Energy & Store
Development Conference

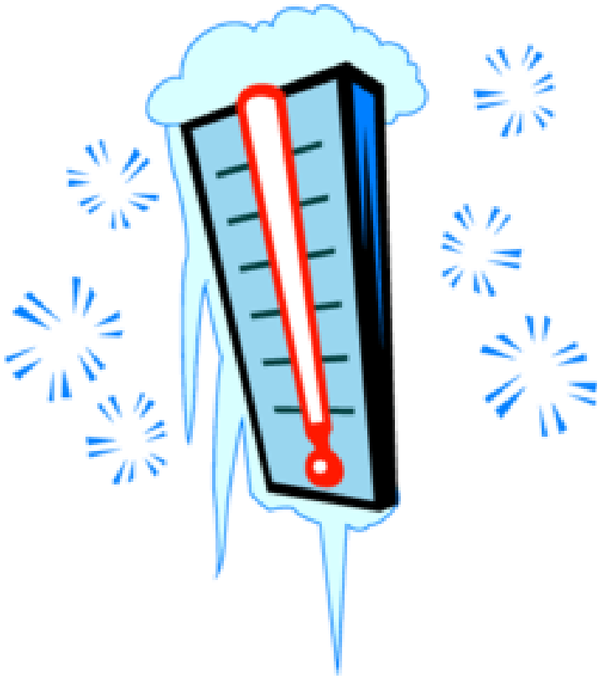
E+SD 2015

Refrigeration 101

Jim Kirk

facilitysource®

I am **Not** that James Kirk !



What Is COLD?

Cold:

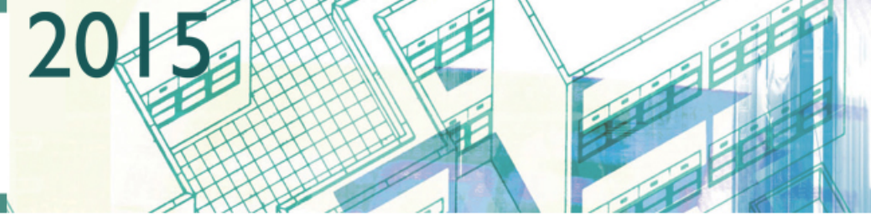
The absence of heat:

- You cannot “make” cold – you can only remove heat.

Heat:

Heat is the transfer of kinetic energy from one medium or object to another, or from an energy source to a medium or object:

- Measured in BTU (British Thermal Unit) – the amount of heat required to raise the temperature of one pound of pure liquid water by one degree Fahrenheit.



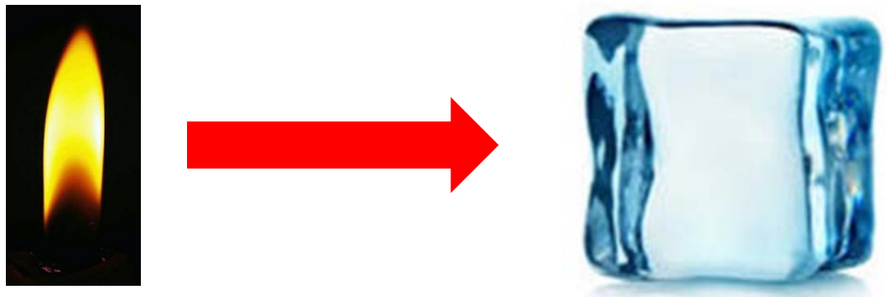
Refrigeration:

Refrigeration is a process of moving heat from one location to another

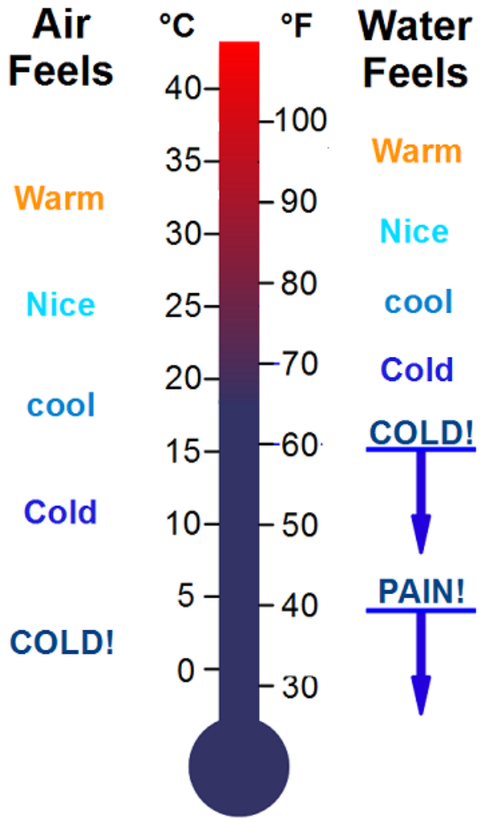
- Low Temp – frozen
- Medium Temp - perishable

Heat Transfer:

Heat transfer always occurs from a region of high temperature to another region of lower temperature.



Heat Transfer:



Methods of Heat Transfer:

- **Conduction:** The transfer of heat within a solid or between solid objects, can only be by conduction. It's due the motion of electrons. The hot molecules vibrate faster against the cool molecules causing them to heat up. Heat transfer is always from hotter to cooler objects. If one end of any object or material is heated, the heat will pass through the other end. Gases and fluids are less conductive than solids.

- **Convection:** It is the transfer of heat by the movement of fluids. Air or water, which is being heated directly, becomes less dense and rises up. The cooler part of the fluid settles down to replace it. This cooler fluid then heats up and forms convection current. Convection is the main form of heat transfer in liquids and gases.

- **Radiation:** Thermal radiation is the transfer of heat through empty space by electromagnetic waves. All objects above zero degree temperature radiate energy. Radiation does not require any medium, as it is transferred by electromagnetic waves and can take place even in vacuum. The heat energy from the Sun travels through the space vacuum by radiation before warming the earth.

Refrigerant:

A refrigerant is a substance or mixture, usually a fluid, used in a refrigeration cycle. In most cycles it undergoes **phase transitions from a liquid to a gas and back again.**

When a liquid changes state to a vapor it absorbs heat from the surrounding environment.

- "Secondary" (Glycol, CO_2, etc.) generally do not require a change state

Pressure Temperature Relationship:

Gay-Lussac's Law

Temperature and pressure are directly proportional to each other. This means that as the temperature decreases, the pressure also decreases, and as the temperature increases, the pressure increases.

One way to think of this is if you increase the speed of the molecules – by increasing their temperature – the force of the molecules hitting their container increases and increases the pressure.

Pressure Temperature Relationship:

- Refrigerant trapped in a container is in a *Saturated State*. This means that fluid is evaporating and condensing at the same rate so there is no change in the pressure or temperature of the fluid during this process.
- When the evaporated vapor is allowed to escape it will take heat with it, lowering the temperature and pressure.
- If vapor is added to the container it will inject heat, raising the temperature and pressure.

Pressure Temperature Relationship:

- By Controlling the pressure we can control the saturation (boiling/evaporation) point and temperature.

Pressure Temperature Relationship:

TEMPERATURE - PRESSURE CHART

PRESSURE-POUNDS PER SQUARE INCH FOR HCFC-22 REFRIGERANT

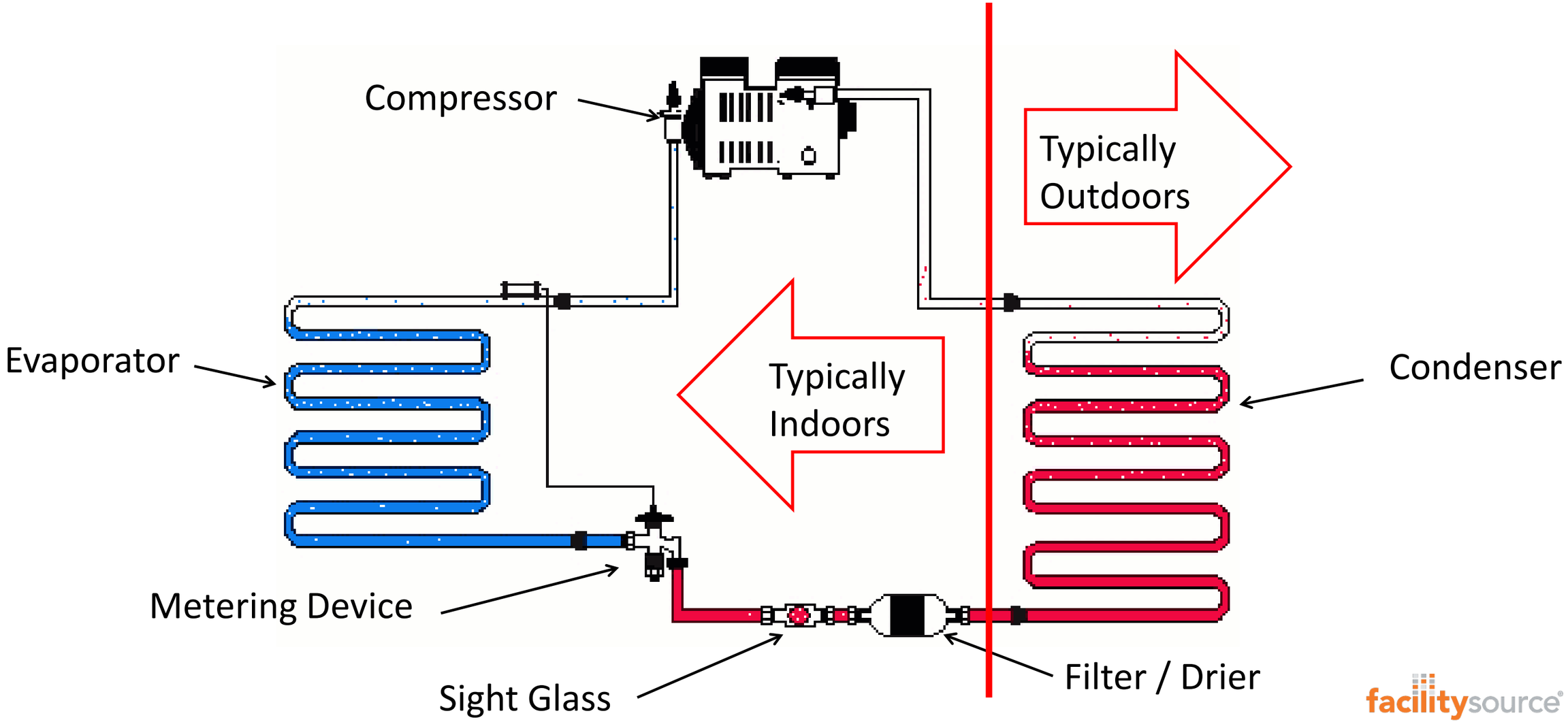
TEMPERATURE °F	PRESSURE PSI	TEMPERATURE °F	PRESSURE PSI	TEMPERATURE °F	PRESSURE PSI
-40	0.5	15	37.7	44	74.5
-35	2.6	16	38.7	45	76.0
-30	4.9	17	39.8	46	77.6
-25	7.4	18	40.9	47	79.2
-20	10.1	19	41.9	48	80.8
-18	11.3	20	43.0	49	82.4
-16	12.5	21	44.1	50	84.0
-14	13.8	22	45.3	55	92.6
-12	15.1	23	46.4	60	101.6
-10	16.5	24	47.6	65	111.2
-8	17.9	25	48.8	70	121.4
-6	19.3	26	49.9	75	132.2
-4	20.8	27	51.2	80	142.6
-2	22.4	28	52.4	85	155.7
0	24.0	29	53.6	90	168.4
1	24.8	30	54.9	95	181.8
2	25.6	31	56.2	100	195.9
3	26.5	32	57.5	105	210.8
4	27.3	33	58.8	110	226.4
5	28.2	34	60.1	115	242.7
6	29.1	35	61.5	120	259.9
7	30.0	36	62.8	125	277.9
8	30.9	37	64.2	130	296.8
9	31.8	38	65.6	135	316.6
10	32.8	39	67.1	140	337.3
11	33.7	40	68.5	145	358.9
12	34.7	41	70.0	150	381.5
13	35.7	42	71.5	155	405.1
14	36.7	43	73.0		

Pressure Temperature Relationship:

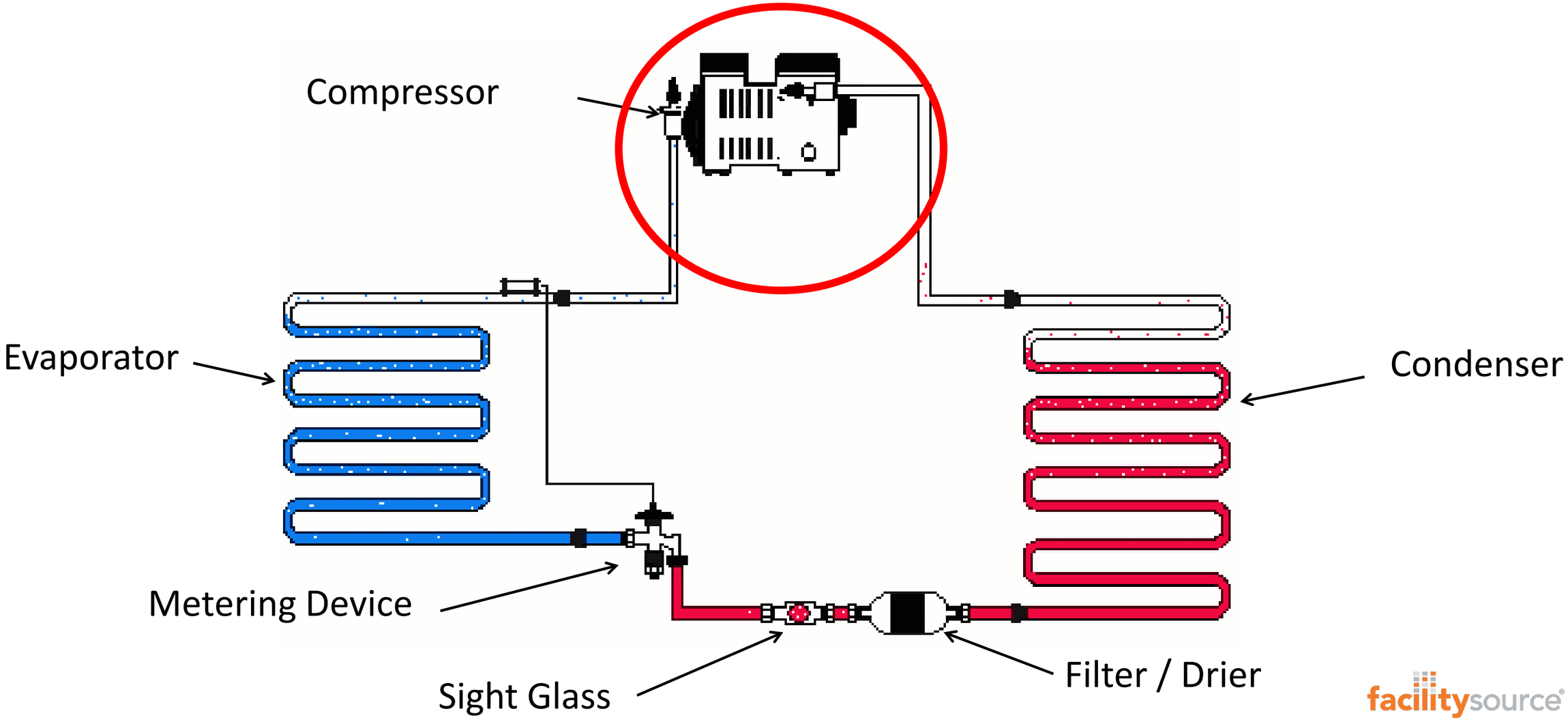
A Few Exceptions….

- Superheated Vapor
- Subcooled Liquid
- Trans-Critical

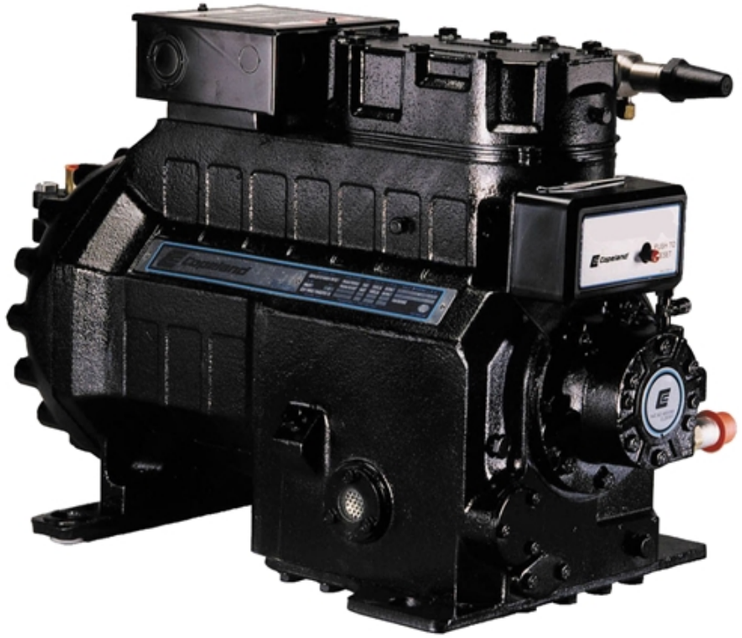
The Mechanical (DX) Refrigeration Cycle:



The Mechanical (DX) Refrigeration Cycle:



The Compressor



Reciprocating Semi-Hermetic - Most Common

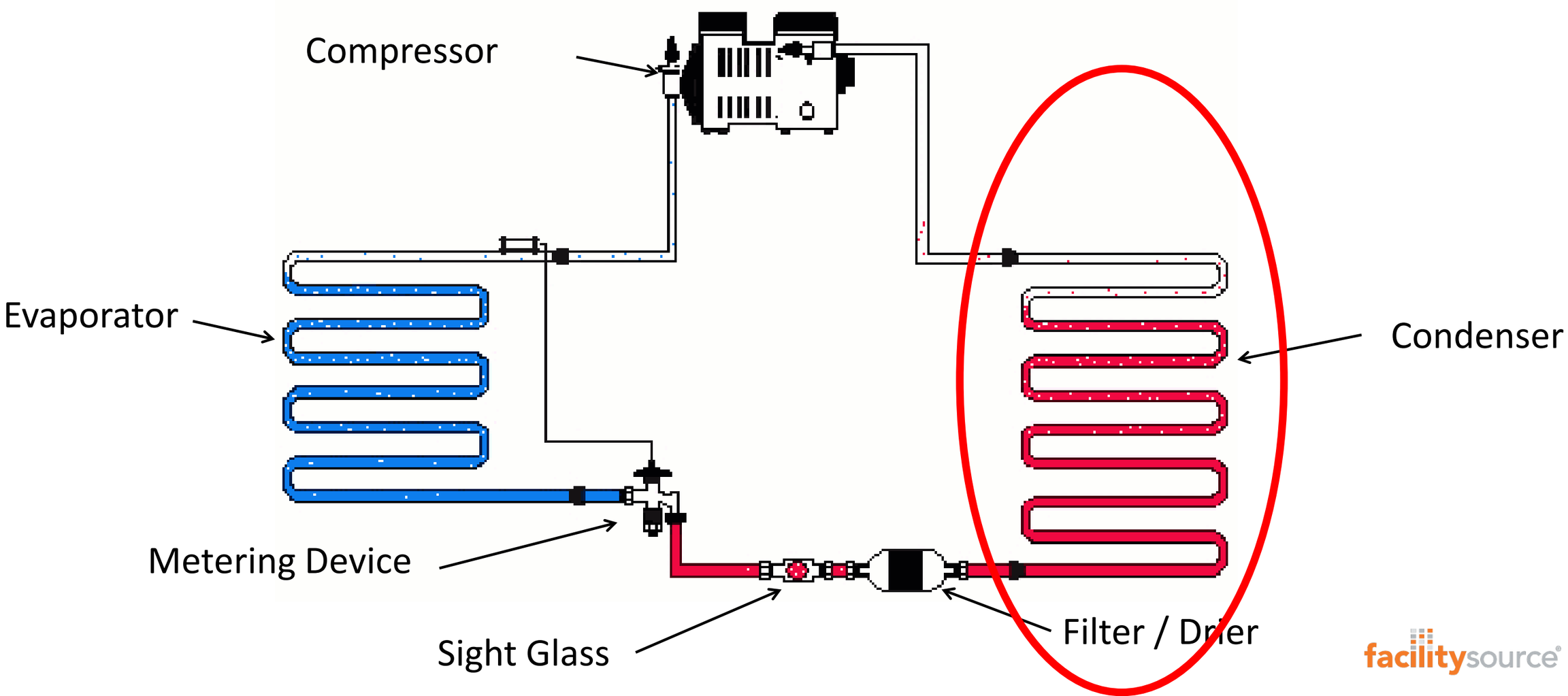
The Compressor

Scroll - Hermetic

The Compressor

Screw - Semi-Hermetic

The Mechanical (DX) Refrigeration Cycle:



The Condenser

Air Cooled – Most Common

The Condenser

Water Cooled

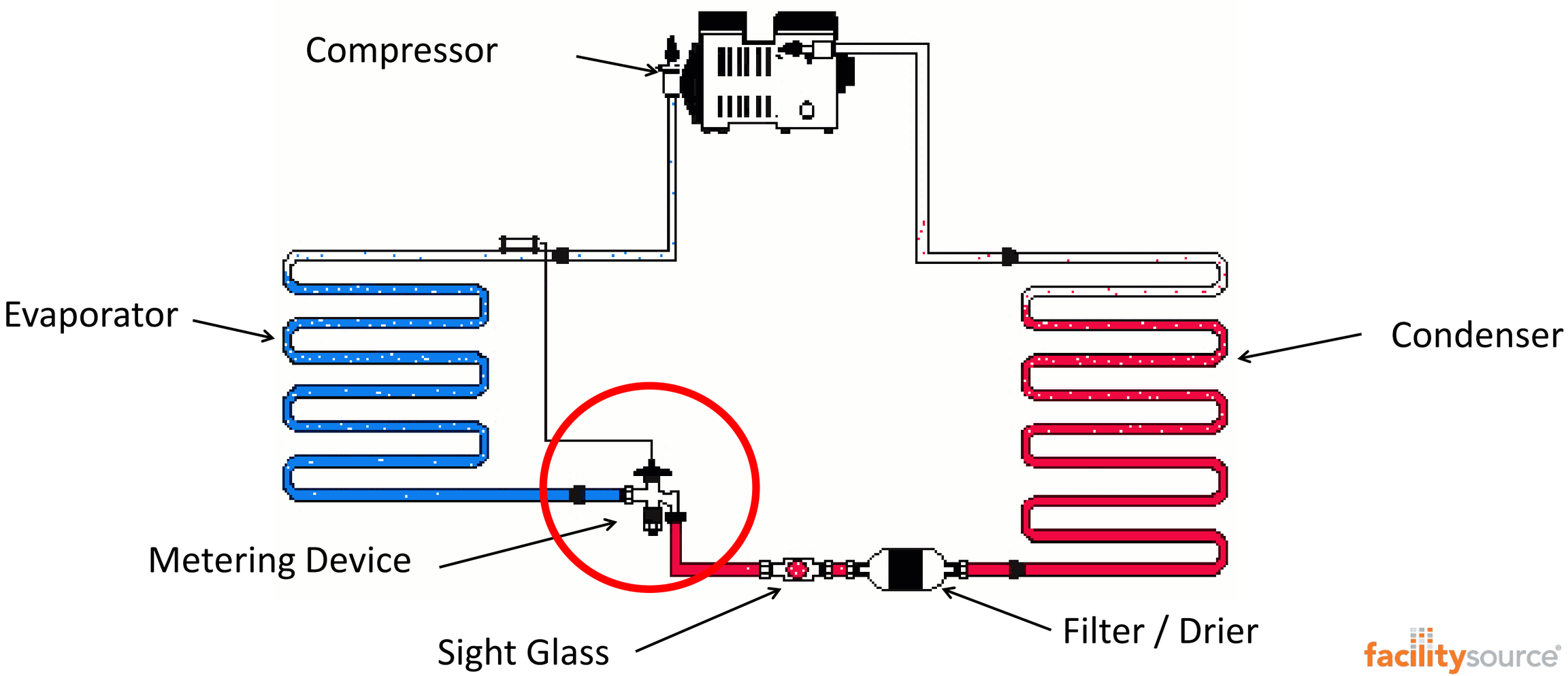
The Condenser

Water Cooled (Evaporative)

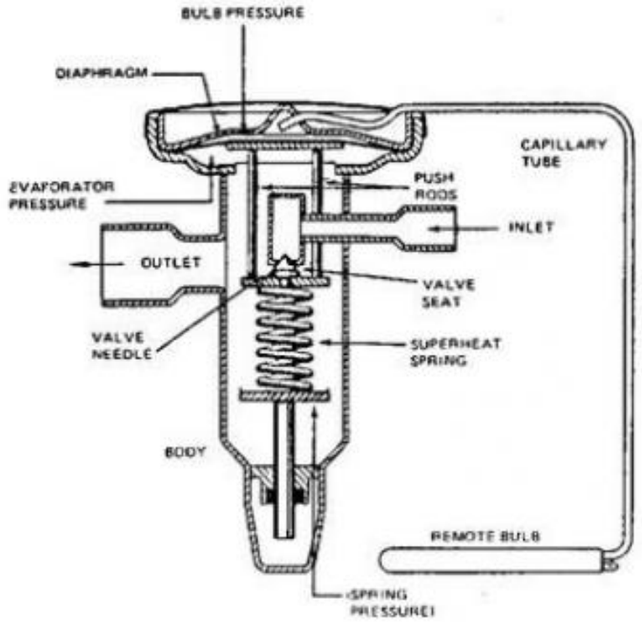
The Condenser

Hybrid (Air/Evaporative)

The Mechanical (DX) Refrigeration Cycle:



The Metering Device

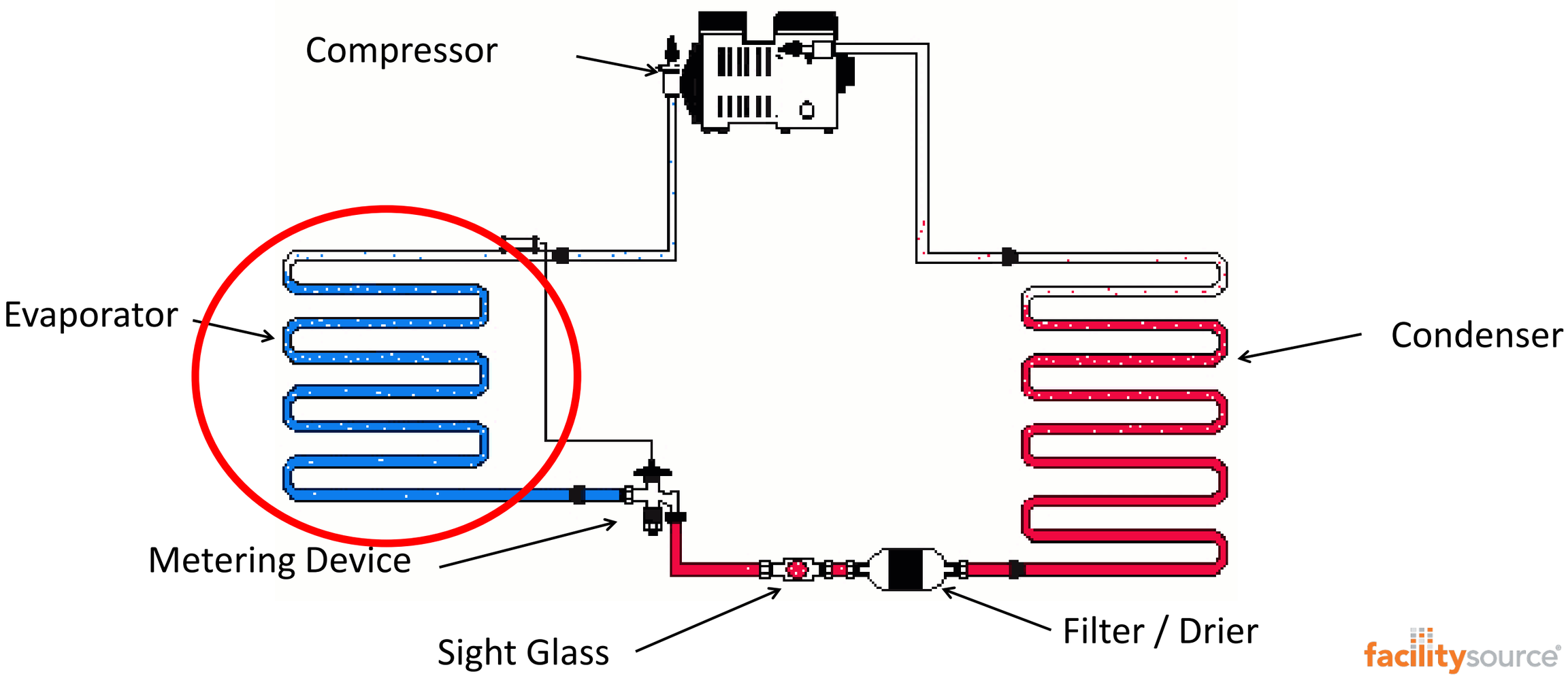


Thermostatic Expansion Valve - Most Common

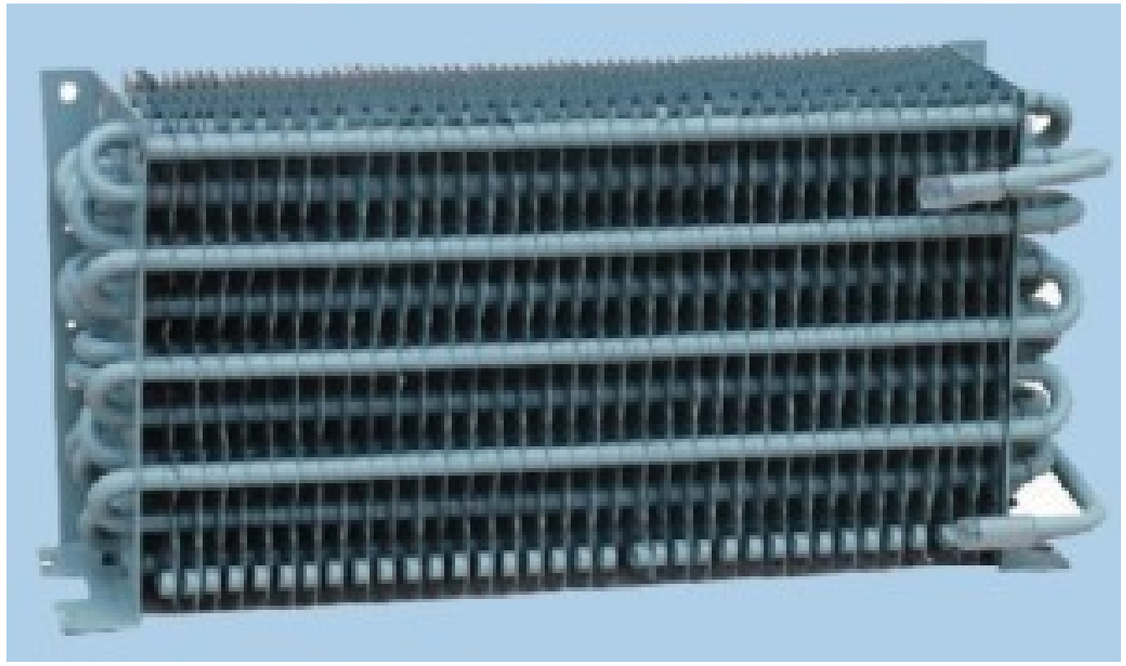
The Metering Device

Electronic Expansion Valve - Becoming More Common

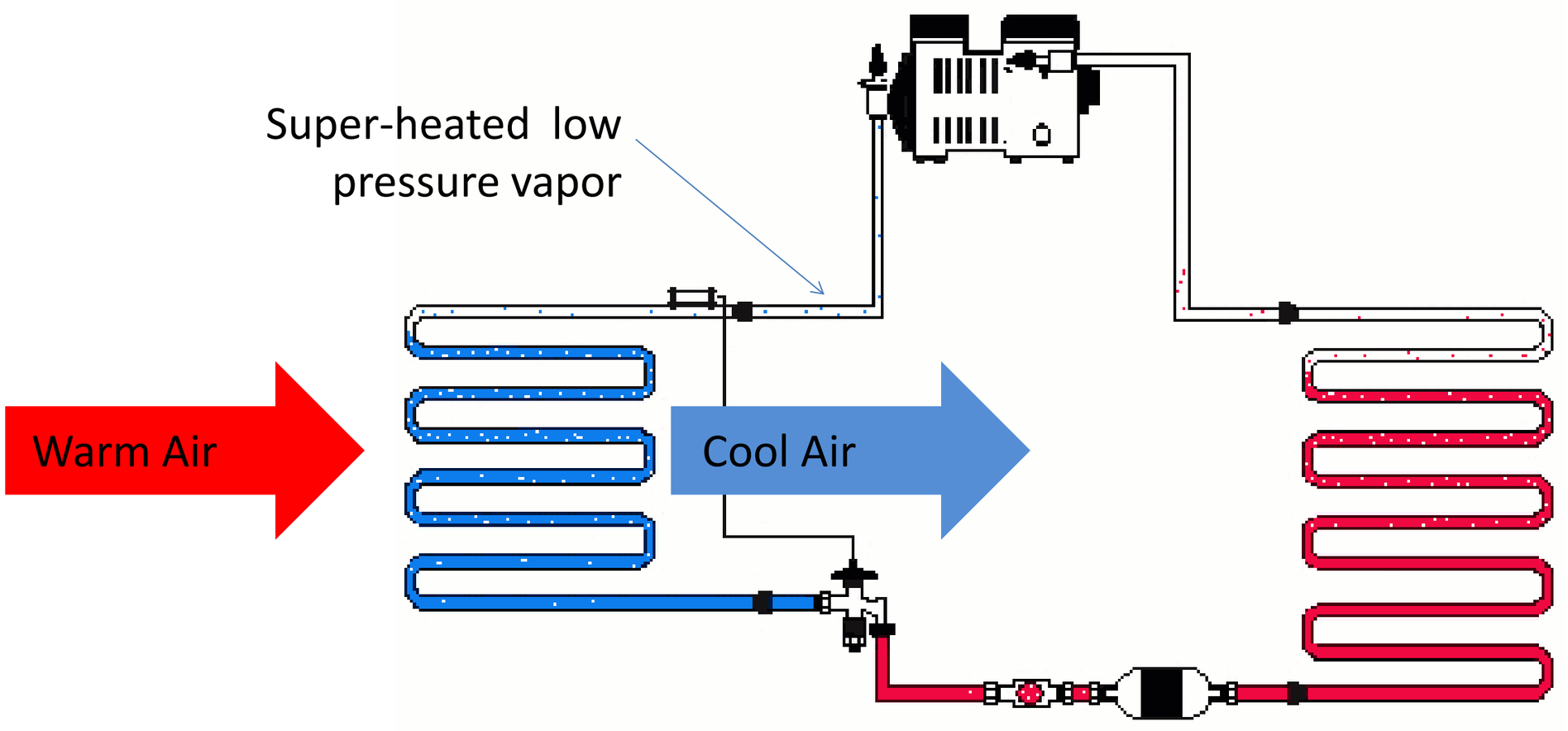
The Mechanical (DX) Refrigeration Cycle:



The Evaporator Coil



The Mechanical (DX) Refrigeration Cycle:



Super-heat

The difference between the actual temperature of the refrigerant vapor and the calculated temperature of the vapor (calculated using PT Chart)

Example:
R-22

43 PSI = 20°(calculated)

30 – 20 = 10° Superheat

TEMPERATURE - PRESSURE CHART

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-20	10.1	19	41.9	48	80.8
-18	11.3	20	43.0	49	82.4
-16	12.5	21	44.1	50	84.0
-14	13.8	22	45.3	55	92.6
-12	15.1	23	46.4	60	101.6
-10	16.5	24	47.6	65	111.2
-8	17.9	25	48.8	70	121.4
-6	19.3	26	49.9	75	132.2
-4	20.8	27	51.2	80	142.6
-2	22.4	28	52.4	85	155.7
0	24.0	29	53.6	90	168.4
1	24.8	30	54.9	95	181.8
2	25.6	31	56.2	100	195.9
3	26.5	32	57.5	105	210.8
4	27.3	33	58.8	110	226.4
5	28.2	34	60.1	115	242.7
6	29.1	35	61.5	120	259.9
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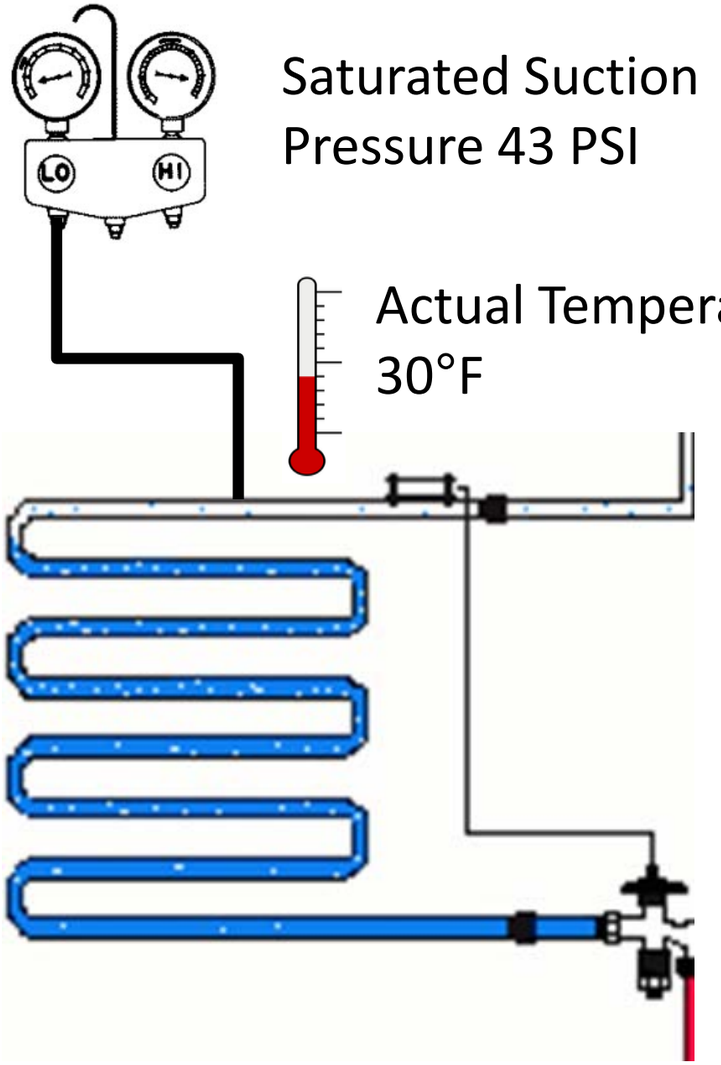

Saturated Suction Pressure 43 PSI

Actual Temperature 30°F

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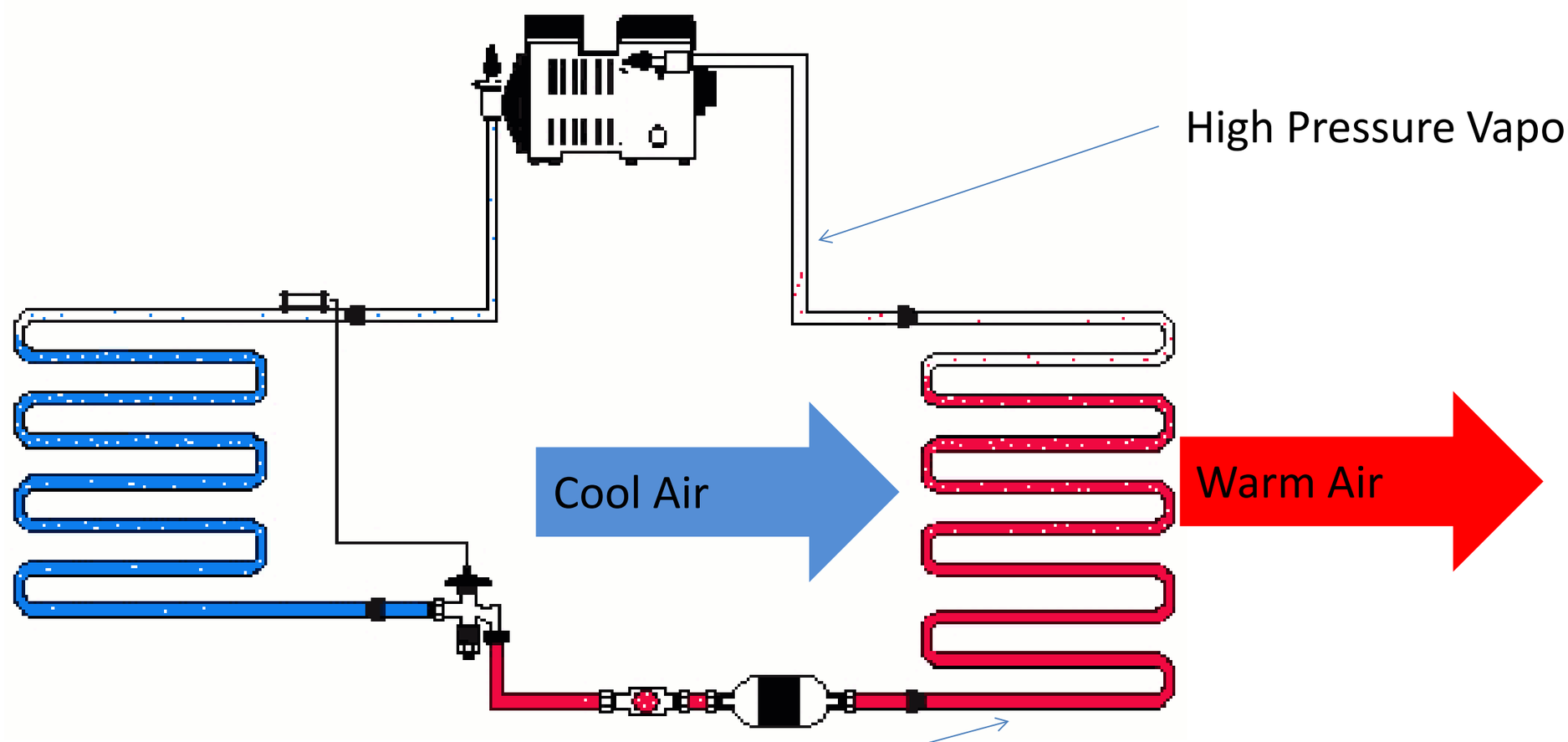
The Mechanical (DX) Refrigeration Cycle:



Sub-cooling

The difference between the calculated temperature of the liquid refrigerant (calculated using PT Chart) and the actual temperature of the liquid refrigerant

Example:
R-22

182 PSI = 95 degrees (calculated)

95 – 85 = 10 Degrees Sub-cooling

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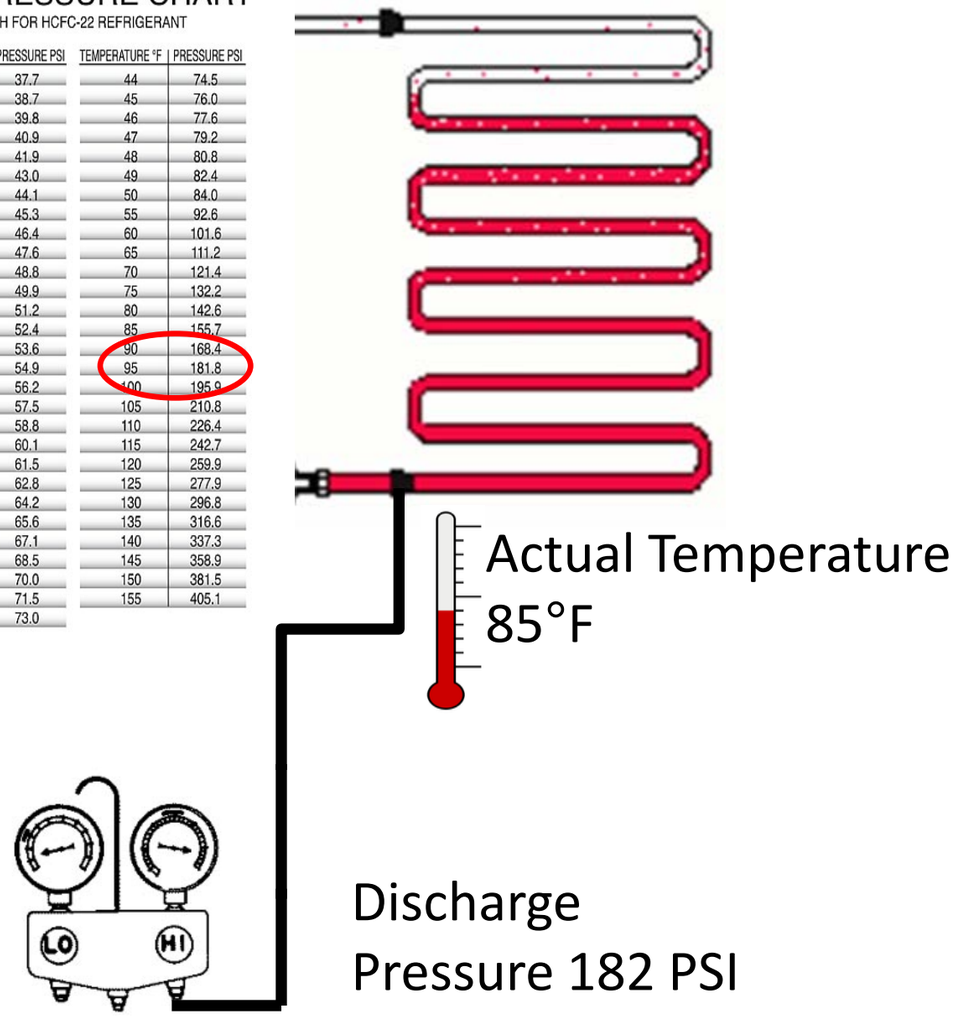
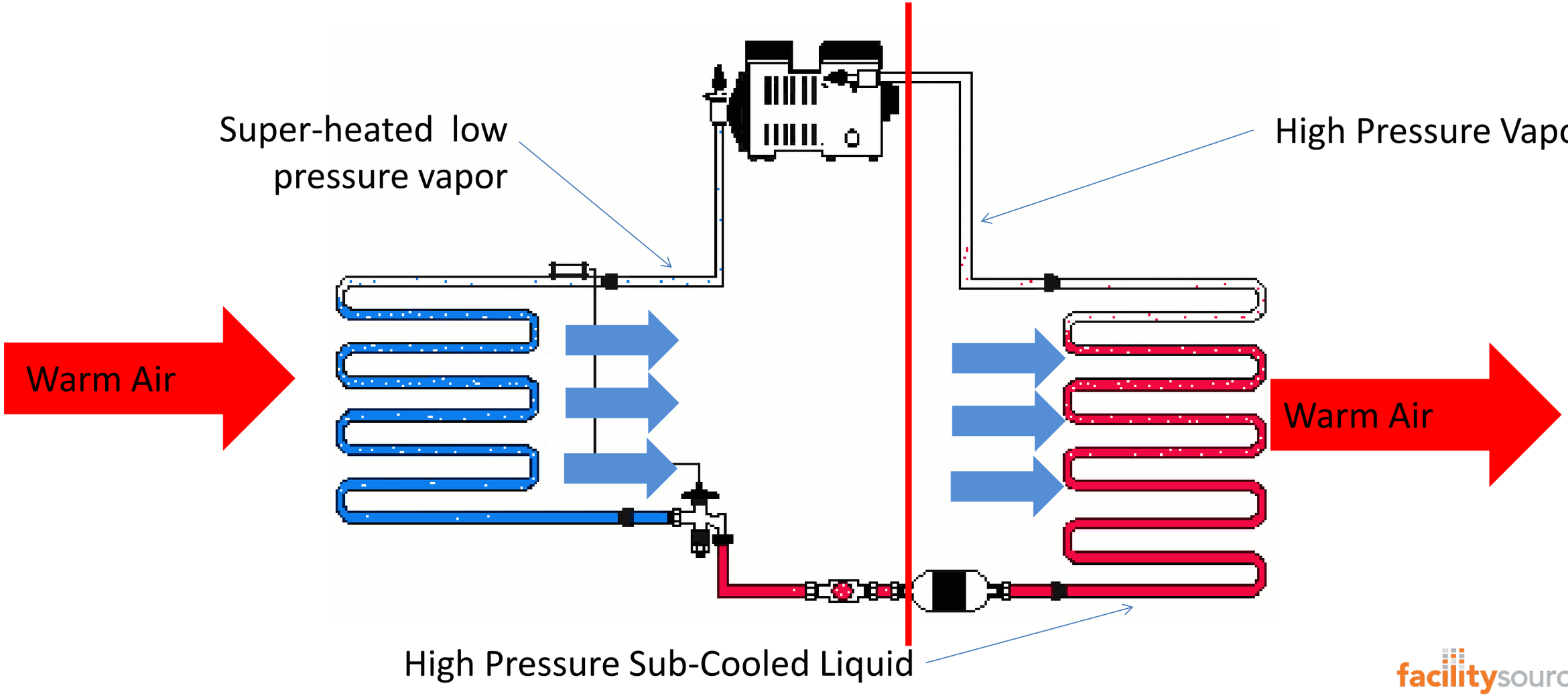


The Mechanical (DX) Refrigeration Cycle:

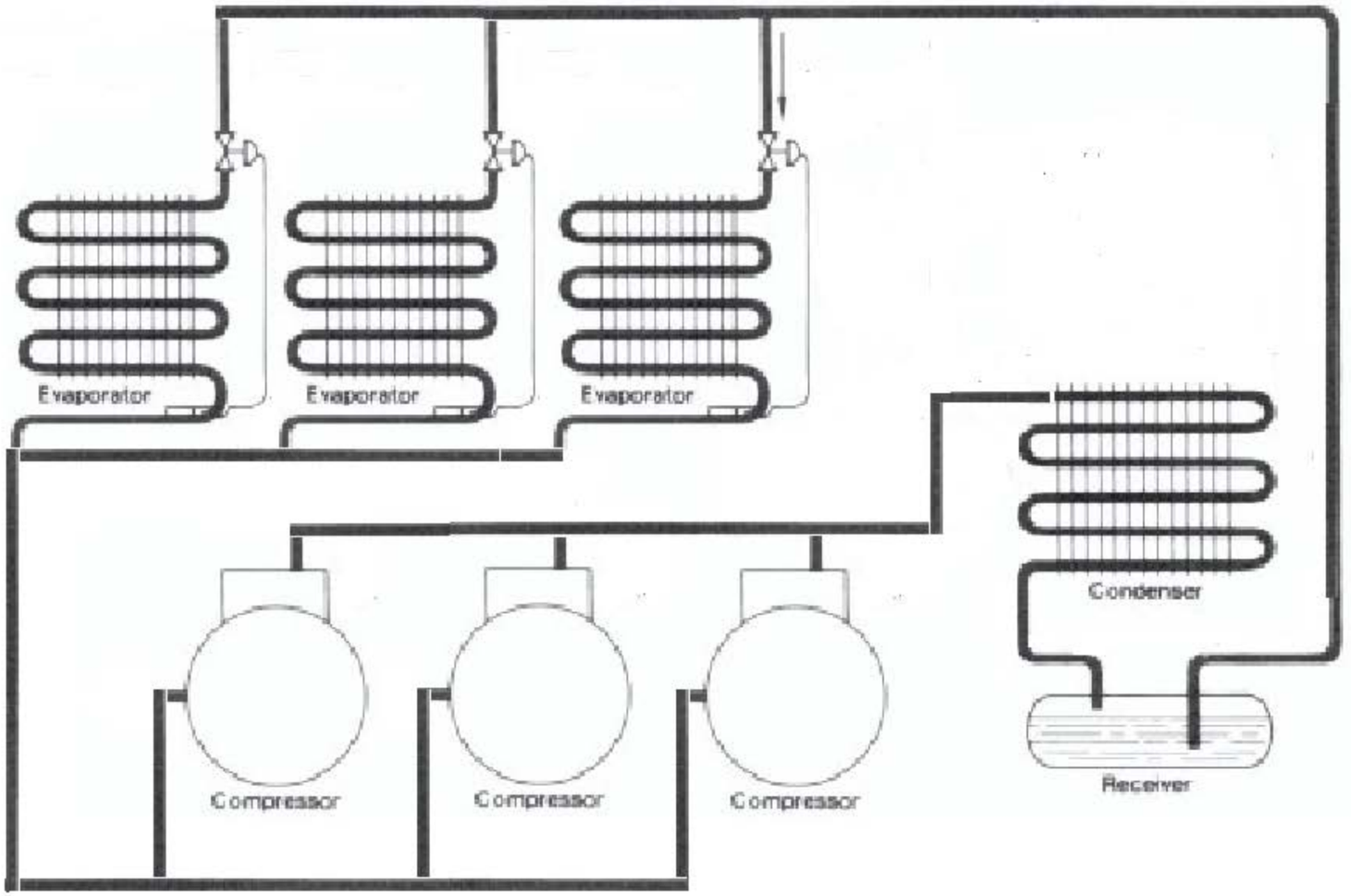


Effects of Temperature on capacity:

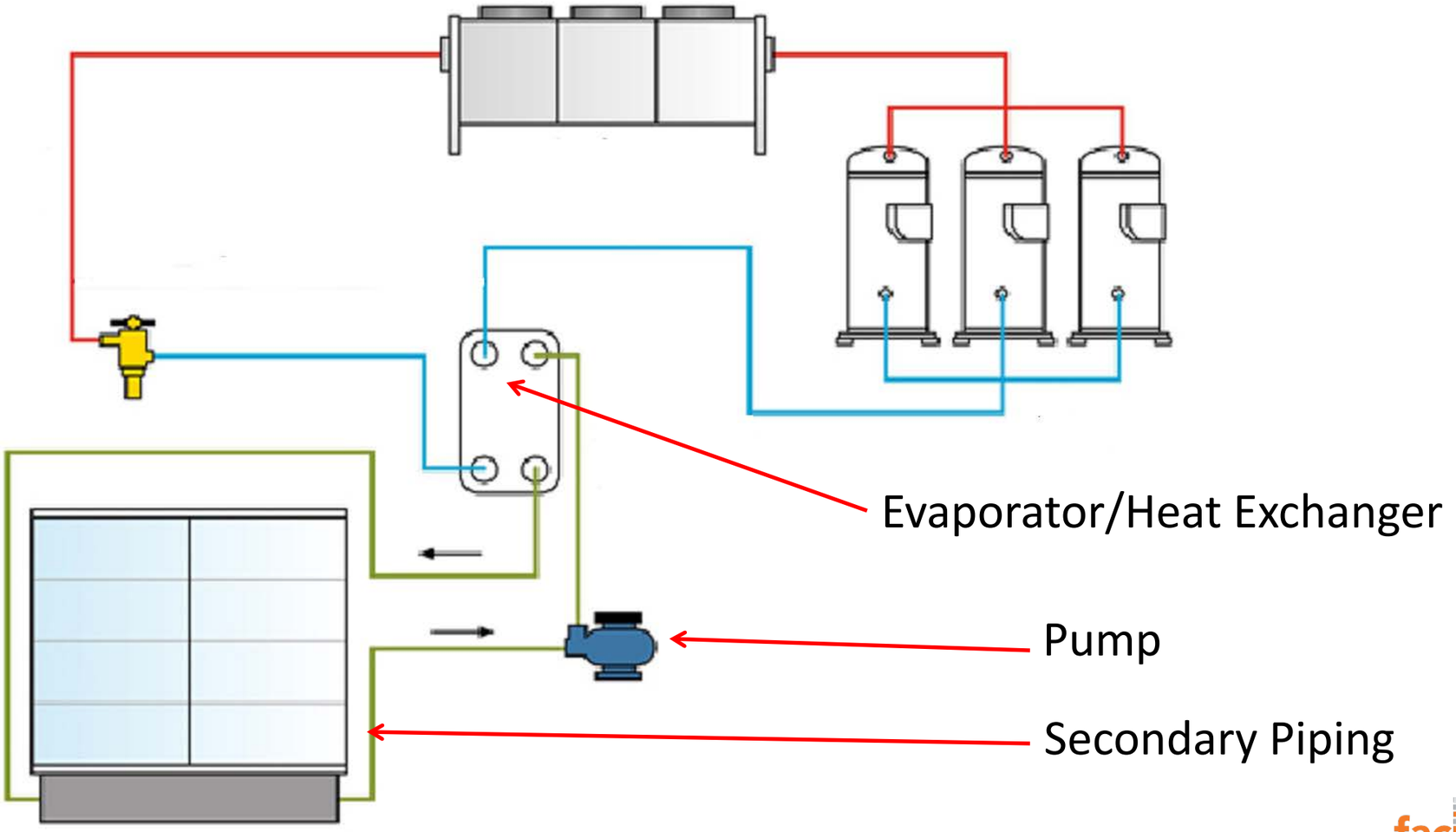
Condensing Temperature °F (Sat. Dew Pt. Pressure, psig)		Evaporating Temperature °F (Sat. Dew Pt. Pressure, psig)										
		-10.0 (17)	0.0 (24)	5.0 (28)	10.0 (33)	15.0 (38)	20.0 (43)	25.0 (49)	30.0 (55)	35.0 (62)	40.0 (69)	45.0 (76)
110.0 (226)	C	68,000	77,600	88,000	99,000	111,000	124,000	138,000	153,000	170,000	188,000	207,000
	P	9,600	10,700	11,300	11,800	12,300	12,800	13,200	13,600	13,900	14,200	14,400
	A	17.0	18.4	19.1	19.7	20.4	20.9	21.5	21.9	22.3	22.6	22.9
	M	815	1,070	1,220	1,380	1,550	1,730	1,940	2,160	2,410	2,680	2,970
	E	8.2	7.2	7.8	8.4	9.0	9.7	10.4	11.2	12.2	13.2	14.4
	%	87.8	88.2	88.5	69.5	69.5	69.5	69.0	68.7	68.2	67.6	66.8
100.0 (196)	C	83,000	82,600	93,500	105,000	118,000	132,000	147,000	163,000	181,000	200,000	221,000
	P	9,060	10,100	10,800	11,100	11,500	11,900	12,200	12,500	12,700	12,800	12,900
	A	18.6	17.7	18.3	18.9	19.4	19.8	20.2	20.5	20.8	21.0	21.0
	M	830	1,090	1,240	1,400	1,580	1,770	1,980	2,210	2,460	2,730	3,030
	E	7.0	8.2	8.8	9.5	10.3	11.1	12.0	13.1	14.3	15.6	17.1
	%	87.8	88.8	88.8	69.0	68.8	68.6	68.2	67.7	67.1	66.2	65.2
90.0 (168)	C	97,500	88,000	100,000	112,000	126,000	141,000	157,000	174,000	193,000	213,000	235,000
	P	8,800	9,660	9,950	10,300	10,700	10,900	11,100	11,300	11,400	11,400	11,300
	A	18.0	17.1	17.5	18.0	18.3	18.7	18.9	19.1	19.2	19.2	19.2
	M	865	1,120	1,270	1,440	1,620	1,810	2,030	2,260	2,510	2,790	3,100
	E	7.8	8.3	10.0	10.9	11.8	12.9	14.1	15.4	16.9	18.7	20.8
	%	87.3	88.1	88.2	68.1	67.9	67.5	67.0	66.3	65.4	64.3	62.8

Parallel System:

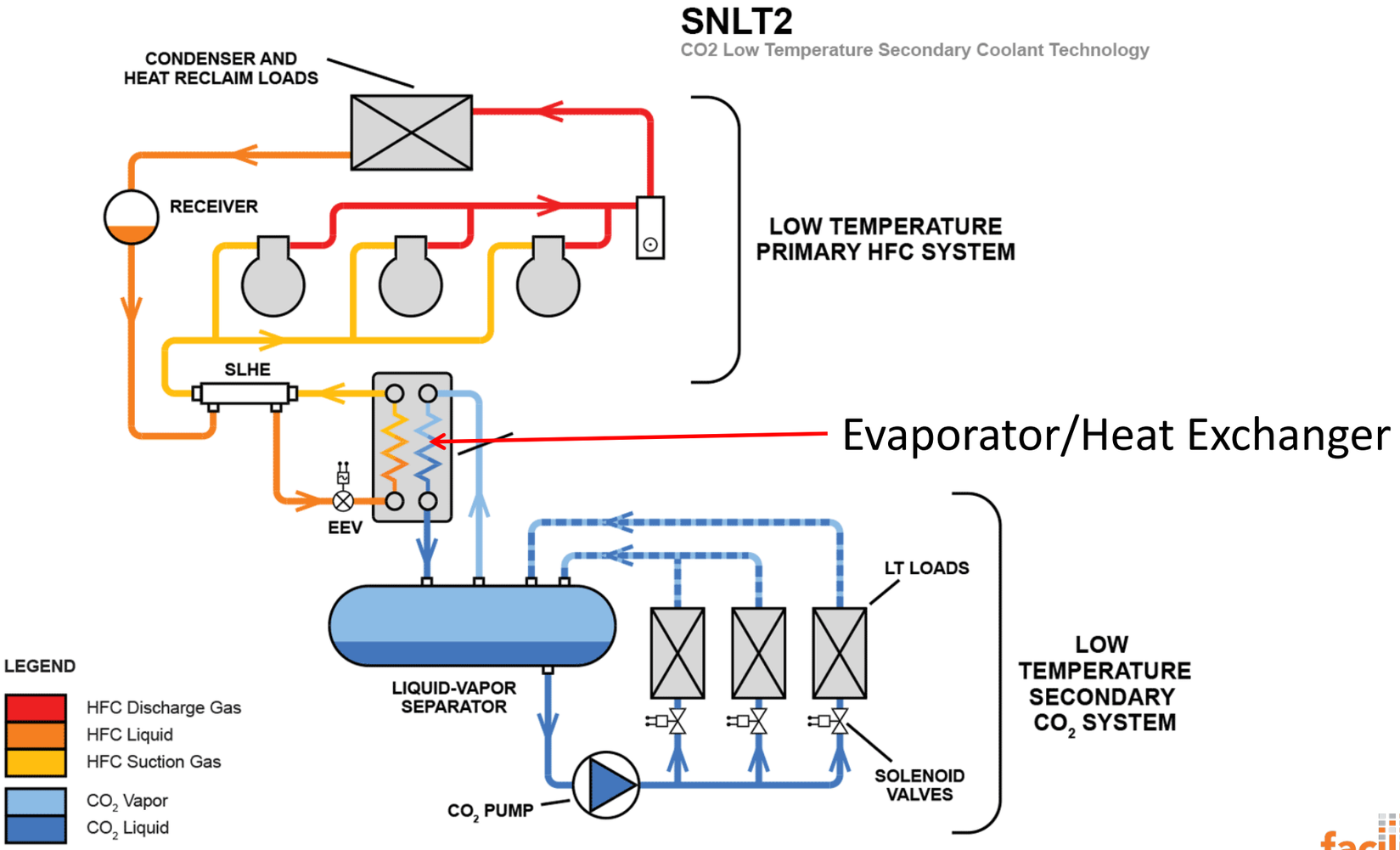
Parallel System:



Secondary System (Glycol):

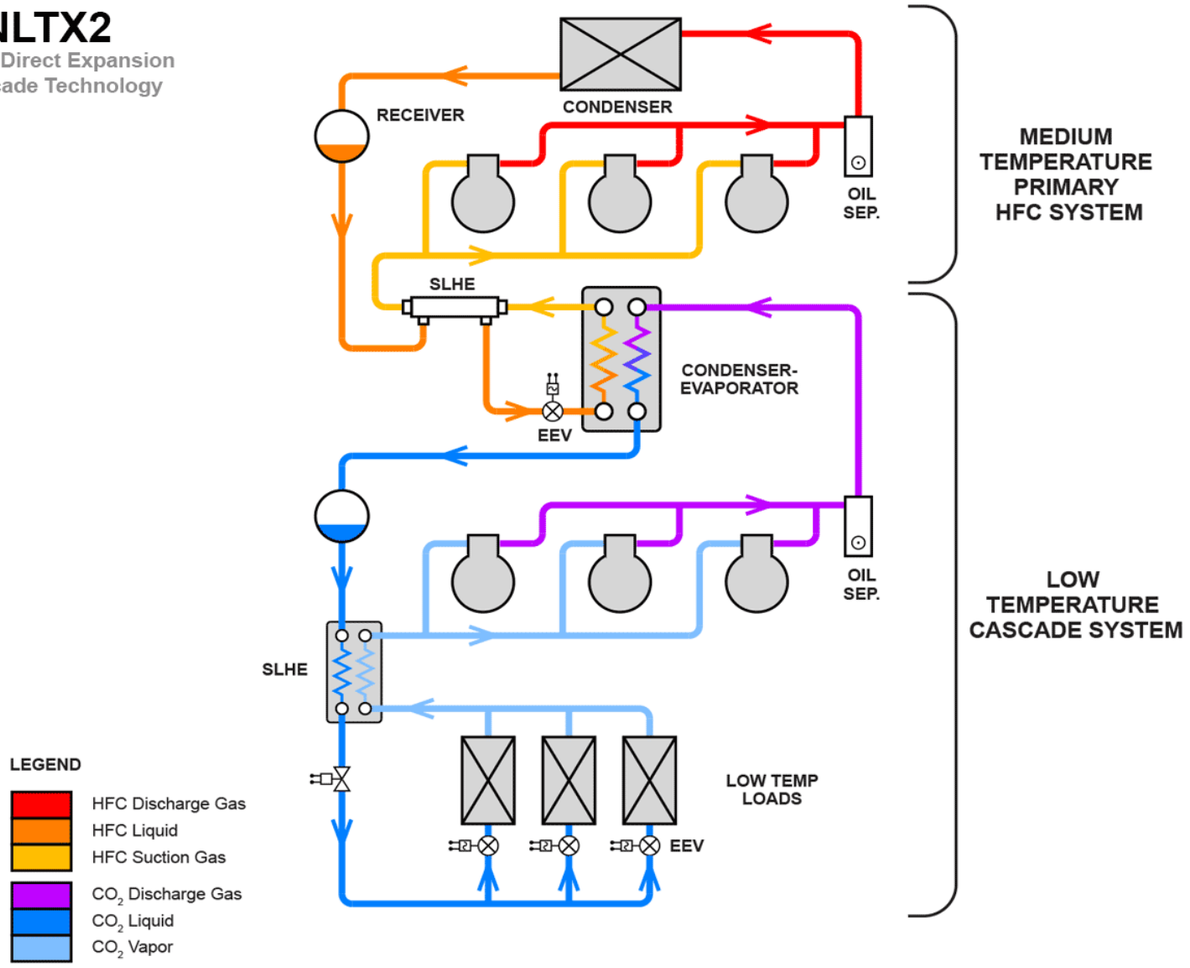


Secondary System (CO_2):



CO_2 Cascade

SNLTX2
CO2 Direct Expansion
Cascade Technology



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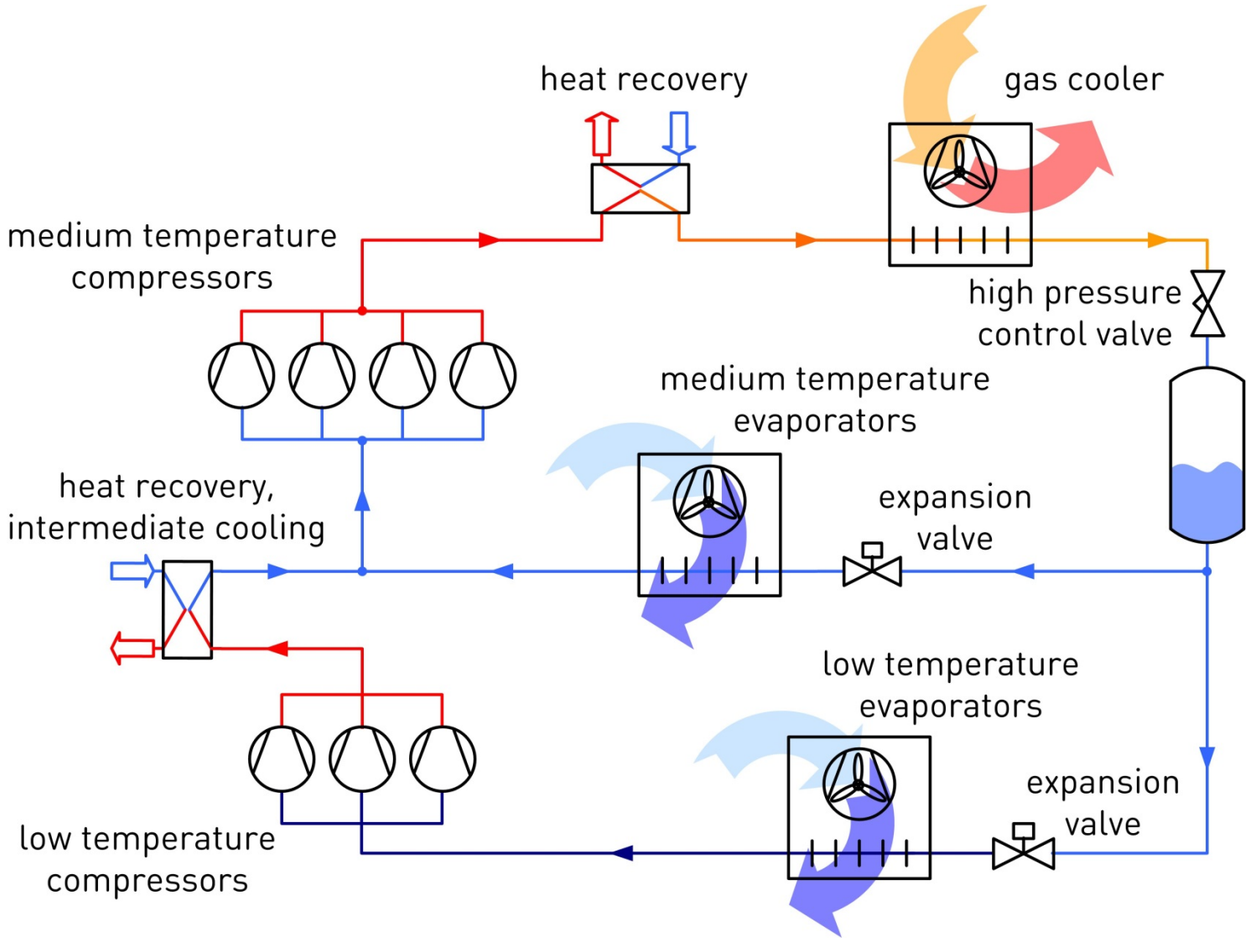
CO_2 Trans-critical

C02 Critical Point:
1067 PSI – 88°F



Questions?

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