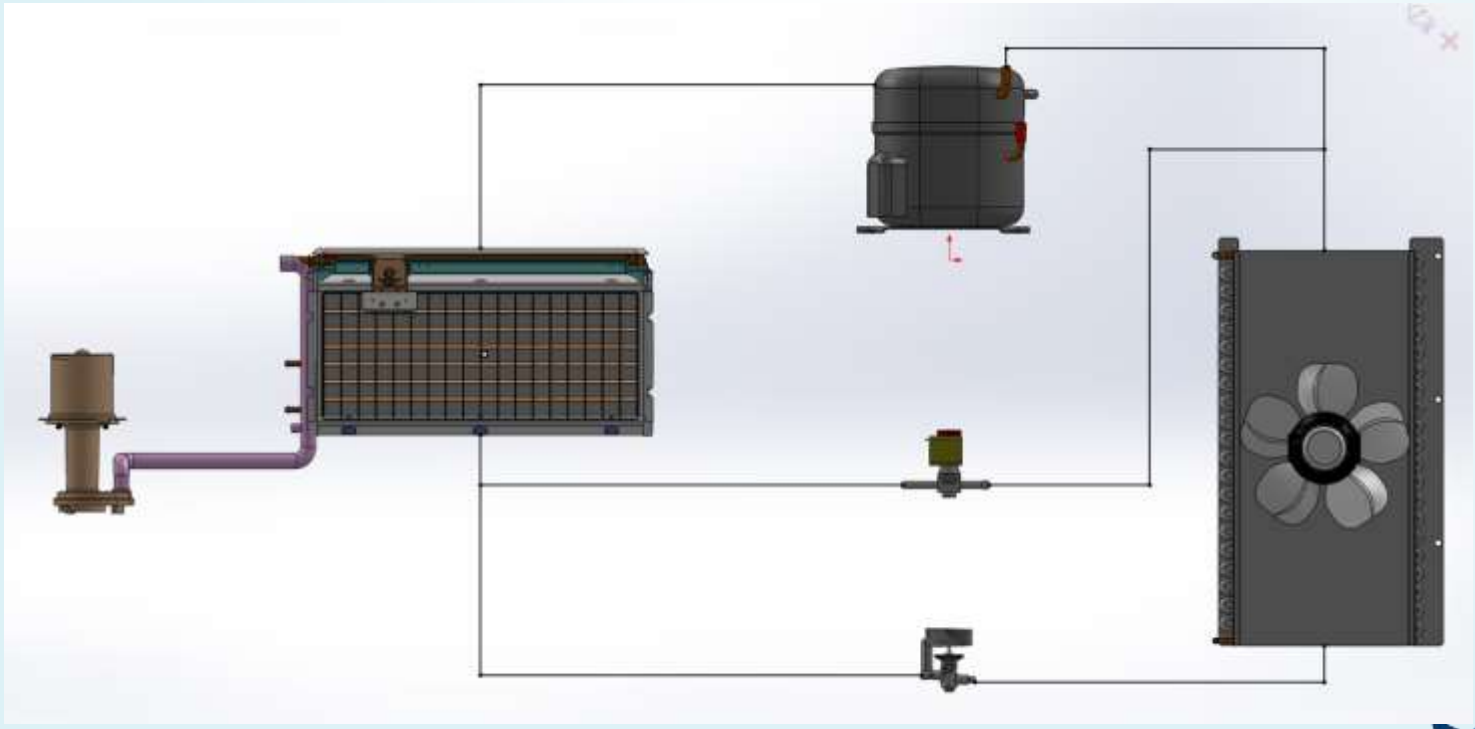
# Vapor Compression System Components

- **Filter Drier – serves three functions:**
  - **absorbs moisture (desiccant called molecular sieve**
  - **filters non-soluble contamination/debris**
  - **removes acid (activated alumina)**



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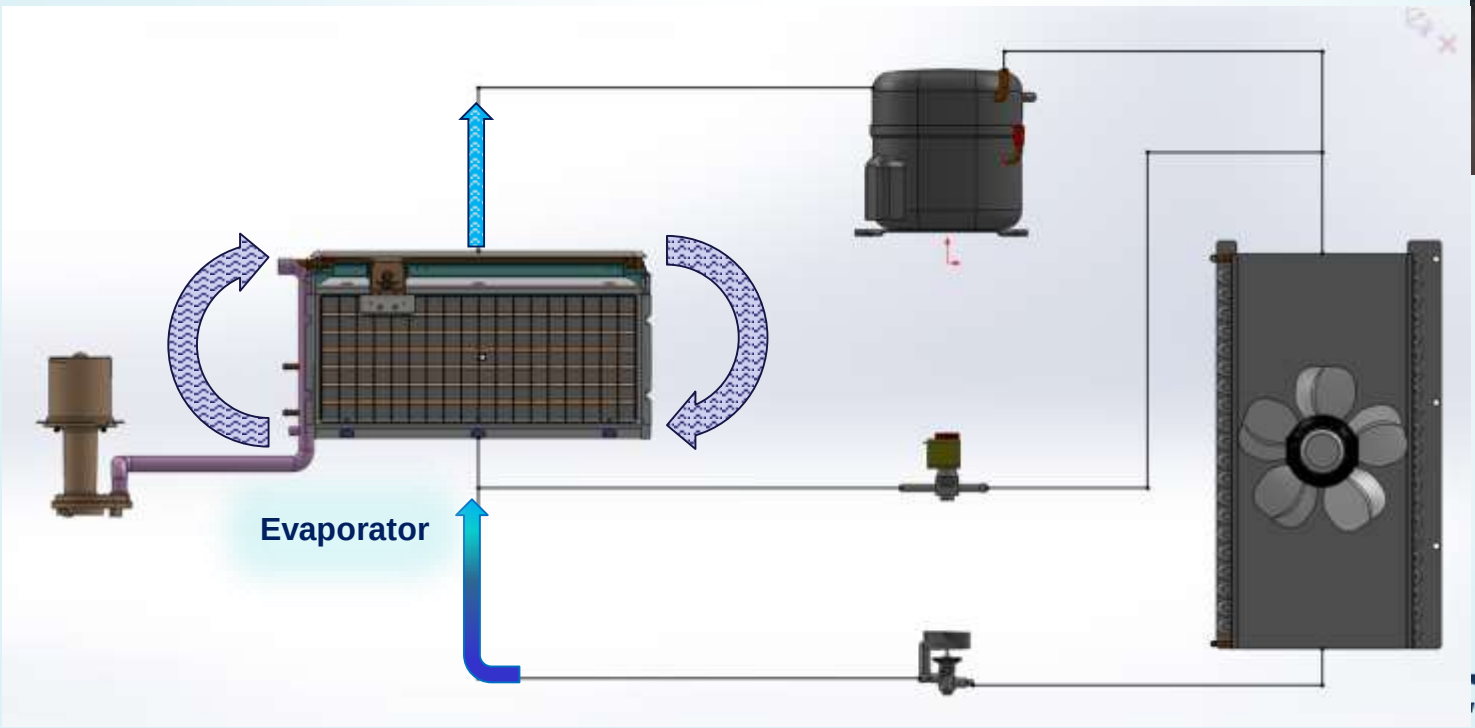
# Vapor Compression System Components

- **Evaporator – the low pressure liquid from the TXV has a saturation temperature well below that of the surrounding medium. This results in rapid boiling of the refrigerant with heat being absorbed from the surroundings – the desired cooling effect.**



# Vapor Compression System Components

- **Hot gas valve**
- **Emerson; Flow Controls**

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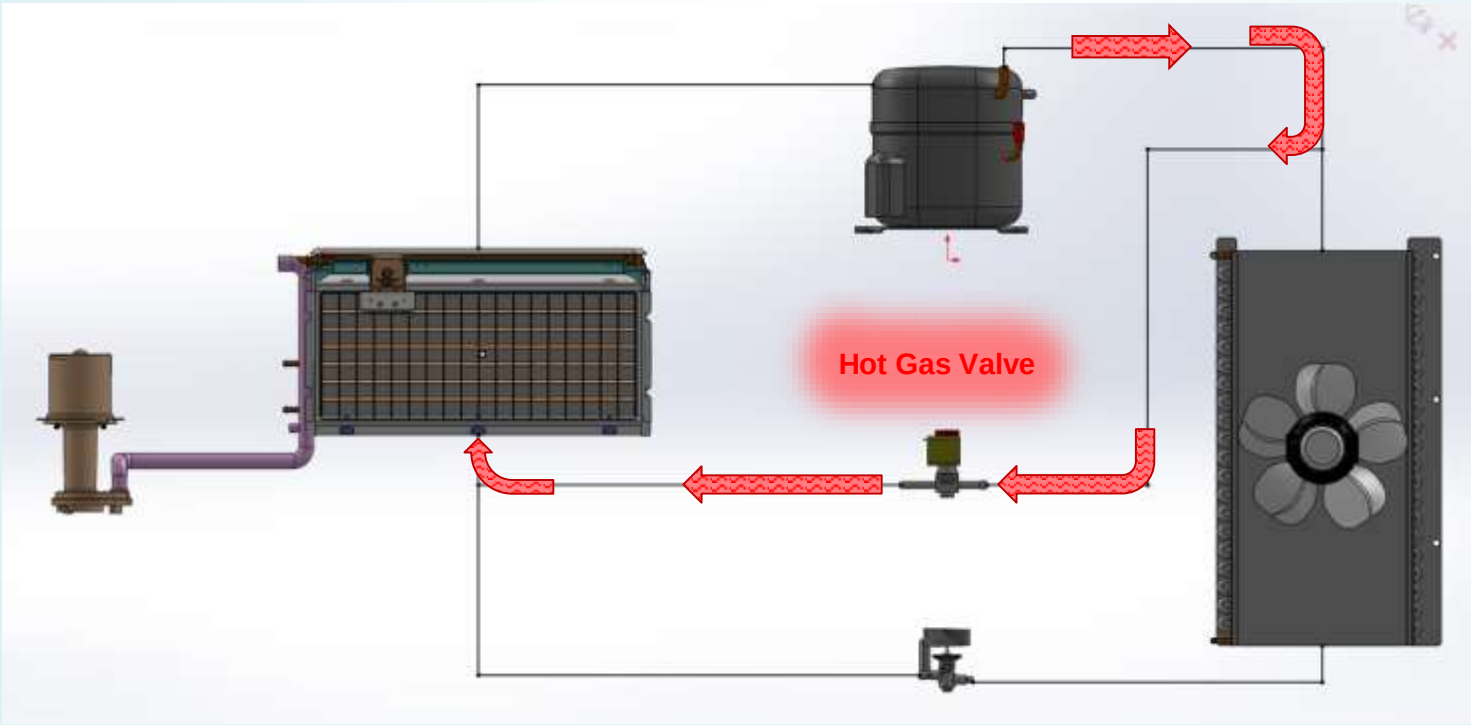
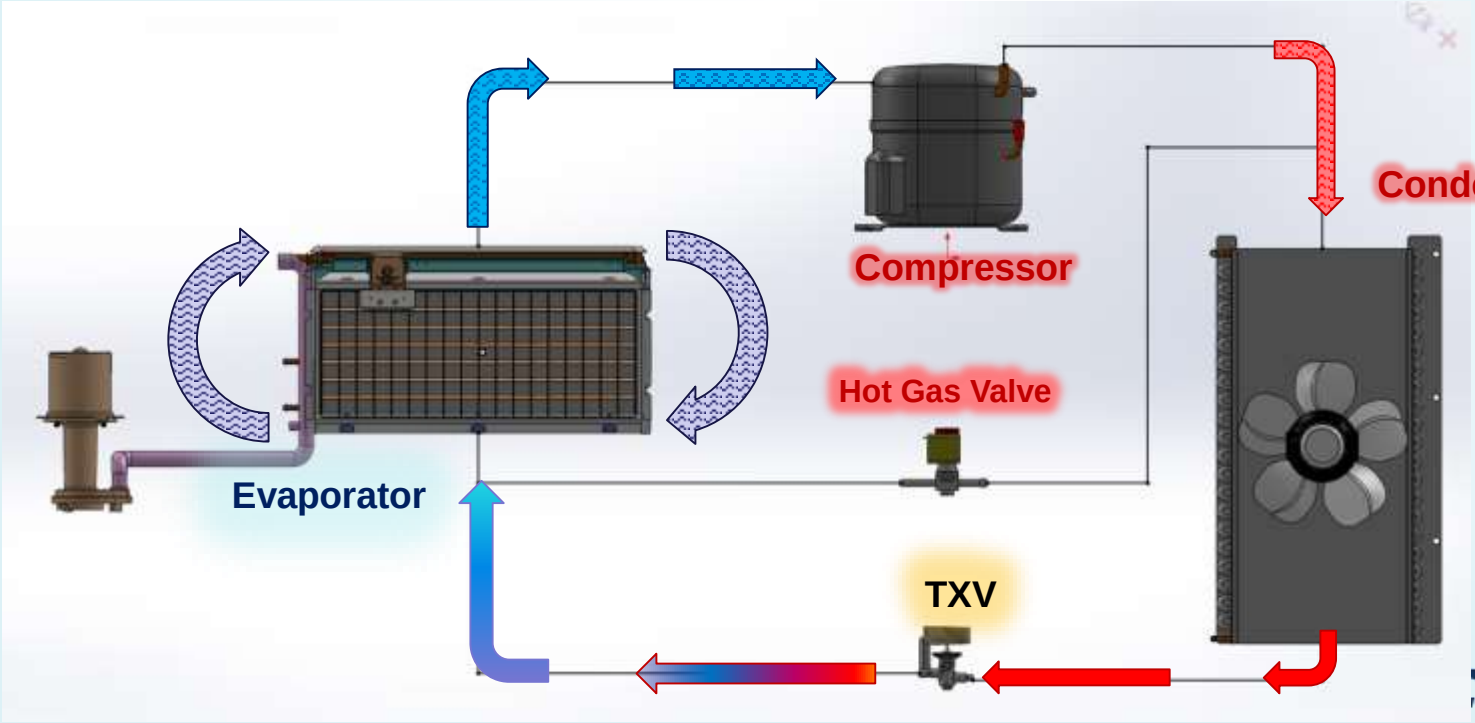
# Vapor Compression System Components

- **Hot gas valve**
  - **valve which is opened during the harvest cycle, allowing hot gas to flow from compressor to evaporator.**
  - **Hot gas warms the evaporator, which assists in releasing the ice slab from the evaporator surfaces.**



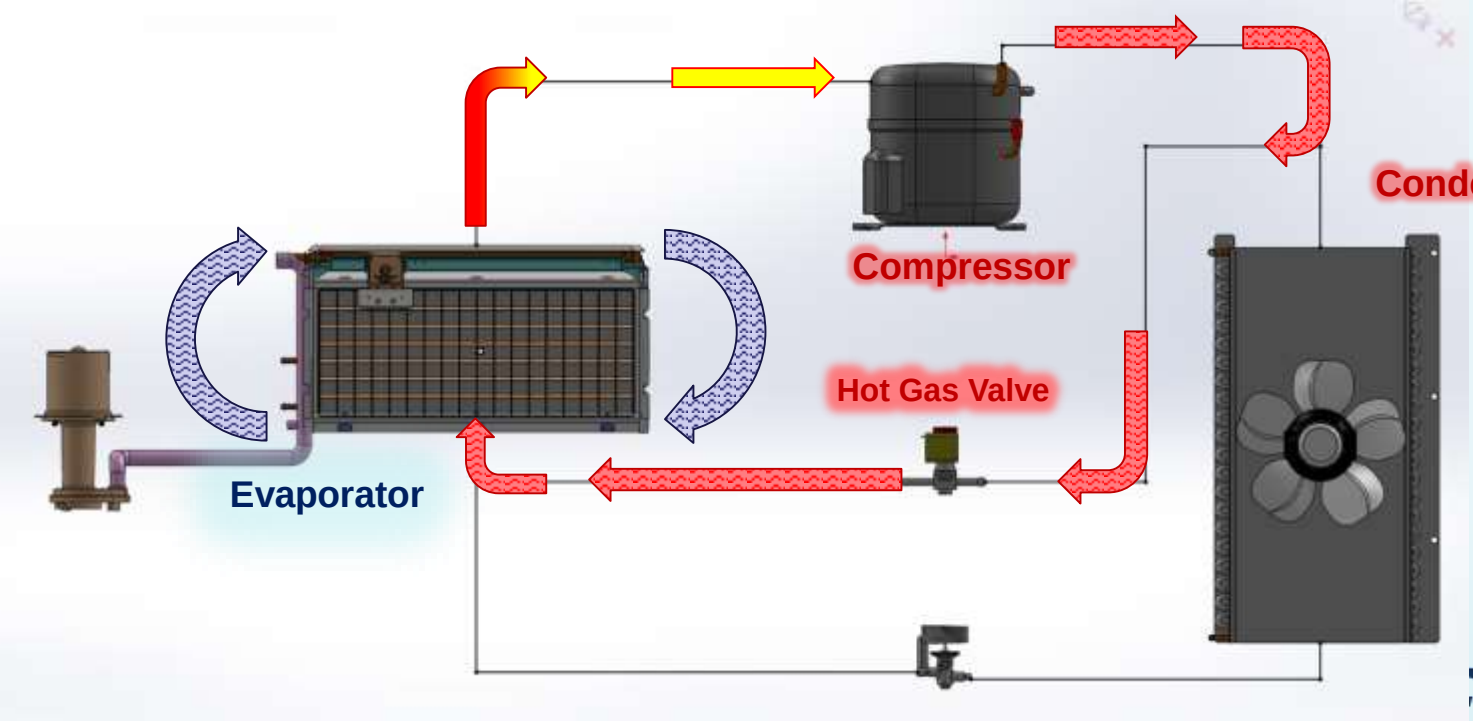
# Ice Maker Vapor Compression Cycles

- **Freeze cycle – portion of the cycle where refrigerant absorbs heat (from water passing over the evaporator) at low temperature & pressure and gives up this heat (to air/water) by condensing at high temperature & pressure.**



# Ice Maker Vapor Compression Cycles

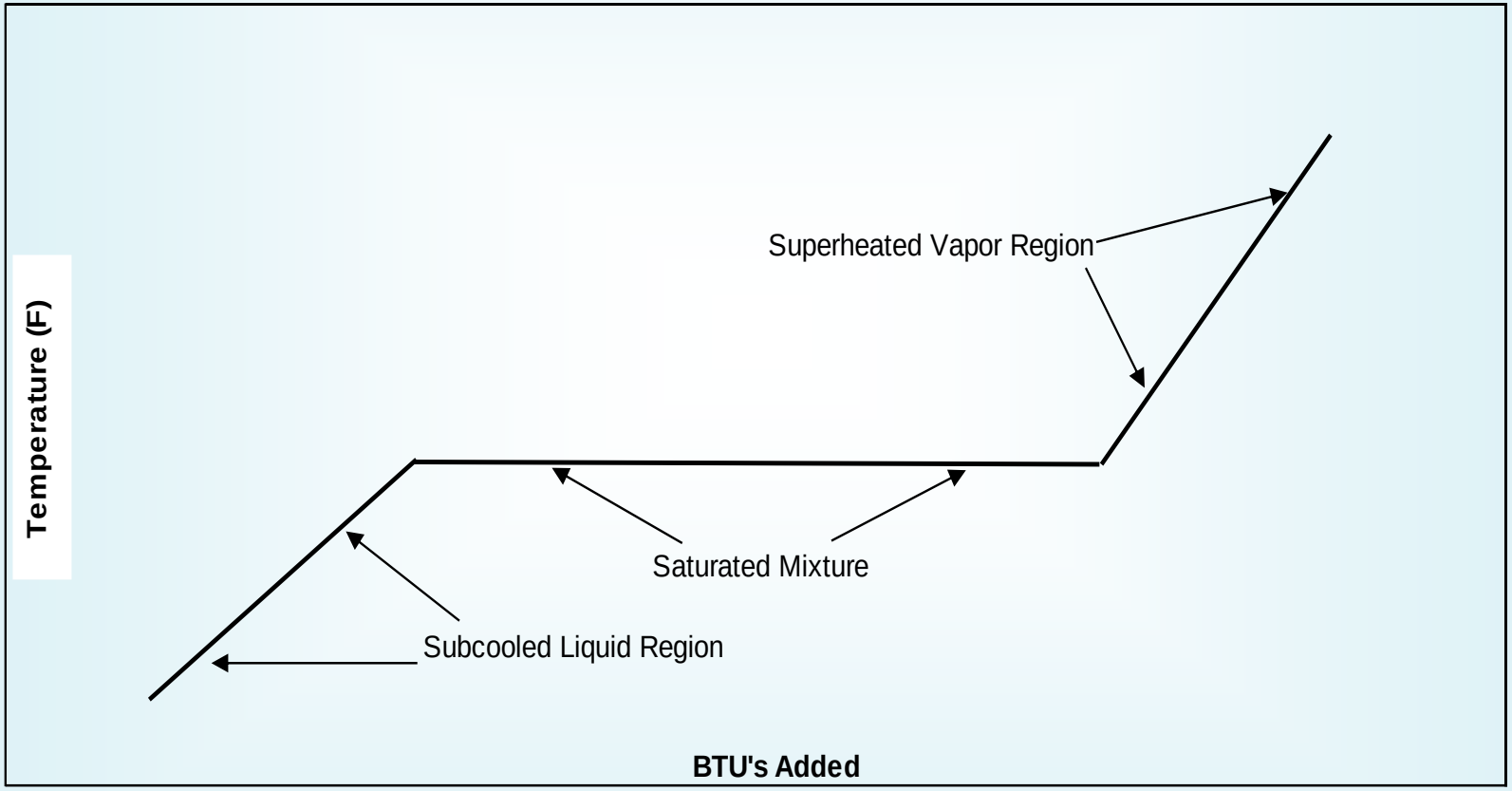
- **Harvest cycle – portion of the cycle where heat is added to the evaporator in order to remove the ice from the evaporator or where the ice is harvested.**



# Superheat & Subcooling

- Superheated – vapor at a temperature above its saturation temperature
- Subcooled – liquid at a temperature below its saturation temperature
- Saturated – condition of a liquid at its boiling temperature, and of a vapor at its condensing temperature:
- Pressure and Saturation Relationship
    - As the pressure increases, saturation temperature will increase. As the pressure decreases, the saturation temperature decreases.

# Superheat & Subcooling

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# Superheat, Subcooling, & CCD

- Pressure/Temperature Charts (PT Charts)
  - saturation temperature can be “looked-up” at any desired pressure
  - Available For Most Natural Substances and Industry Refrigerants

- Example #1 – Superheat Calculation
- Example #2 – Subcooling Calculation

# Superheat, Subcooling & CCD

**Example #1: What is the superheat of R-404A at 50° F and 60 psia?**

- **SH = Ref. Temp. – Sat. Temp.**
- **SH = 50° F – 10.4° F**

Answer: the superheat would be 39.6° F

| R404A | BUBBLE |
|---|---|
| PSIA | TSAT |
| 14.696 | -51.82 |
| 16.00 | -48.59 |
| 18.00 | -44.02 |
| 20.00 | -39.83 |
| 22.00 | -35.95 |
| 24.00 | -32.34 |
| 26.00 | -28.95 |
| 28.00 | -25.77 |
| 30.00 | -22.75 |
| 32.00 | -19.88 |
| 34.00 | -17.15 |
| 36.00 | -14.54 |
| 38.00 | -12.04 |
| 40.00 | -9.64 |
| 42.00 | -7.33 |
| 44.00 | -5.10 |
| 46.00 | -2.94 |
| 48.00 | -0.86 |
| 50.00 | 1.16 |
| 55.00 | 5.94 |
| 60.00 | 10.41 |
| 65.00 | 14.61 |
| 70.00 | 18.57 |
| 75.00 | 22.32 |
| 80.00 | 25.88 |

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# Superheat, Subcooling & CCD

- **Example #2**: What is the subcooling of R-404A at 50° F and 150 psia?
- SC = Sat. Temp. - Ref. Temp.
- SC = 64.6° F – 50° F

**Answer: 14.6° F of subcooling**

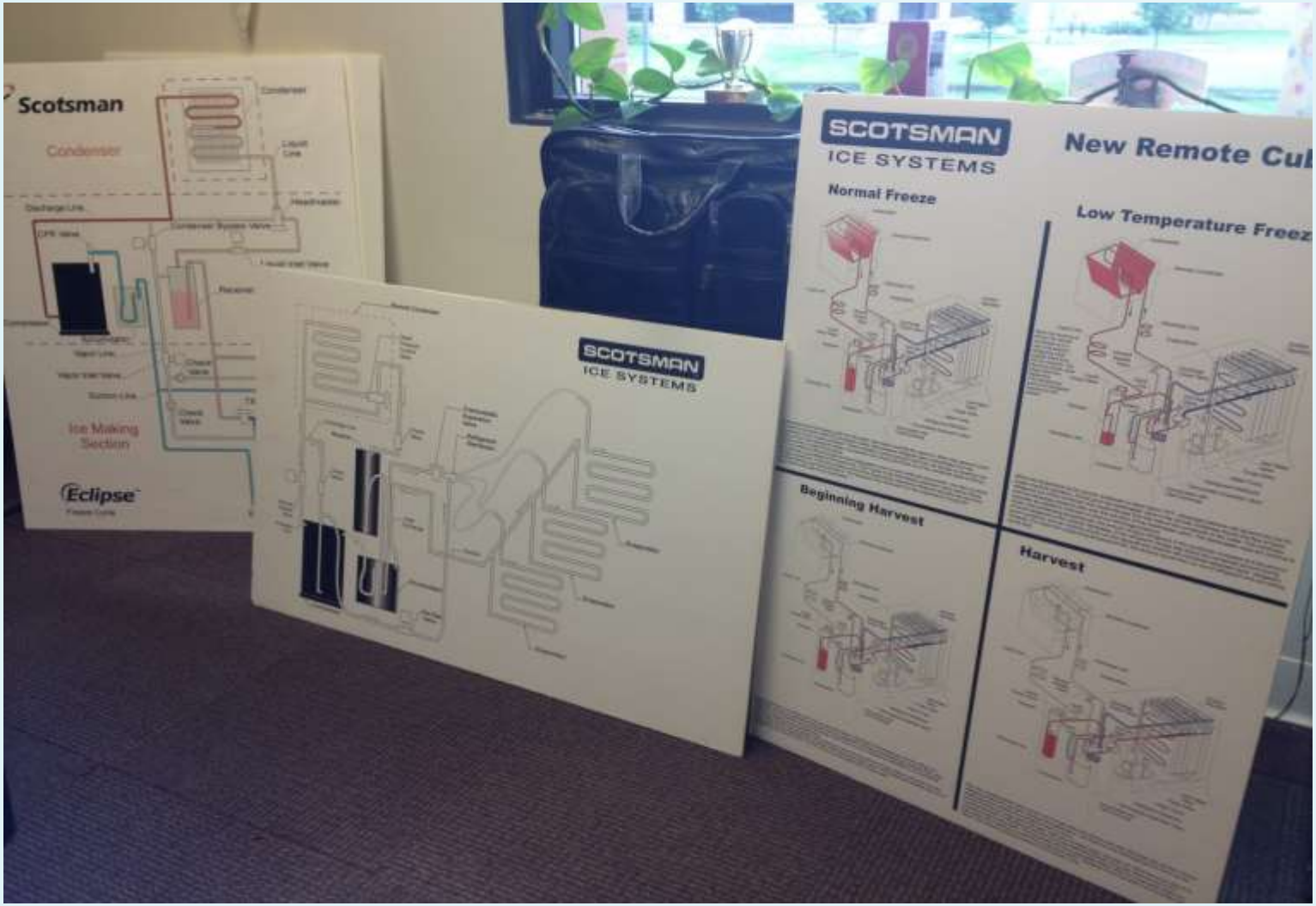
| R404A | BUBBLE |
|---|---|
| PSIA | TSAT |
| 40.00 | -8.49 |
| 42.00 | -6.19 |
| 44.00 | -3.97 |
| 46.00 | -1.83 |
| 48.00 | 0.24 |
| 50.00 | 2.25 |
| 55.00 | 7.01 |
| 60.00 | 11.46 |
| 65.00 | 15.64 |
| 70.00 | 19.58 |
| 75.00 | 23.31 |
| 80.00 | 26.86 |
| 85.00 | 30.25 |
| 90.00 | 33.49 |
| 95.00 | 36.59 |
| 100.00 | 39.58 |
| 110.00 | 45.24 |
| 120.00 | 50.52 |
| 130.00 | 55.48 |
| 140.00 | 60.17 |
| 150.00 | 64.61 |
| 160.00 | 68.83 |

Scotsman
ICE THE WORLD DEMANDS

# Scotsman Refrigeration 201

- Refrigeration System Analogy (Heart, Brain & Body)
- Scotsman Cuber; Batch ice maker
  - General refrigeration layout (air, water, remote condensing)
  - Control System and sensors
  - Scotsman Freeze operation (SH targets, CCD, anti-slush, headmaster, LL, refrigerant charge, TXV-capillary tube, water pump operation,  Heat Exchange, )
  - Scotsman Harvest operation (HGV sizing, HGV bypass, Harvest assist, Water pump operation, )
- Scotsman Flaker/Nugget; Continuous ice maker
  - General refrigeration layout
  - Evaporator configuration
  - Control System and sensors

Scotsman
ICE THE WORLD DEMANDS



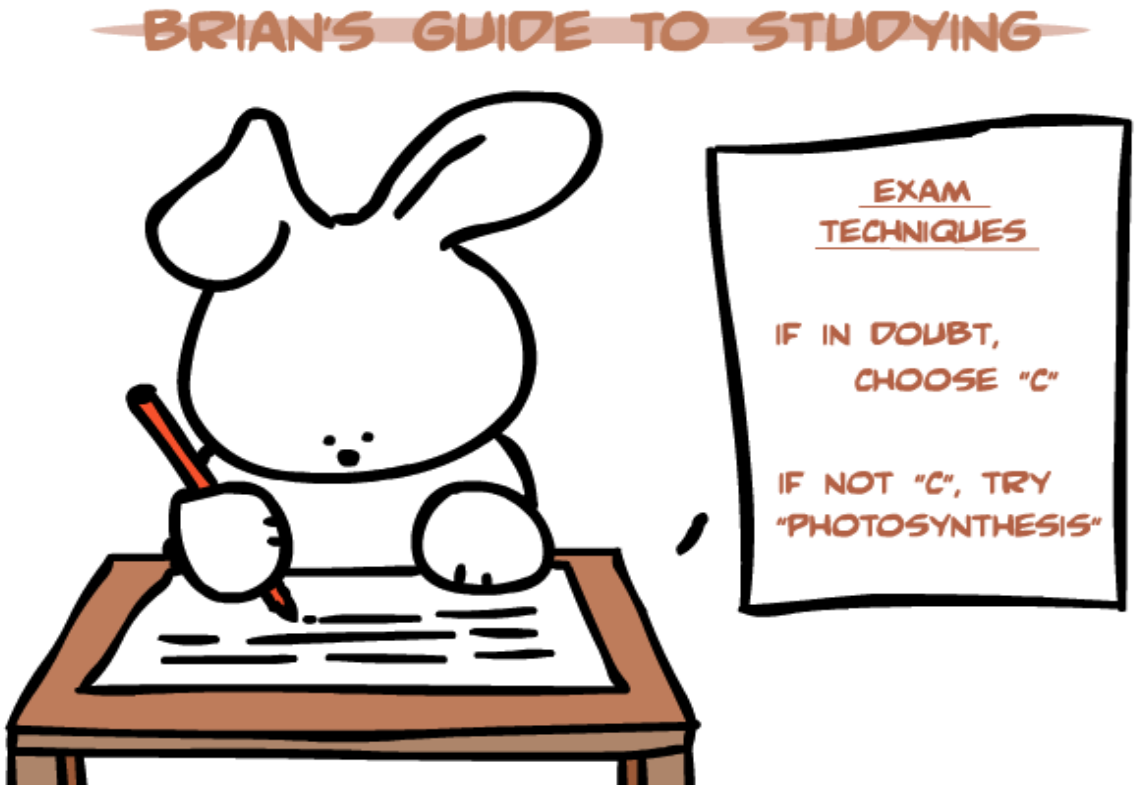

Scotsman
ICE THE WORLD DEMANDS

# Scotsman Engineering Continuing Education

- Refrigeration 101
- Refrigeration 201
- Scotsman Design 101
- Scotsman Design 201
- Engineering TR/Product Verification process 101
- Scotsman PDP/Project Management

Scotsman
ICE THE WORLD DEMANDS

# BRINGS GUIDE T0 STUDYING




Scotsman
ICE THE WORLD DEMANDS