The Systematic Approach to Troubleshooting an HVAC System

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Heat Transfer

Air Conditioning and Refrigeration is the transfer of heat from a place it is not wanted to a place that makes little or no difference.

- ***Air Conditioning: Cool's people (comfort cooling)***
- ***Refrigeration: Cool's products***

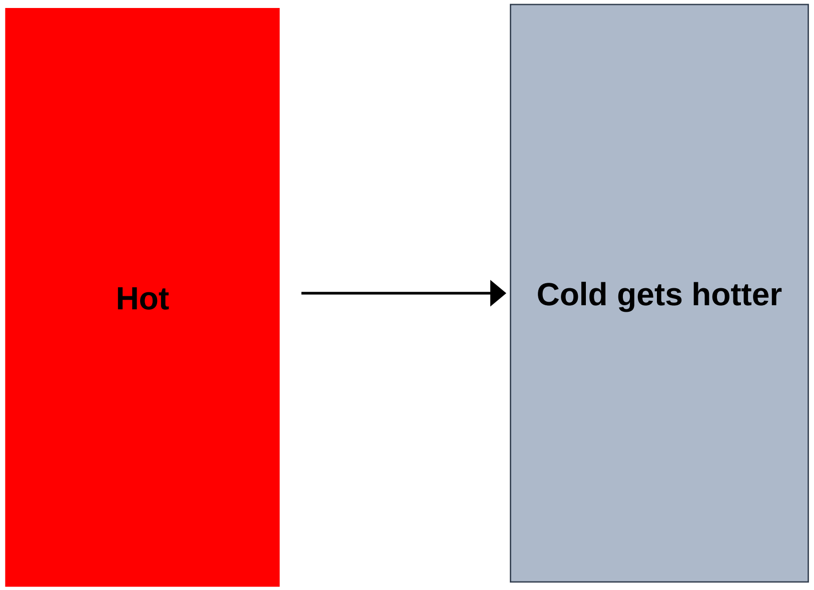
Component Tasks

- **Transfer heat:**
  Heat exchangers, coils, terminal units
- **Move refrigerant (R-22, R-410a, etc.):**
  Compressors, refrigerant piping
- **Move or distribute air:**
  Fans, ductwork, air handlers

Thermodynamics

The Second Law of Thermodynamics

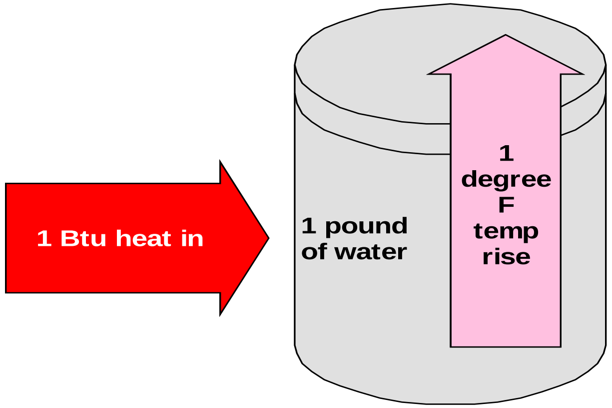
“Heat flows from a warmer place to a cooler place”

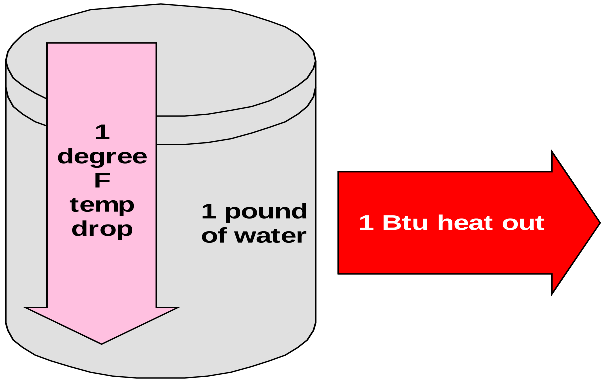


British Thermal Unit

1 Btu is the amount of heat required to raise the temperature of

1 pound of water 1° F





If 1 Btu is removed from 1 pound of water the temperature will decrease by 1° F


Test and Charging Manifold
YELLOW JACKET

Refrigerant Composition

Refrigerant Temperature / Pressure Chart									
Temperature (°F)	Pressure (PSI) Red numbers = inches Hg Black numbers = psig								
	R-11	R-12	R-22	R-123	R-134A	R-404A	R-410A	R-500	R-502
-100	29.8	27.0	25.0	29.9	27.8	-	20.9	26.4	25.3
-90	29.7	25.7	23.0	29.8	26.9	-	17.3	24.9	20.6
-80	29.6	24.1	20.2	29.7	25.6	-	12.6	22.9	17.2
-70	29.4	21.8	16.6	29.6	23.8	-	6.4	20.3	12.8
-60	29.2	19.0	12.0	29.5	21.5	-	1.3	17.0	7.2
-50	28.9	15.4	6.2	29.2	18.5	5.9	4.3	12.8	0.2
-40	28.4	11.0	0.5	28.9	14.7	4.3	10.1	7.6	4.1
-30	27.8	5.4	4.9	28.5	9.8	9.6	17.2	1.2	9.2
-20	27.0	0.6	10.2	27.8	3.8	16.0	25.9	3.2	15.3
-10	26.0	4.4	16.4	27.0	1.8	23.6	36.1	7.8	22.6
0	24.7	9.2	24.0	26.0	6.3	32.6	48.2	13.3	31.1
10	23.1	14.6	32.8	24.7	11.6	43.1	62.3	19.7	41.0
20	21.1	21.0	43.0	23.0	18.0	55.3	78.7	27.2	52.4
30	18.6	28.4	54.9	20.8	25.6	69.3	97.5	36.0	65.6
40	15.6	37.0	68.5	18.2	34.5	85.4	118.9	46.0	80.5
50	12.0	46.7	84.0	15.0	44.9	103.6	143.3	57.5	97.4
60	7.8	57.7	101.3	11.2	56.9	124.2	170.7	70.6	116.4
70	2.8	70.2	121.4	6.6	70.7	147.4	201.5	85.3	137.6
80	1.5	84.2	143.6	1.1	86.4	173.4	235.9	101.9	161.2
90	4.9	99.8	168.4	2.6	104.2	202.4	274.3	120.4	187.4
100	8.8	117.2	195.9	6.3	124.3	234.6	316.9	141.1	216.2
110	13.1	136.4	226.4	10.5	146.3	270.4	364.1	164.0	247.9
120	18.3	157.7	259.9	15.4	171.9	309.9	416.4	189.2	282.7
130	24.0	181.0	296.8	21.0	199.4	353.5	474	217.0	320.8
140	30.4	206.6	337.2	27.3	230.5	401.7	537.6	247.4	362.6
150	37.7	234.4	381.5	34.5	264.4	455.1	607.6	280.7	408.4

Blended Refrigerants

- Azeotropes
  - Blends made from two or more single compounds
  - Combine to form a new compound that acts like a single compound

- Zeotropes
  - Blends made from two or more refrigerants
  - Retain characteristics of each ingredient
  - May have temperature glide

Blended Refrigerants

- NARMs
  - Near Azeotropic Refrigerant Mixtures
  - Are Zeotropes, but perform like an Azeotrope
  - Negligible temperature glide

- Fractionation
  - Component separation
  - May affect leak ratio

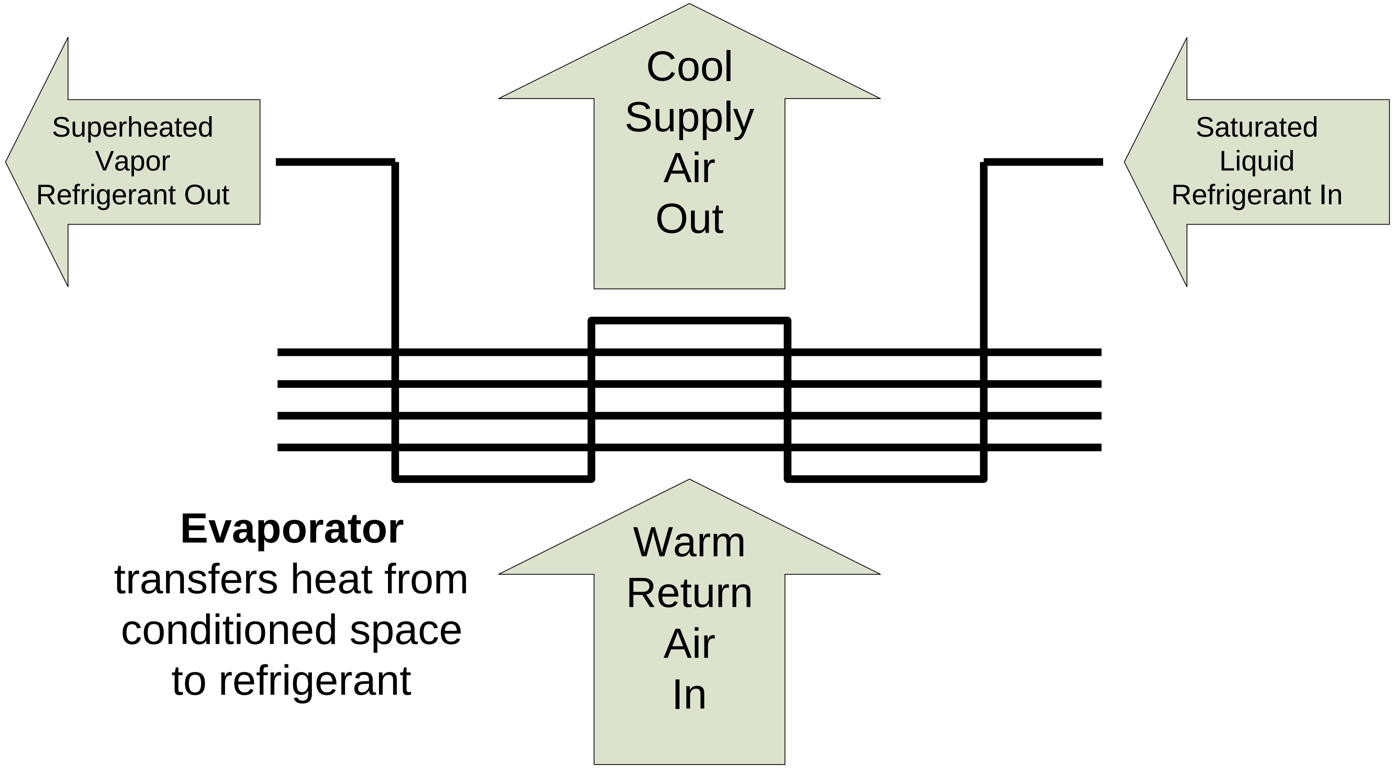
Temperature Glide

Dew Point is the saturation temperature in the evaporator at which the refrigerant changes state from a liquid to a vapor

Bubble Point is the saturation temperature in the condenser at which the refrigerant changes state from a vapor to a liquid

Temperature Glide is the difference between the Dew Point and the Bubble Point

Follow-the-Heat

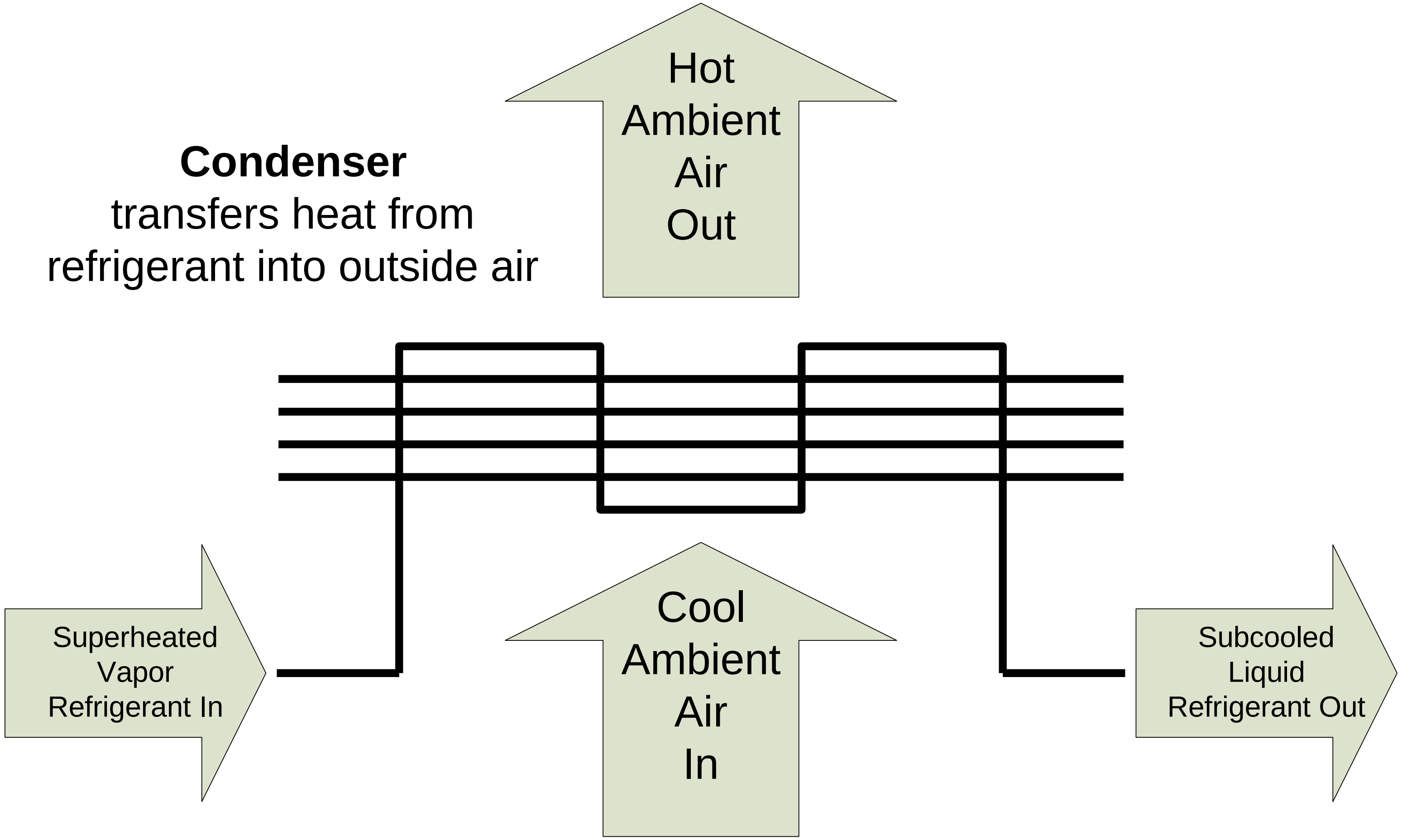


Evaporator
transfers heat from conditioned space to refrigerant

Follow the Heat ™
Evaporator

Follow-the-Heat

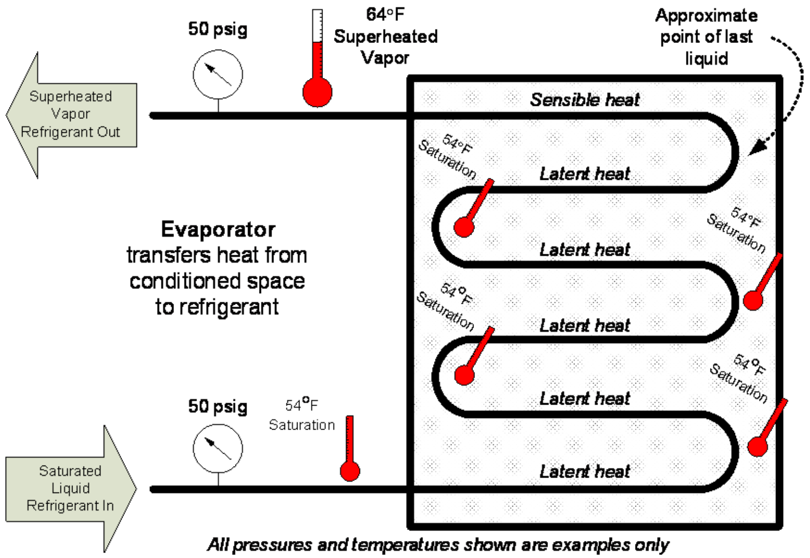
Condenser
transfers heat from
refrigerant into outside air

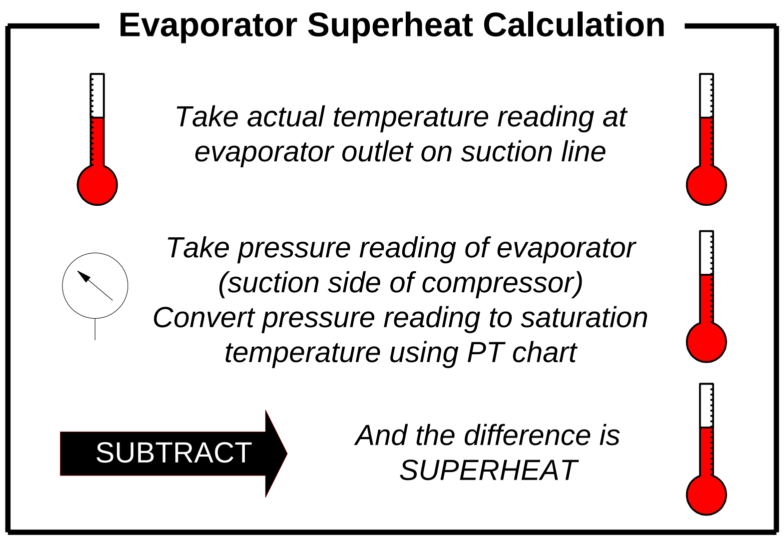


Evaporator Superheat

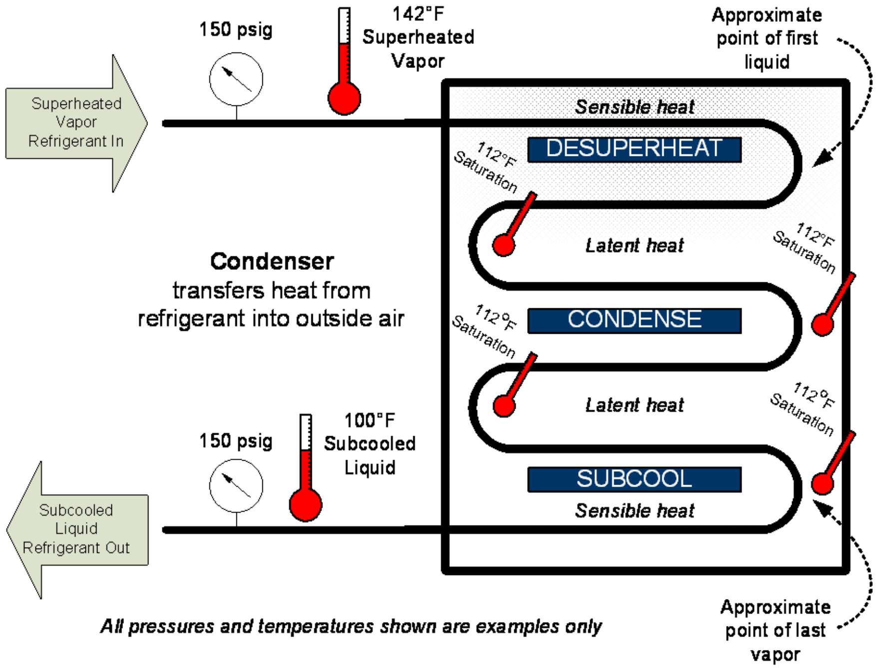
Evaporator Superheat Example

Actual suction line temperature: 64° F
Minus suction pressure (50 psig for R-134a)
converted to saturation temperature: 54° F
SUPERHEAT………………10° F





Condensers



Condenser Subcooling Calculation

Take pressure reading of condenser (discharge side of compressor) Convert pressure reading to saturation temperature using PT chart

Take actual temperature reading of liquid line where it enters metering device

SUBTRACT

And the difference is SUBCOOLING

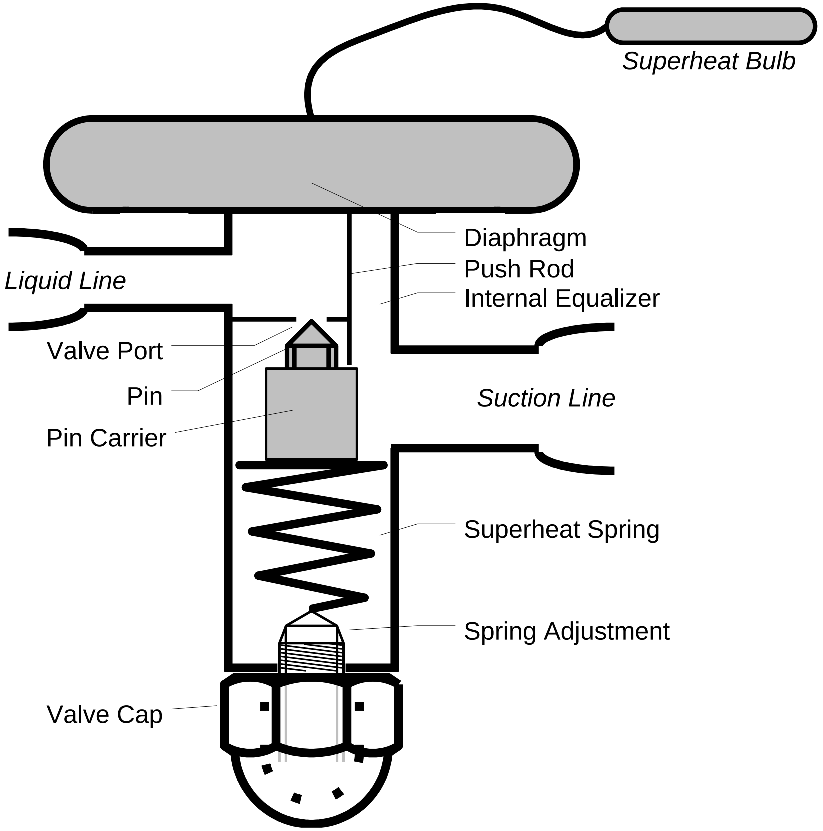
Subcooling Example

High side (head) pressure
(150 psig for R-134a)

converted to saturation temperature:	**112° F**
Minus actual liquid line temperature:	**- 100° F**
SUBCOOLING……………………………	**12 ° F**

Metering Devices

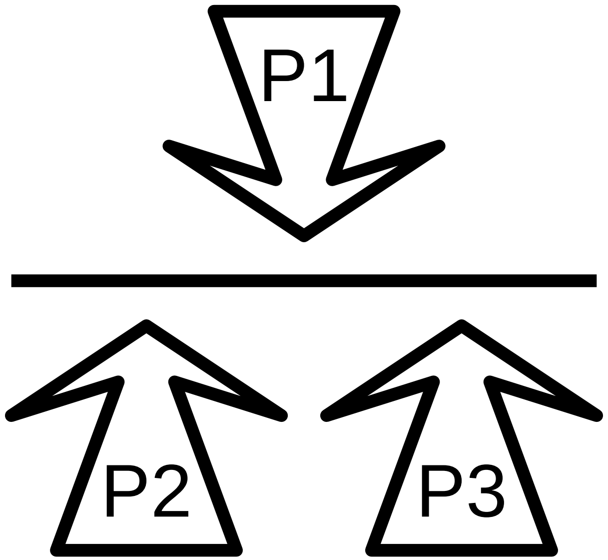
Thermostatic Expansion Valve



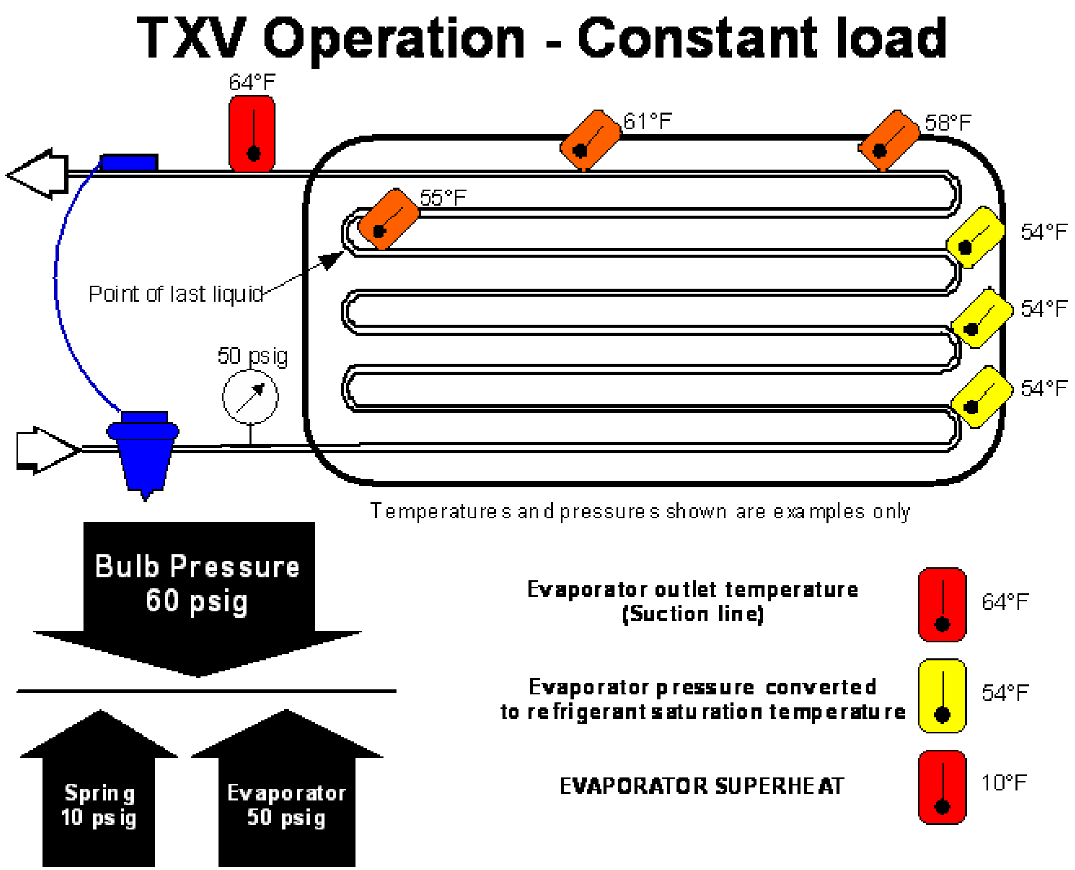
Metering Devices

Thermostatic Expansion Valve

- Opposing forces modulate valve
  - P1 Opening force (remote bulb)
  - P2 Closing force (evaporator pressure)
  - P3 Closing force (superheat spring)

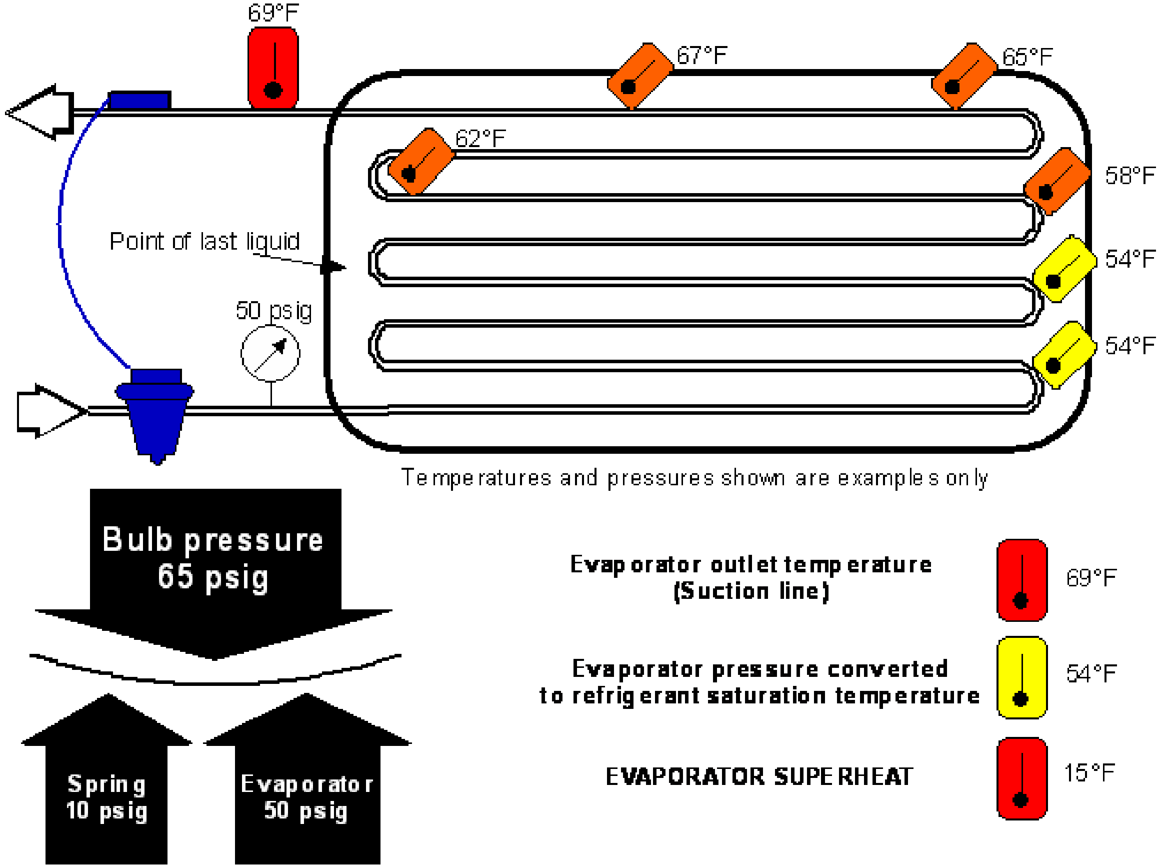


Metering Devices

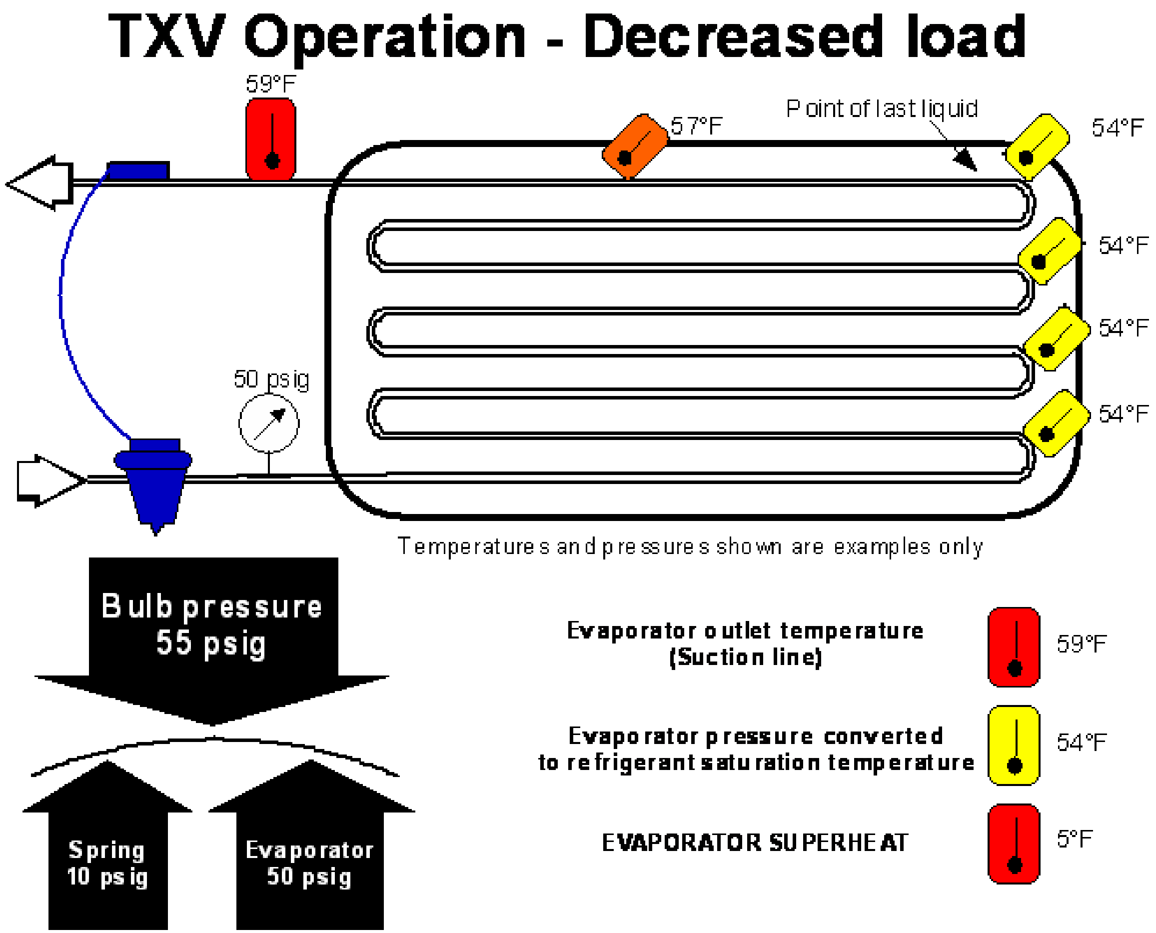


Metering Devices

TXV Operation - Increased load



Metering Devices

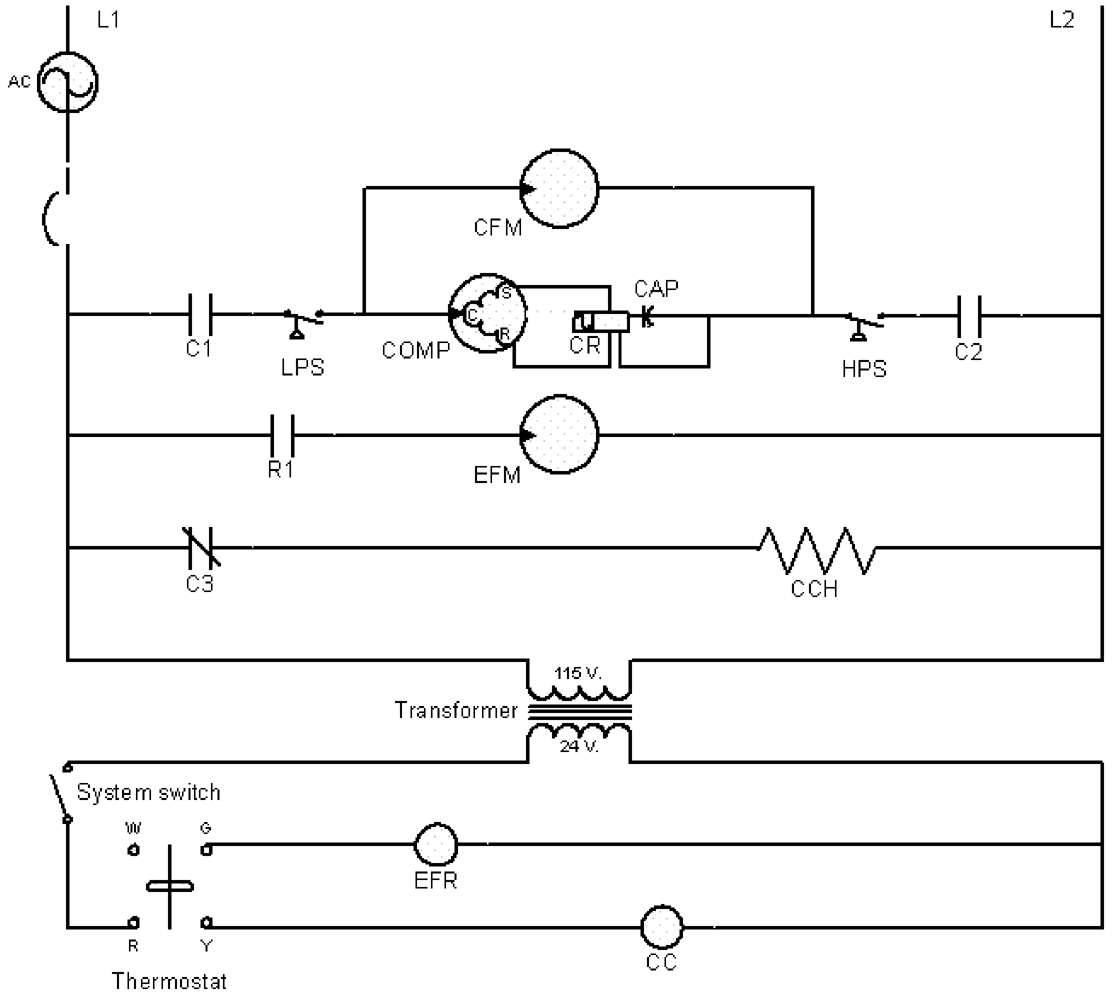


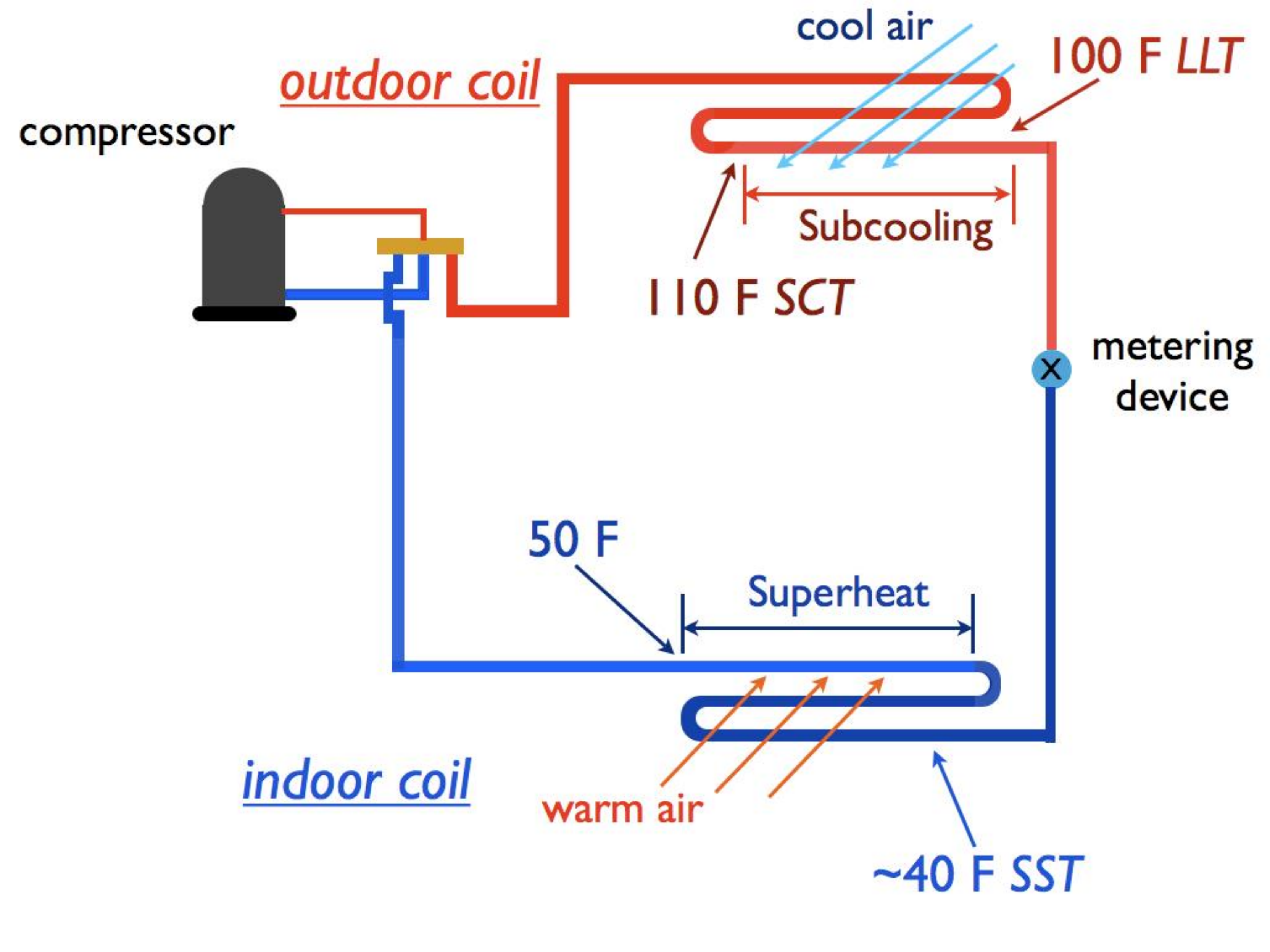
Electrical Troubleshooting

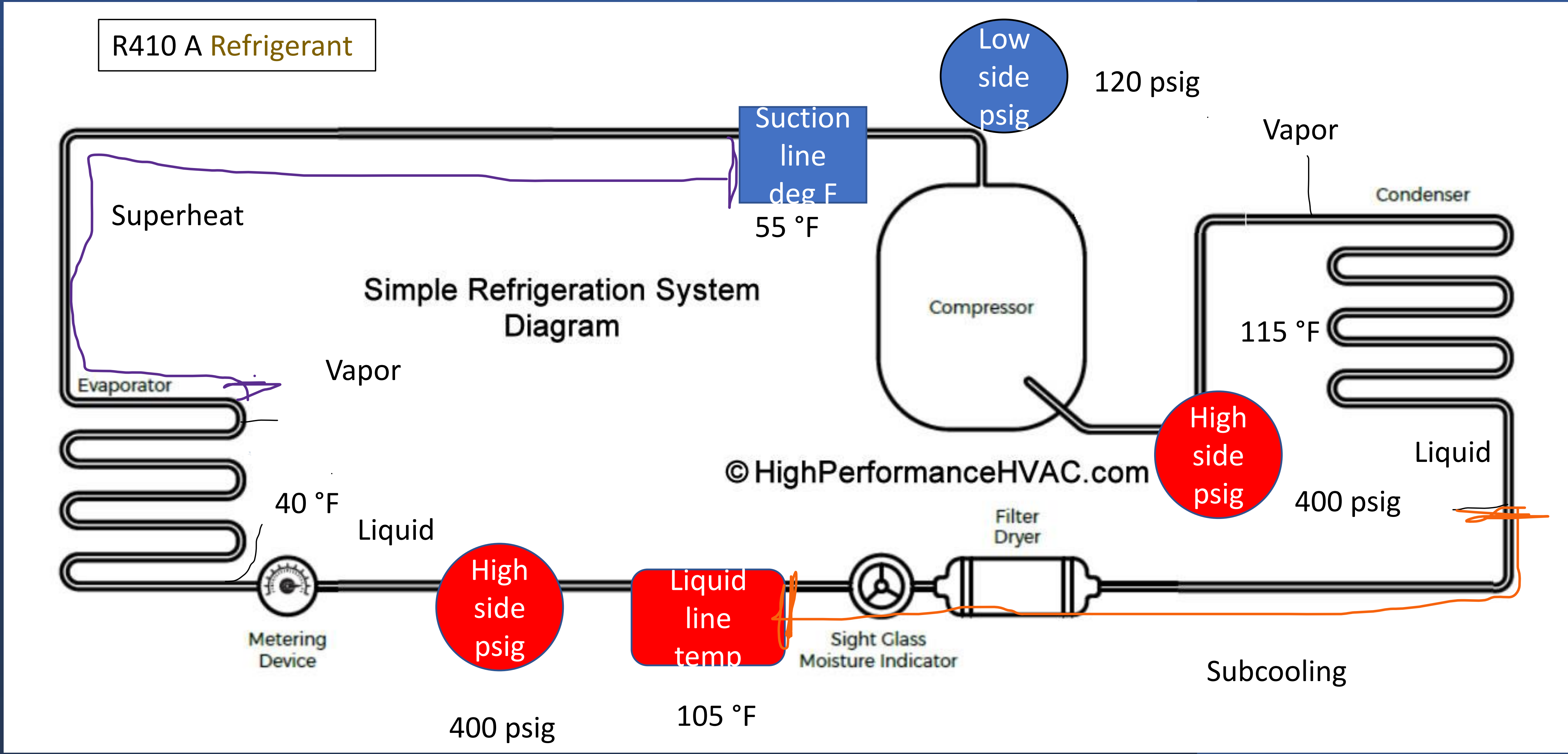
AC Ladder Diagram

Let's review and discuss

CFM	Condenser fan motor	EFM	Evaporator fan motor
COMP	Compressor	CCH	Crankcase heater
LPS	Low pressure switch	CC	Compressor contactor
HPS	High pressure switch	CR	Current relay
CAP	Start capacitor	EFR	Evaporator fan relay




cool air
outdoor coil
100 F LLT
compressor
Subcooling
110 F SCT
metering
device
50 F
Superheat
indoor coil
warm air
~40 F SST



R410 A Refrigerant
Low side psig
120 psig
Suction line deg F
55 °F
Vapor
Condenser
Superheat
Simple Refrigeration System Diagram
Compressor
115 °F
Vapor
Evaporator
High side psig
Liquid
©HighPerformanceHVAC.com
400 psig
40 °F
Liquid
Filter Dryer
High side psig
Liquid line temp
Metering Device
Sight Glass Moisture Indicator
Subcooling
400 psig
105 °F

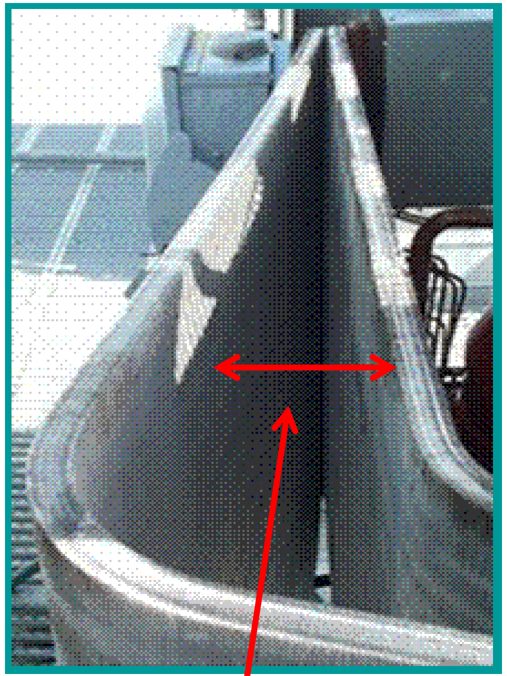
Symptom	SUCTION PSI	SUPER HEAT	HEAD PSI	SUB COOL	AMPS
Restricted Cond. Coil	↑	↓	↑	↓	↑
Restricted Evap. Coil	↓	↓	↓	↓	↑
Heavy Load	↑	↑	↑	↑	↑
Light Load	↓	↓	↓	↓	
Noncondensable	↑	↓	↑	↓	↑
Undercharge	↓	↑	↓	↓	↓
Overcharge	↑	↓	↑	↑	↑
Bad Valves	↑	↔	↓	↔	↓
Liquid Line Restriction	↓	↑	↓	↑	↓
Suction Line Restriction	↓	↑	↓	↑	↓
Overfeeding Metering Device	↑	↓	↓	↓	↑
Missed Refrigerants	↓	↔	↓	↔	
Underful Metering Device	↓	↑	↓	↑	↓
Low Outdoor Ambient	↓	↑	↓	↑	↓

Troubleshooting TXV Problems

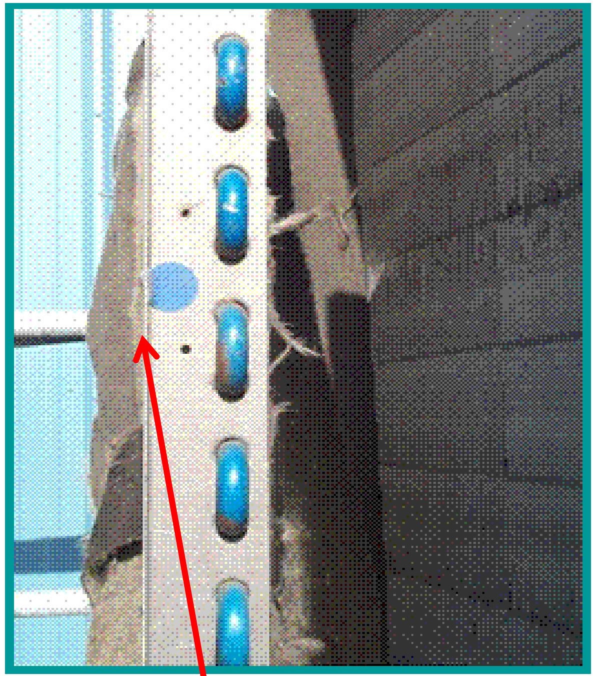
Symptom	Look for...
High Operating Superheat	Load temperature (air or fluid) too high
	Low refrigerant charge
	Insufficient subcooling (bubbles in liquid line)
	Improperly adjusted TXV
	Excessive pressure drop with internally equalized TXV
	Contamination blocking valve
	Leaking thermal bulb charge or dead charge
	Valve not sized properly — too small a valve
	Restricted, plugged, or capped equalizer line
Low Operating Superheat	Poor bulb mounting/contact (bulb senses too high temperature)
	Improperly adjusted TXV
	Incorrect thermostatic charge
	Contamination in valve not allowing it to close fully
	An oversized valve
	Oil logging in the evaporator
	Poor distribution or unequal circuit loading
	An inefficient compressor
Excessive Hunting	Oversized expansion valve (valve overcompensates)
	Incorrect type bulb charge ("X" charges have best stability)
	Uneven heat loading in multi-circuit evaporator (flooding circuit(s) affects suction line temperature)
	Poor distribution or unequal circuit loading
	The thermal bulb is located improperly, possibly in a trap where oil can pool
	Valve superheat not set properly

AC/R System Service

Preventive Maintenance



Clean Coil



Dirty Coil

Frozen Coil

Preventive Maintenance

Fan Performance

Filter Maintenance

- Filter changes
  - Frequency (scheduled PM)
  - Visual inspection
  - Measurement of pressure drop

Follow Manufacturer's Recommendations

Always remember to follow these steps

1. Check for a dirty air filter.
2. Check your thermostat settings.
3. Check your **air conditioner** circuit breakers.
4. Check your outdoor **unit**.
5. Check all air vents.
6. Then proceed to hooking up manifold gauges
7. Check for proper super heat and subcooling and use diagnostics to find the right solution
8. Don't just assume that it is a refrigerant problem know your tools and use them

Questions?

- If you'd like to learn more about how to troubleshooting HVAC systems at your facility,

  TPC can help!

Email: sales@tpctraining.com

Phone: (847) 808-4000