# Refrigeration 101

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**Hill PHOENIX**

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E+sd 2010
Energy & Store Development Conference

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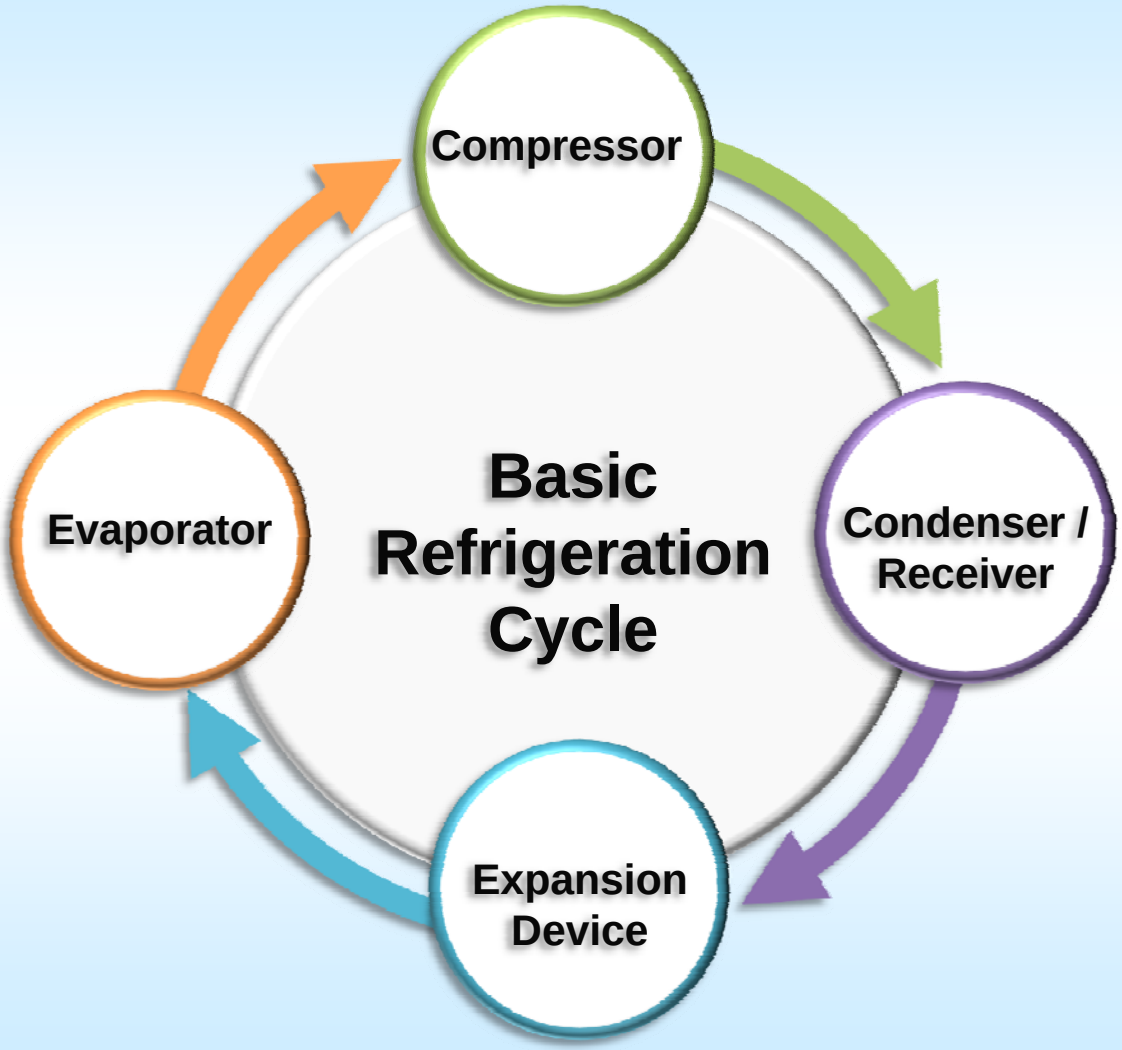
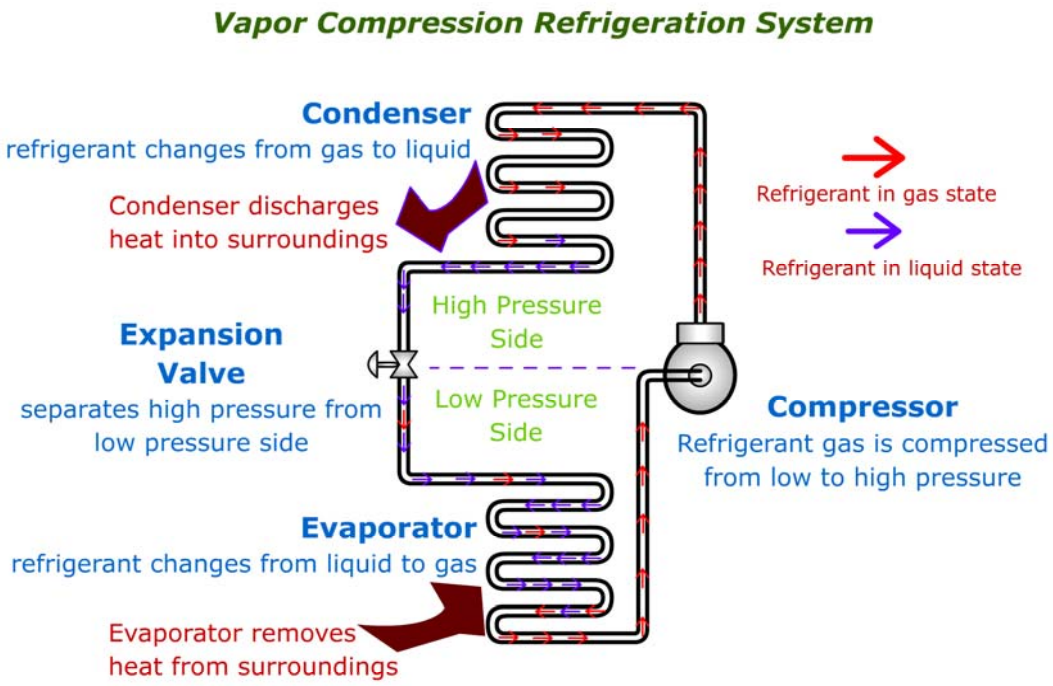

Compressor
Condenser / Receiver
Expansion Device
Evaporator
Basic Refrigeration Cycle

# Vapor Compression Cycle

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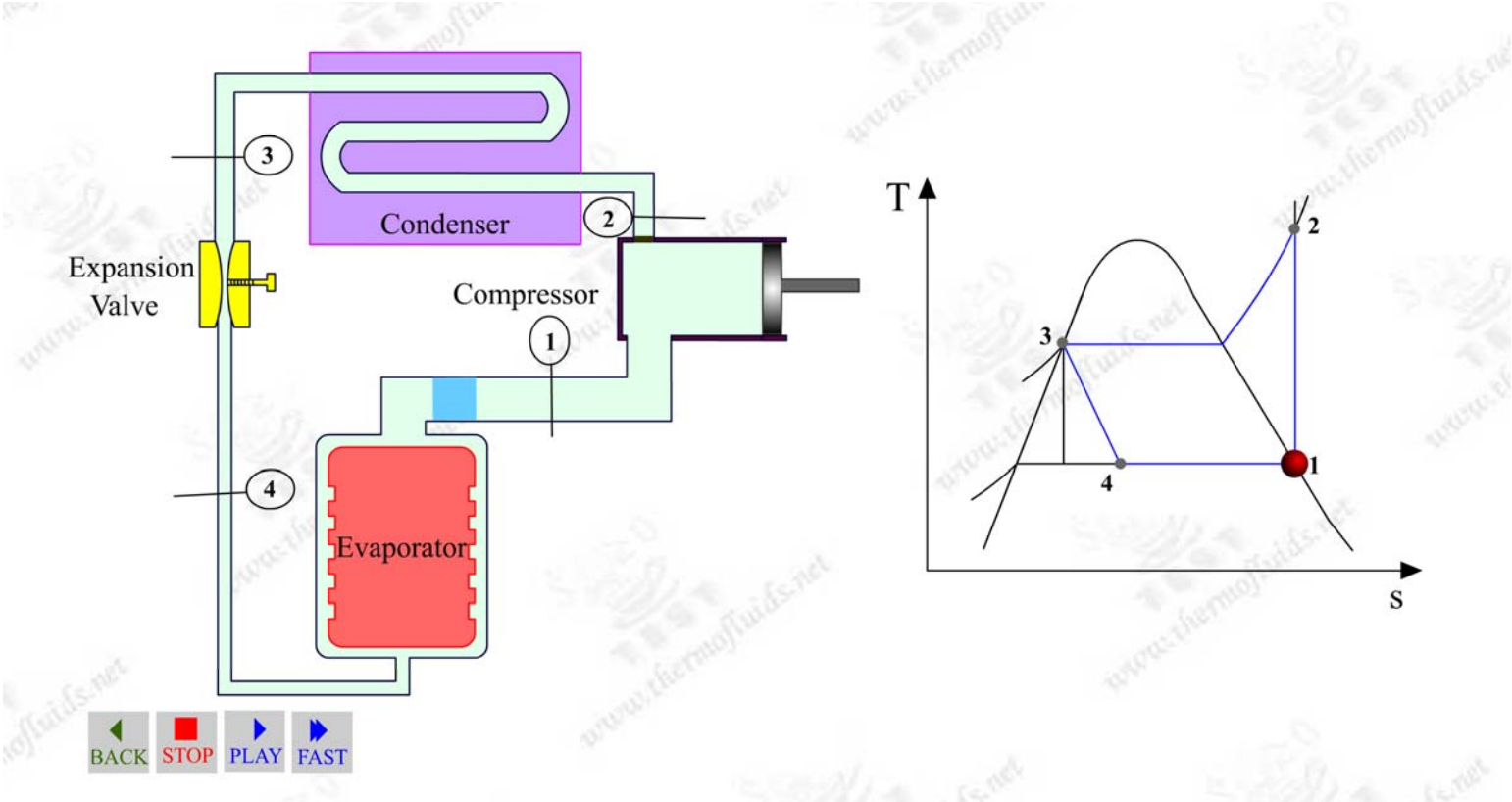
Cooling by the removal of heat

**The MOVEMENT of HEAT from a place where it is not wanted to a place where it is unobjectionable**

# What is Refrigeration?

# How Heat is Removed



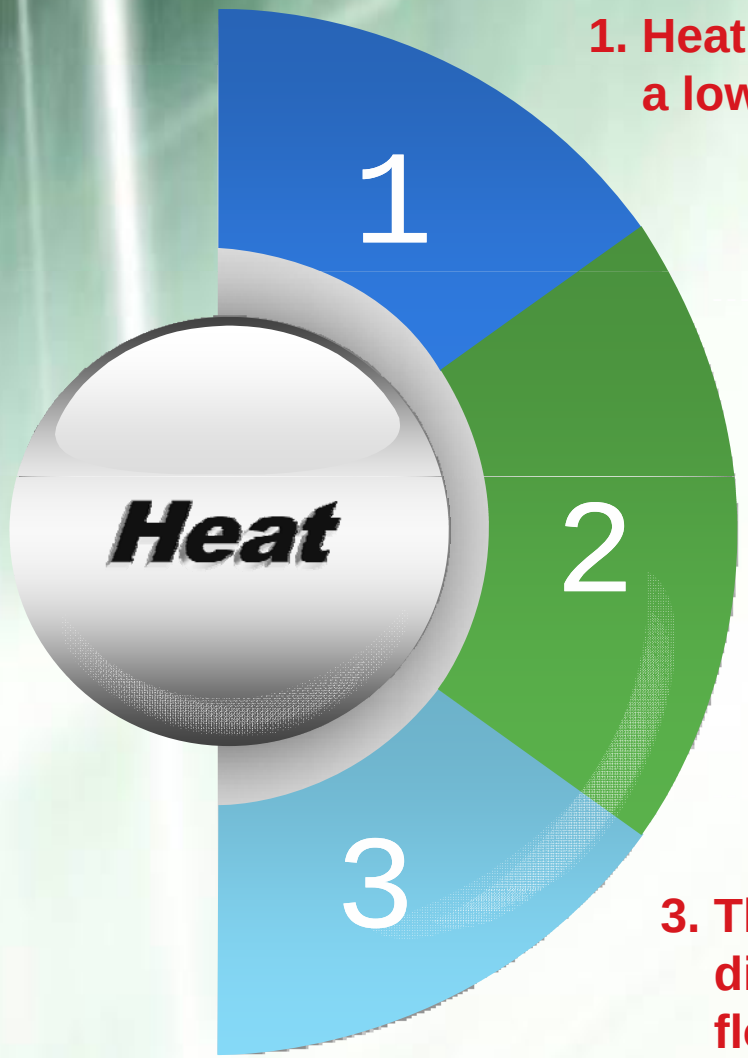
# Basic Refrigeration Concepts

| | |
|---|---|
| **What is heat?** | A form of energy |
| **What is cold?** | Absences of heat. |
| **How does heat flow?** | High heat to low heat |
| **Does cold flow?** | NO |
| **How is heat measured?** | British Thermal Unit (BTU) |

# British Thermal Unit (BTU)

Heat is a form of energy and is measured in BTU's.

A BTU is the quantity of heat required to raise the temperature, of one pound of water, one degree Fahrenheit.




1. Heat flows from high energy levels to a lower energy level.

2. Heat will not flow without a temperature difference

3. The greater the temperature difference, the faster the energy will flow.

# Heat Flows Three Ways

# Conduction

The transfer of heat from molecule to molecule through a substance by chain collision

Example:

Heating one end of a copper tube, will cause the other end to get hot.

# Convection

Heat transfer by the movement of molecules from one place to another.

Example:

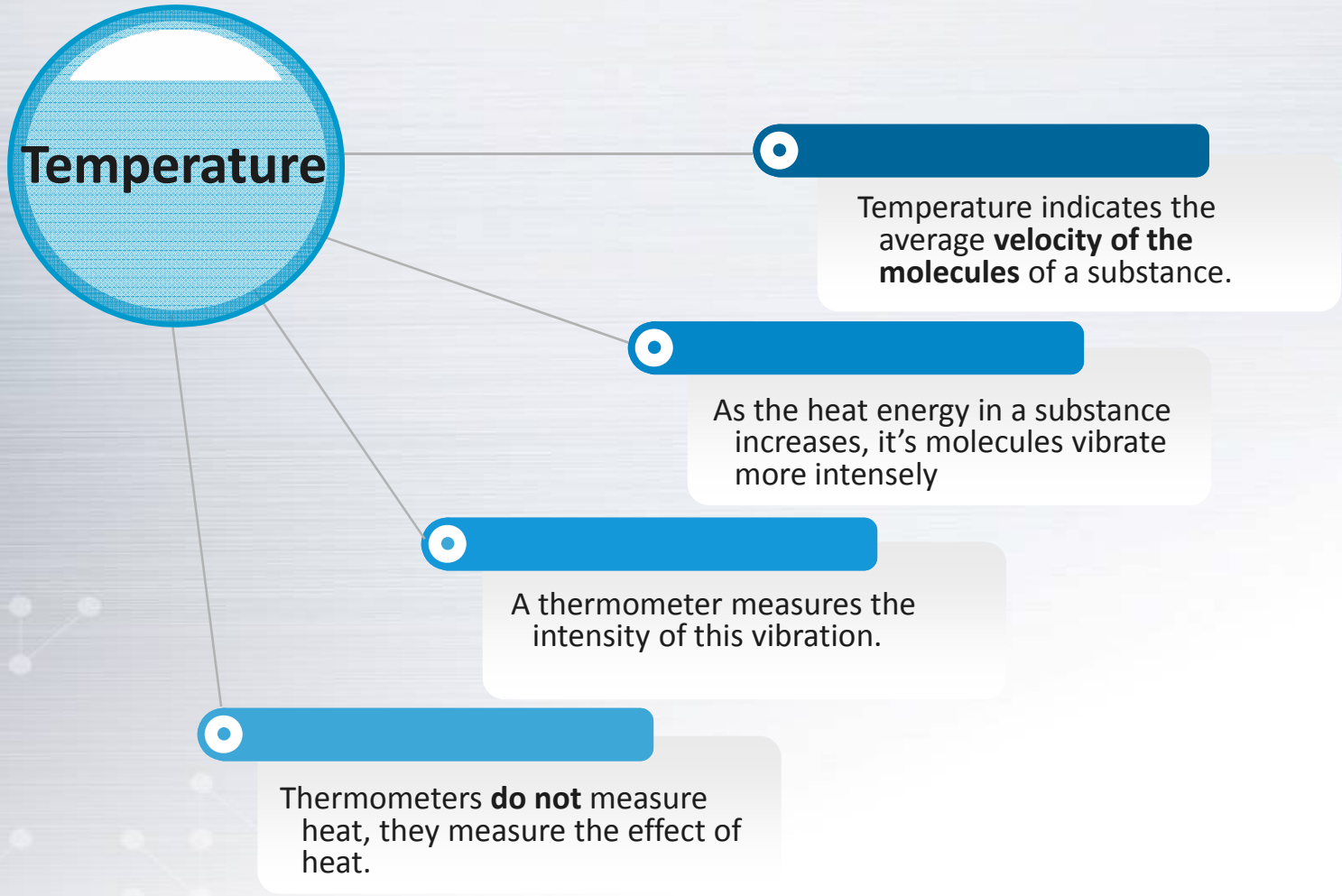
- Convection oven
- Forced air furnace

# Radiation

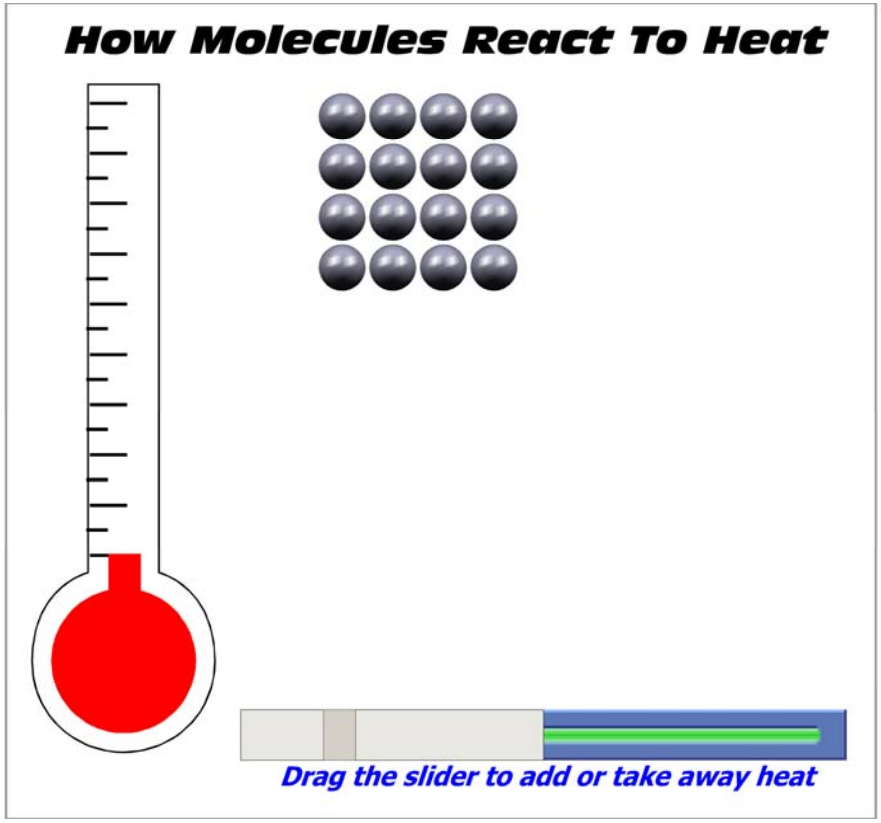
The transfer of heat by passing from a source to an absorbent surface without heating the space in between.

Example:

Sunlight – goes through a window without heating the glass but heats the surface in the room it is shinning on.


Temperature
Temperature indicates the average **velocity of the molecules** of a substance.
As the heat energy in a substance increases, it's molecules vibrate more intensely
A thermometer measures the intensity of this vibration.
Thermometers **do not** measure heat, they measure the effect of heat.

# Temperature Animation

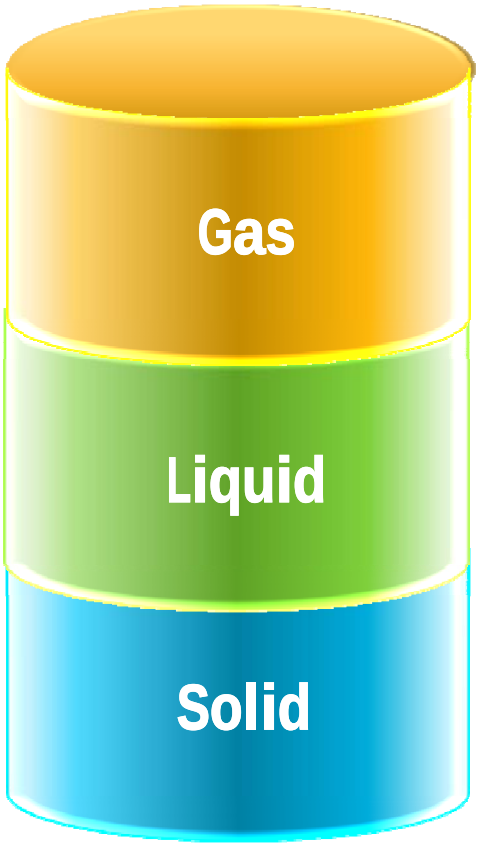


# Specific Heat

**The amount of heat (measured in BTU's) required to raise one pound of a substance one degree Fahrenheit.**

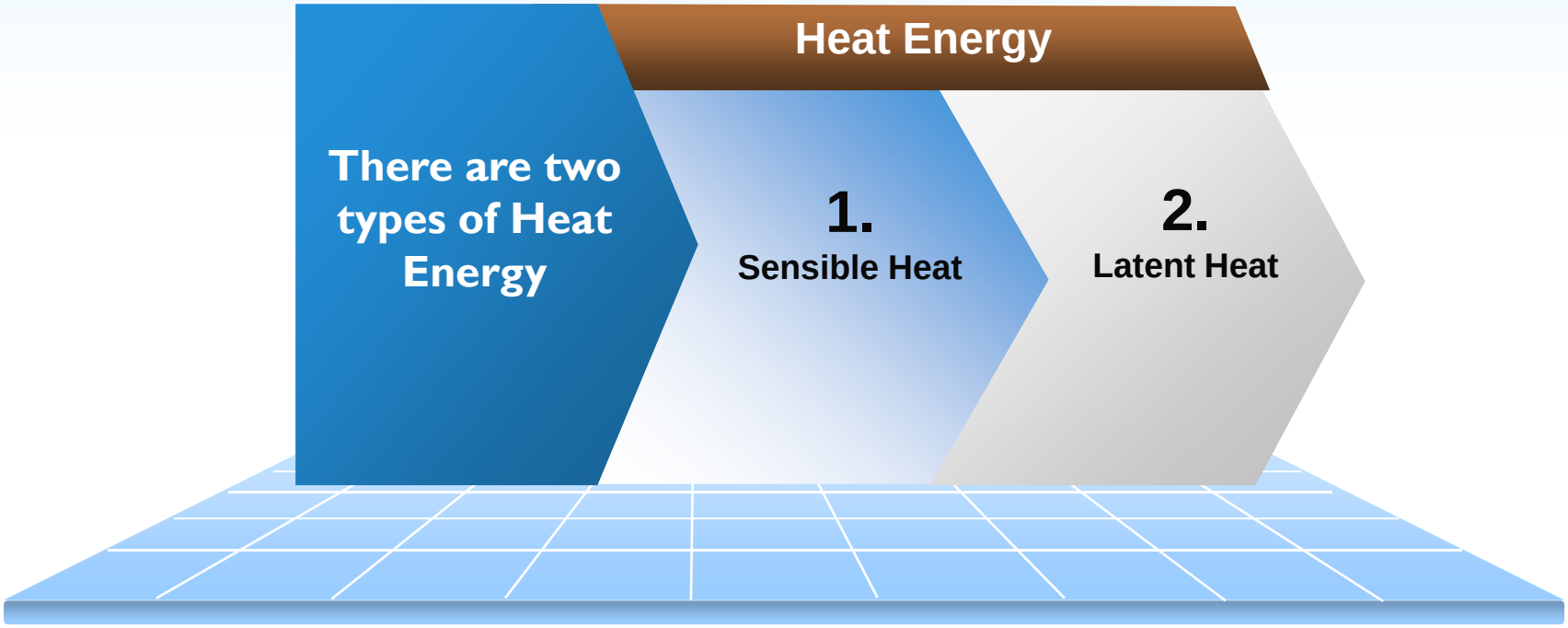
| Substance | Specific Heat (BTU/LB/Deg F) | Temp Rise (Deg F) (From 1 BTU Addition) |
|---|---|---|
| Water (Liquid) | 1.00 | 1.00 |
| Ice | 0.50 | 2.00 |
| Steam | 0.48 | 2.08 |
| Aluminum | 0.22 | 4.54 |
| Brass | 0.09 | 11.11 |

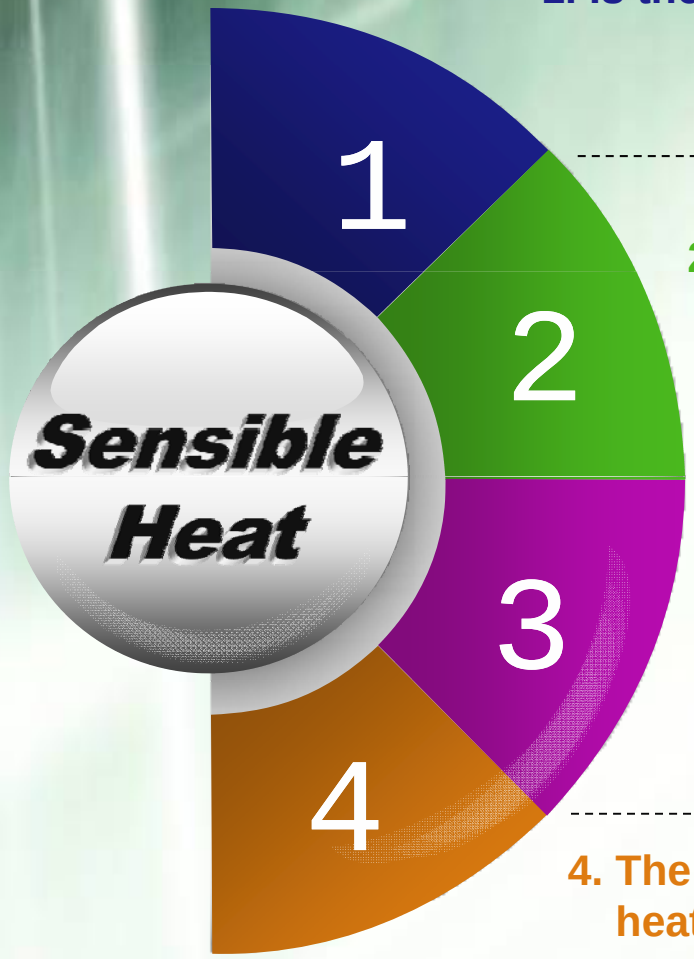
# Physical State of a Substance




Adding heat energy in any of the three states will increase the temperature.

Changing the state of a substance will require a larger quantity of heat energy.


Heat Energy
There are two types of Heat Energy
1.
Sensible Heat
2.
Latent Heat

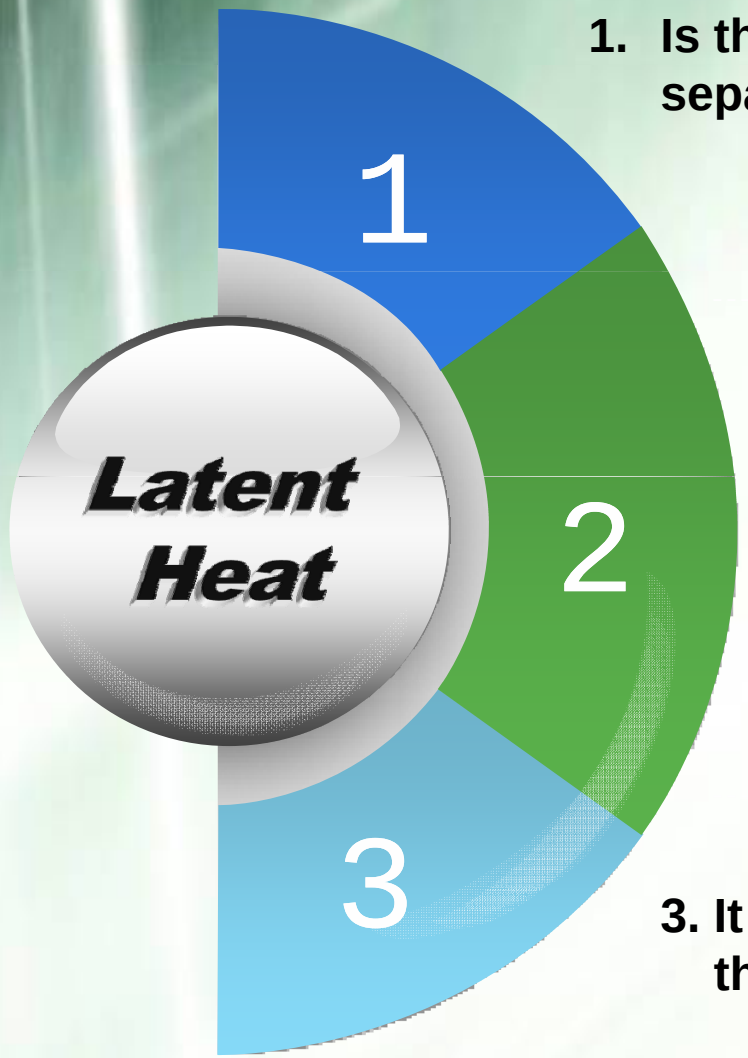



1. Is the energy of molecular motion

2. Causes a change in temperature, with No change in state.

3. Sensible heat causes an increase in molecular motion.

4. The addition or removal of sensible heat is measurable with a thermometer




1. **Is the energy of molecular separation and arrangement.**

2. **Causes a change in state, while there is <u>no change In temperature</u>.**

3. **It <u>can not be measured</u> with a thermometer.**

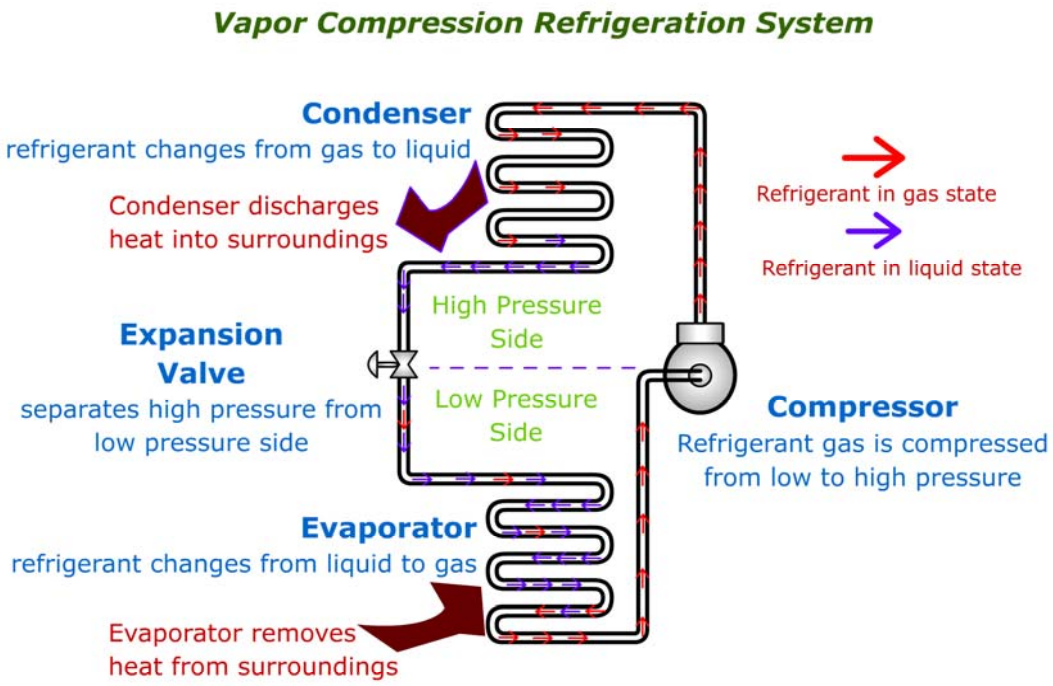
# Refrigeration

**Mechanical refrigeration works by changing the state of the refrigerant.**

**The majority of heat is removed from the temperature controlled space as the refrigerant absorbs heat when it changes state from a liquid to a gas in the evaporator.**

**The majority of the absorbed heat is removed from the refrigeration system in the condenser as the refrigerant changes state from a gas back to a liquid.**

# Vapor Compression Cycle

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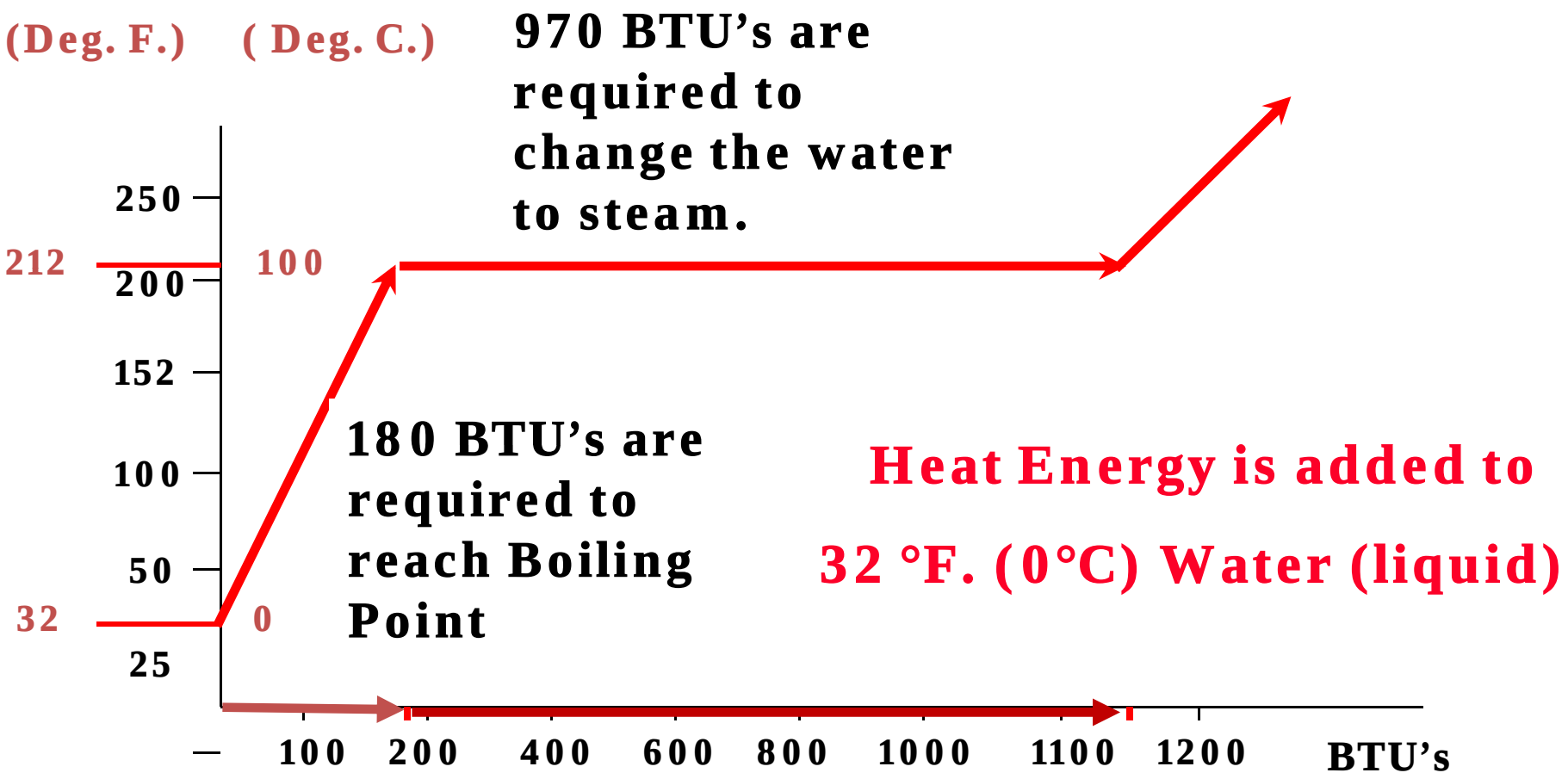
# Example


(Deg. F.)
( Deg. C.)
970 BTU's are required to change the water to steam.
250
212
200
100
152
100
50
32
0
25
180 BTU's are required to reach Boiling Point
Heat Energy is added to
32 °F. (0°C) Water (liquid)
100
200
400
600
800
1000
1100
1200
BTU's

# Saturation Temperature

**The temperature at which a substance will change state from a liquid to a vapor or a vapor to a liquid**

Add Heat = Liquid to Vapor (Vaporization)

Remove Heat = Vapor to Liquid (Condensation)

# Saturated Mixture

**At a temperature equal to it's boiling point or condensing point, a substance can be both vapor and liquid.**

Addition of Heat = Boiling

Removal Heat = Condensing

# Sub-Cooled Liquid

**At a temperature <u>below</u> it's boiling point, a substance is:**

100% Liquid, no vapor present

1lb. Of water @ 200$^{o}$ F. What is the state of water?
- Sub-cooled liquid
- Sub-cooled by 12$^{o}$ F.

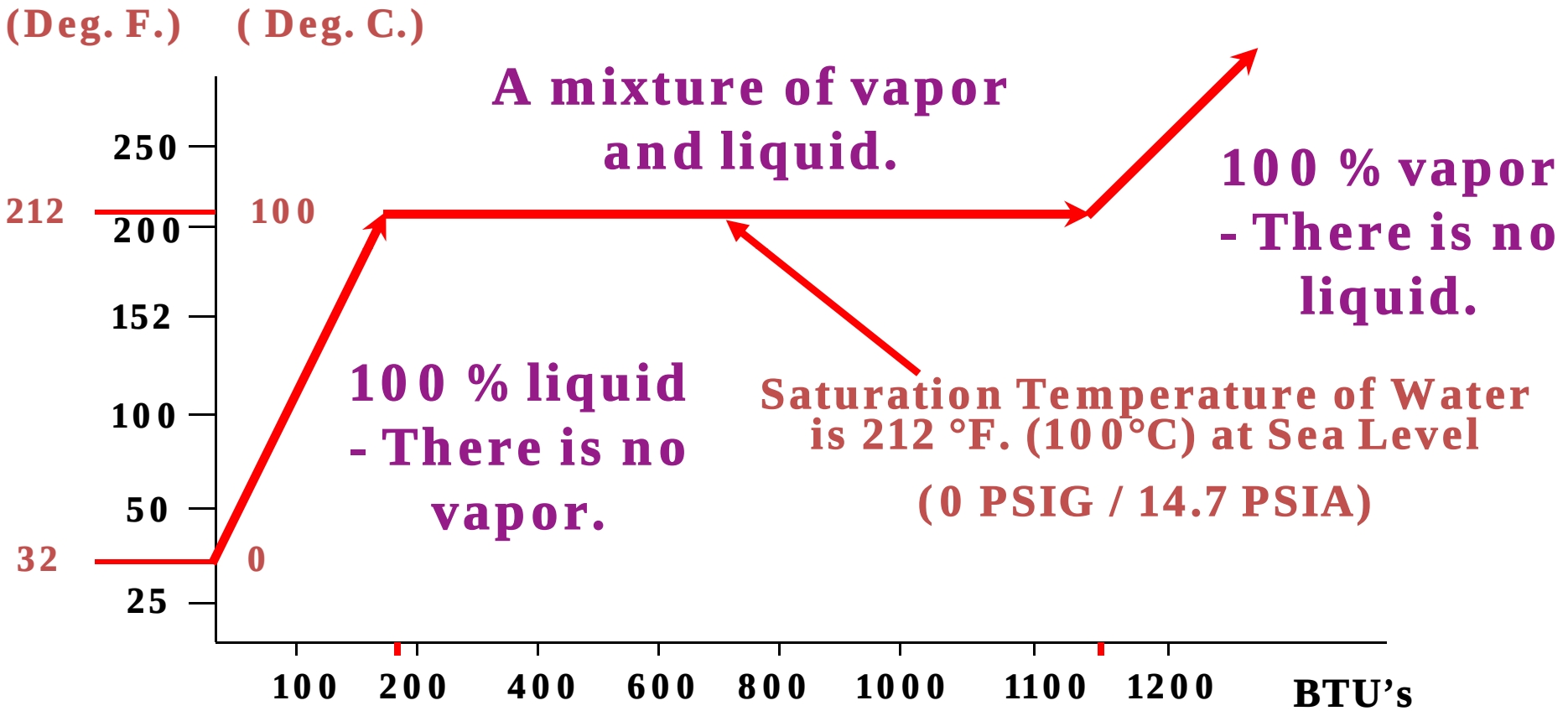
# Super Heated Vapor

**At a temperature <u>above</u> it's boiling point, a substance is:**

100% vapor, no liquid present

1lb. Of water @ 220$^{o}$ F. What is the state of water?
- Super heated vapor (steam)
- Super heated by 8$^{o}$ F.

# Example


(Deg. F.)
( Deg. C.)
A mixture of vapor and liquid.
100 % vapor - There is no liquid.
100 % liquid - There is no vapor.
Saturation Temperature of Water is 212 °F. (100°C) at Sea Level
(0 PSIG / 14.7 PSIA)
250
212
200
152
100
50
32
25
100
0
100
200
400
600
800
1000
1100
1200
BTU's

## ***Pressure:***

Defined as a force per unit of area

# Pressure Movement

## How does pressure flow?

**High** To **Low**

What would happen if you take two refrigerant tanks, one with refrigerant and the other in a vacuum and connect a hose between them?

Refrigerant flows from the tank with refrigerant to the tank that is in a vacuum, until the pressures equalize.

# Pressure vs. Boiling Point

**As the pressure on a substance increases, boiling temperature will increase. As pressure decreases, boiling temperature will also decrease.**

**Pressure and boiling temperature follow each other**

**At the boiling point we have both Liquid and Vapor.**

# Pressure vs. Saturation Temperature

**As the pressure increases, saturation temperature will increase. As pressure decreases, saturation temperature will also decrease.**

**Pressure and boiling temperature follow each other**

**At the saturation temperature we have a saturated mixture (both liquid and vapor are present).**

# Atmospheric Pressure

- **At Sea Level, the atmospheric pressure on our bodies is 14.7 PSIA.**

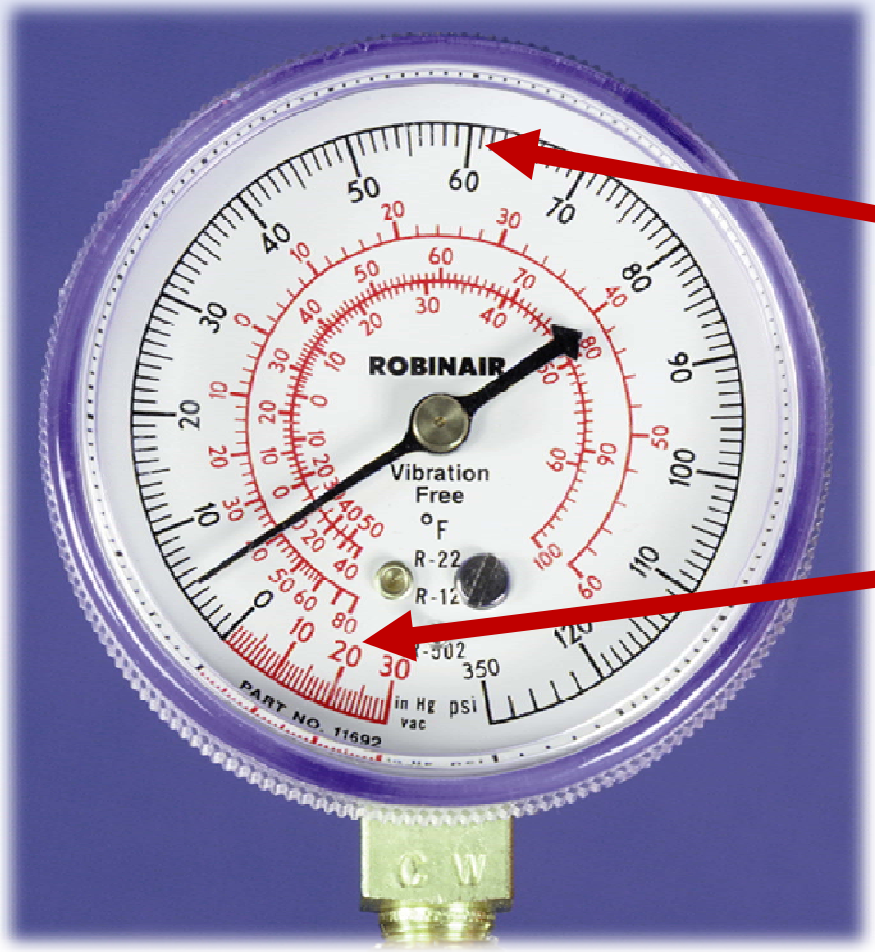
- **A column of air, one inch square and 60 miles high weighs 14.7 pounds.**

# Pressure Scales

| | Gauge Scale | Absolute Scale |
|---|---|---|
| **ATMOSPHERE**<br>**(Pressure @ Sea Level)** | **0 PSIG**<br>**0 in Hg** | **14.7 PSIA**<br>**29.92 in Hg** |
| **VACUUM** | **29.92 in Hg** | **0 in Hg** |

Hg is the symbol for Mercury.

# Compound Gauge




**Gauge Scale:**

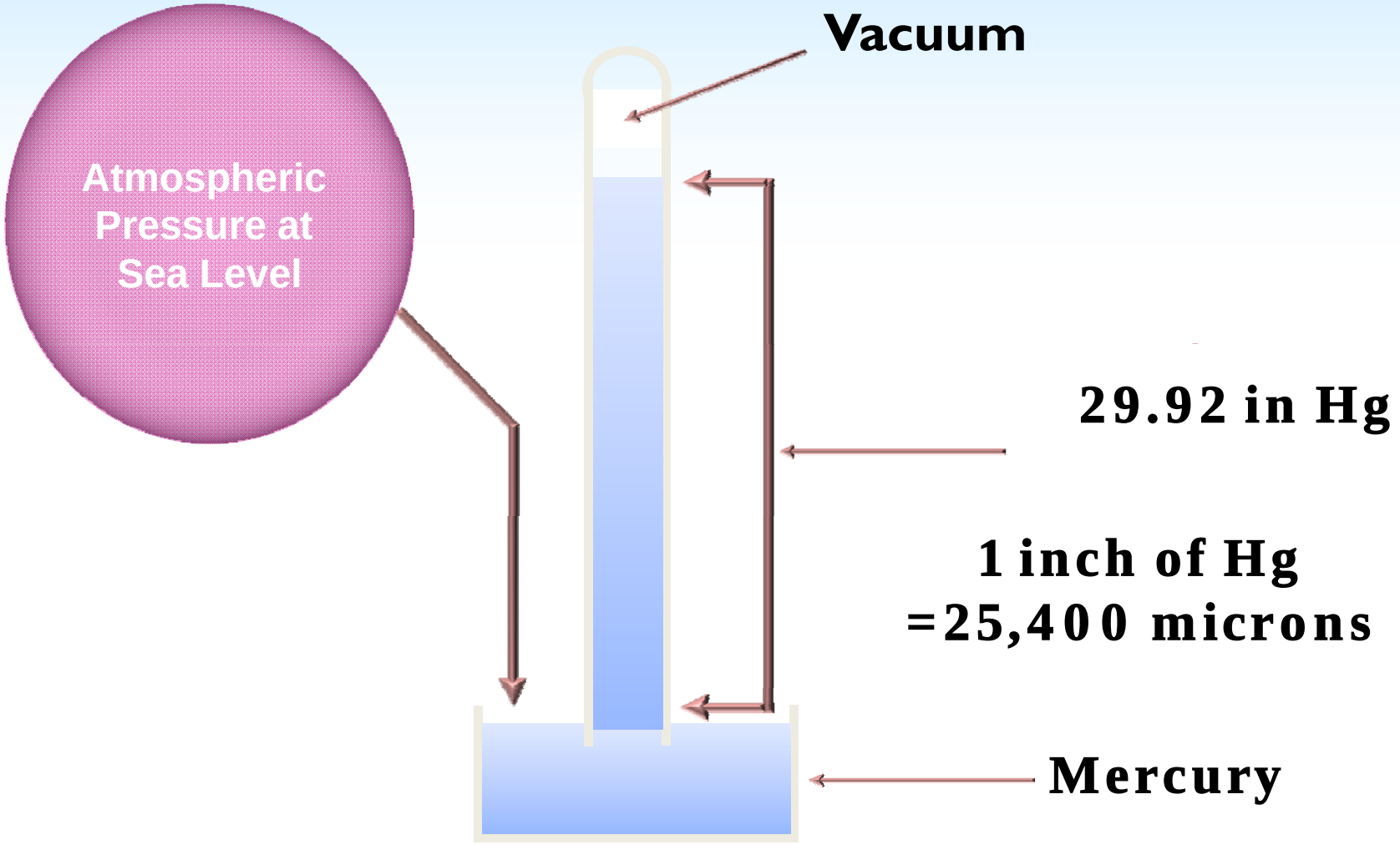
**Positive Pressure Scale**

**Vacuum Scale (Reference Only!)**

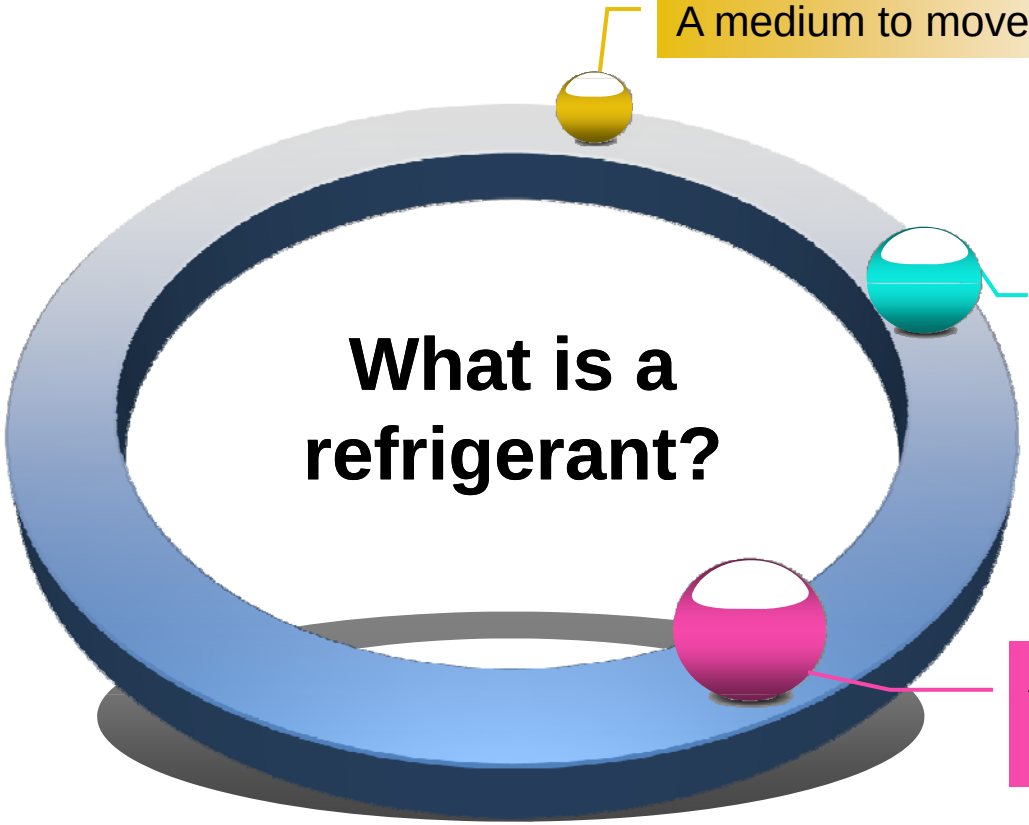
# Vacuum Gauge

**Absolute Pressure in microns of Hg.**

# Mercury Barometer



# What is a refrigerant?



A medium to move heat

A substance that **absorbs heat by evaporating** at low temperatures and pressures.

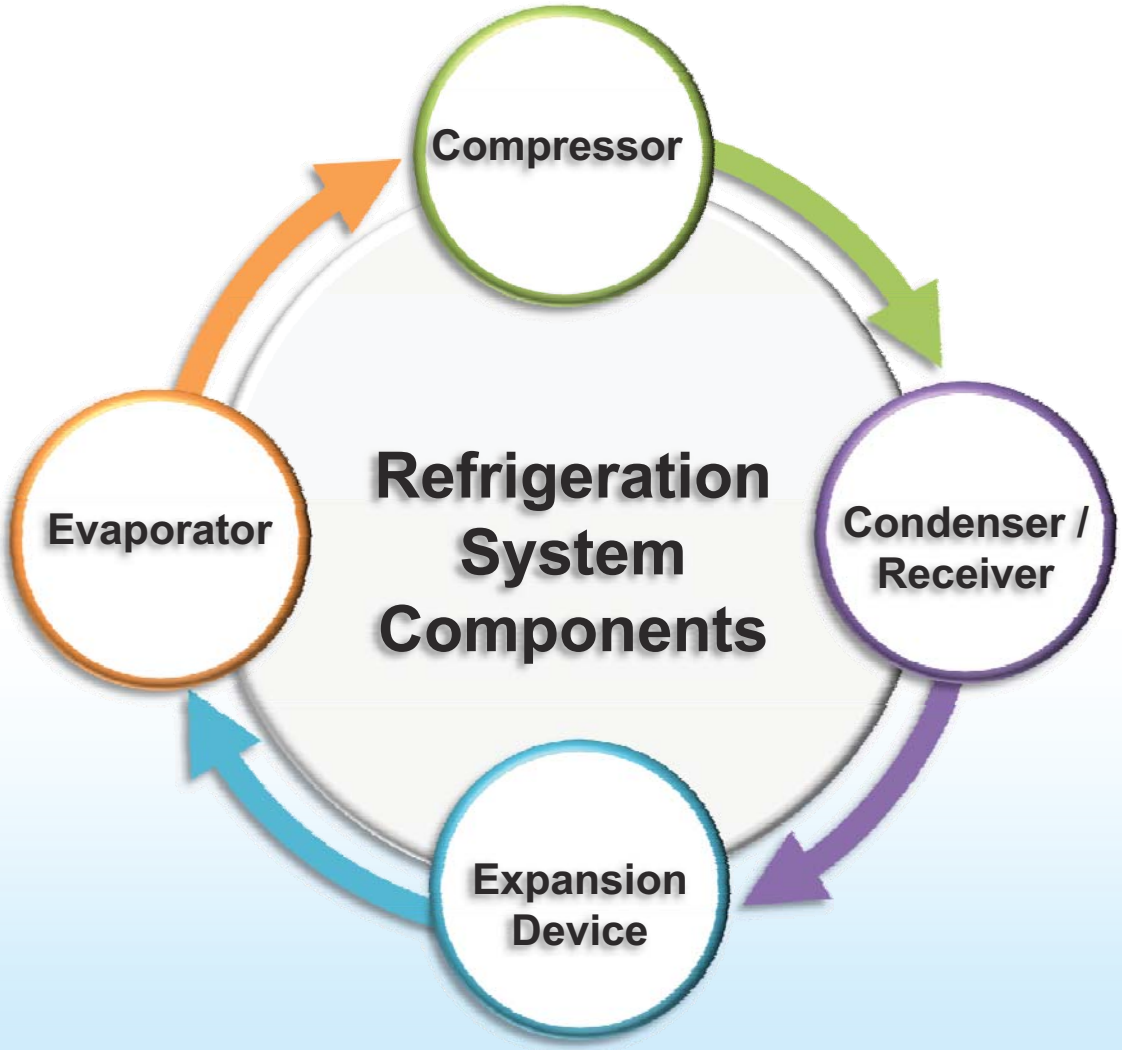
And **gives up heat** by **condensing** at high temperatures and pressures

# Refrigerants No Longer Available

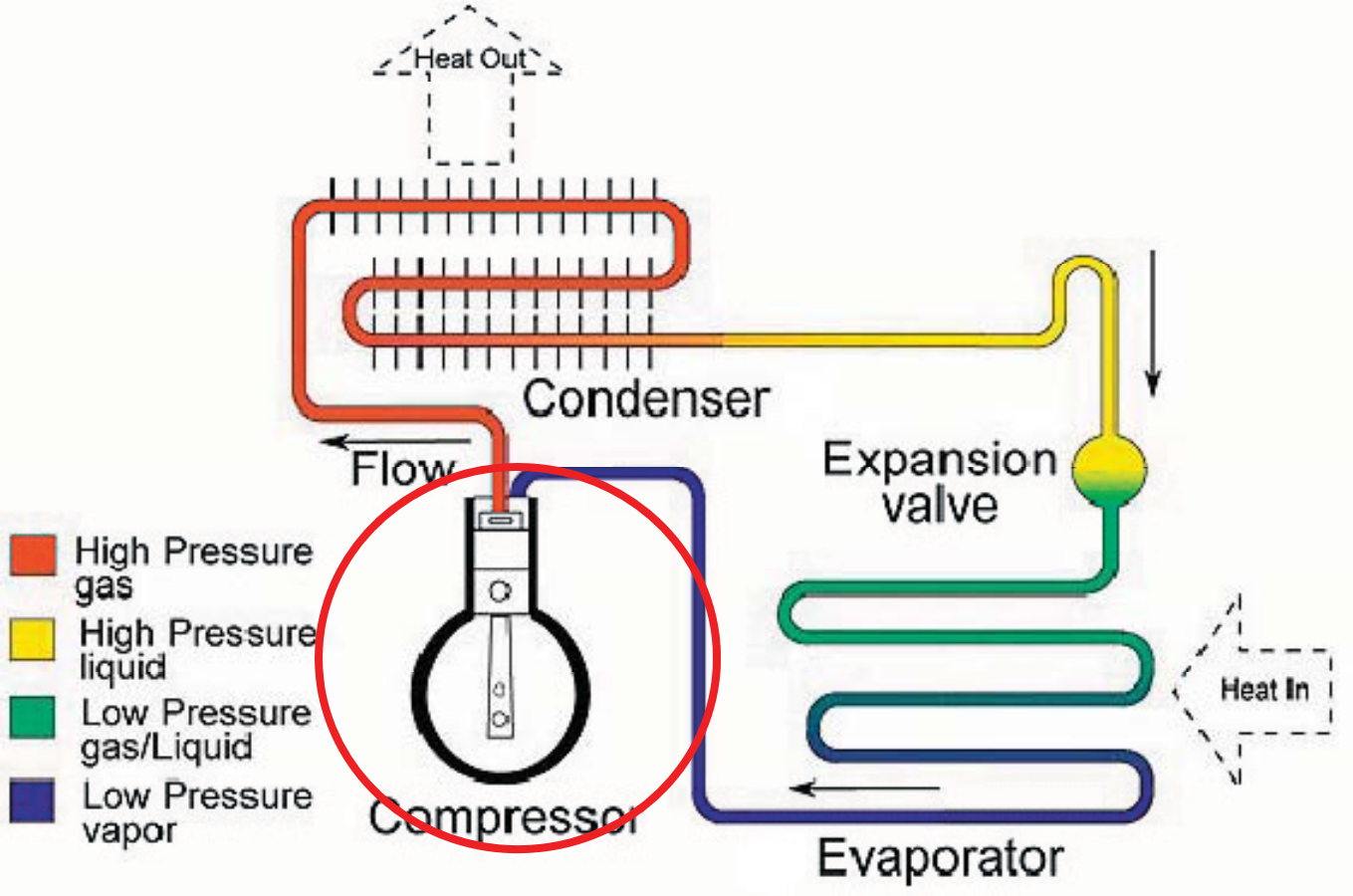
| R-12 CFC | R-11 CFC | R-500 CFC | R-502 CFC |
|---|---|---|---|
| • 100% Ozone depletion potential<br>• Used in every thing<br>• Med. – Low temp. | • 100% Ozone depletion<br>• Used in centrifugals<br>• Med. Temp | • 66% Ozone depletion<br>• Used in 50hz<br>• Med. - Low Temp | • 28% Ozone depletion<br>• Used in deep freezers<br>• Low. Temp |
| Production ceased in 1995 | Production ceased in 1995 | Production ceased in 1995 | Production ceased in 1995 |

# Refrigerants Currently in Use

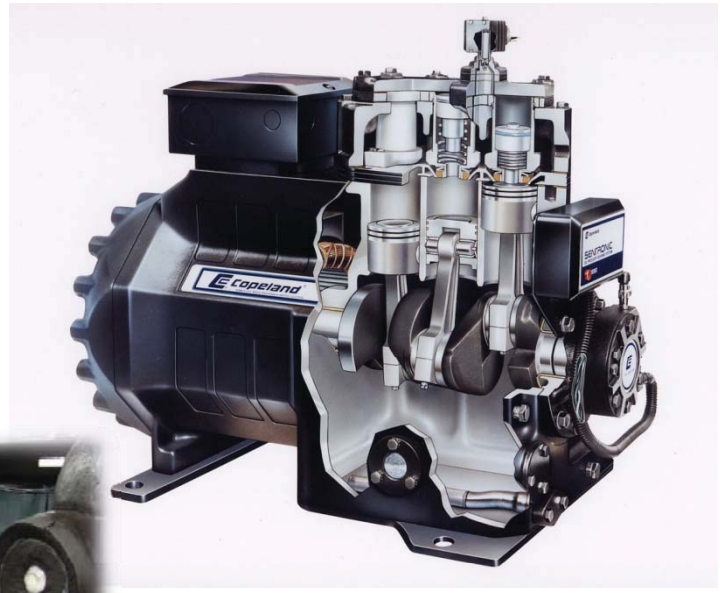
| R-22 HCFC | R-134a HFC | R-507 HFC | 404A HFC |
|---|---|---|---|
| • 5% Ozone depletion potential<br>• Used in every thing<br>• Med. – Low temp.<br><br>Production phase out | • 0% Ozone depletion<br>• Used in auto A/C<br>• Med. - Low Temp<br><br>Replaced R-12 | • 0% Ozone depletion<br>• Used in freezers<br>•Low Temp | • 0% Ozone depletion<br>• Used in deep freezers<br>• Med. – Low Temp<br><br>Replaced R-502 |


Compressor
Condenser / Receiver
Expansion Device
Evaporator
Refrigeration System Components

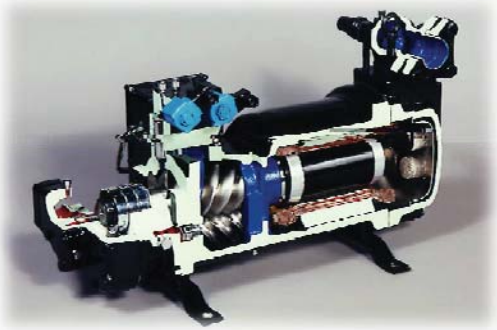
# Compressors

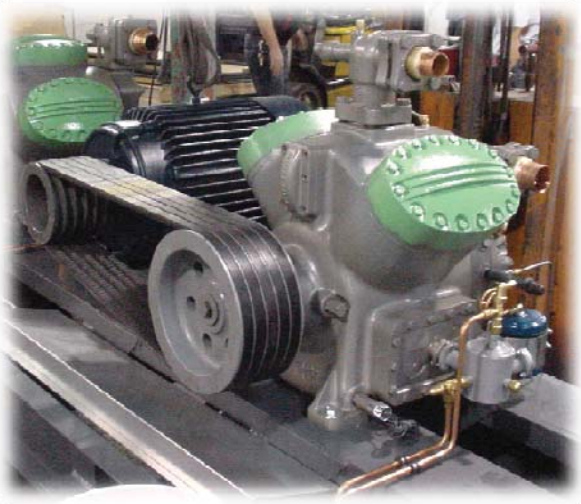


# Compressors

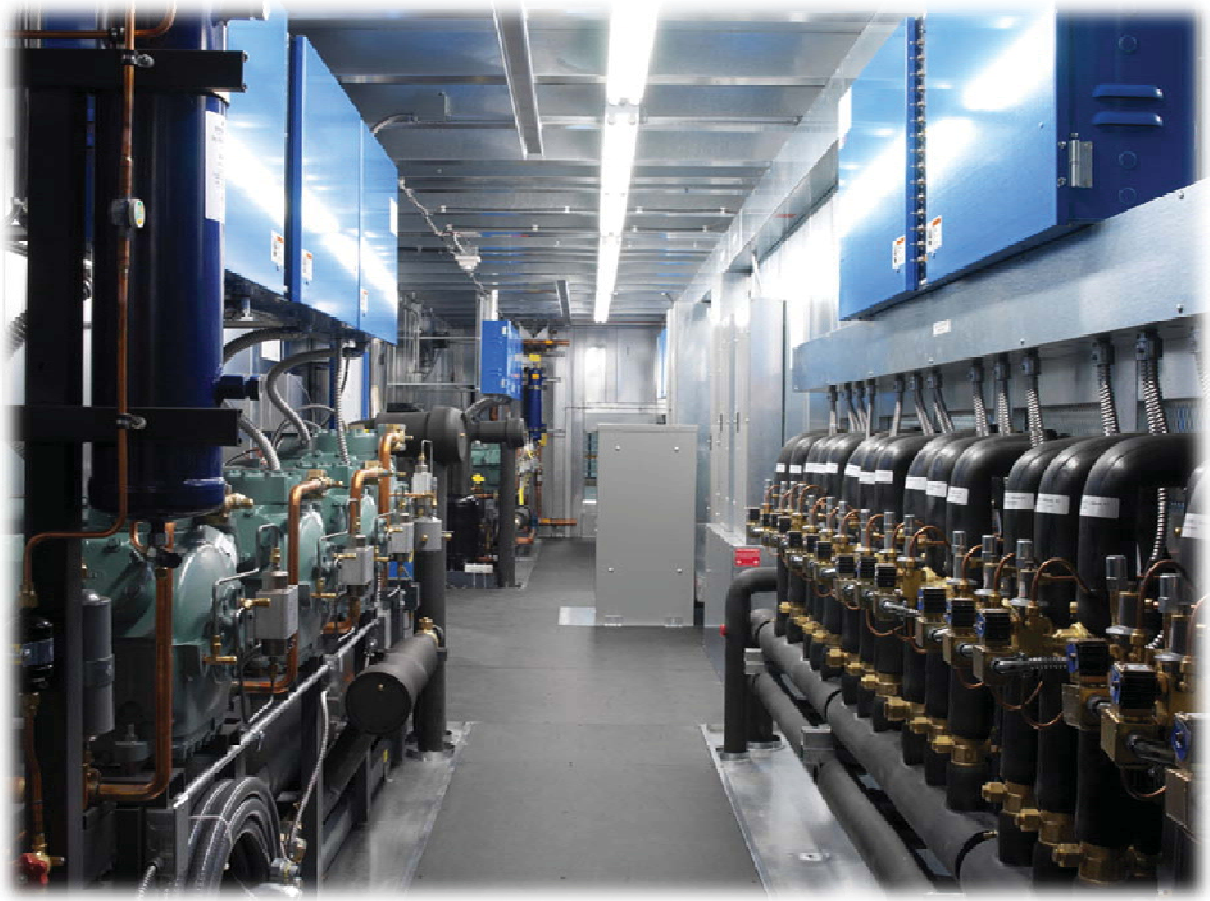



# Additional Compressor Types

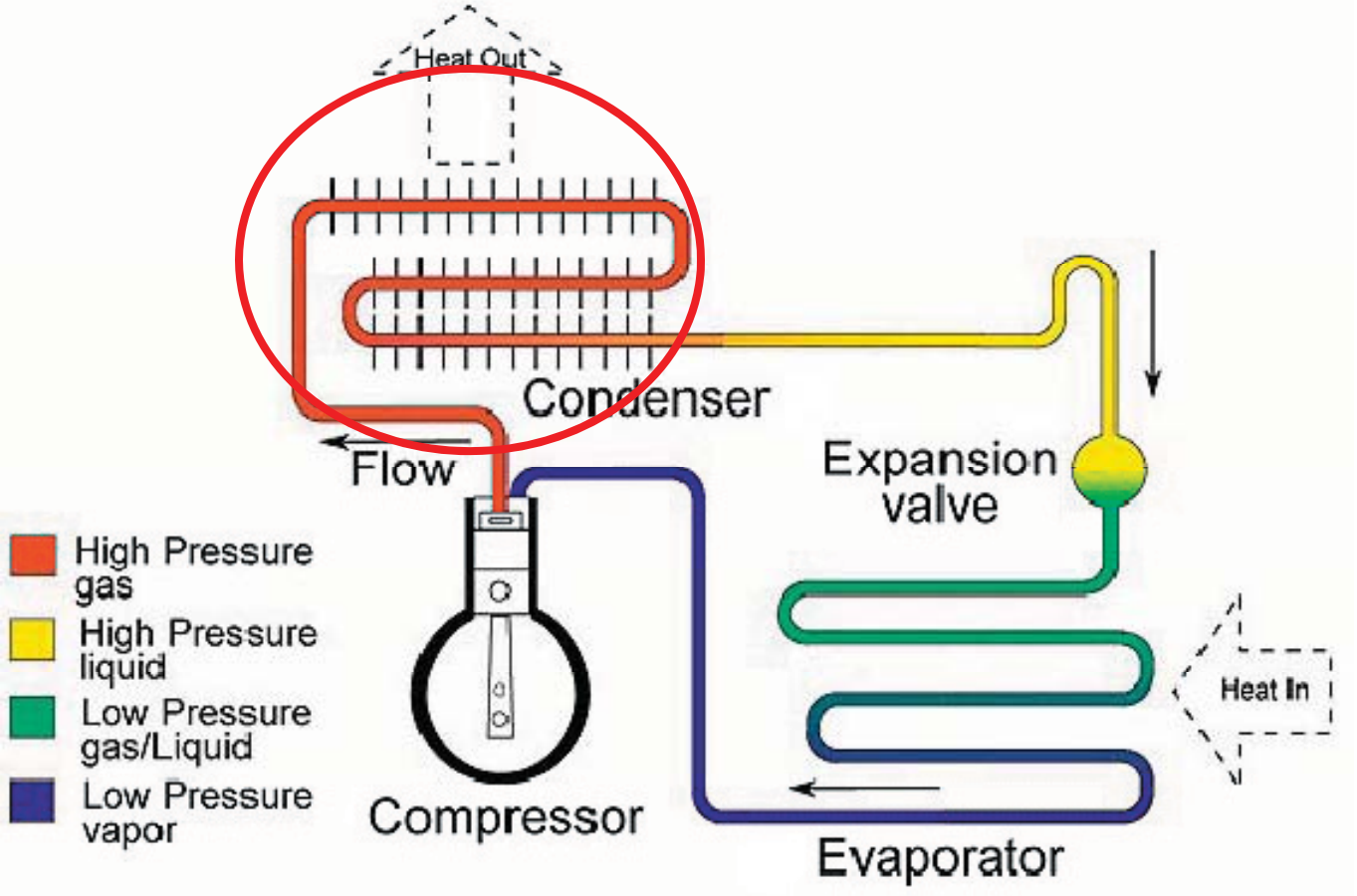




# Example Mechanical Center



# Condensers


Heat Out
Condenser
Flow
Expansion valve
High Pressure gas
High Pressure liquid
Low Pressure gas/Liquid
Low Pressure vapor
Heat In
Compressor
Evaporator

# Condensers

## Air Cooled

- Tube and fin

## Water Cooled

- Shell and tube
- Plate
- Evaporative

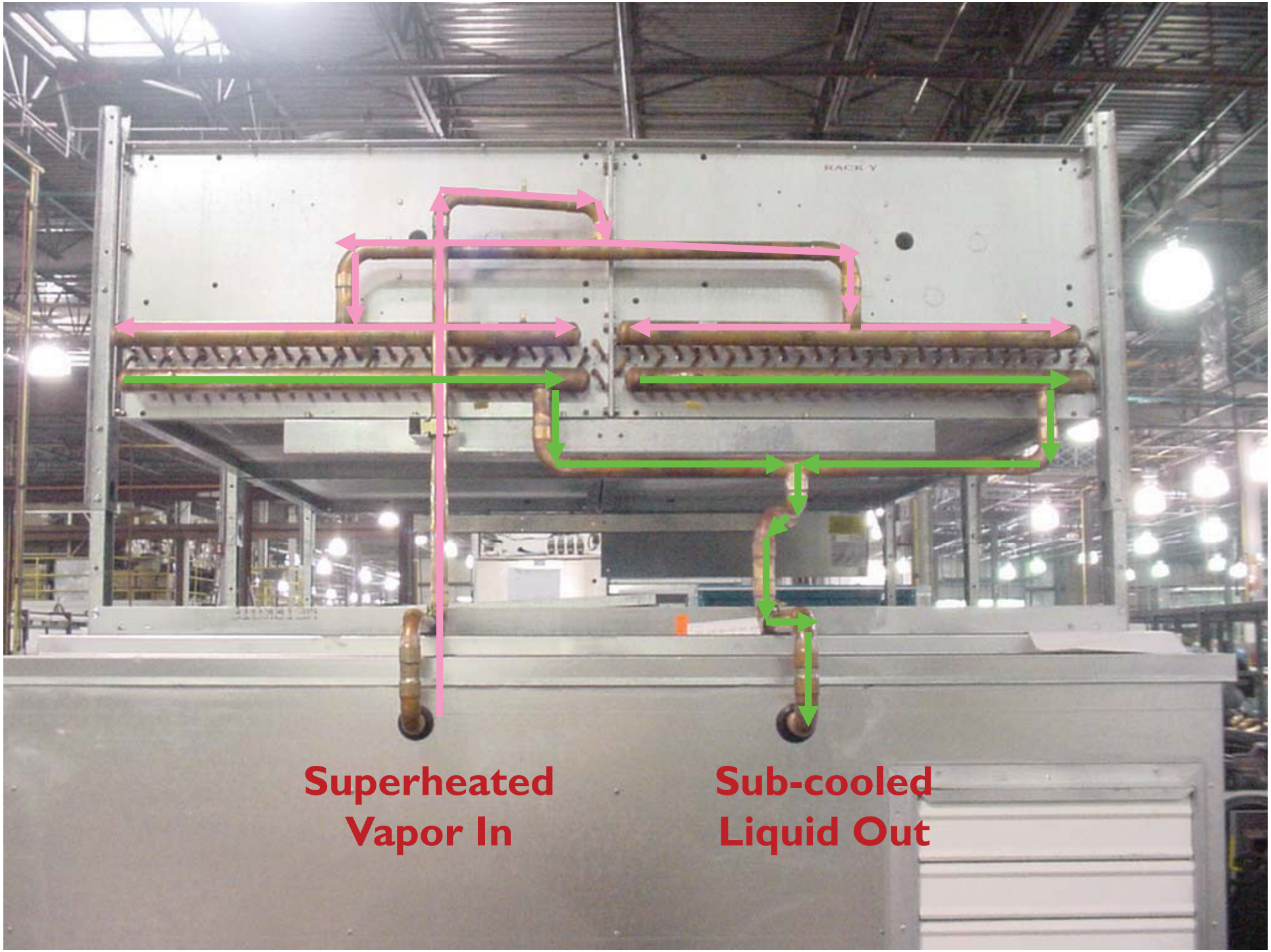

Superheated
Vapor In
Sub-cooled
Liquid Out


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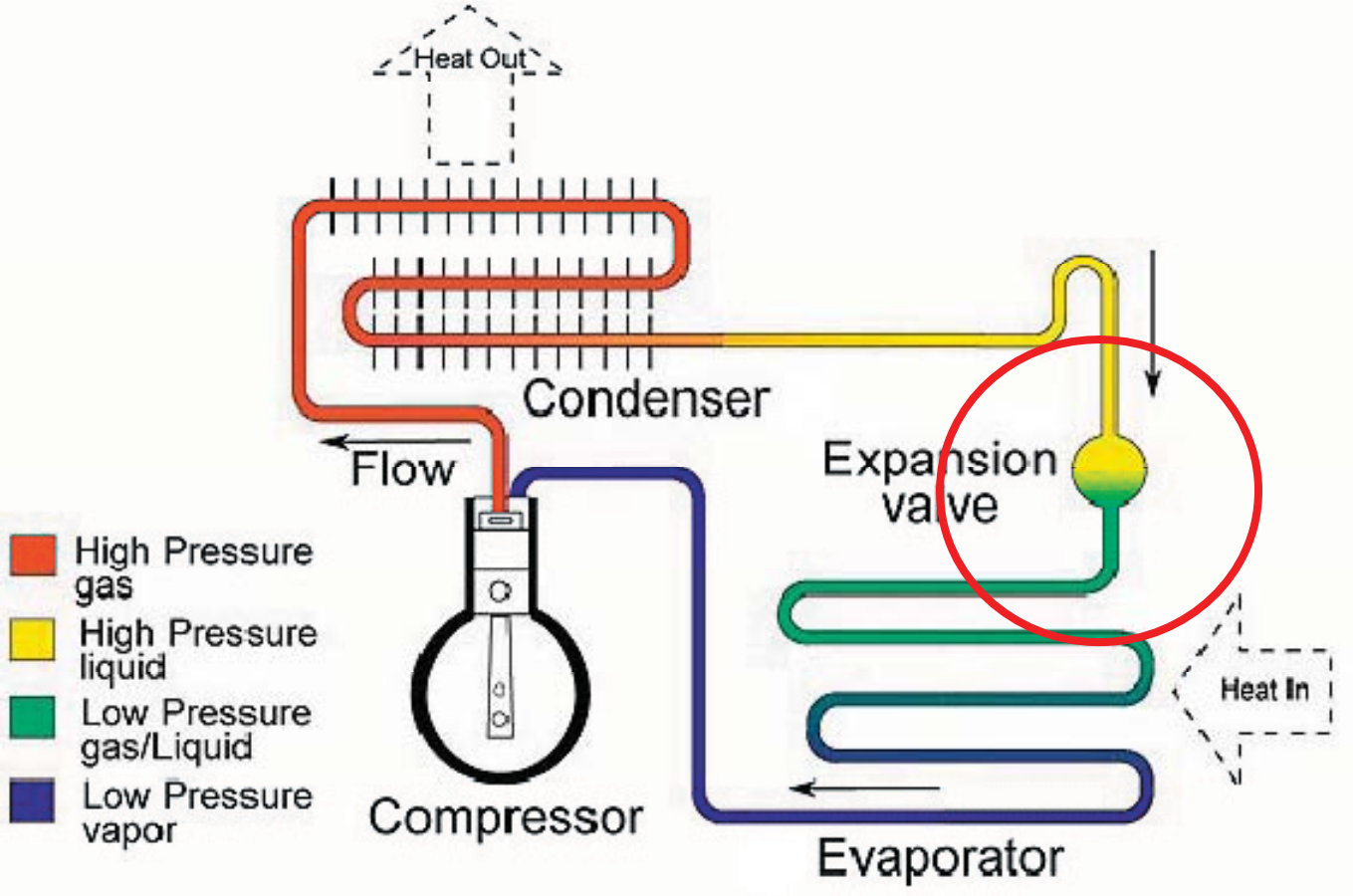
**Plate**

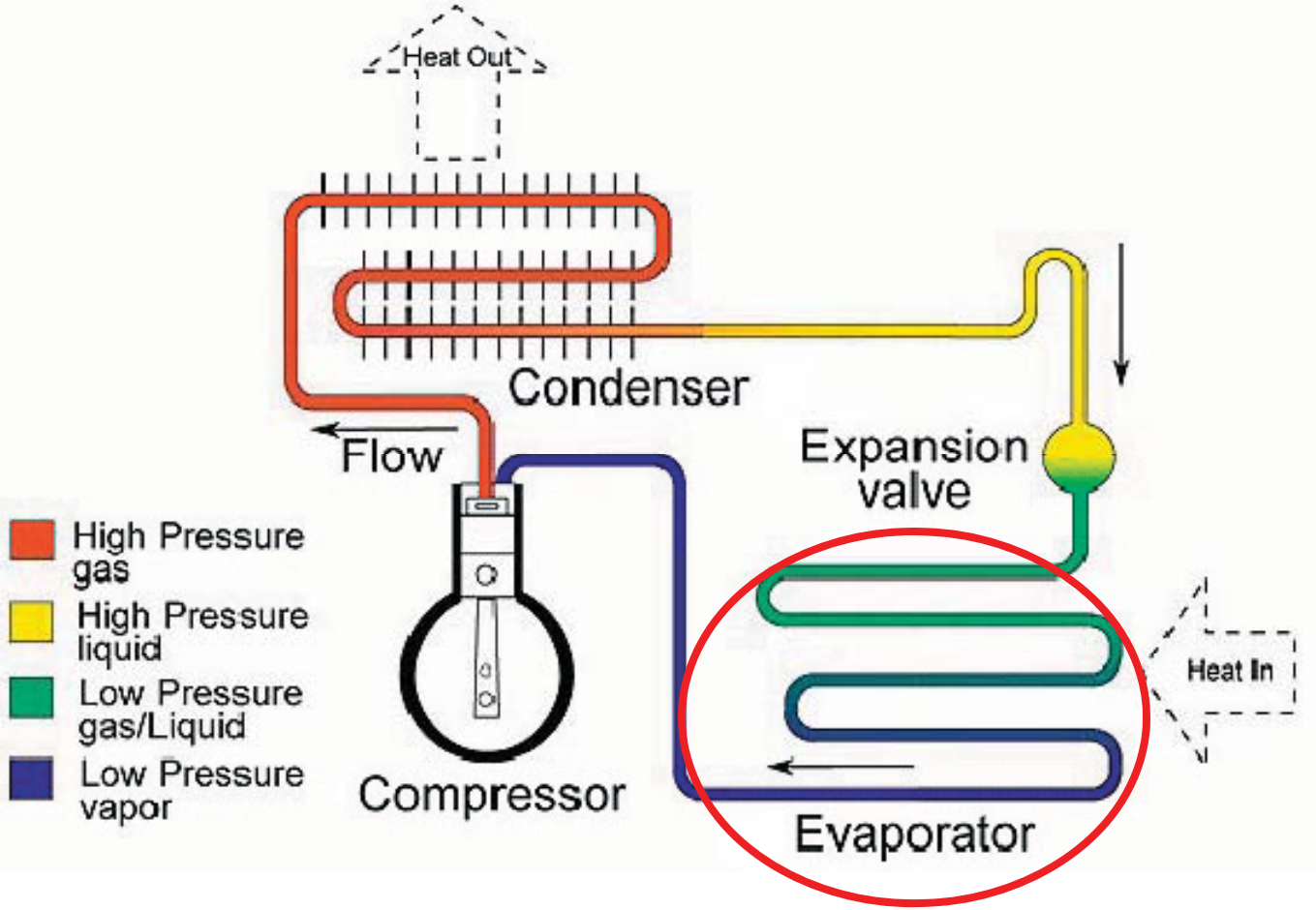
## Evaporative

# Metering Device

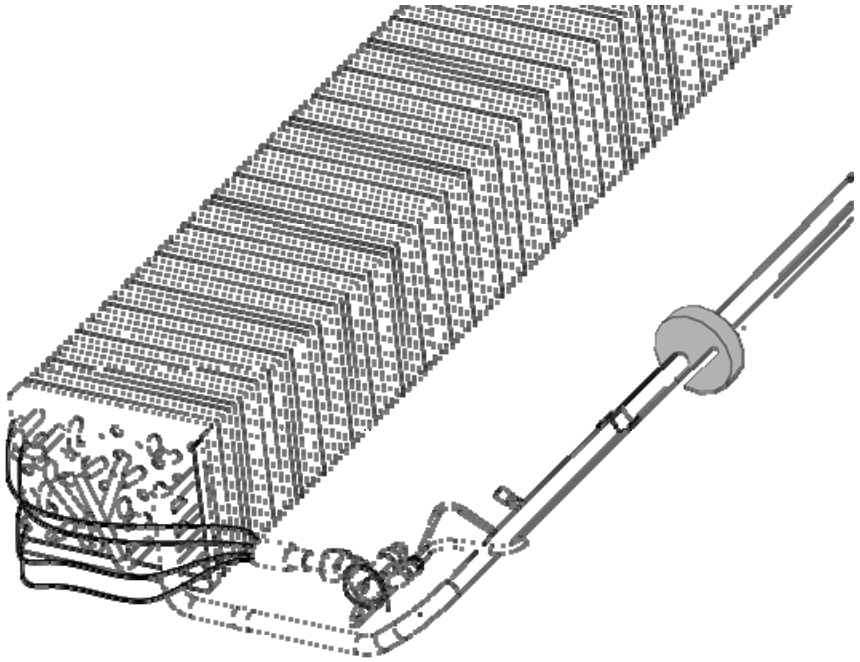


# TXV and Electronic

# Evaporators



# Display Case Evaporators



# Walk-In Evaporators


# Plate to Plate Heat Exchanger

# Questions