HEAT PUMPS

Bruce Sotelo

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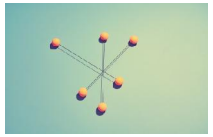
WHAT DO YOU NEED TO KNOW

Heat is a form of energy- 

Heat always goes from warm to cold (thermodynamics)

Heat causes some solids to become liquids or gasses and some liquids to become a vapor(gas)

Example : below 32* ice 

Above 32* water 

Above 212* vapor 

Refrigerant has a very low boiling point (R-410A boils @ -60*F at atmospheric pressure) which allows it to absorb and release heat at a much lower temp than water

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WHAT DO YOU NEED TO KNOW

When the volume and amount of a vapor is held constant/contained, pressure and temperature are directly related and can be measured

As a vapor is compressed its temperature rises because the pressure increases

As pressure drops so does temperature

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What the homeowner needs to know

During the heating cycle, air from the registers may seem cooler than the homeowner is used to or may expect. This is because the heat pump will deliver a constant flow of air at around 90*-105*. Much less than a typical furnace airflow temp.
Though the airflow may seem cool , it is warm enough to keep your house comfortable.
This is why it is important that you “set it and forget it” with the thermostat when using a heat pump.

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What the homeowner needs to know

Ice or frost may form on the outdoor unit during winter operation. The heat pump will automatically melt the ice using defrost. During defrost, you may see steam or fog rising from the outdoor unit. THIS IS NORMAL

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What the homeowner needs to do(OR NOT DO)

- **Keep Filter Clean**

A clogged or improperly installed air filter on your indoor unit will increase operating costs and shorten the life of the unit. For detailed filter cleaning information refer to indoor unit literature.

- **Do Not Block Floor, Wall or Ceiling Vents**

When drapes, furniture, toys or other common household items block vents, the restricted airflow lessens the system's efficiency and life span.

- **Do Not Cover or Block Outdoor Unit**

The outdoor unit needs unrestricted airflow. Do not cover it or place items on or next to it. Do not allow grass clippings, leaves, or other debris to accumulate on the sides or top of the unit. And, maintain a 12" (305 mm) minimum clearance between the outdoor unit and tall grass, vines, shrubs, etc.

"I was just clearing the weeds around the unit like I was told to do"

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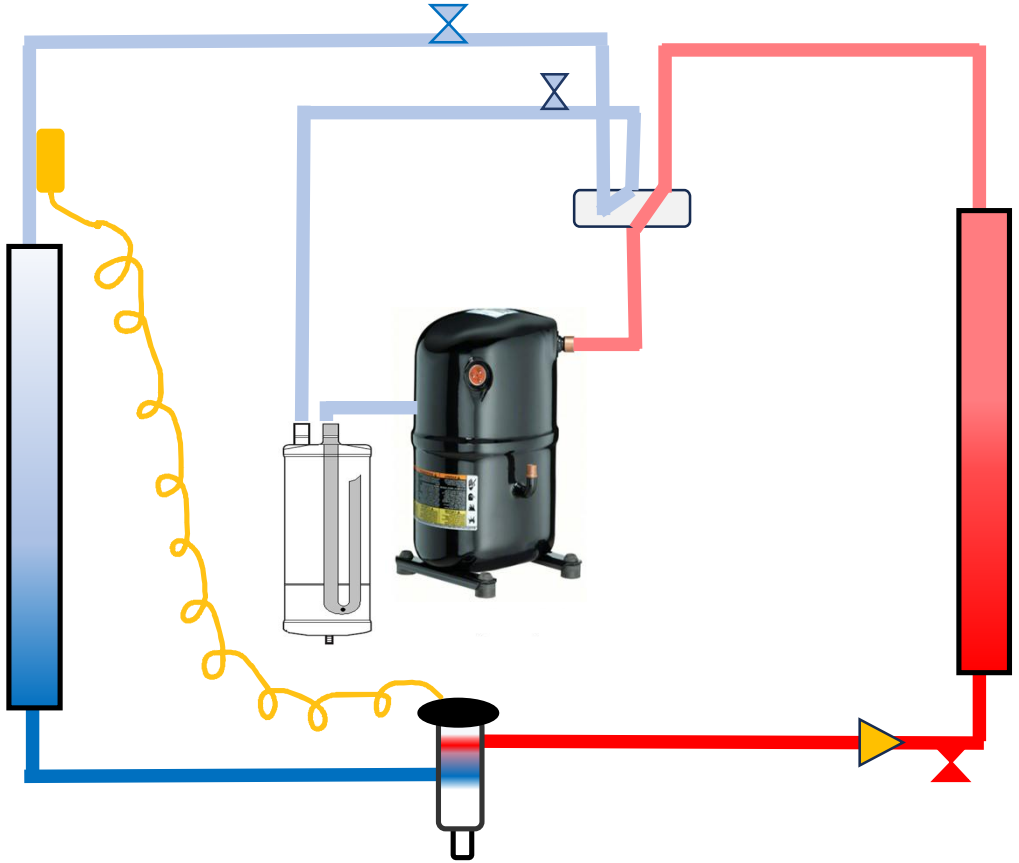
IT ALL STARTS HERE



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COMPRESSOR

Compressor- A one way vapor pump that compresses refrigerant from low pressure/low temp vapor to a high pressure/higher temp vapor

Reciprocating

Scroll

Rotary

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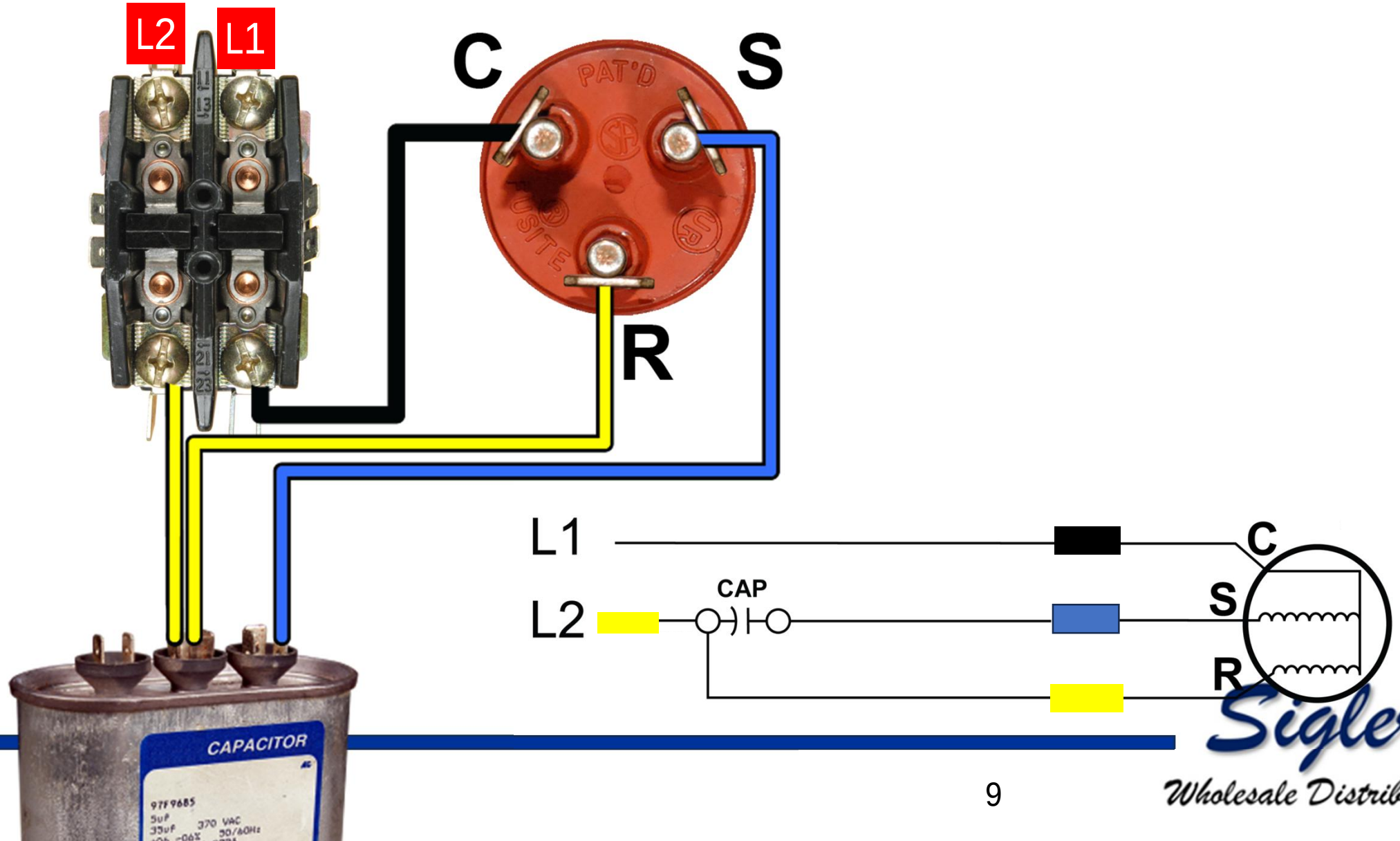
Run Capacitor



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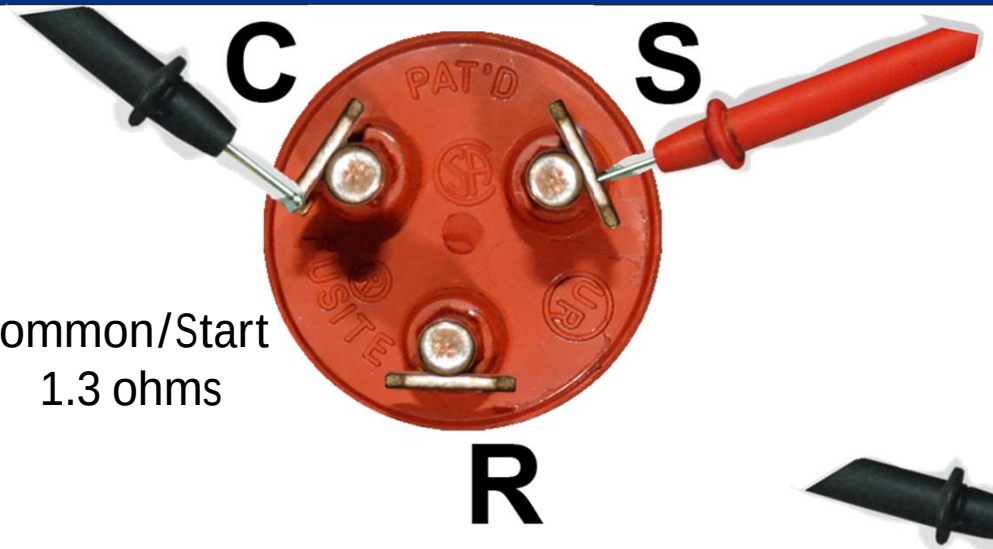
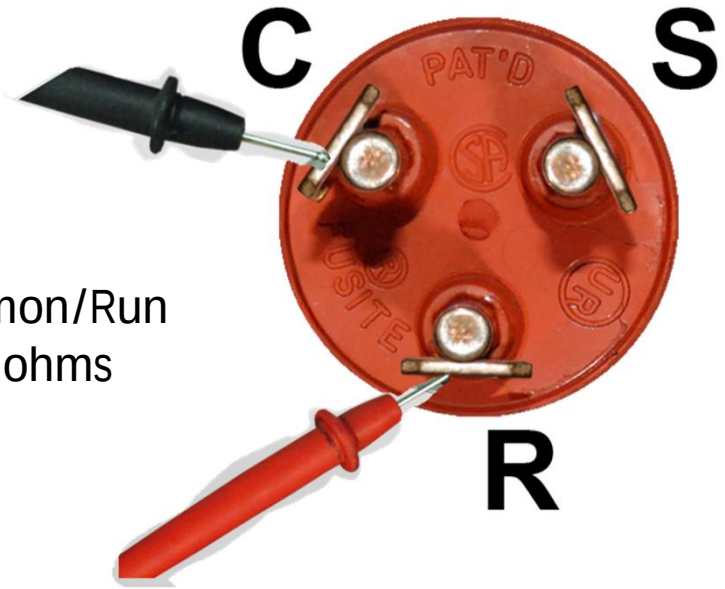
SINGLE PHASE COMPRESSOR TESTING

Common/Start + Common/Run = Start/Run



Common/Start
1.3 ohms



Common/Run
.8 ohms

Start/Run
2.1 ohms

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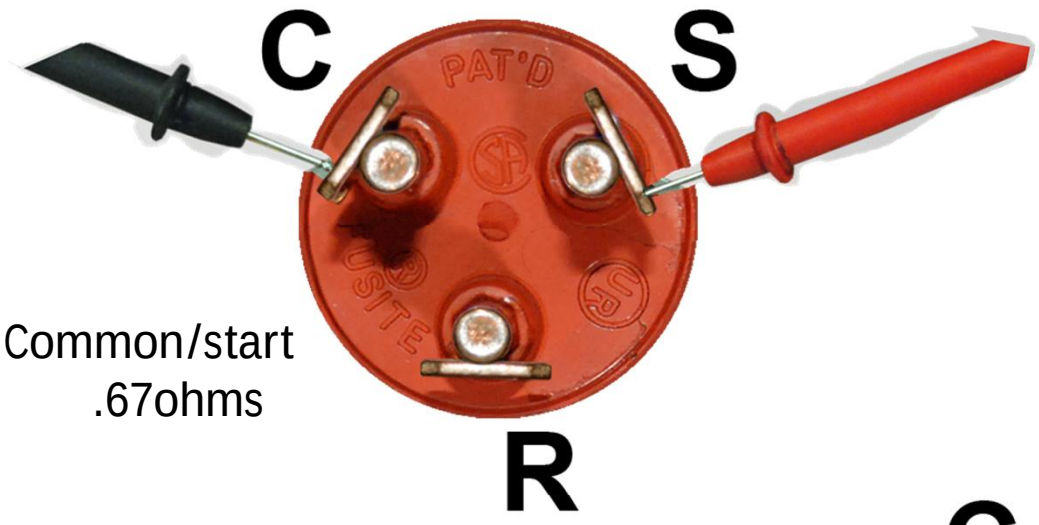
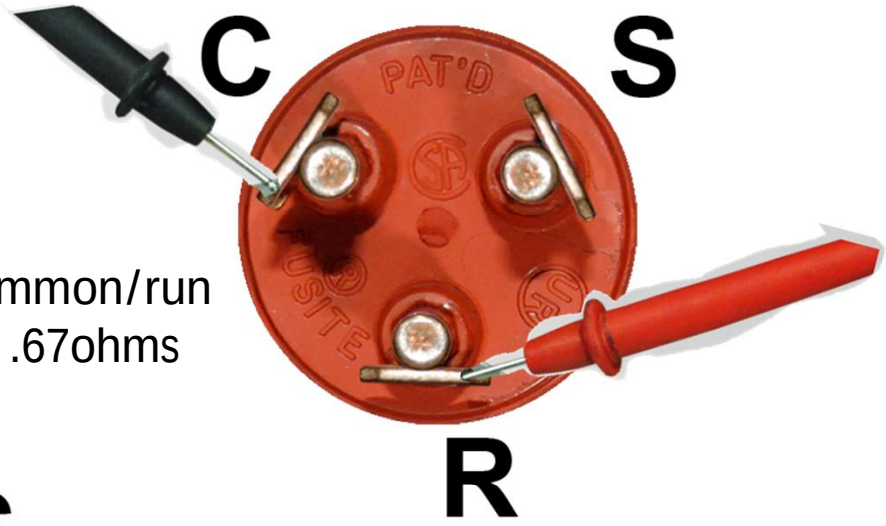
3 PHASE/ Inverter driven compressor testing

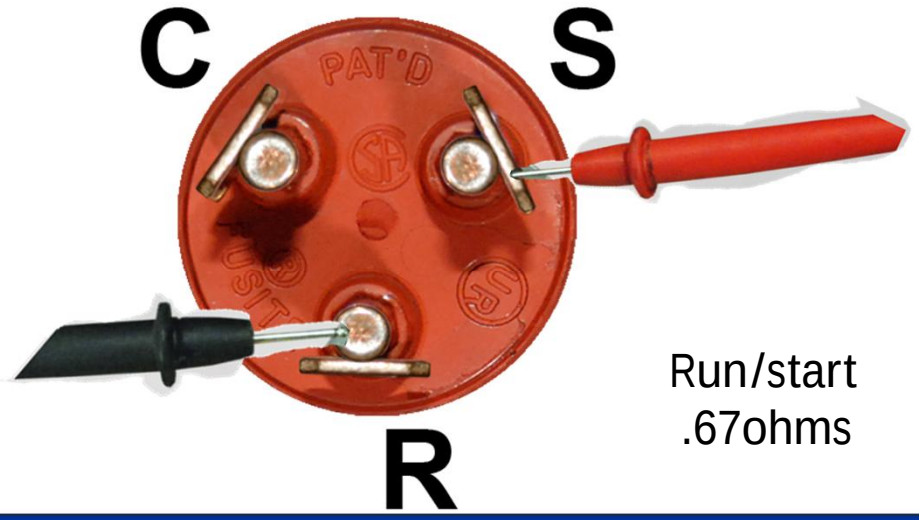
All windings have equal values



Common/start
.67ohms



Common/run
.67ohms



Run/start
.67ohms

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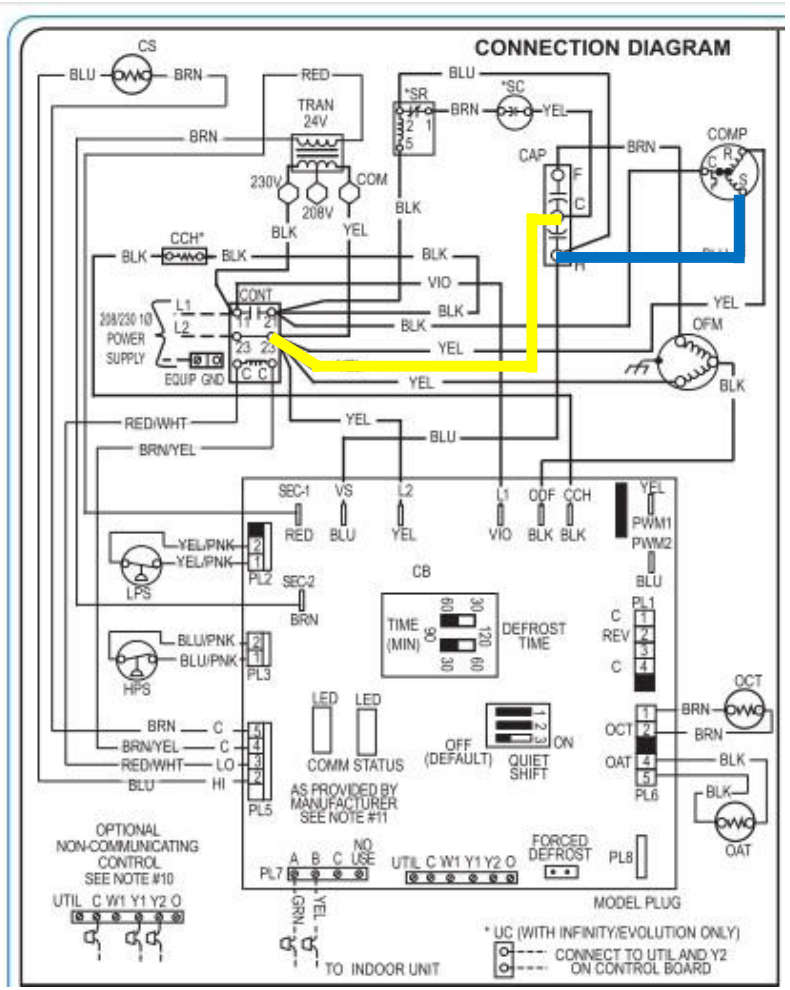
Run Capacitor

- Lowers the running current of the motor
- Improves the running efficiency
- Reduces the motor winding temperature
- Extends the life of the motor
- Continuous duty – Series start winding
- Metal casing and oil help to dissipate heat



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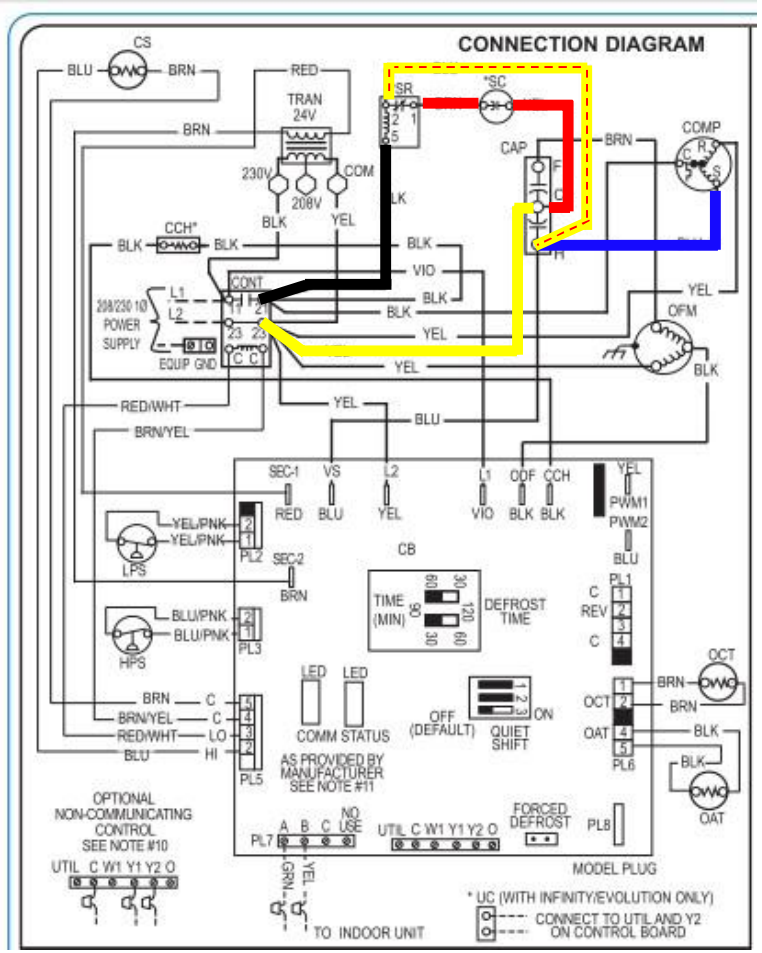
Start Assist Kit- 5-2-1

- Short time in circuit –
- Centrifugal switch or potential type start relay (3 seconds)
- Series with start winding
- High µF rating – Physically small
- High starting torque



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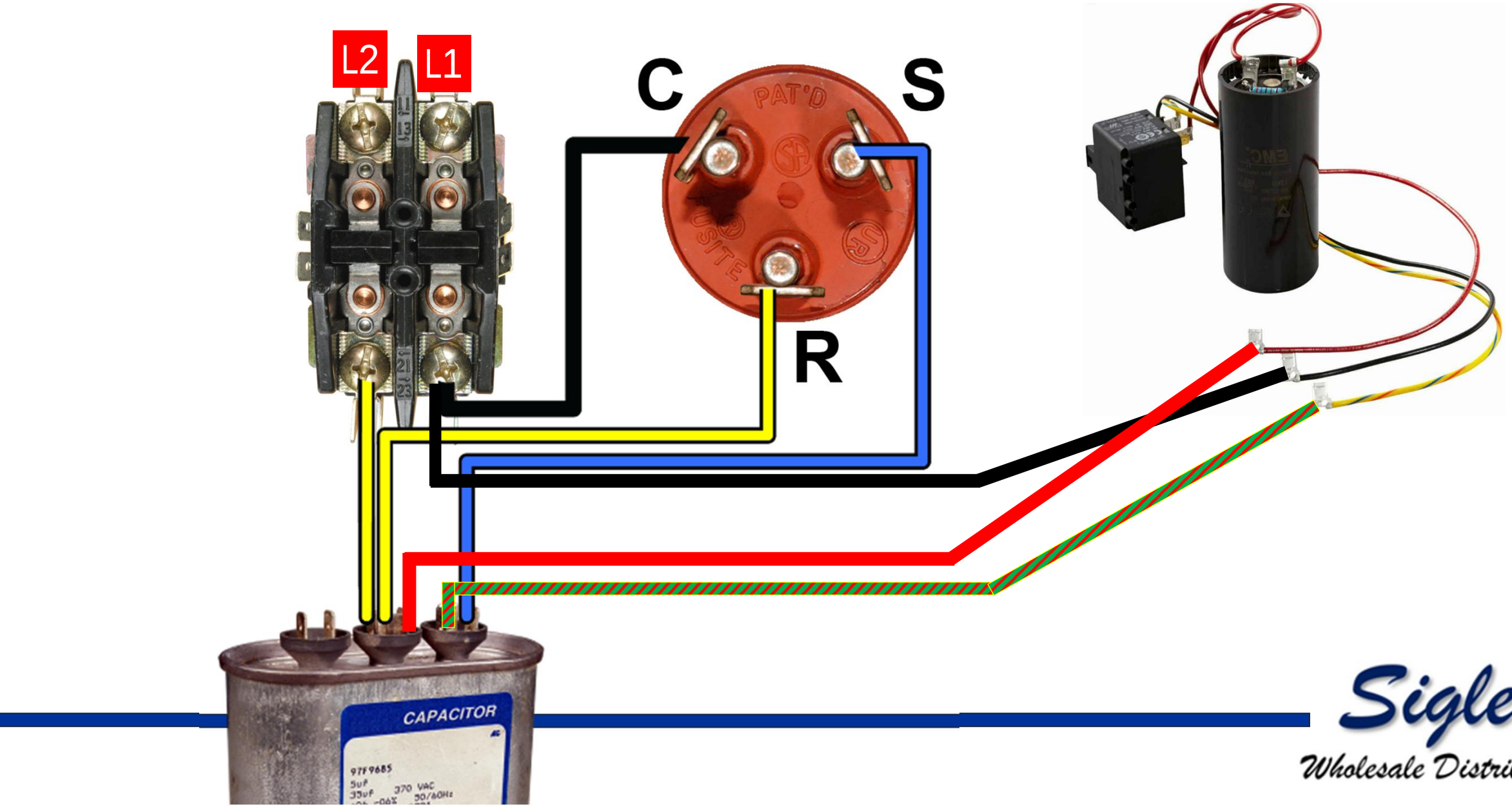
Wiring 5-2-1



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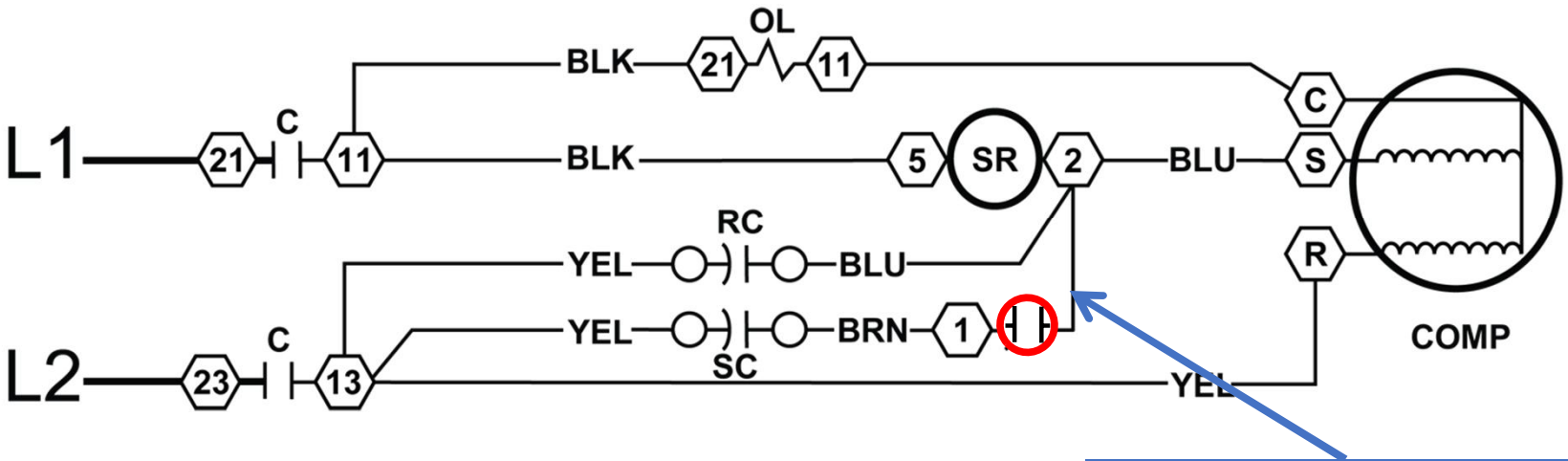
1. Start relay contacts stuck open



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The compressor may start, depending on conditions. It has lost the starting torque the start capacitor provides.

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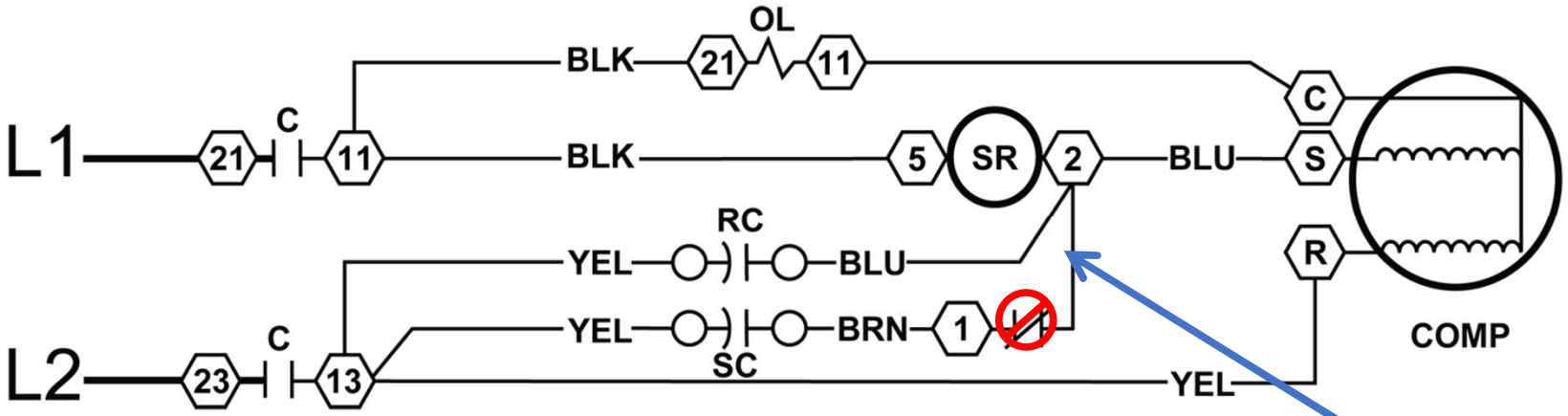
Compressor Circuit Failures

2. Start relay contacts welded closed



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Amp draw after compressor starts

The compressor will start but will soon overheat.

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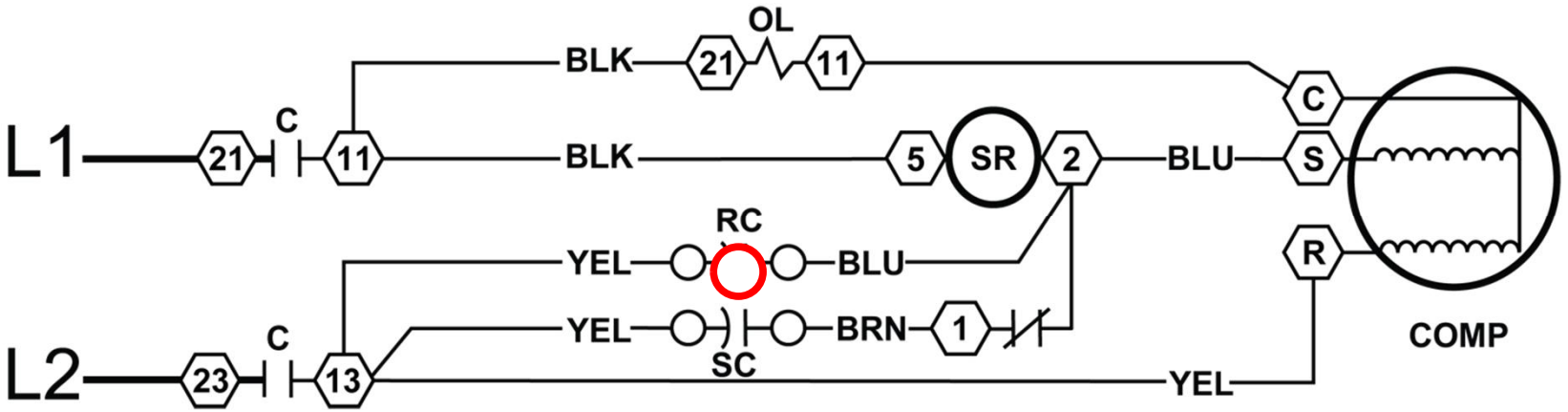
Compressor Circuit Failures

4. Run capacitor is open



Checking the capacitors with a multi-meter

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Compressor may start and may stay running, depending on load.
It would run hotter than normal.

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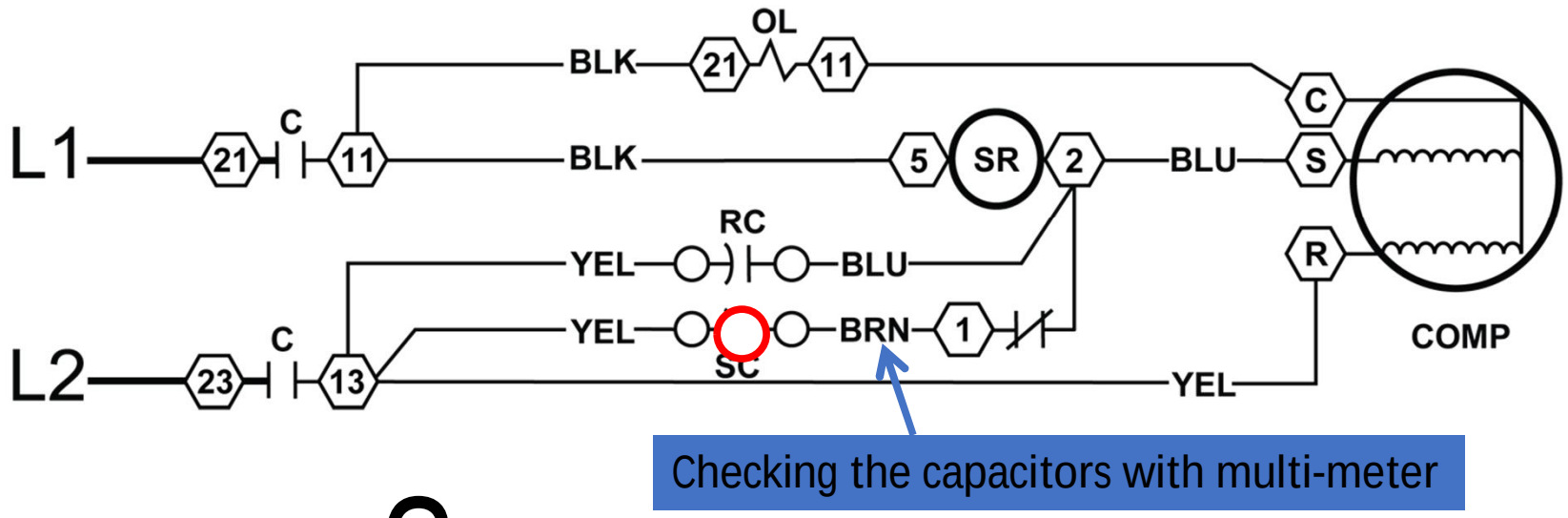
Compressor Circuit Failures

6. Start capacitor open



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Compressor may start depending on load, starting torque is lost.
If it starts it should continue to run.

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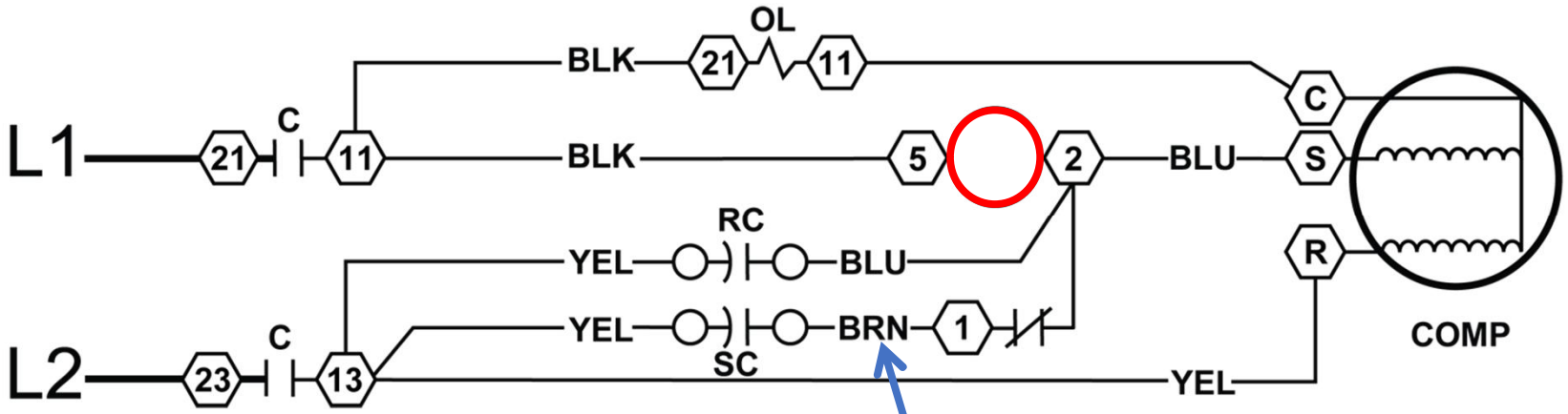
Compressor Circuit Failures

7. Start relay coil open



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There will be a amp draw through the Start capacitor after start-up

Compressor will start but will overheat.

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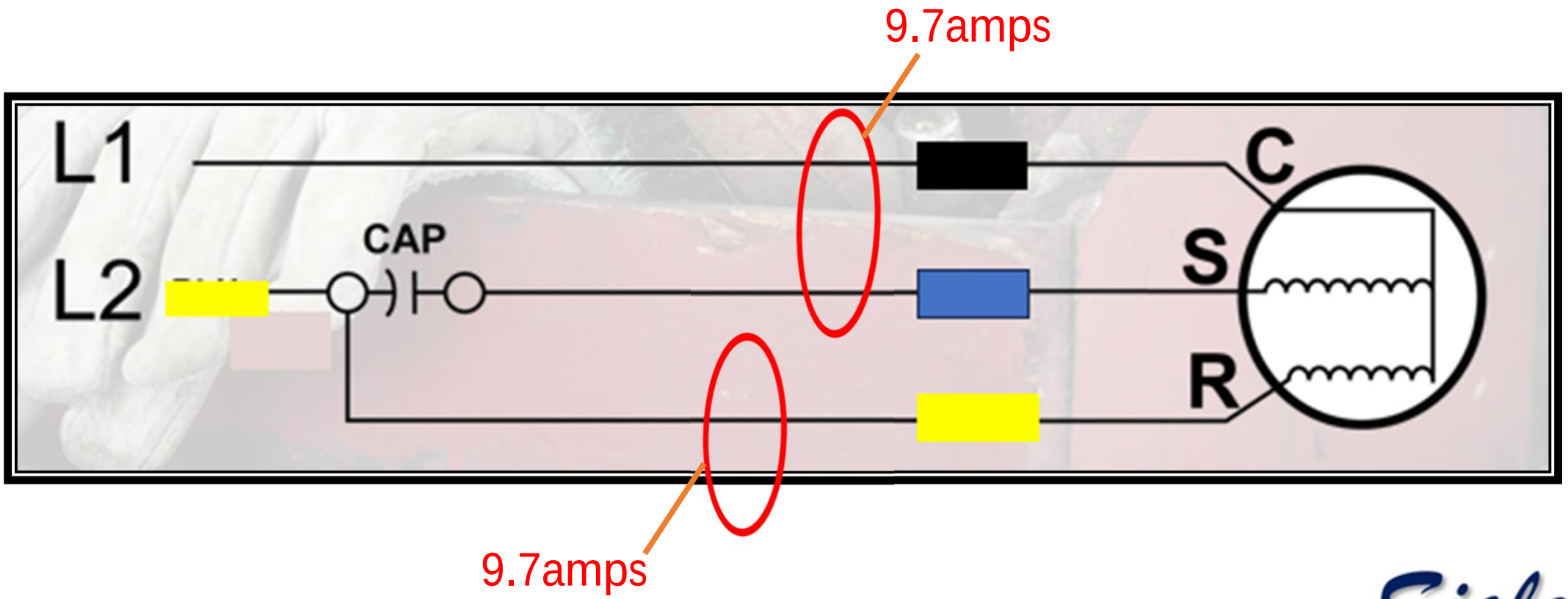
Testing capacitor under load

Common + Start = Run



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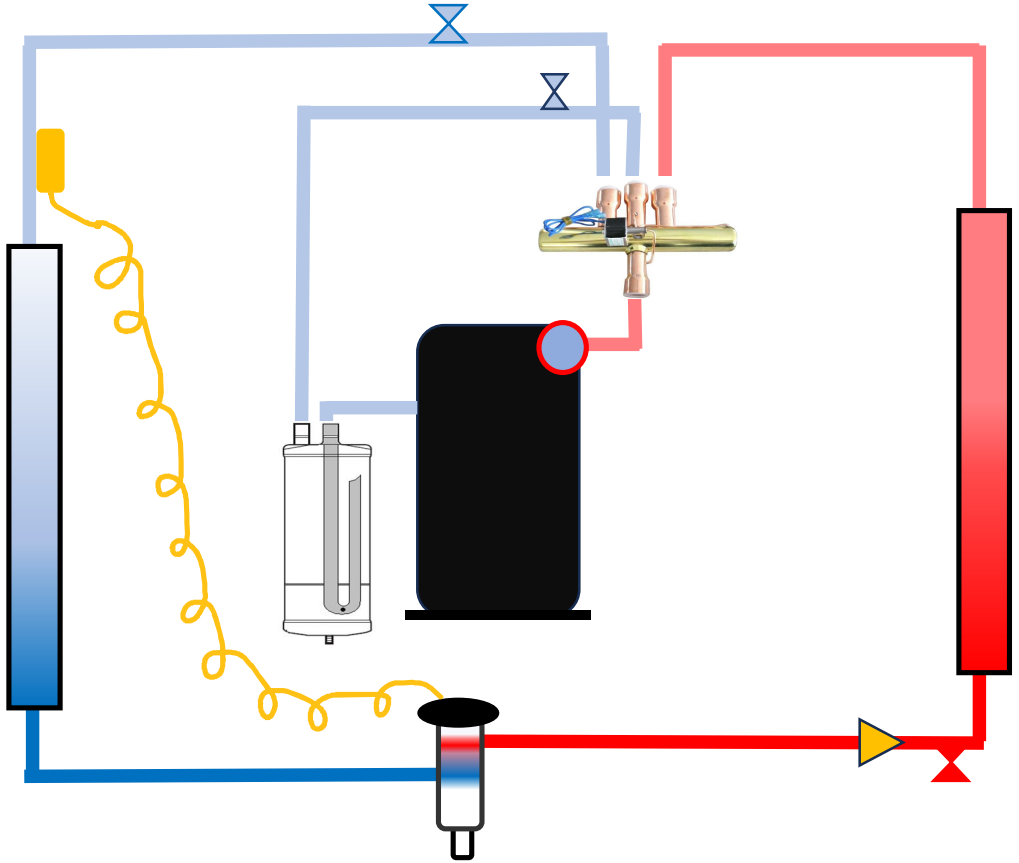
Next stop reversing valve



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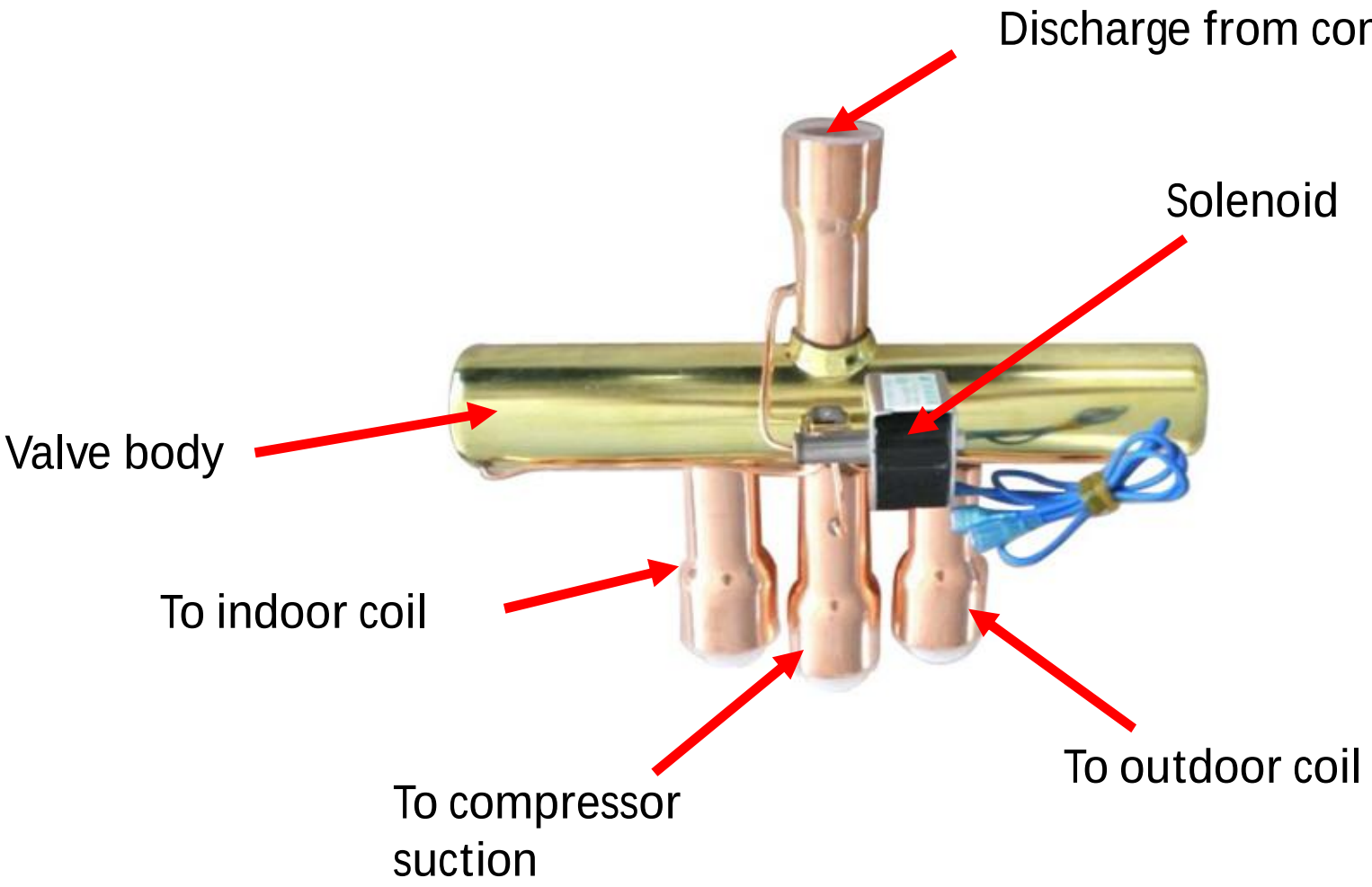
REVERSING VALVE/4 WAY VALVE

Used to reverse the direction of the refrigerant flow through system



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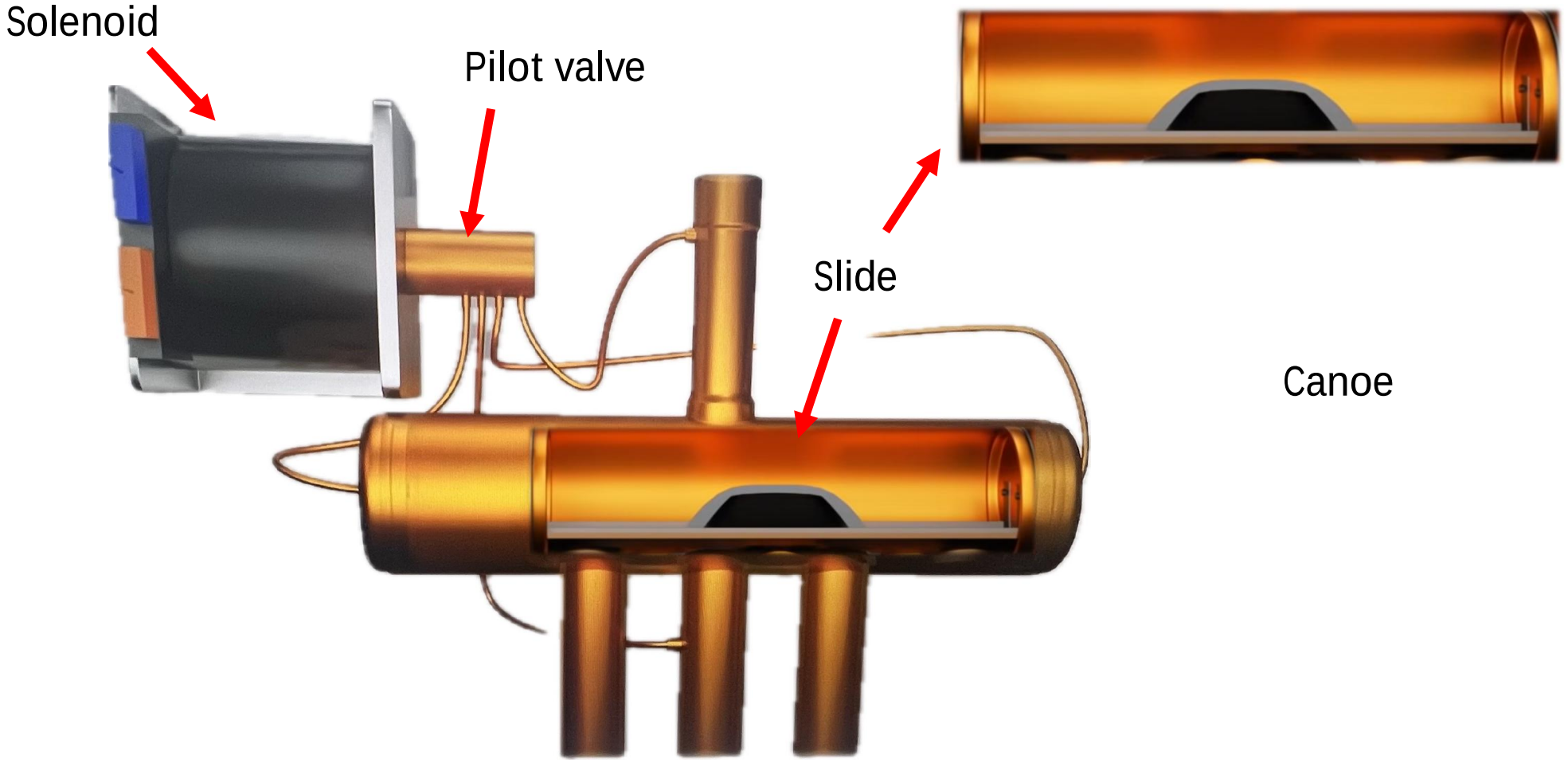
REVERSING VALVE/4 WAY VALVE



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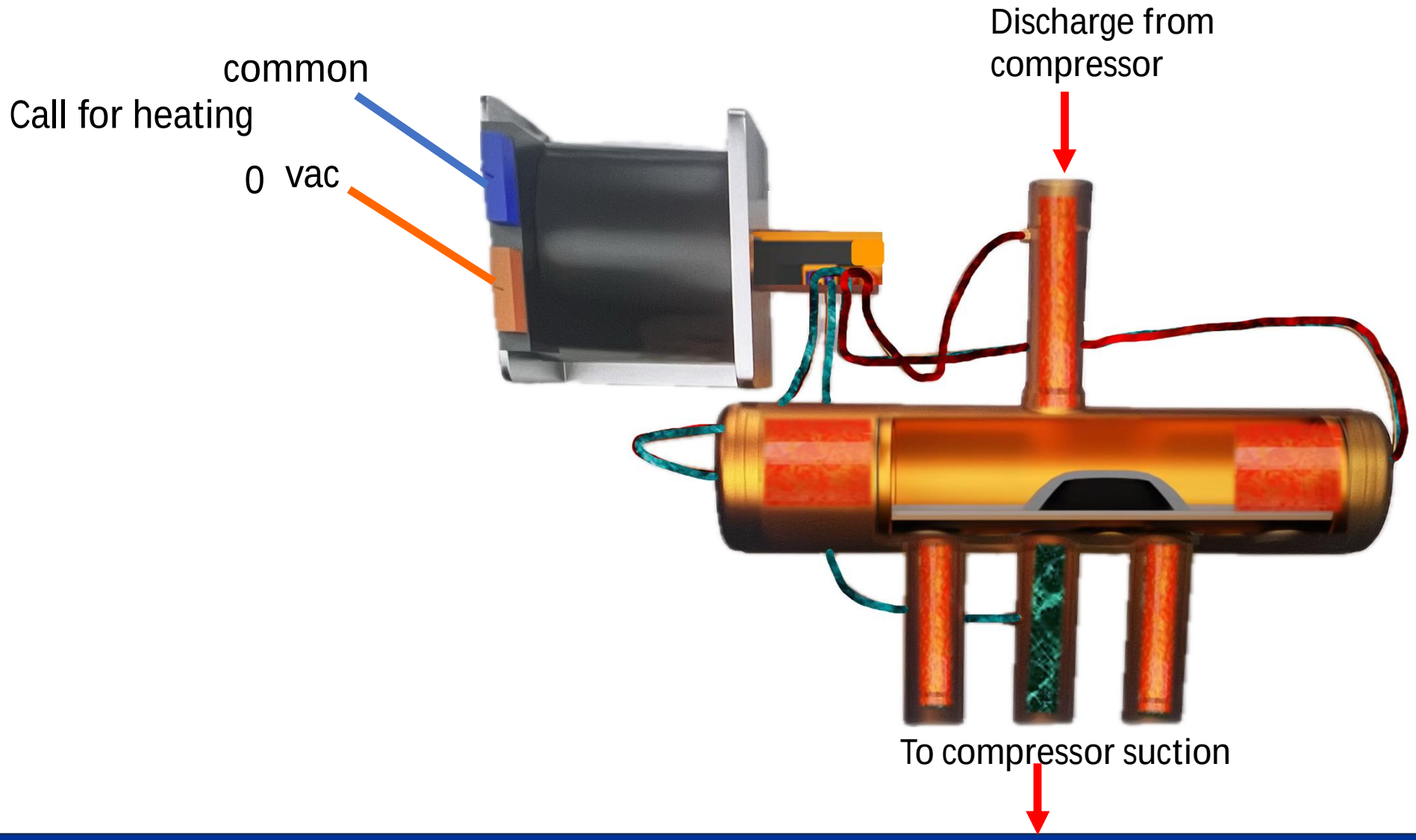
REVERSING VALVE/4 WAY VALVE



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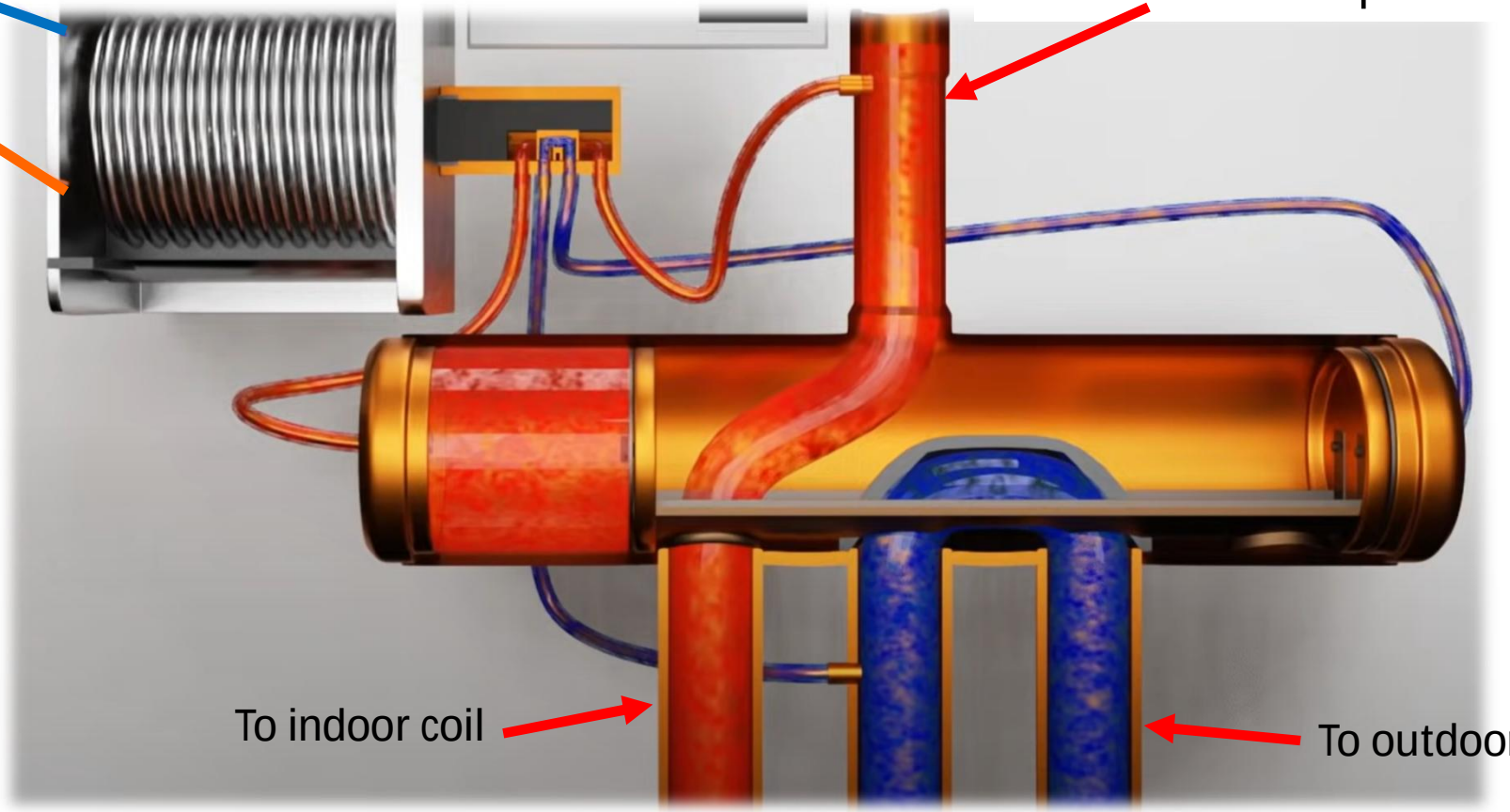
REVERSING VALVE/4 WAY VALVE

De-energized



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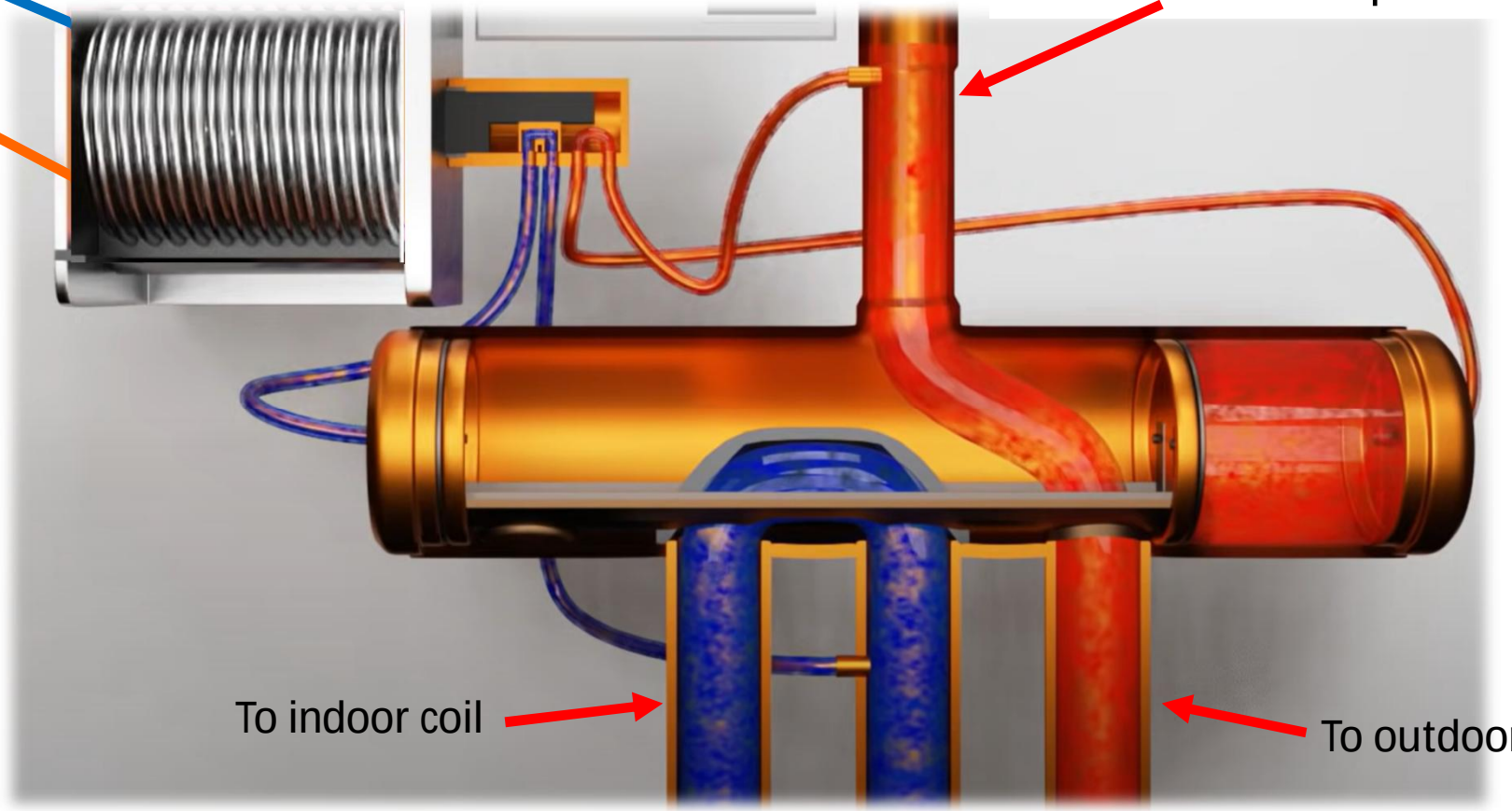
REVERSING VALVE/4 WAY VALVE

Energized



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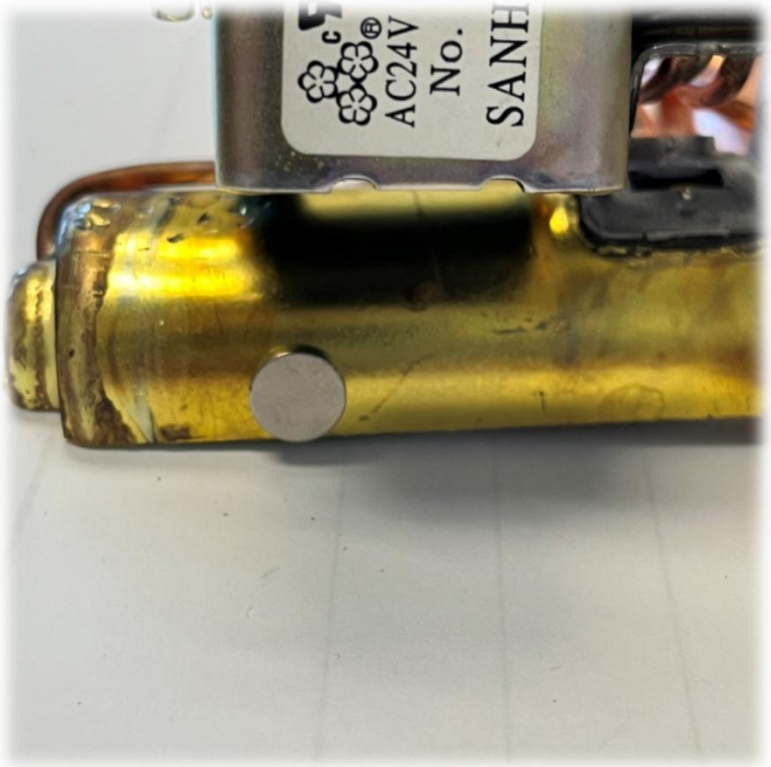
Testing reversing valve

Confirm 24vac to solenoid

Ohm solenoid coil

Use magnet on valve body



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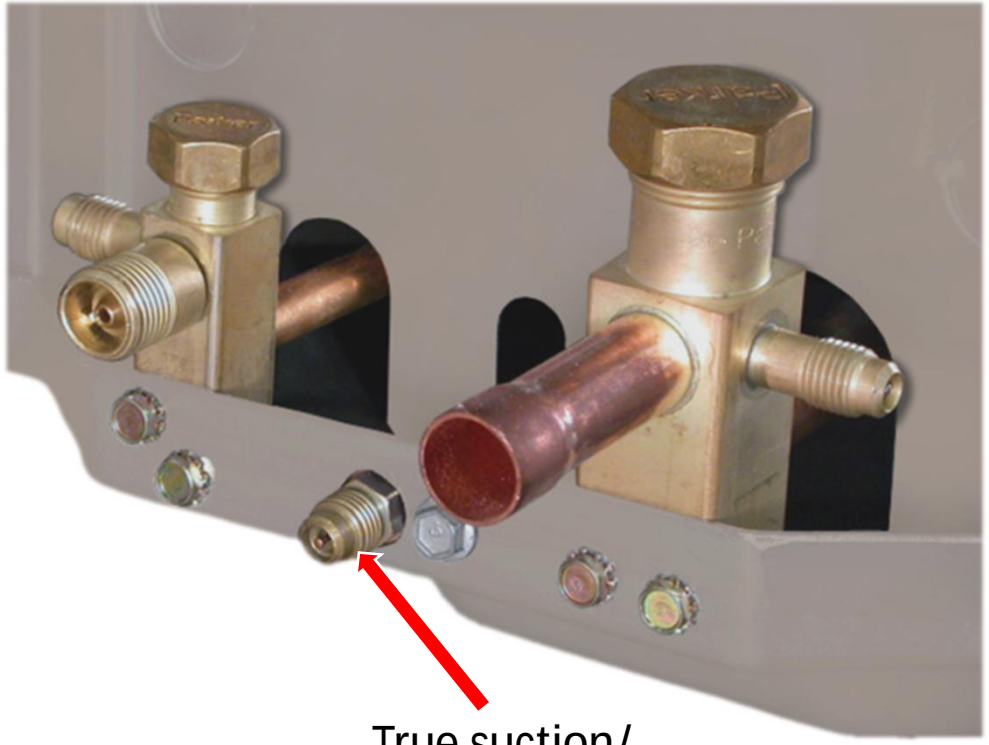
When connecting gauges connect to the true suction



True suction/
Suction service port

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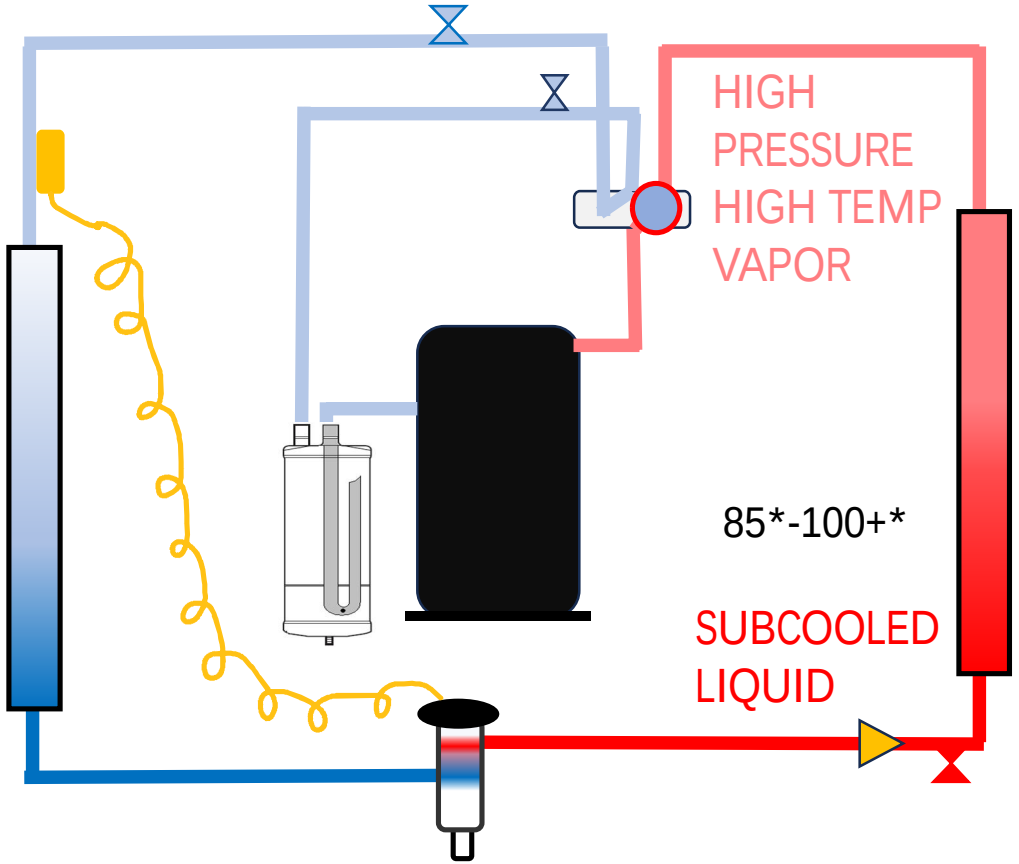
Next stop condenser coil



Condenser coil-
(heat rejecter)
Reject/releases heat and causes the vapor to condense to a liquid refrigerant. This coil must be warmer than the ambient temp to perform its job.

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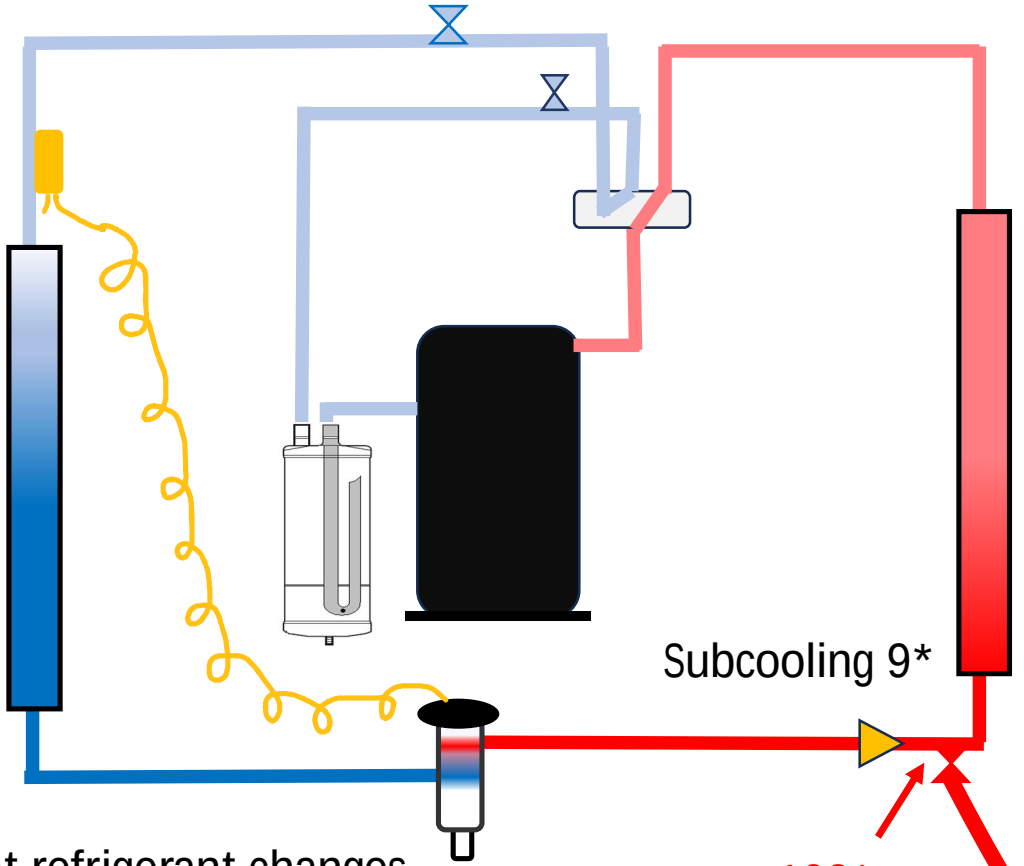
Subcool

Low subcool can cause flashing of vapor refrigerant through the TXV. Too high of subcool means flooded condensor



Subcool- difference between condensing pressure/temp and the actual liquid temp exiting the coil

Saturation temp is temp that refrigerant changes state from liquid to vapor or vapor to liquid

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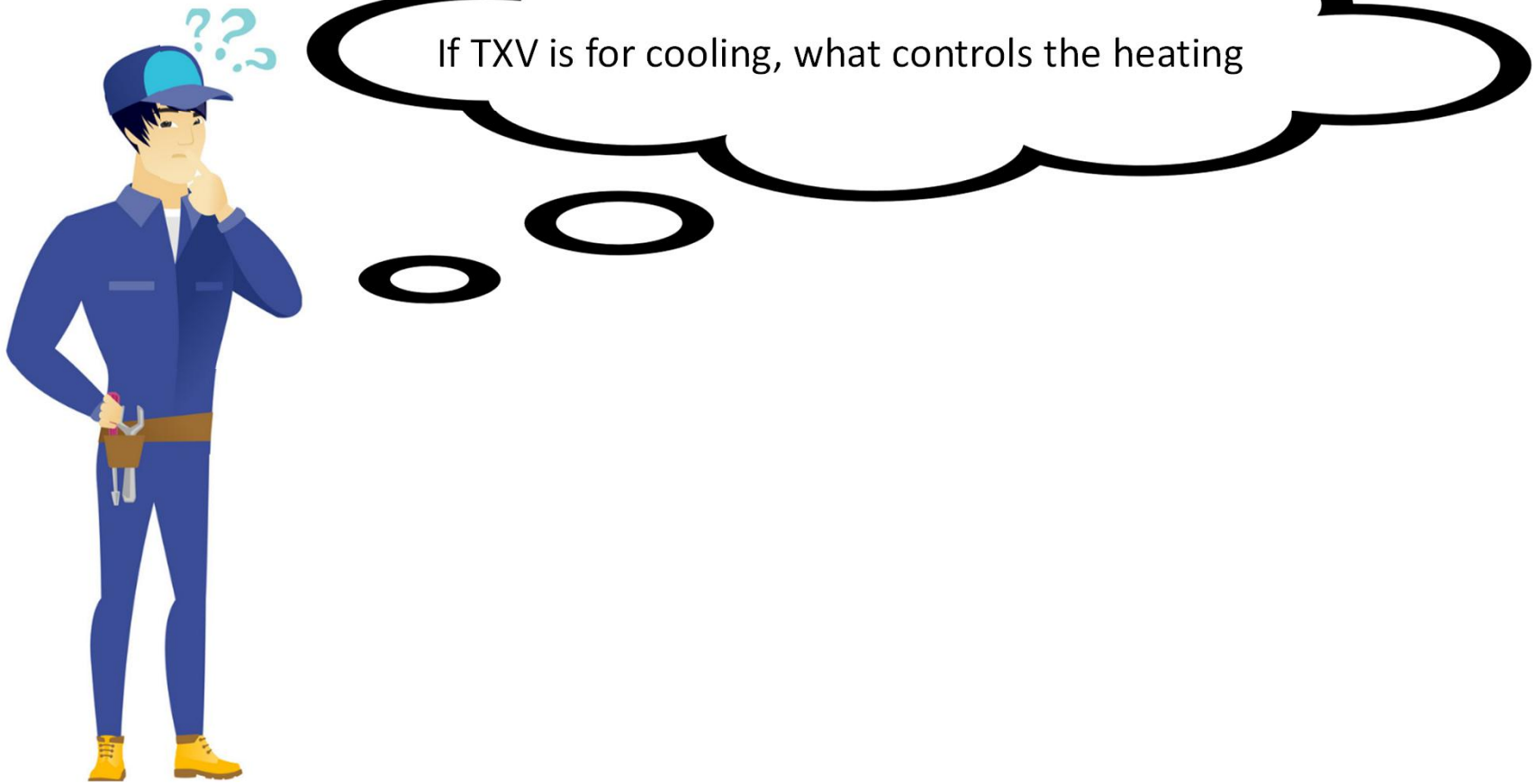

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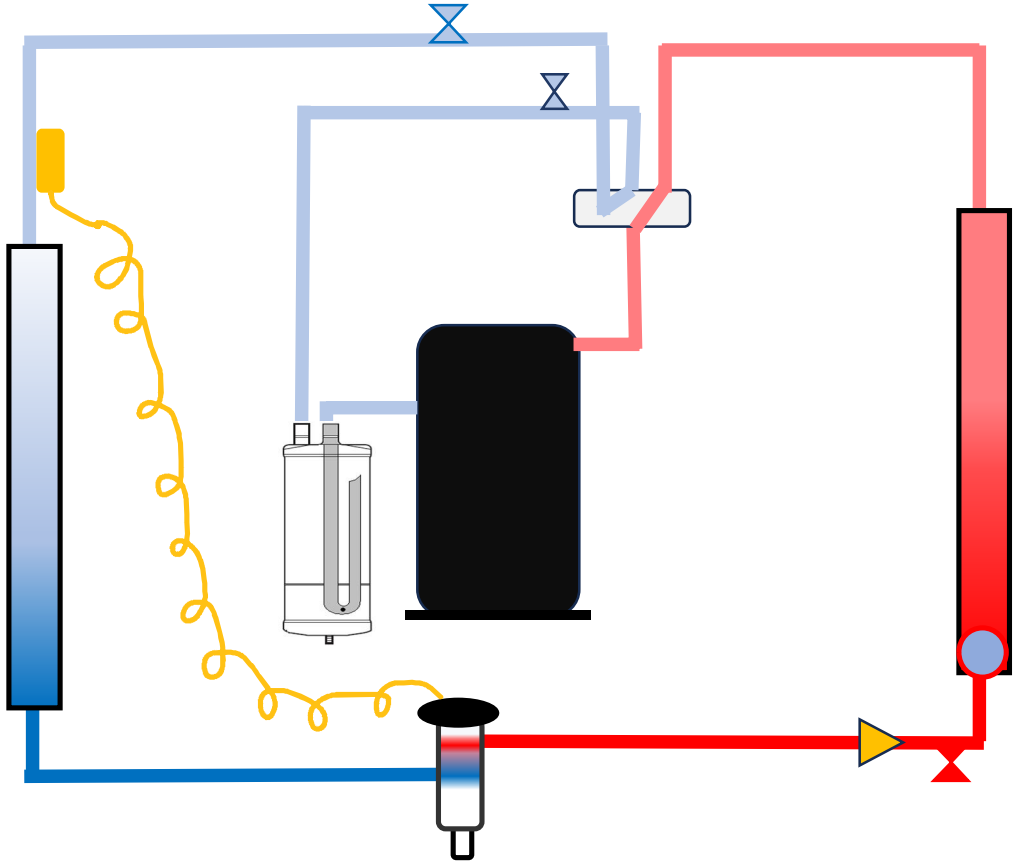
Next stop heating piston



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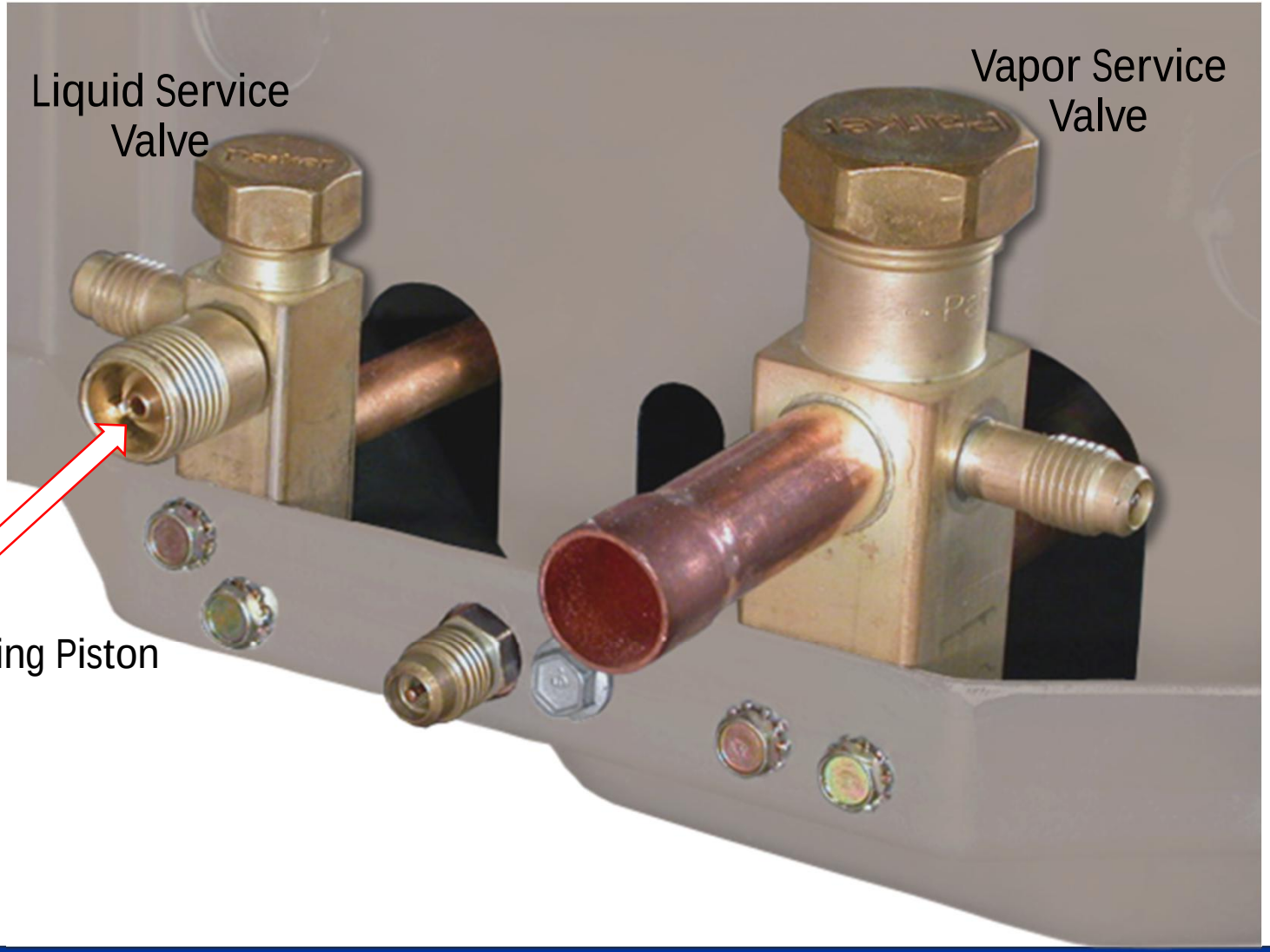
Heating Piston



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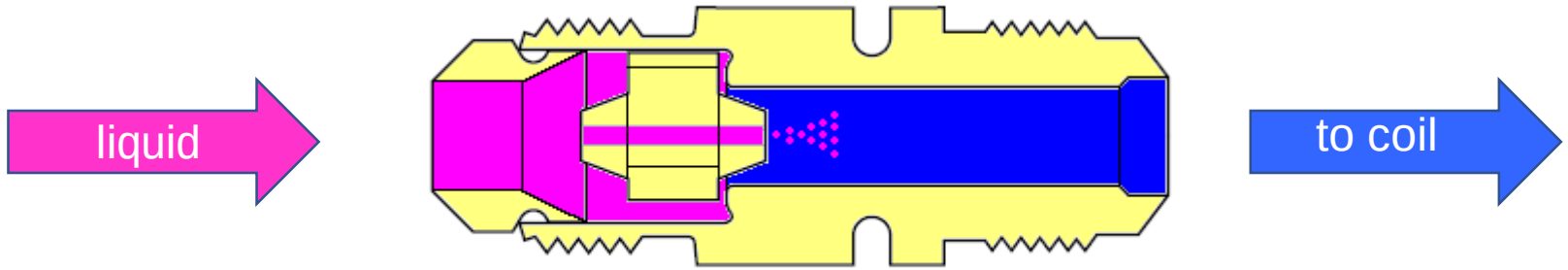
Accurator Piston

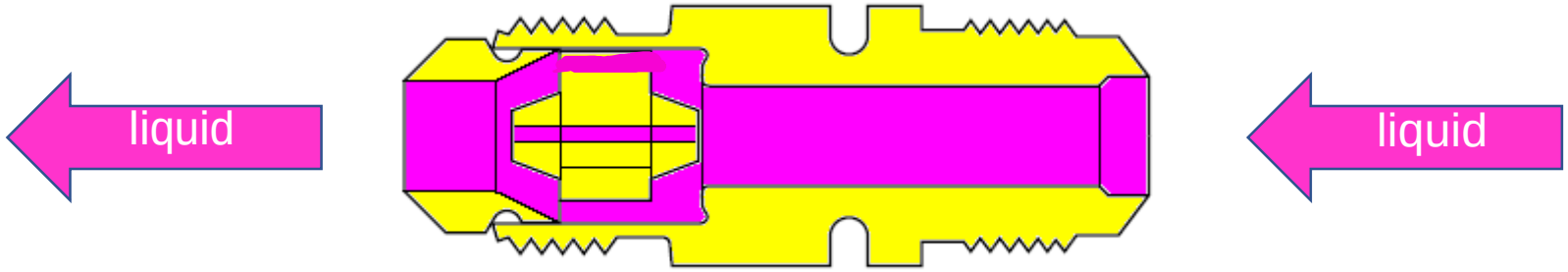
Heating mode



METERING POSITION

Accurator Piston

Cooling mode



BYPASS POSITION

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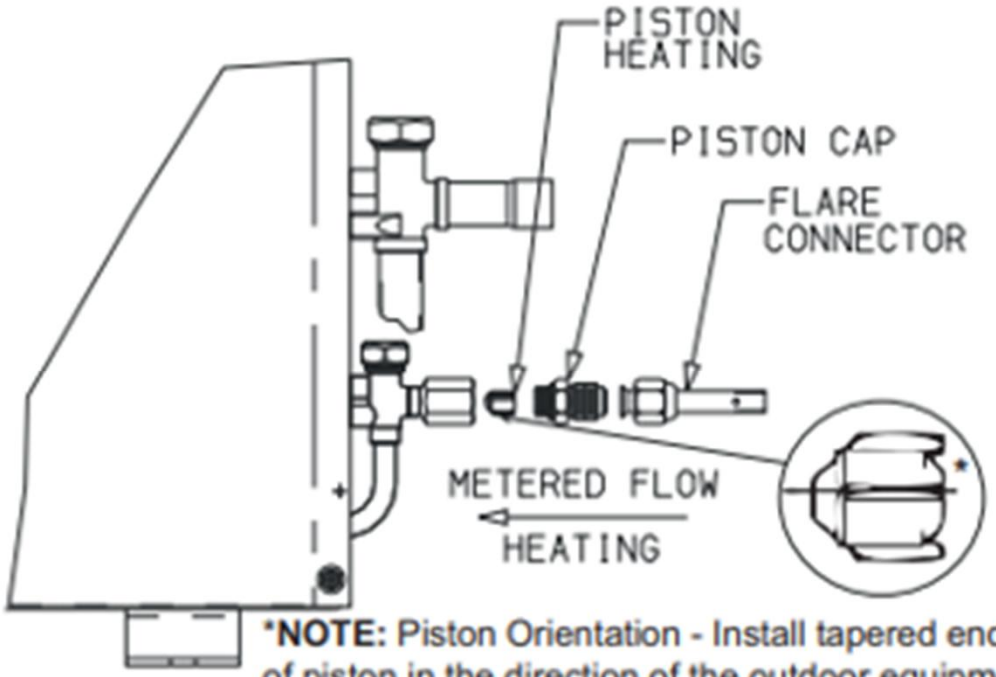
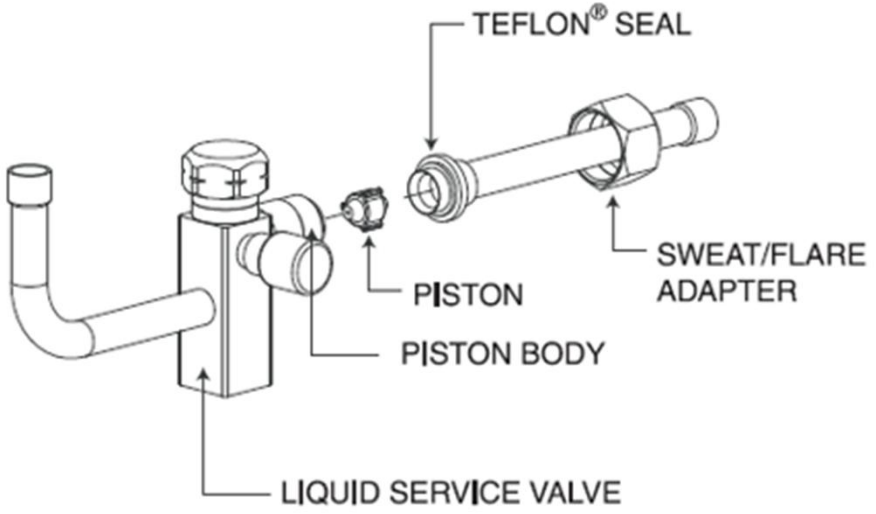
Piston Orientation



*NOTE: Piston Orientation - Install tapered end of piston in the direction of the outdoor equipment for proper heating operation



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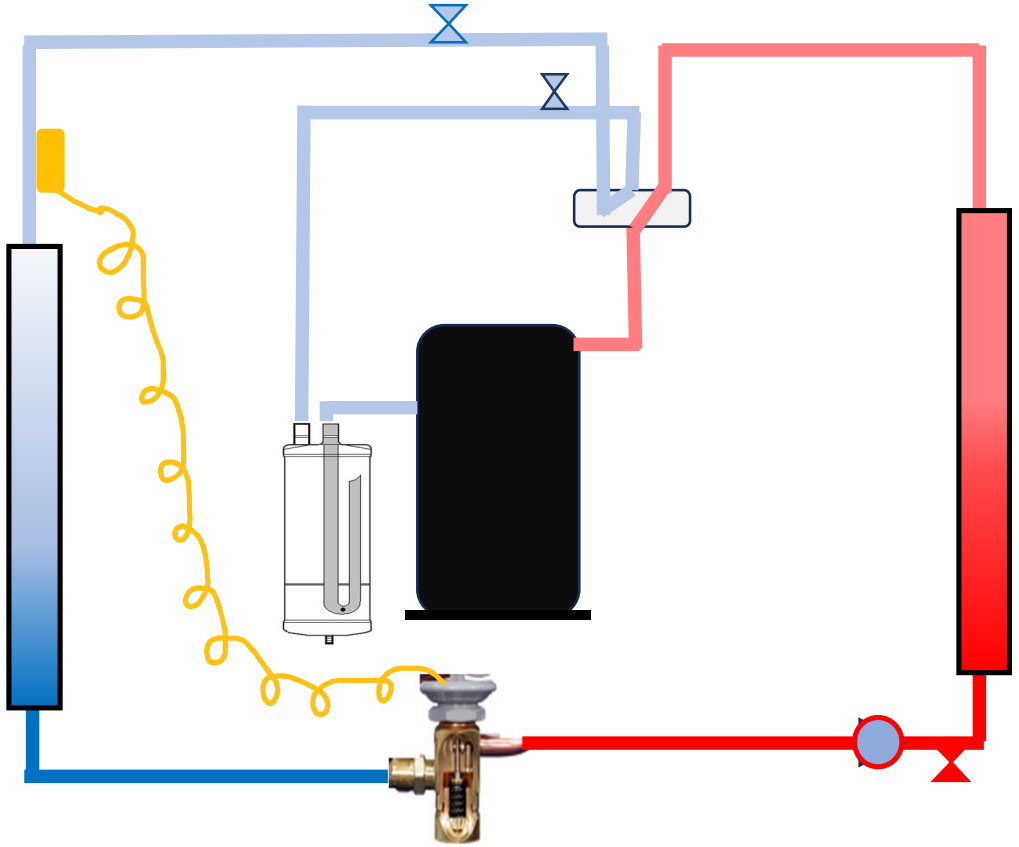
Next stop TXV



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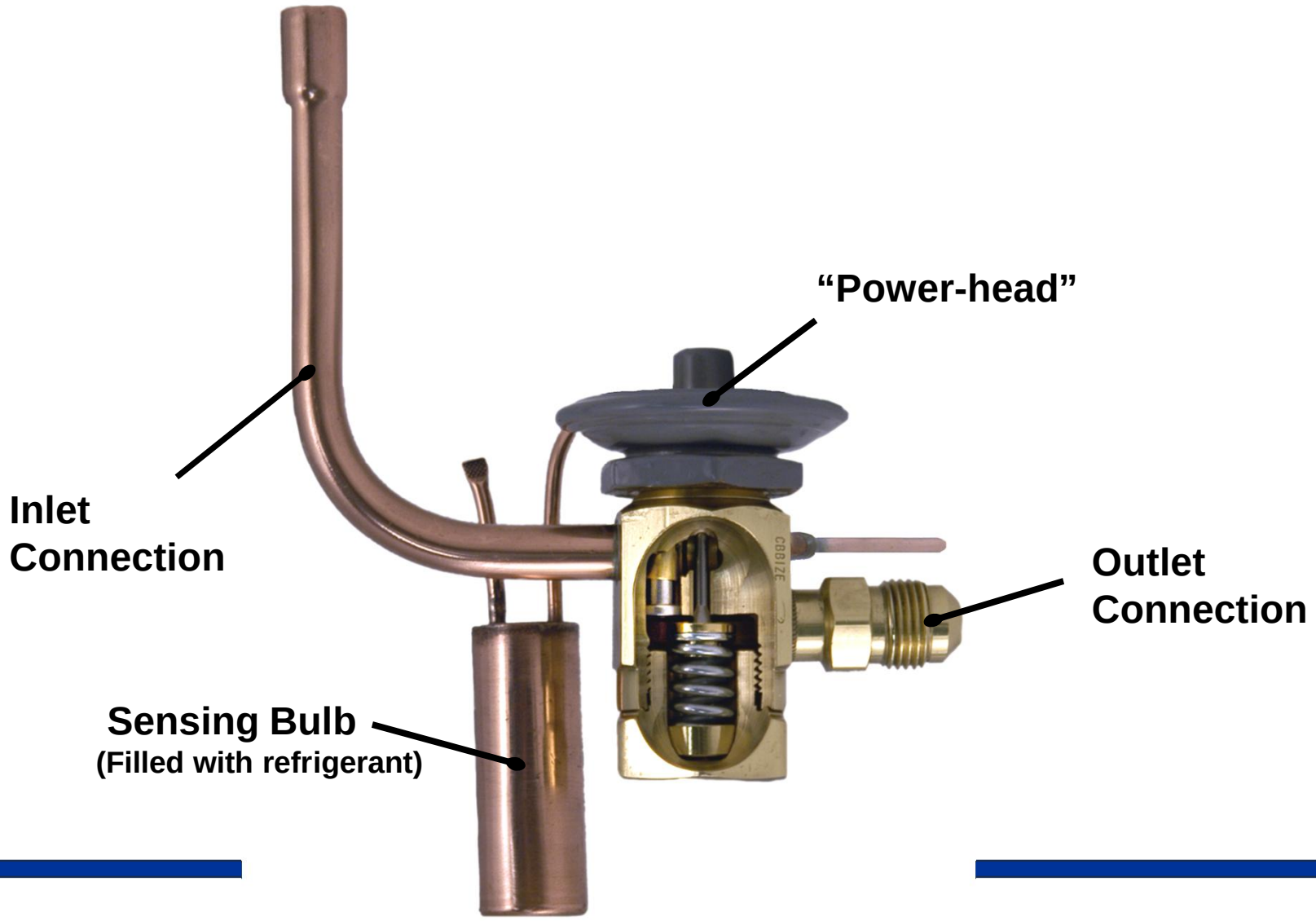
TXV



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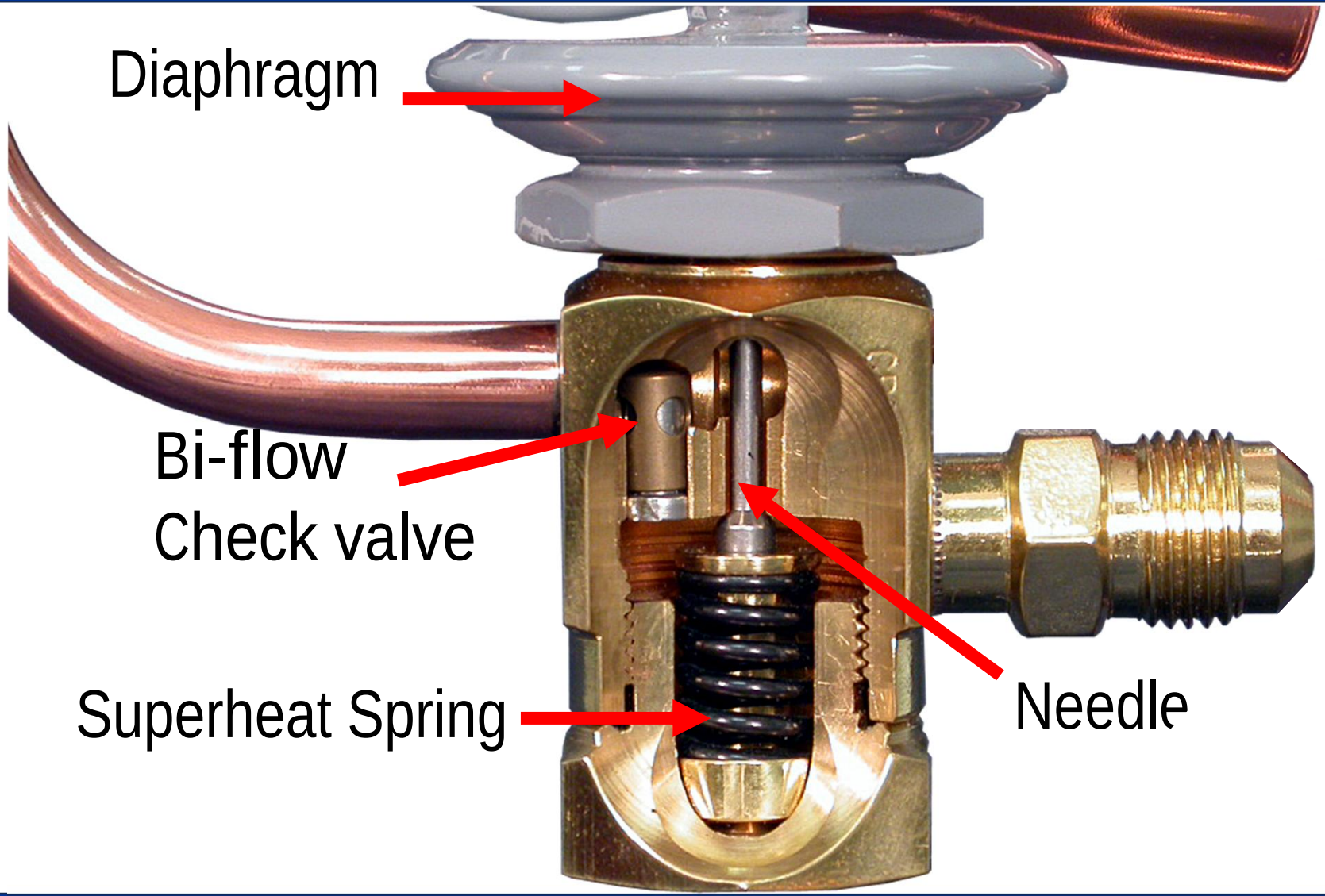
TXV



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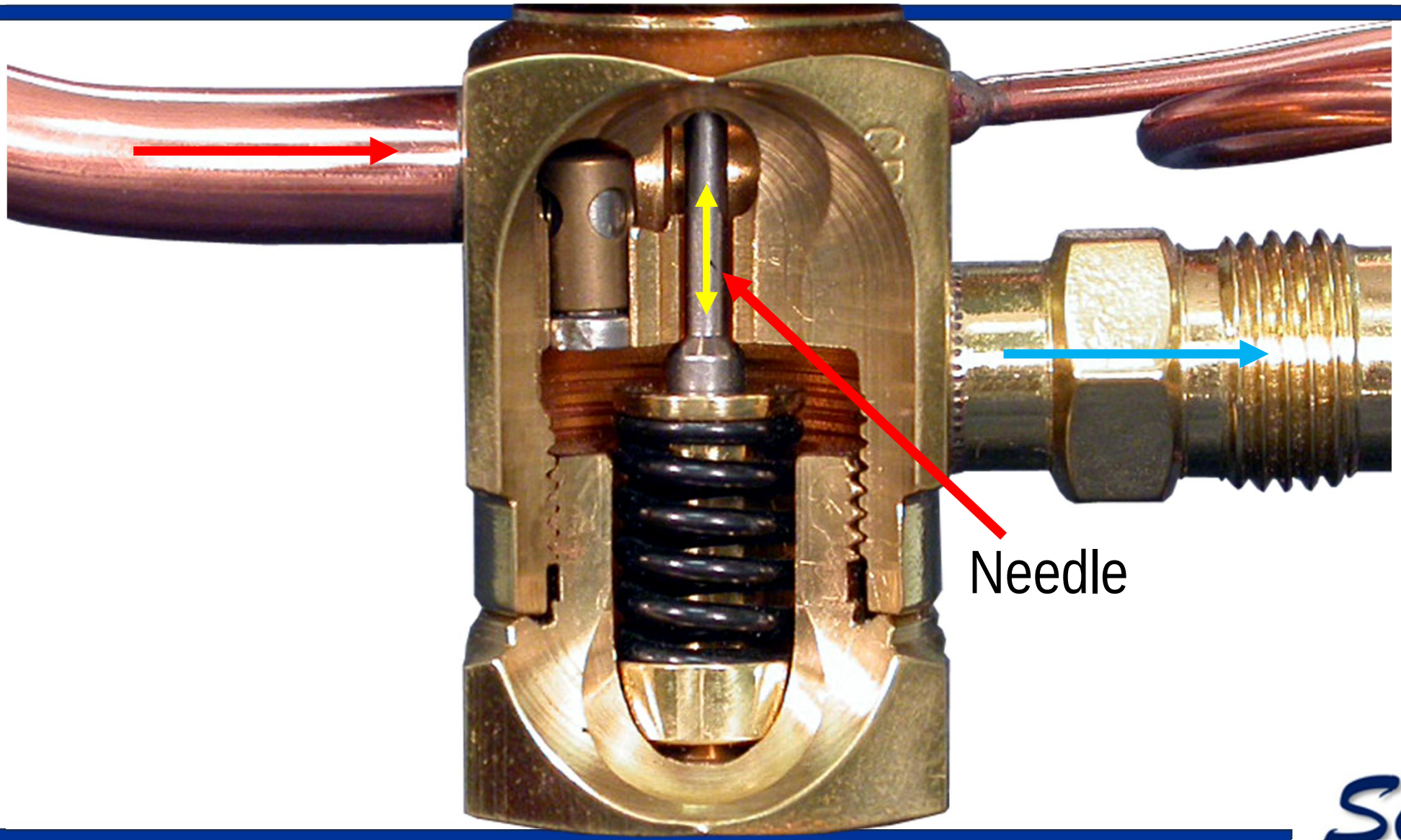
Needle



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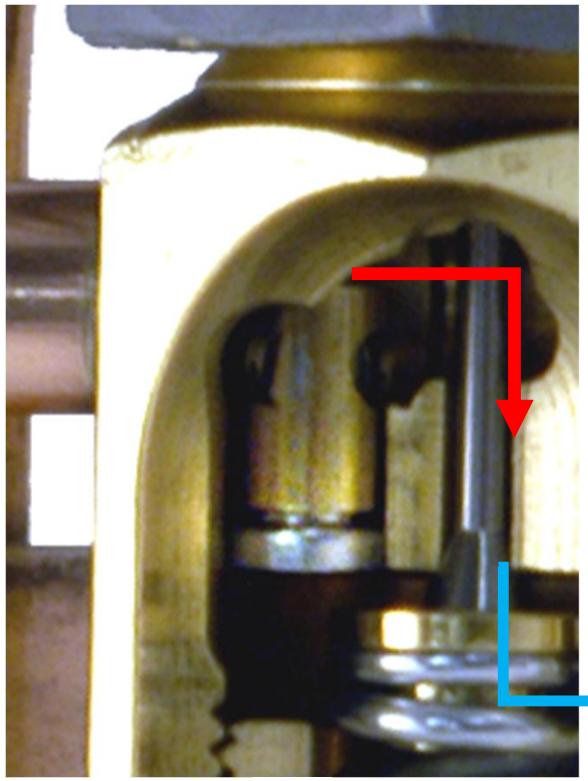
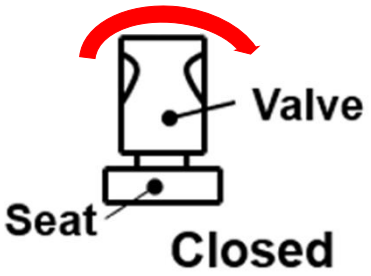
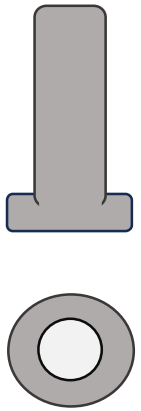
Bi-flow check valve

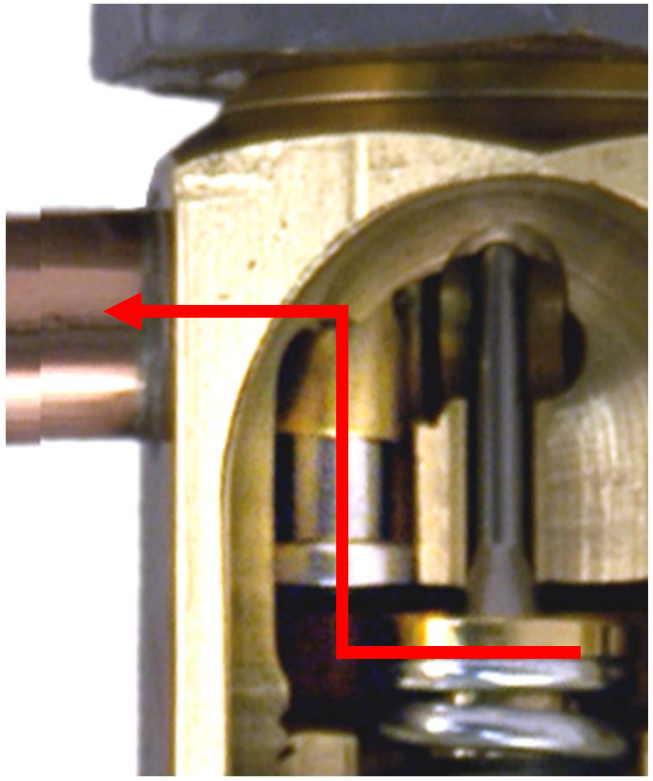
COOLING

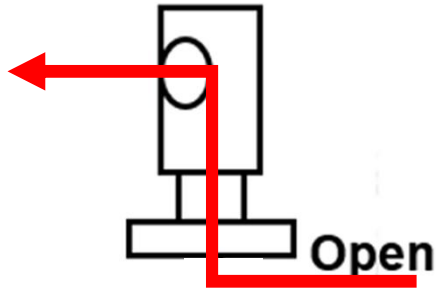






HEATING





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Sensing bulb facts

Bulb is filled with liquid refrigerant

Do not allow capillary tube to be in contact with any other piping from evaporator coil during operation

Mount bulb on clean flat portion of pipe with copper, brass, or stainless strapping. Do not mount on elbow or coupling

Capillary tube and bulb are fragile and will break or kink easily if not careful when handling

Best practice-
Insulate bulb so it is not influenced by the ambient air temp

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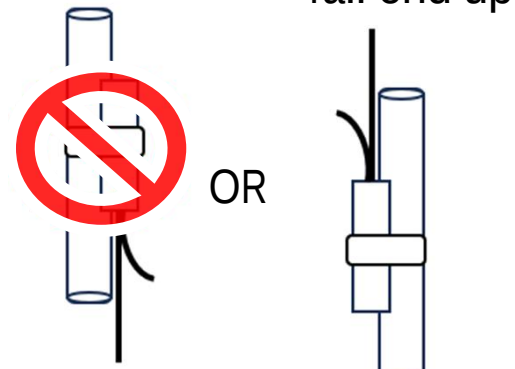
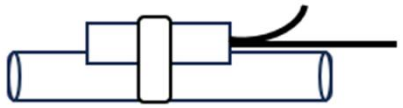
Sensing bulb positioning



When mounting bulb on vertical pipe



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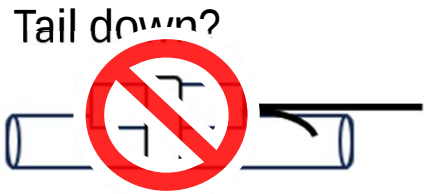
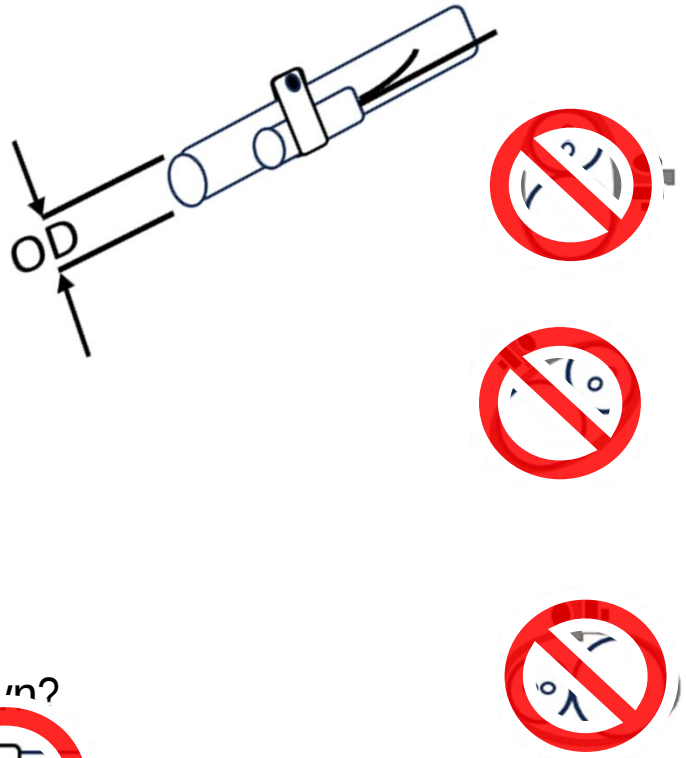


When mounting bulb on horizontal pipe



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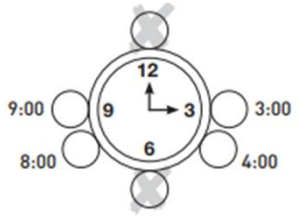
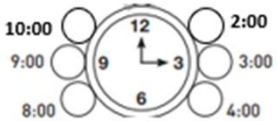
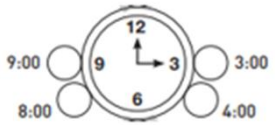
Why is this important?





3/8” - 5/8” OD



3/4” – 7/8” OD

The larger the pipe the lower you should place bulb

3/4” – 1 1/4” OD

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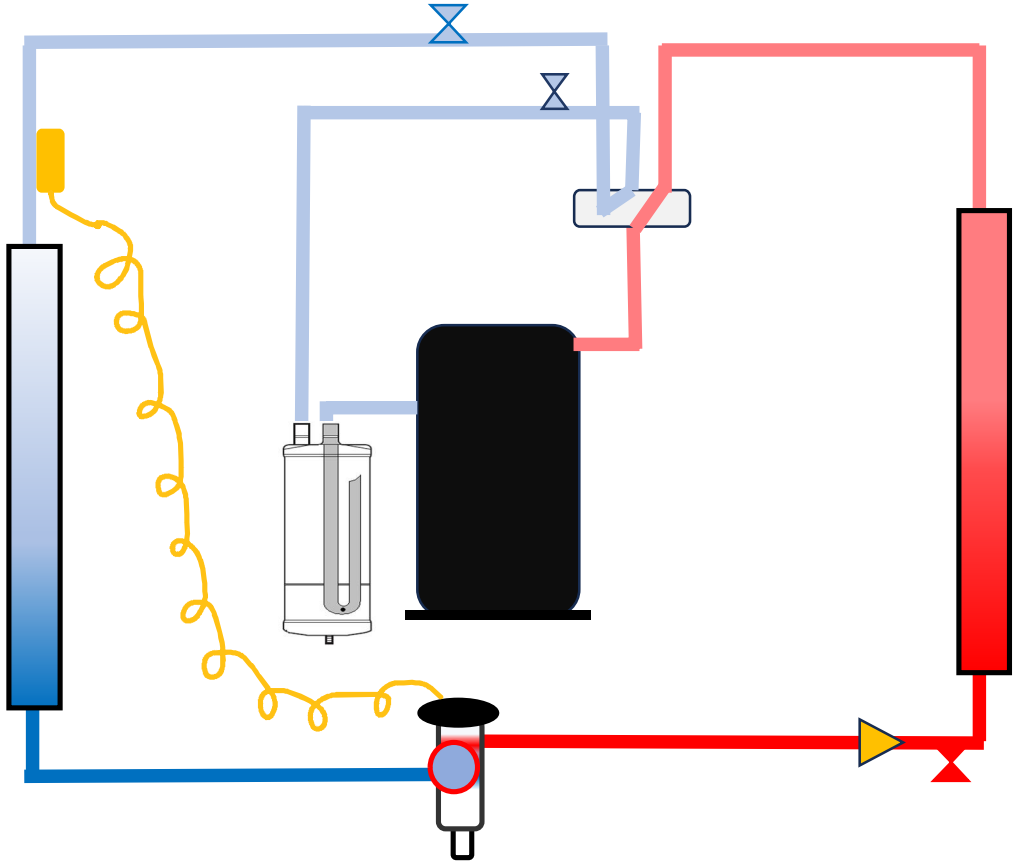
Next stop evaporator coil



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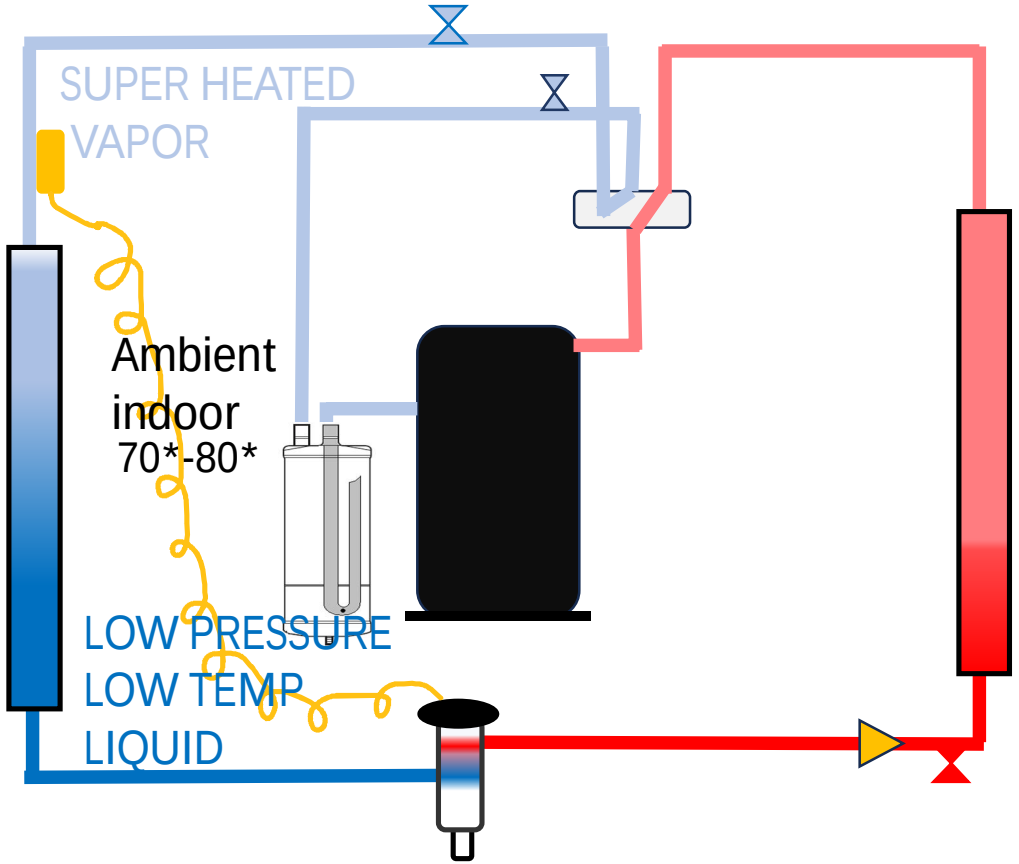
Evaporator coil

Evaporator coil- (heat absorber) Absorbs heat and causes the liquid refrigerant to boil or evaporate into a vapor. This coil is the "cooling coil" where the cooling takes place. Must be colder than the ambient temperature to perform its job.



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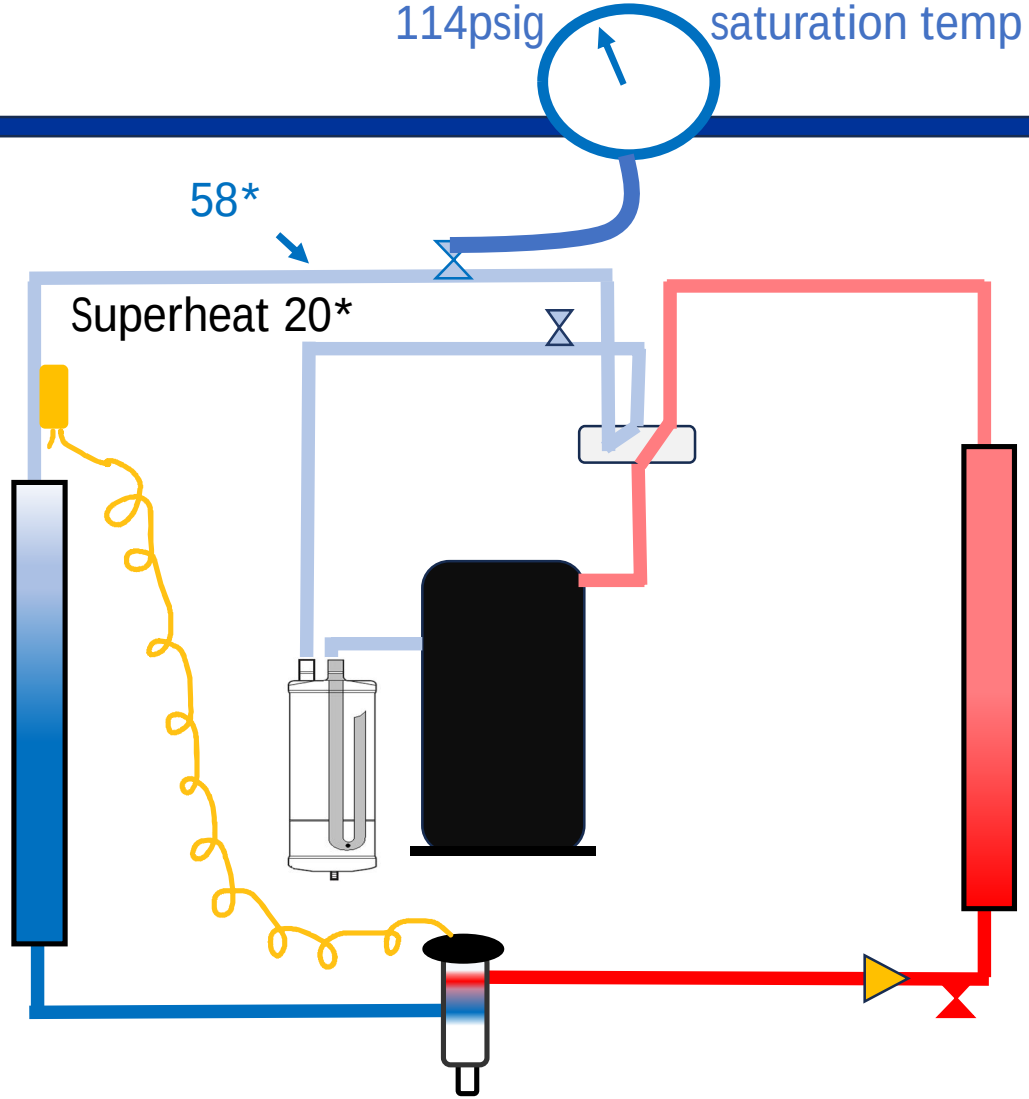
Superheat

Superheat- difference between the actual temp of the vapor refrigerant and the saturation pressure/temp inside the evaporator.
-The temp difference of the refrigerant vapor leaving the evap coil above the temp that the refrigerant is changing states inside the evap coil.



High superheat means liquid refrigerant is making it through less of the coil.
Low superheat means flooded evaporator and can cause liquid refrigerant to enter the compressor.

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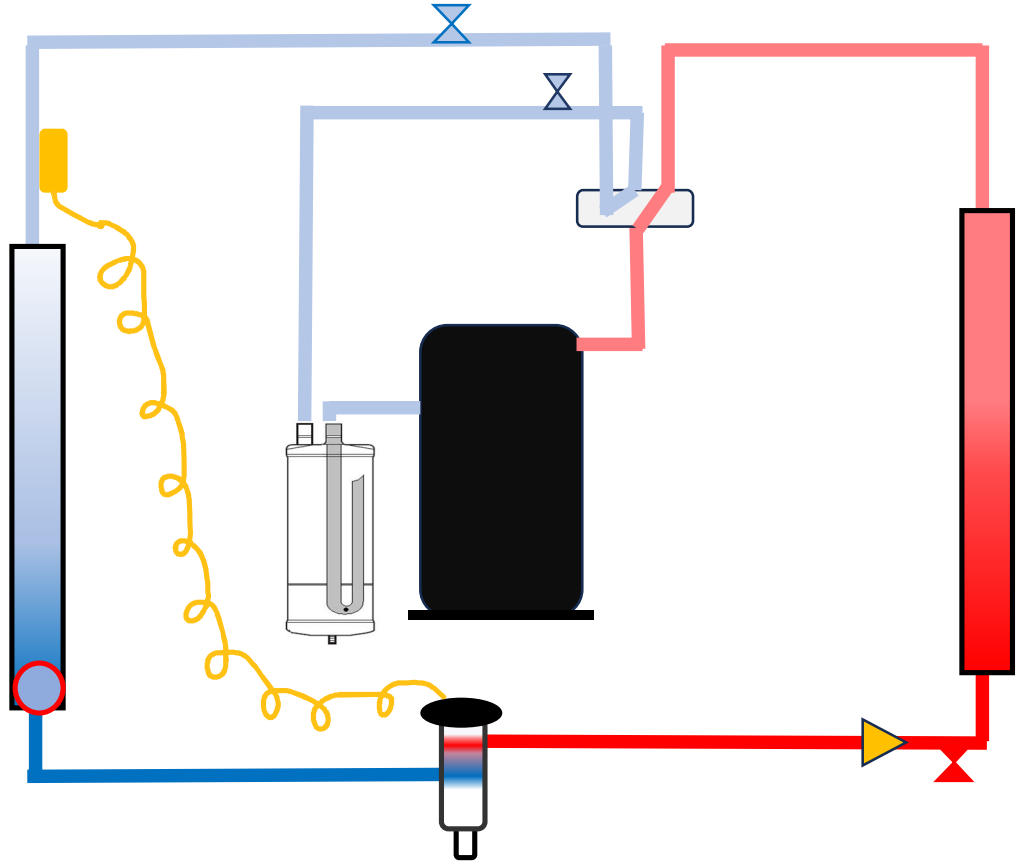
Next stop accumulator



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ACCUMULATOR

Accumulator- Storage tank that protects the compressor by receiving or accumulating liquid refrigerant before it can enter the compressor.

Accumulator

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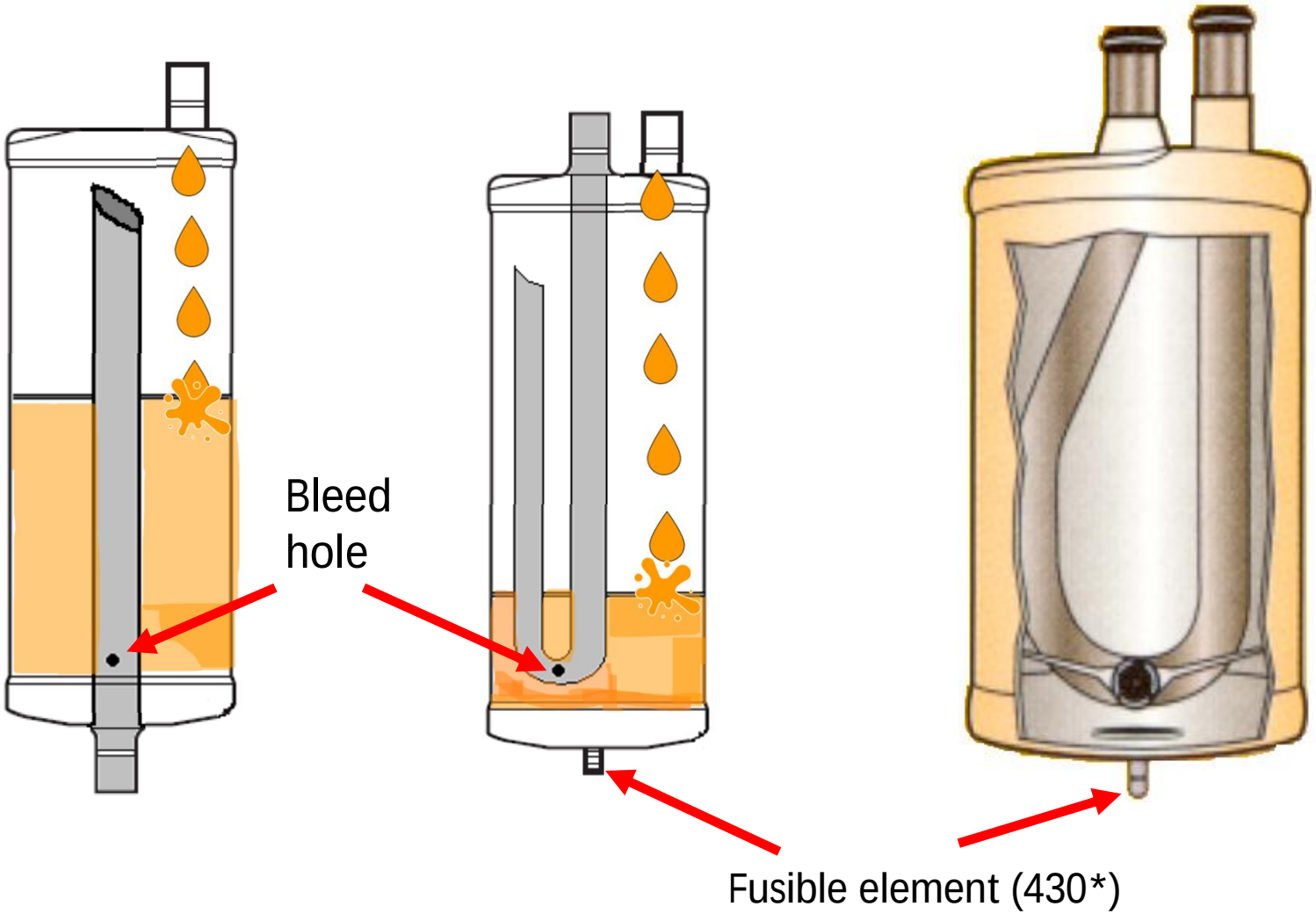
ACCUMULATOR



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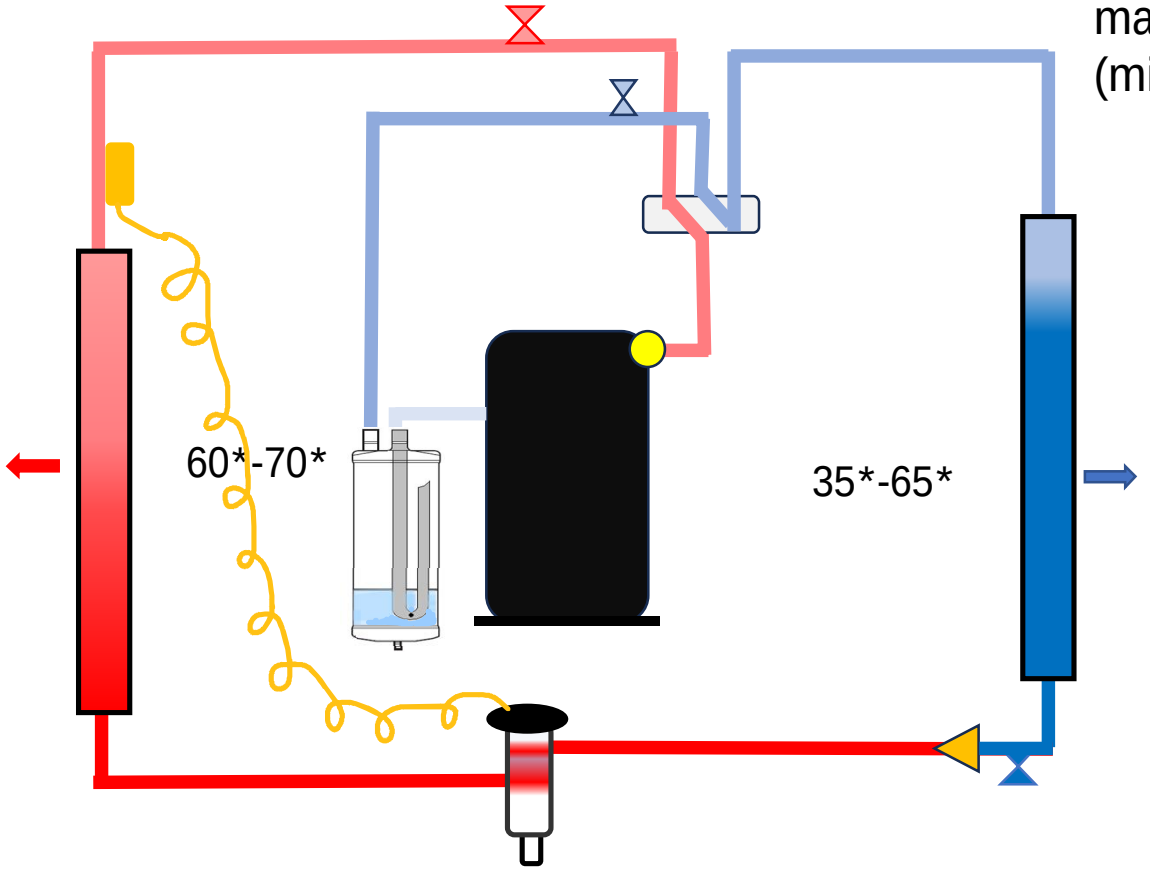
Why use an accumulator?

On colder nights/days refrigerant may not completely vaporize. (mixed phase)

HIGH PRESSURE
HIGH TEMP
VAPOR



LOW PRESSURE
LOW TEMP
VAPOR

HIGH PRESSURE
HIGH TEMP
LIQUID

LOW PRESSURE
LOW TEMP
LIQUID

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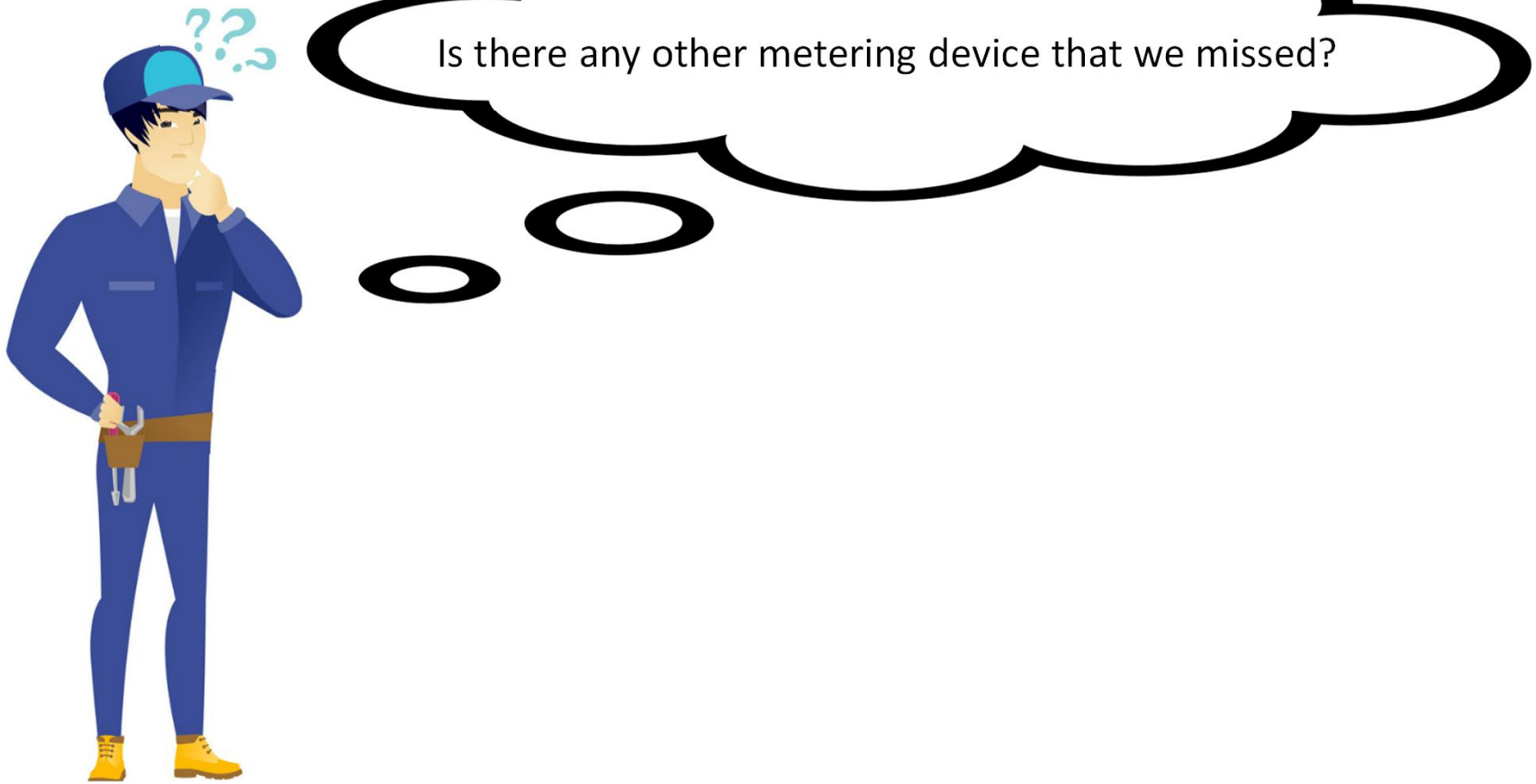

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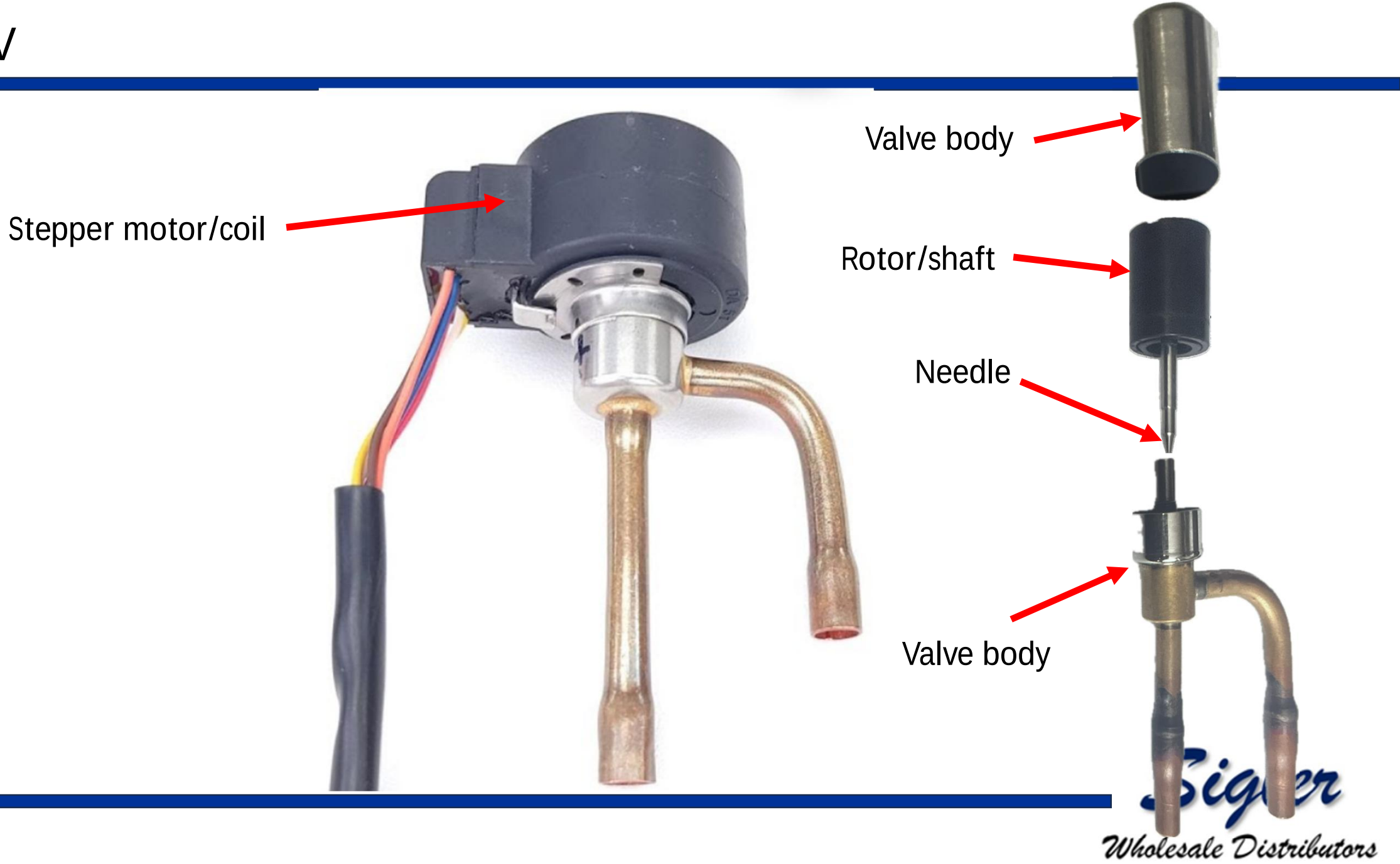
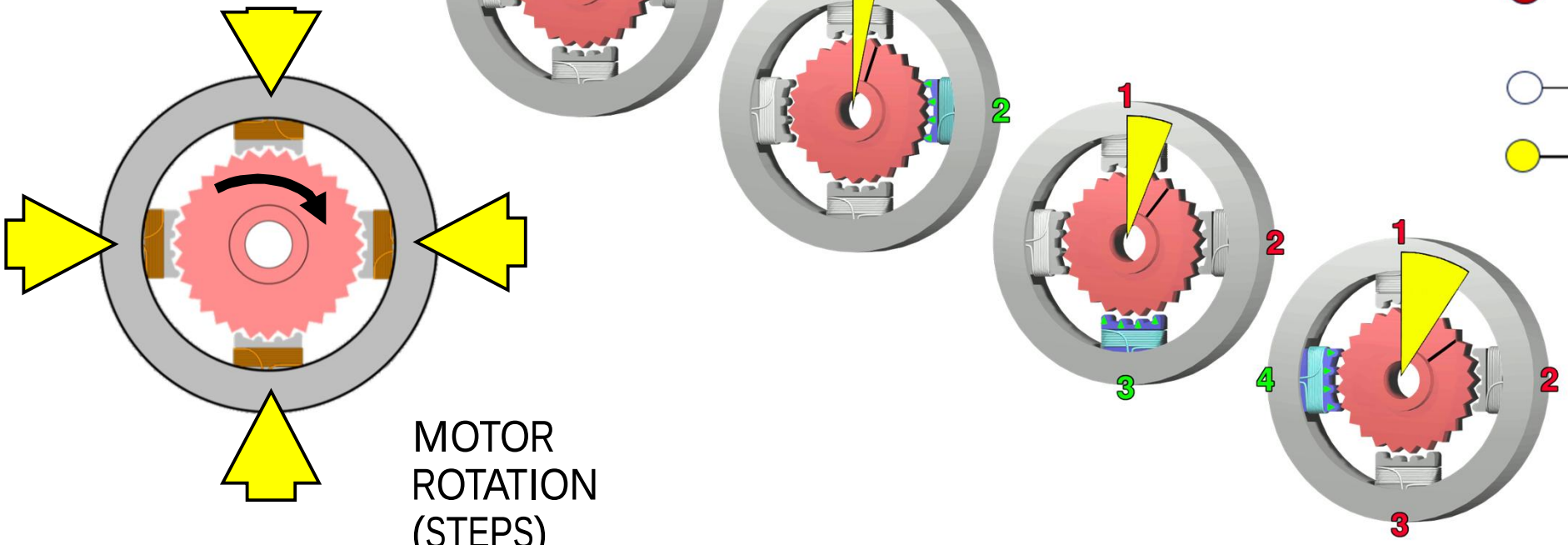
EEV/EXV

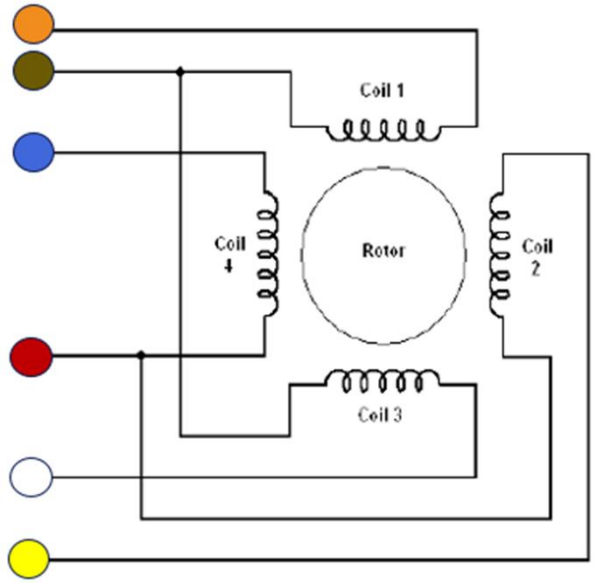


Wholesale Distributors

EEV/EXV

AS EACH SEQUENTIAL COIL
IS ENERGIZED, MOTOR ROTATES
OR “STEPS” IN INCREMENTS





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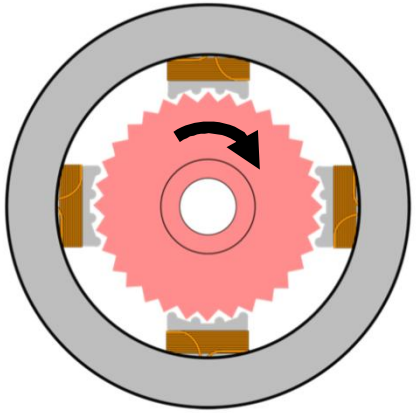
EEV/EXV

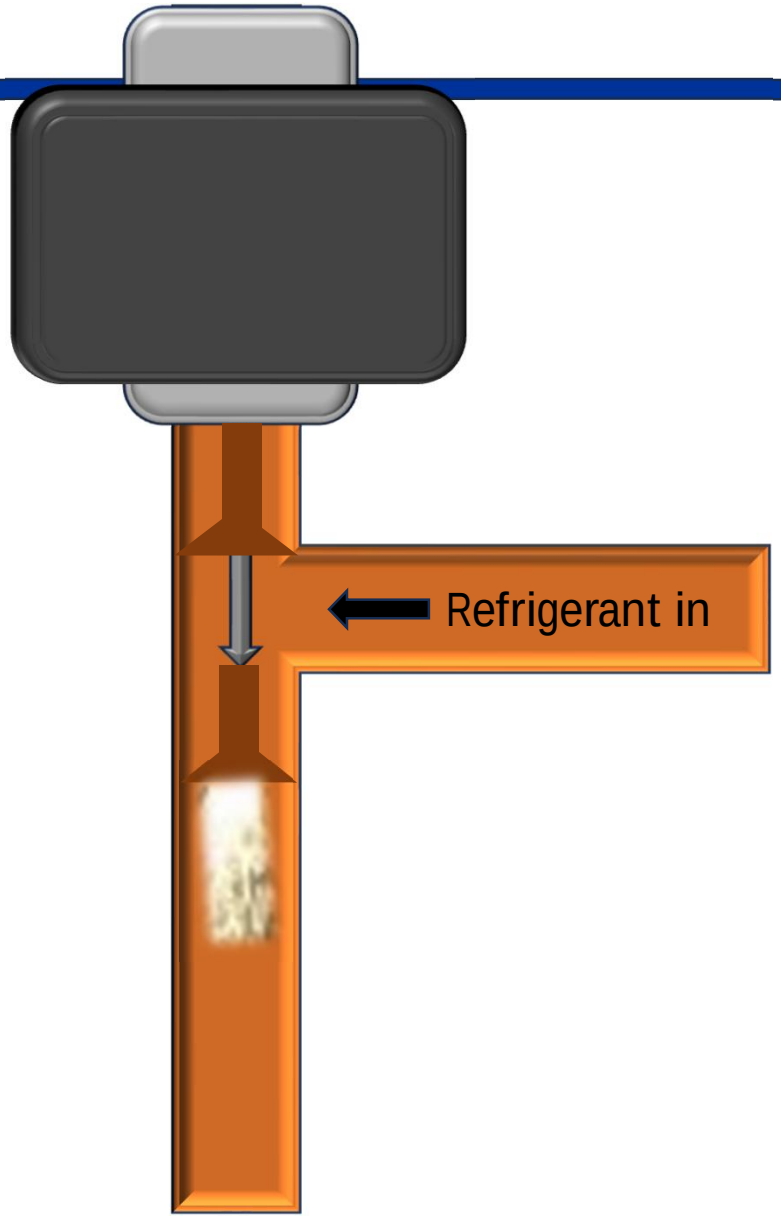
Each time power is applied to the unit the EXV will operate to a known position as the valve does not provide feedback to the PCM of its position.

The PCM software must know the starting point and then count as EXV stepper motor is pulsed(steps)

600 steps from fully open to fully close

EEV/EXV





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EEV/EXV

Condensation can cause build up on the valve body and needs to be cleaned

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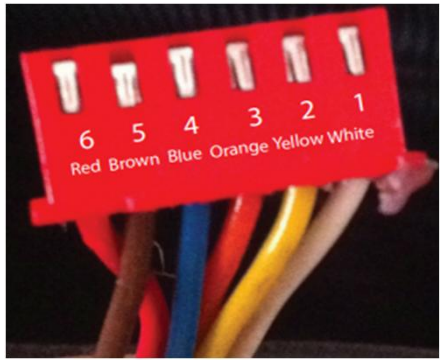
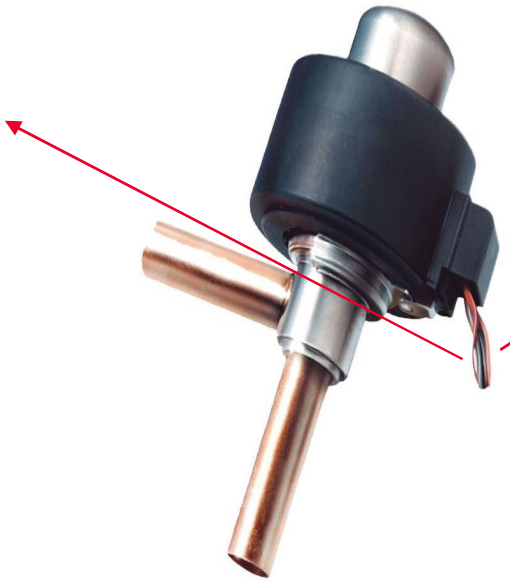
Testing stepper motor





Measurement Pin	Normal Standard
6-4	50Ω
6-2	50Ω
5-3	50Ω
5-1	50Ω

Measurement Pin	Normal Standard
3-1	100Ω
2-4	100Ω
6-5	OL

There may be differences in the resistance depending upon EEV model type

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EEV/EXV

To remove stepper motor from valve body

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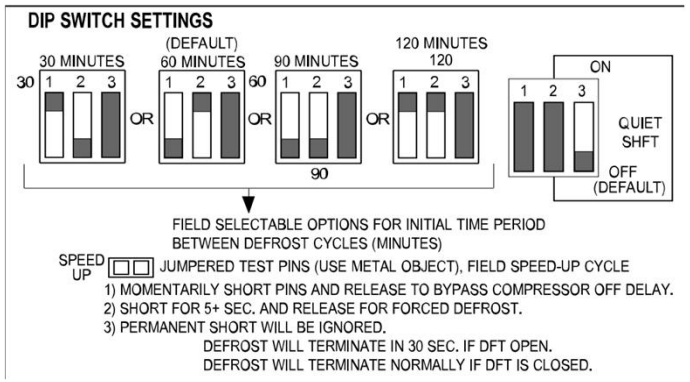
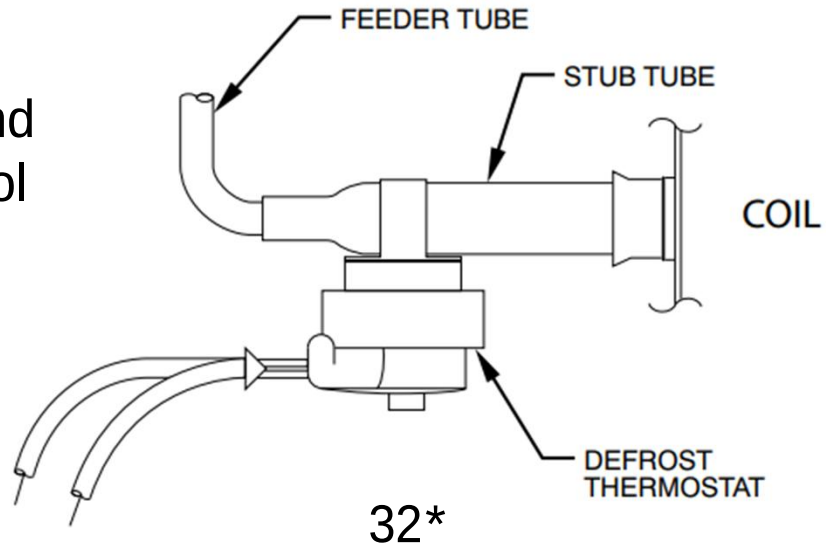
Manual OPEN/CLOSE

DEFROST CONTROL

These settings represent the initial time that must pass after defrost thermostat closes before defrost begins



Defrost is a time and temperature control



32*

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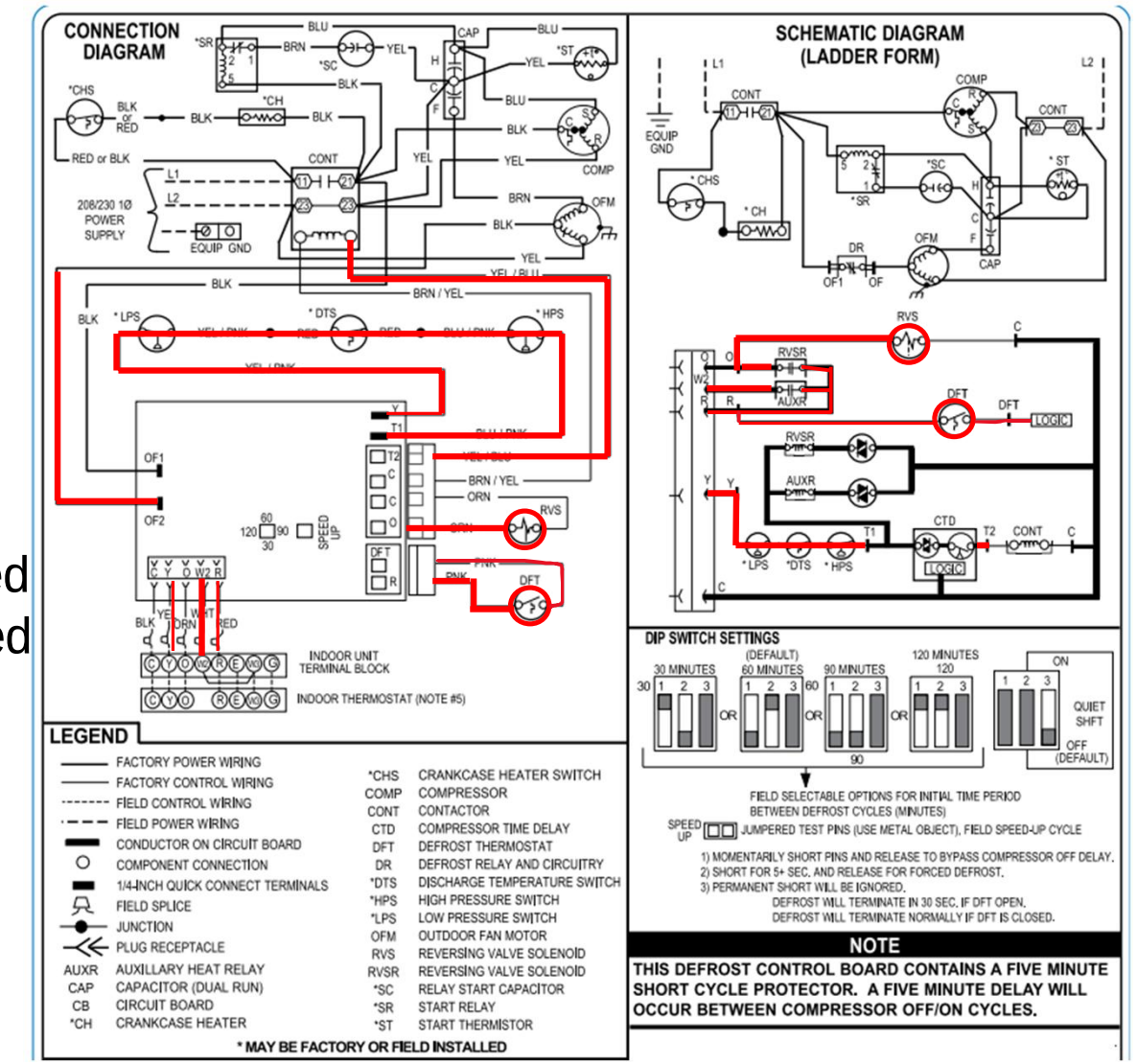
Understanding Defrost

- Call for heating
- Coil ices up and defrost thermostat closes
- Timer starts
- Defrost initiated
- Aux heat energized
- Reversing valve energized
- Outdoor fan de-energized
- Coil defrosts
- Heating resumes



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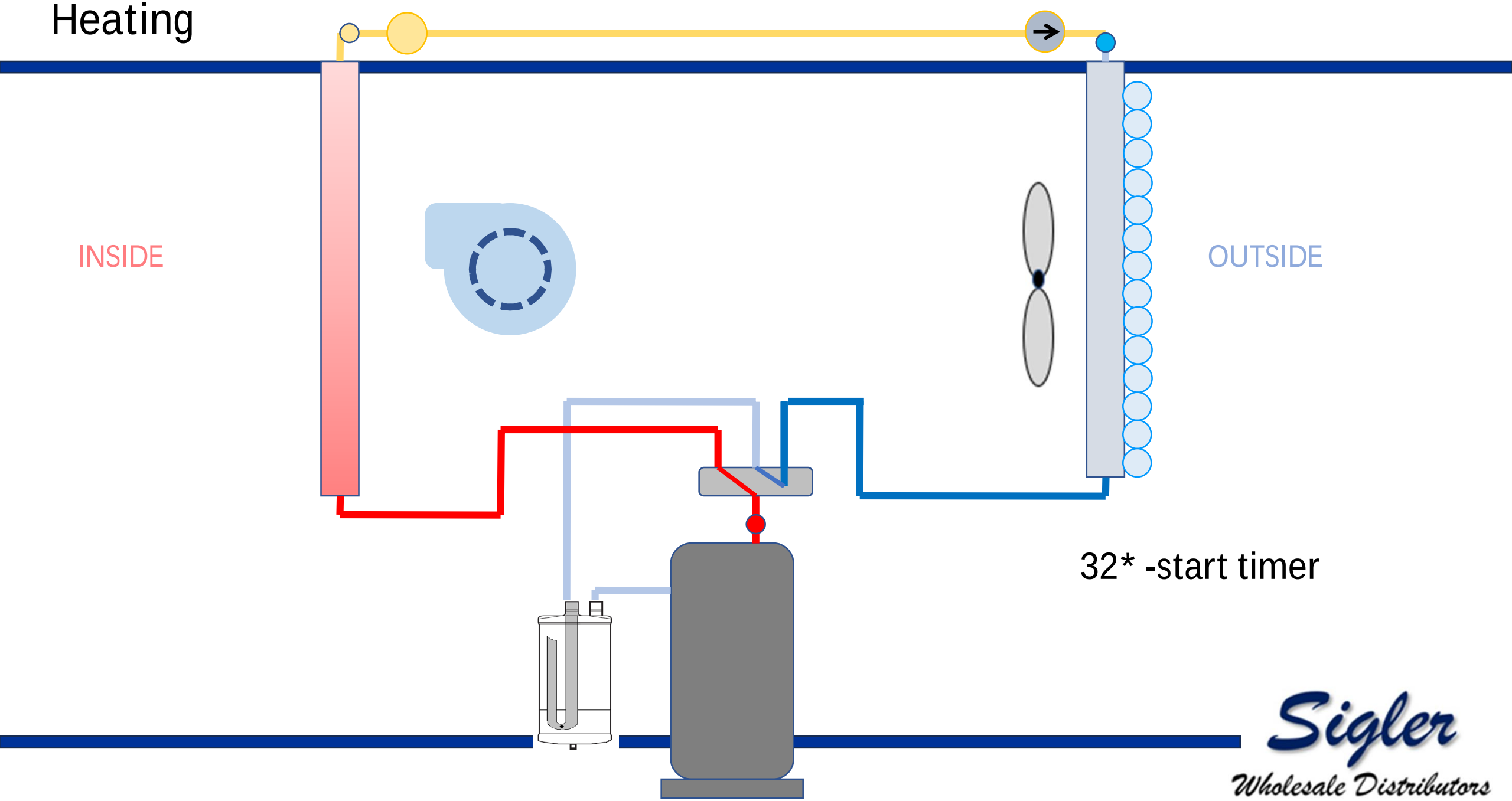
Heating



32* -start timer

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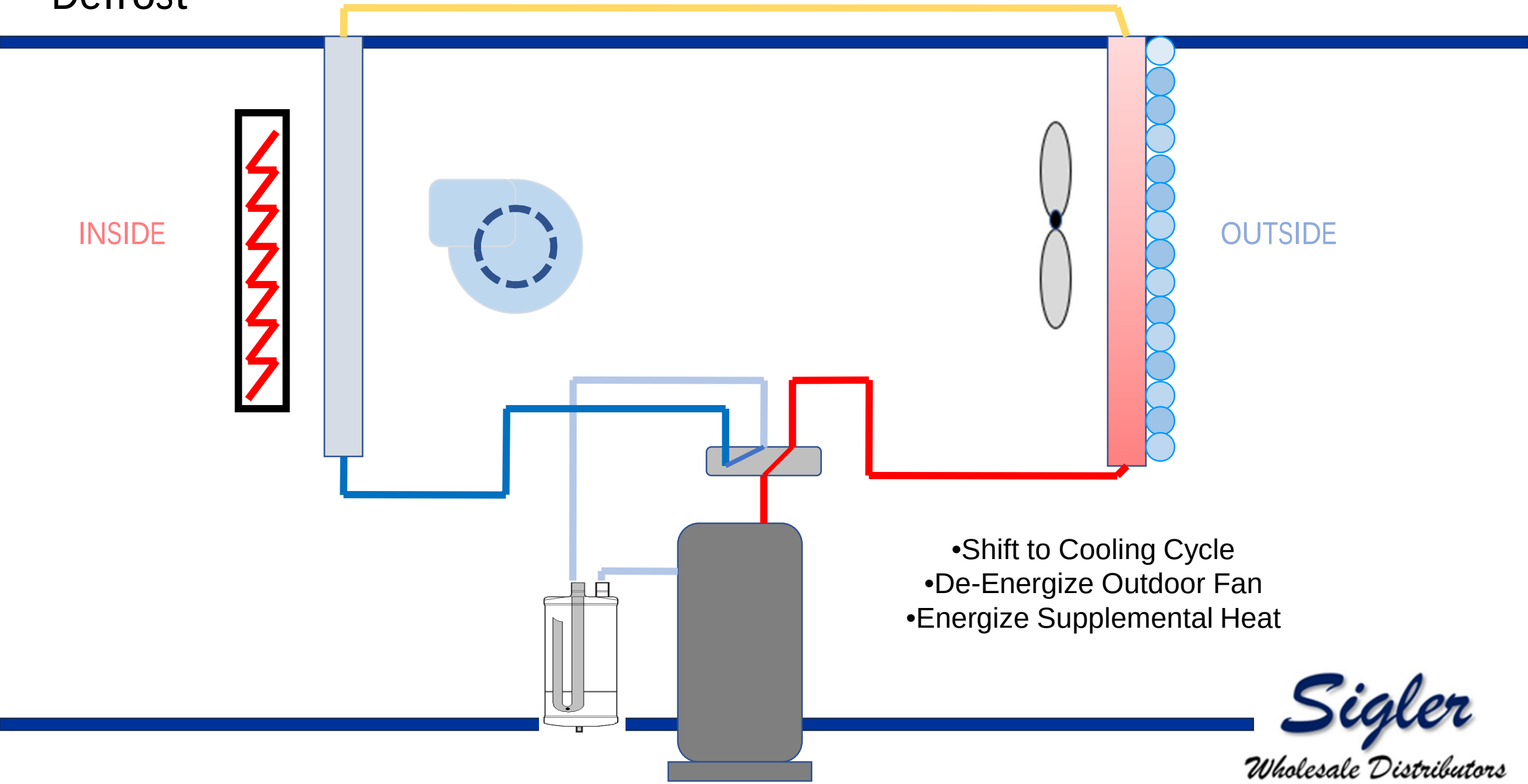
Defrost



- Shift to Cooling Cycle
- De-Energize Outdoor Fan
- Energize Supplemental Heat

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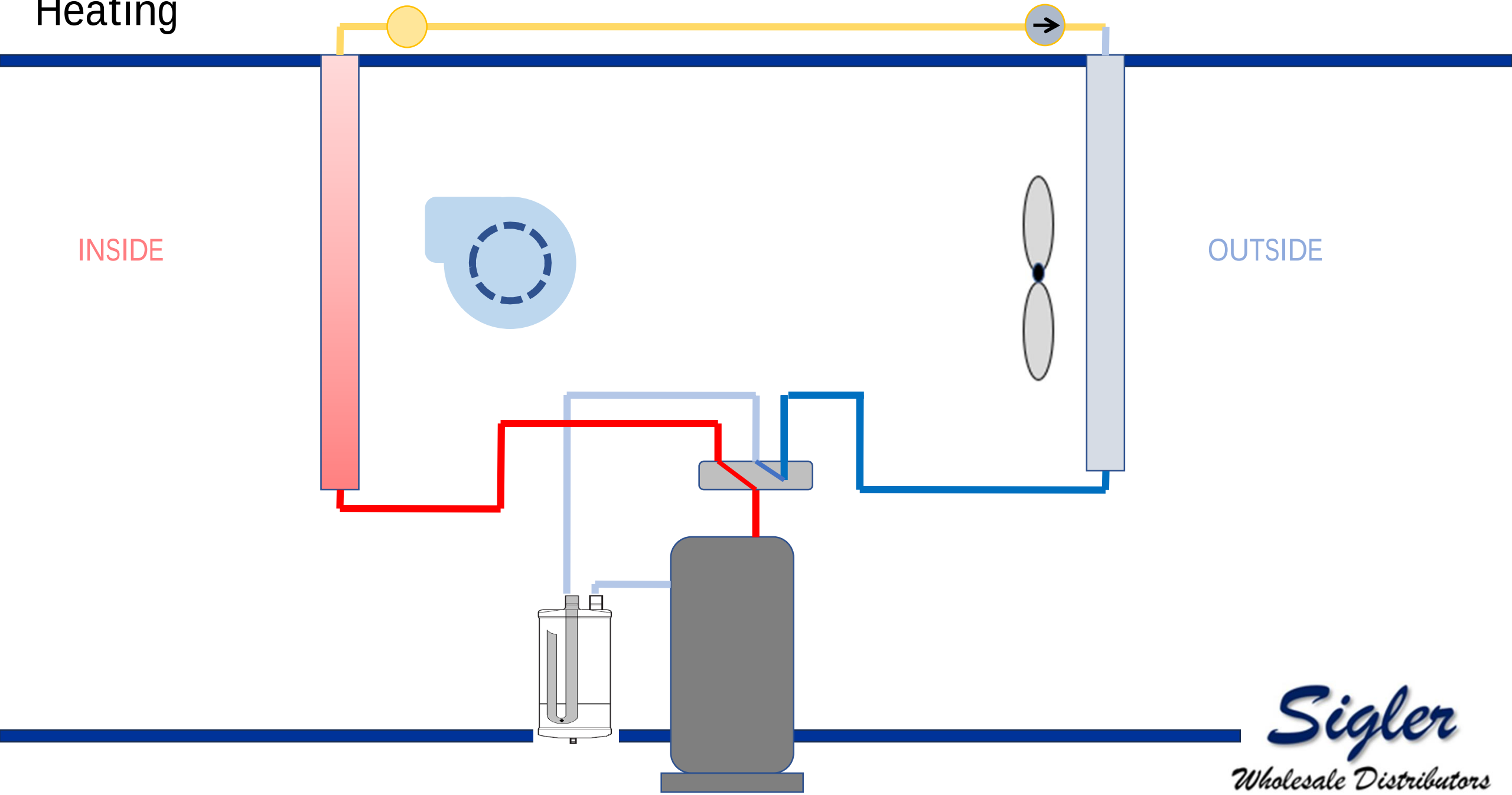
Heating



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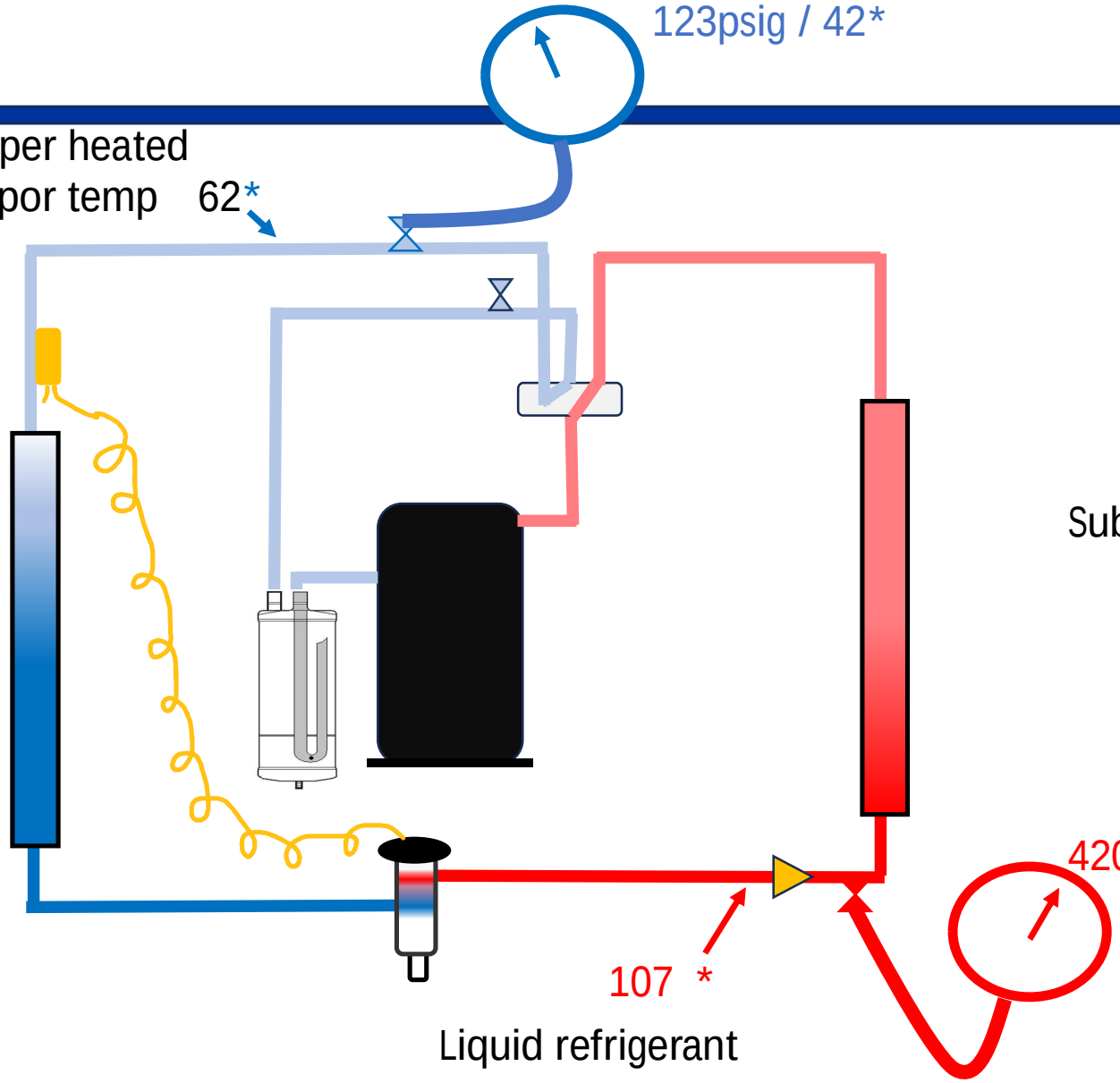
Superheat / Subcool



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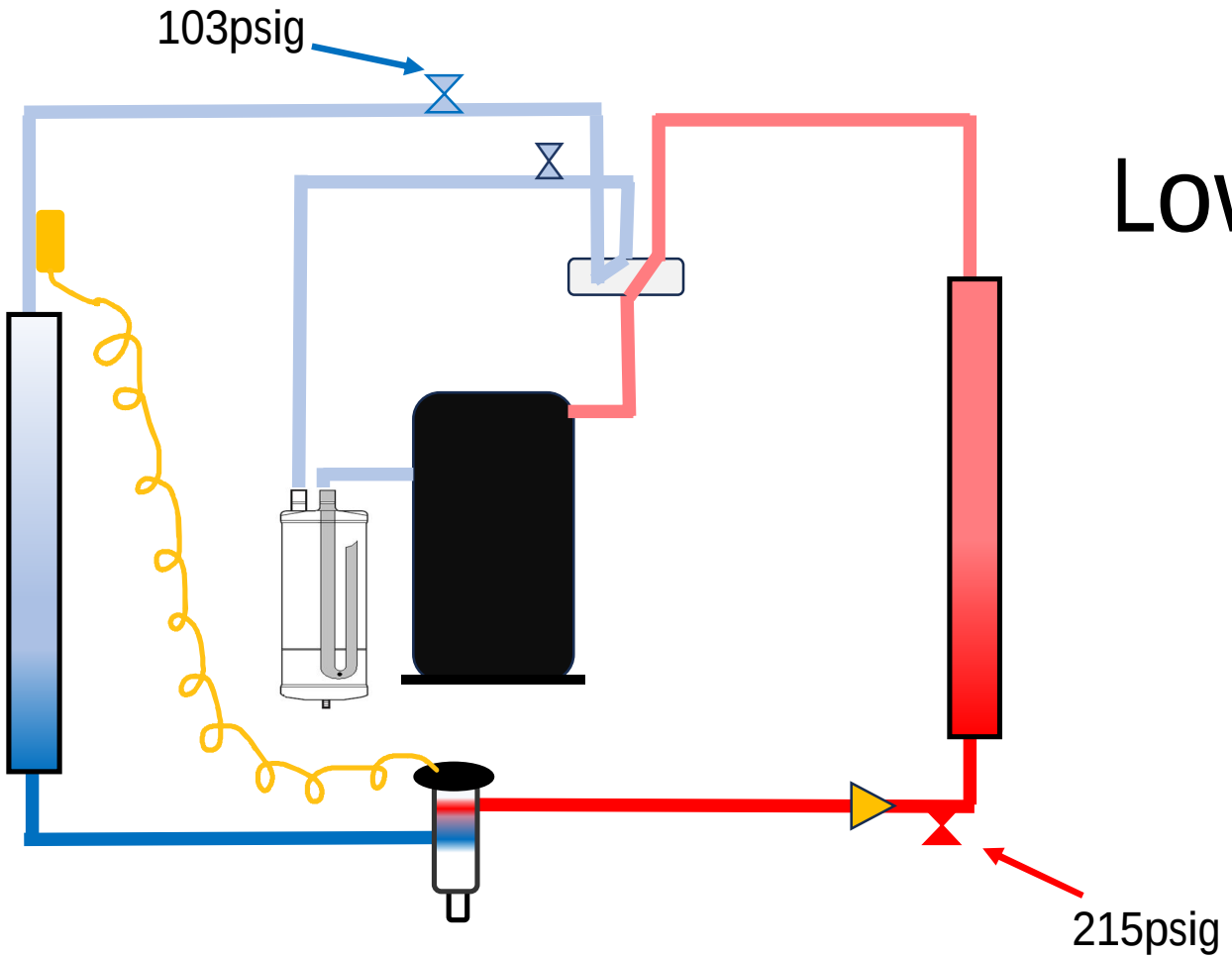
WHAT'S POSSIBLY WRONG?

Outdoor Ambient
93*
Suction pressure
103
Discharge pressure
215
Subcooling
6*
Superheat
25*
Delta T
8*



Low charge

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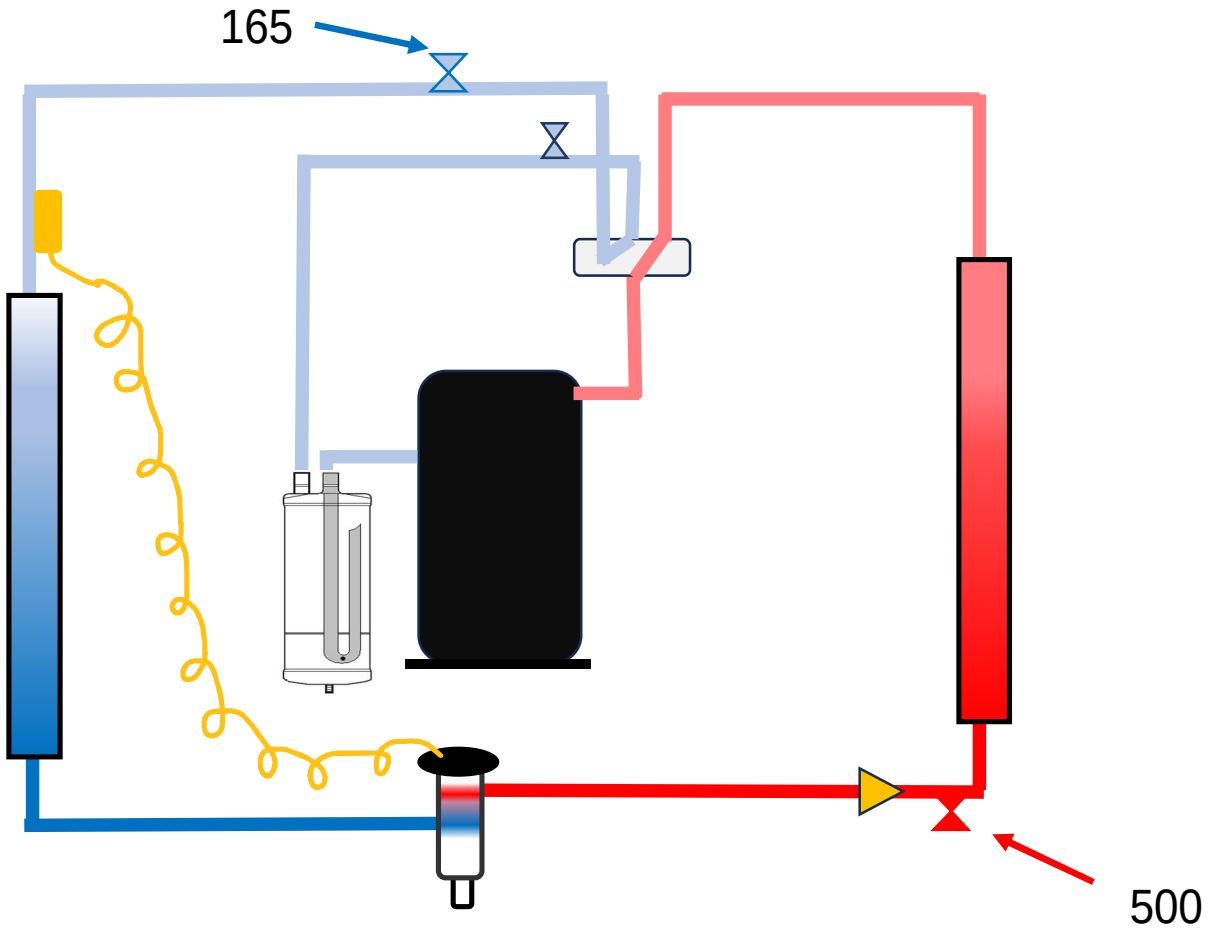
WHAT'S POSSIBLY WRONG?

Outdoor ambient
82
Suction pressure
165
Discharge pressure
500
Subcooling
17*
Superheat
12*
Delta T
20*



Over charged

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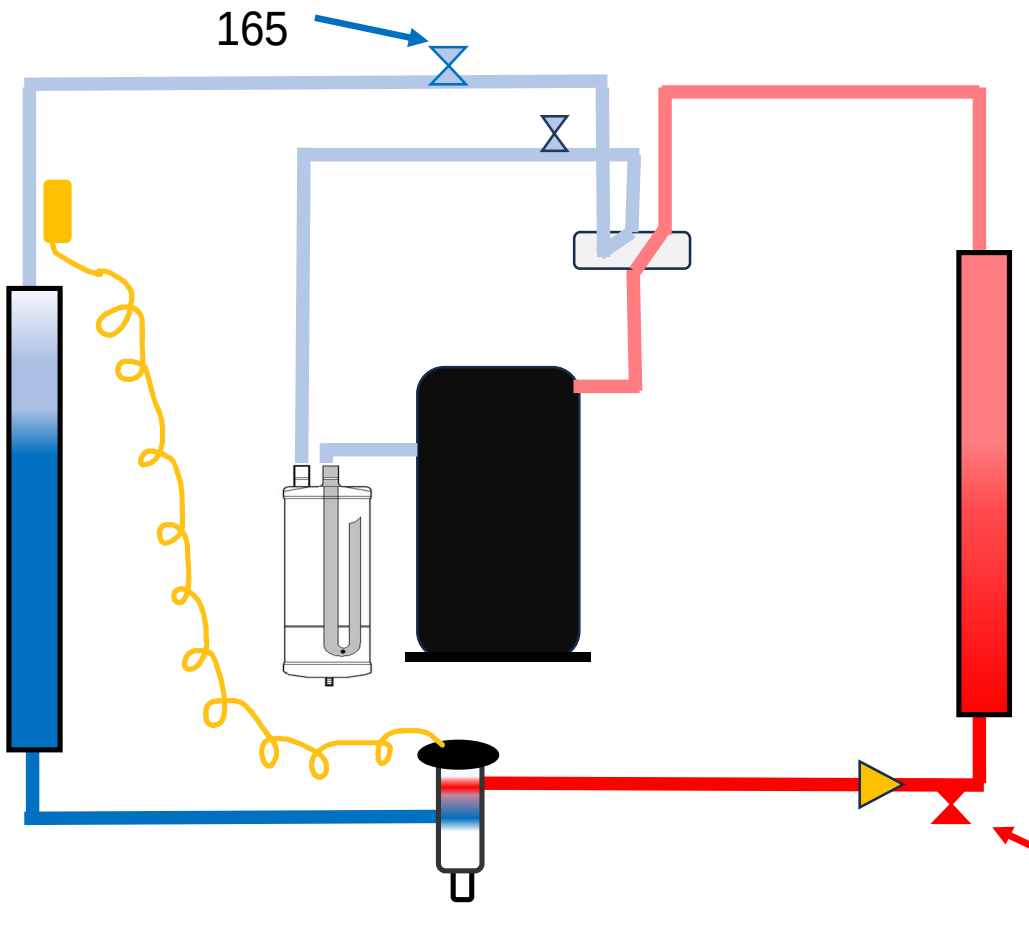
Wholesale Distributors

WHAT'S POSSIBLY WRONG?

Outdoor ambient
90
Suction pressure
165
Discharge pressure
225
Subcooling
5
Superheat
5
Delta T
7



TXV Bulb loose/ overfeeding

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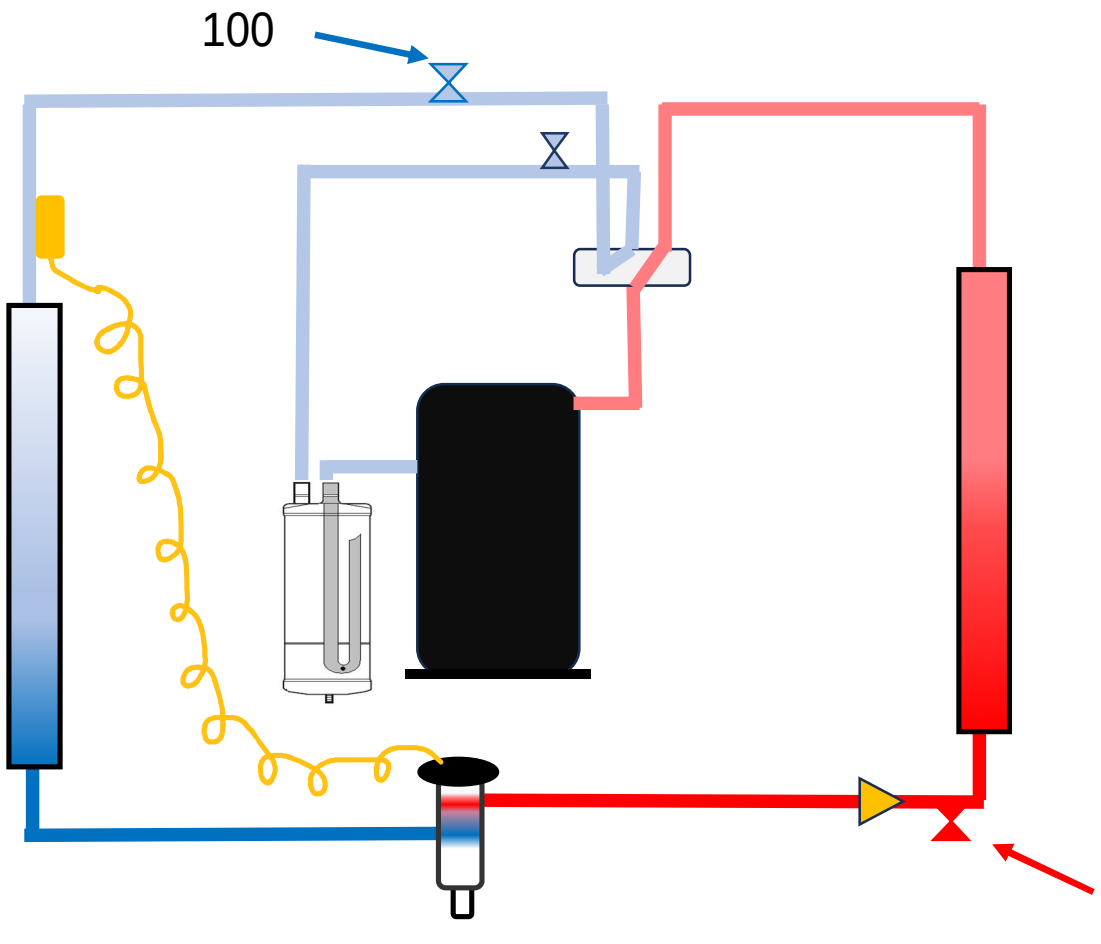
Wholesale Distributors

WHAT'S POSSIBLY WRONG?

Outdoor ambient
90
Suction pressure
100
Discharge pressure
200
Subcooling
12
Superheat
25
Delta T
13



Restriction in condenser coil

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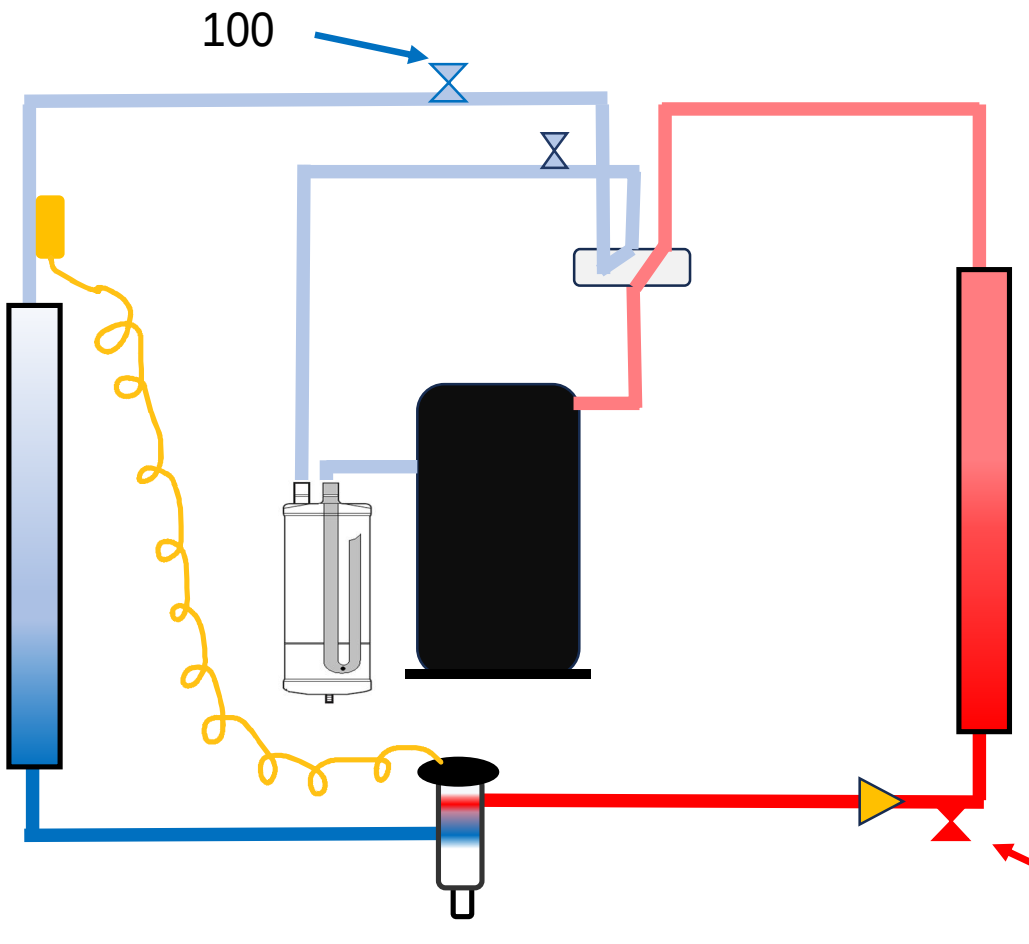
WHAT'S POSSIBLY WRONG?

Outdoor ambient
90
Suction pressure
100
Discharge pressure
450
Subcooling
12
Superheat
25
Delta T
13



Restriction in Liquid line filter dryer

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Filter dryers

Is there really a difference between a one-way filter/dryer and a bi-flow filter/dryer?

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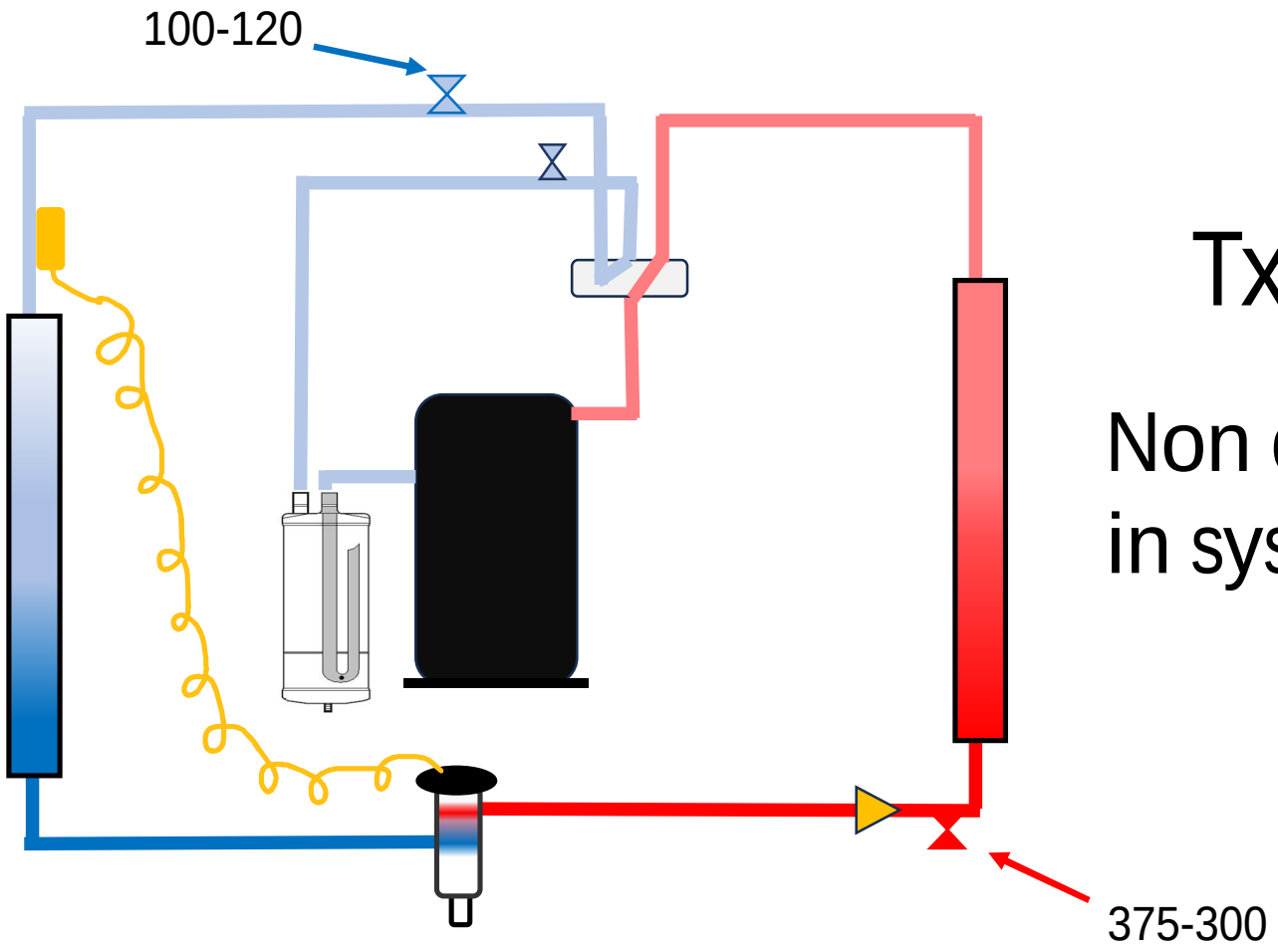
WHAT'S POSSIBLY WRONG?

Outdoor ambient
90
Suction pressure
100-120
Discharge pressure
375-300
Subcooling
8-13
Superheat
20
Delta T
15-20

Pressures "hunting"



Txv bad

Non condensables in system

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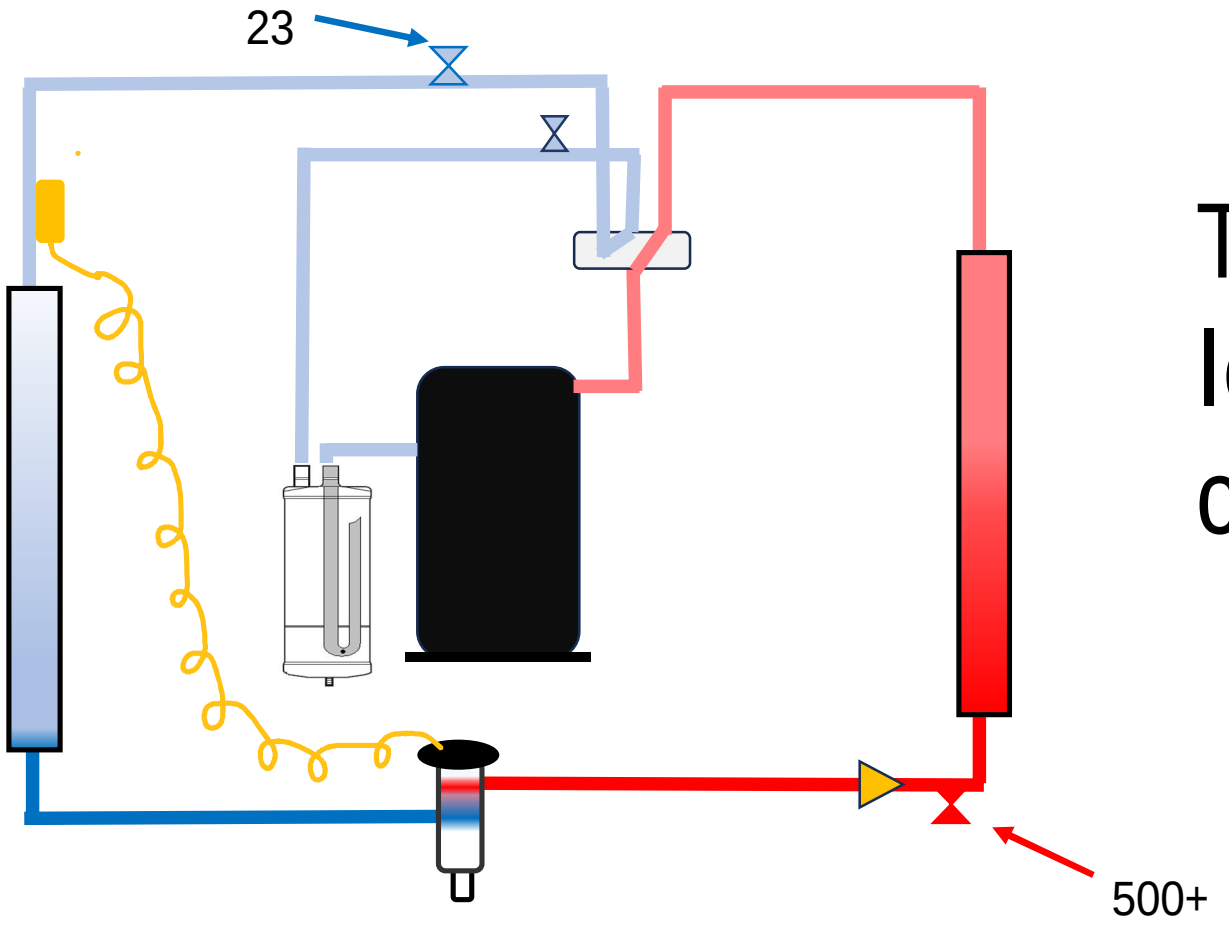
WHAT'S POSSIBLY WRONG?

Outdoor ambient
90
Suction pressure
23
Discharge pressure
500+
Delta T
3
Superheat
30+
Subcool
18



Txv bulb lost charge

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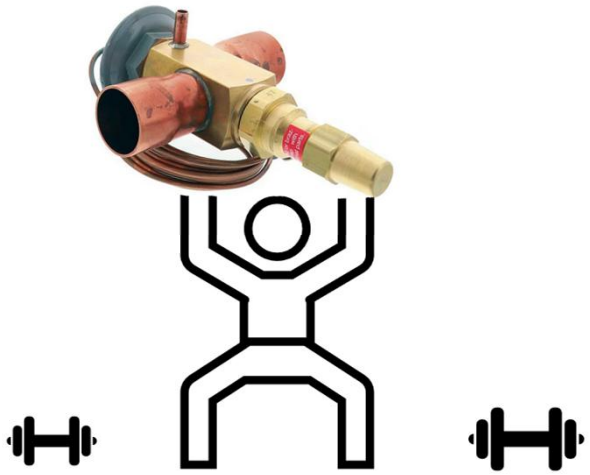
Exercise the TXV bulb



Need to check if TXV is opening/closing? With call for cooling, remove sensing bulb from header pipe and place in cup of warm/cold water. This will cause diaphragm to open/close. Check pressure on manifold gauges to confirm movement.

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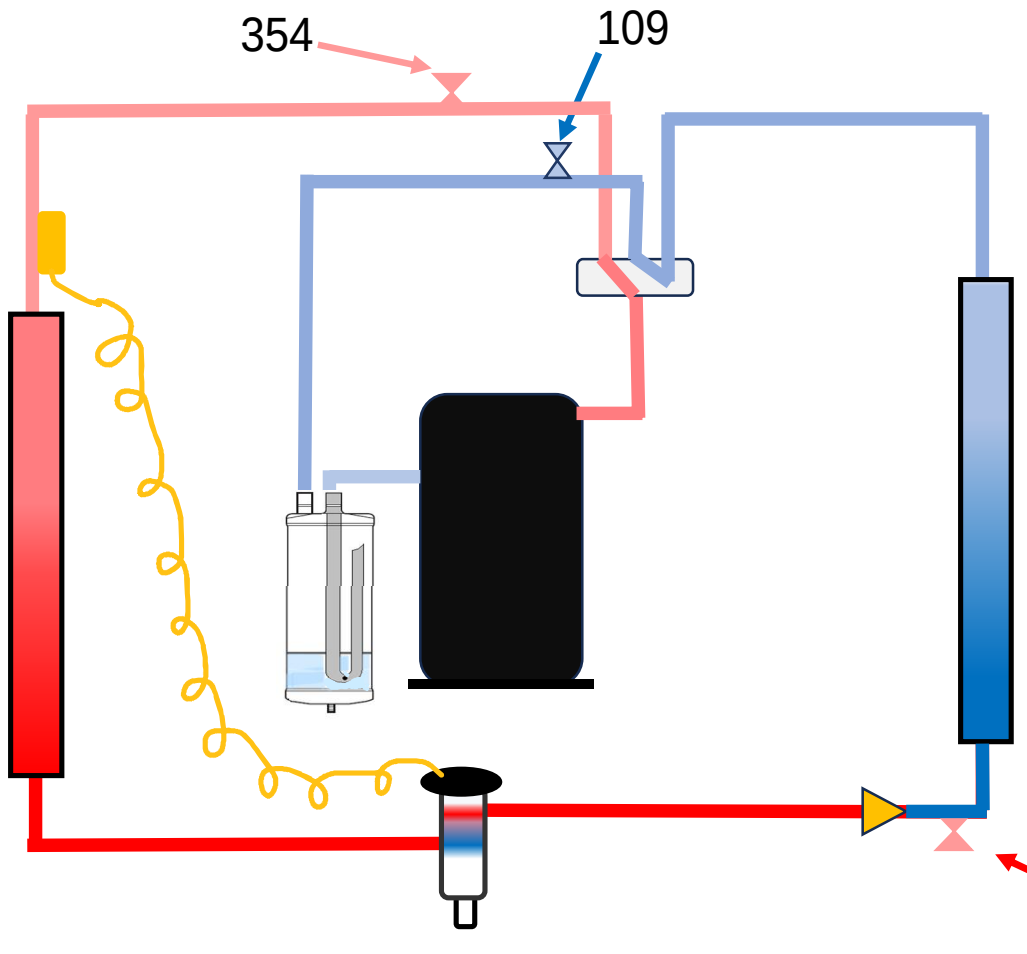
WHAT'S POSSIBLY WRONG?

Indoor ambient
60
Outdoor temp
55
True suction pressure
109
Suction pressure
342
Discharge pressure
354
Delta T
20



Nothing-
In heating
mode

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Charging

Conventional HP

Charging Formula:

[(Lineset oz/ft x total length) – (factory charge for lineset)] = charge adjustment

Total lineset length – 15’ = additional feet requiring charge

Multiply Additional feet x .6oz = Additional charge required

82’ – 15’ = 67’

x .6 = 40.2 oz(2.51 lbs.)

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Charging

Table 3 – Refrigerant Charge Adjustments

Liquid Line Size	Puron Charge oz/ft (g/m)
3/8	0.60 (17.74) (Factory charge for lineset = 9 oz / 266.16 g)
5/16	0.40 (11.83)
1/4	0.27 (7.98)

: System has 15 ft of line set using existing 1/4“ liquid line. What charge adjustment is required?

(.27oz x 15’) - 9oz = - 4.95oz

4.05oz

Remove 4.95oz

System has 45 ft of existing 5/16” liquid line. What is the charge adjustment?

(.40oz x 45’) - 9oz = 9oz

18oz

Add 9oz

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CHARGING

When checking or adjusting charge , CHARGE IN HIGH STAGE ONLY!

When system switches from low to high stage.

- Suction pressure will be reduced by approx. 10-15%
- Compressor current will be increased by approx. 20%-45%

When indoor temp is below 70* or above 80*, or outdoor temp is not within charging “favorable” range(65*-100*), weigh in/adjust charge for line set length only. Then return to check charge when conditions are in a more “favorable” range.

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Charging

IMPORTANT TO READ PRODUCT LITERATURE PRIOR TO ADJUSTING CHARGE

38MURA

System Size	Max. Piping Length with no additional refrigerant charge per System	Additional refrigerant charge
	ft. (m)	Oz/ft (g/m)
18K	24.6 (7.5)	0.69 (65)
24K - 30K		
36K - 60K		

DLS MULTI-ZONE

UNIT SIZE	ZONES	CHARGE OZ. (KG.)	ADDITIONAL CHARGE REQUIRED AFTER FT. (M)	ADDITIONAL CHARGE OZ./ FT. (G/M)
18	2	70.55 (2.0)	49 (15)	0.16 (15)
24	3	98.76 (2.8)	74 (22.5)	
30	4	105.82 (3.0)	98 (30)	
36	4	162.26 (4.6)	123 (37.5)	
[illegible]	5	162.26 (4.6)	123 (37.5)	

DLS SINGLE-ZONE

	SYSTEM SIZE		36K	48K
Piping	Min. Piping Length	ft (m)	10 (3)	10 (3)
	Standard Piping Length	ft (m)	25 (7.5)	25 (7.5)
	Max. outdoor - indoor height difference (OU higher than IU)	ft (m)	98 (30)	98 (30)
	Max. outdoor - indoor height difference (IU higher than OU)	ft (m)	98 (30)	98 (30)
	Max. Piping length with no additional refrigerant charge	ft (m)	25 (7.5)	25 (7.5)
	Max. Piping Length	ft (m)	213 (65)	213 (65)
	Additional refrigerant charge (between Standard - Max piping length)	Oz/ ft (g/m)	0.32 (30)	0.32 (30)
	Gas Pipe (size - connection type)	in (mm)	5/8 (16)	5/8 (16)
	Liquid Pipe (size- connection type)	in (mm)	3/8 (9.52)	3/8 (9.52)
Refrigerant	Refrigerant Type	- -	R410A	R410A
	Charge Amount	Lbs (kg)	7.05 (3.2)	9.92 (4.5)

Sigler Wholesale Distributors

Heating check charge

Only to check if charge is correct/do not adjust charge to chart

Indoor txv – outdoor txv

Outdoor temp 45*

Indoor temp 60*

FIELD OPERATING PRESSURE CHARGING TABLE FIXED RESTRICTOR
(HIGH PRESSURE @ VAPOR VALVE, SUCTION PRESSURE @ SUCTION SERVICE PORT)

UNIT	INDOOR DRY BULB		OUTDOOR TEMP. °F DRY BULB/WET BULB						
			60/56	50/47	40/38	30/28	20/18	10/9	0/-1
024	60°	HIGH	408	363	319	292	265	247	229
		SUCT	139	120	101	86	70	57	44
	70°	HIGH	447	400	353	326	300	281	261
		SUCT	141	121	101	86	71	58	46
	80°	HIGH	485	437	389	363	337	317	297
		SUCT						59	46
036	60°	HIGH	331		310			246	230
		SUCT						55	43
	70°	HIGH	102		91			280	264
		SUCT						56	45
	80°	HIGH	454	424	395	365	335	318	301
		SUCT	124	110	97	83	68	57	46
048	60°	HIGH	397	363	330	299	268	252	237
		SUCT	121	106	91	77	63	52	42
	70°	HIGH	445	403	361	333	305	288	271
		SUCT	124	107	90	77	65	54	43
	80°	HIGH	488	443	397	370	343	324	306
		SUCT	128	108	89	77	65	54	43
060	60°	HIGH	368	343	318	289	259	247	234
		SUCT	114	102	91	75	58	48	37
	70°	HIGH	412	386	359	330	301	284	268
		SUCT	118	106	94	78	62	50	38
	80°	HIGH	463	431	399	368	337	321	306
		SUCT	123	109	95	78	61	50	39

Check product literature for specific heating check chart

Sigler Wholesale Distributors

Heating check charge

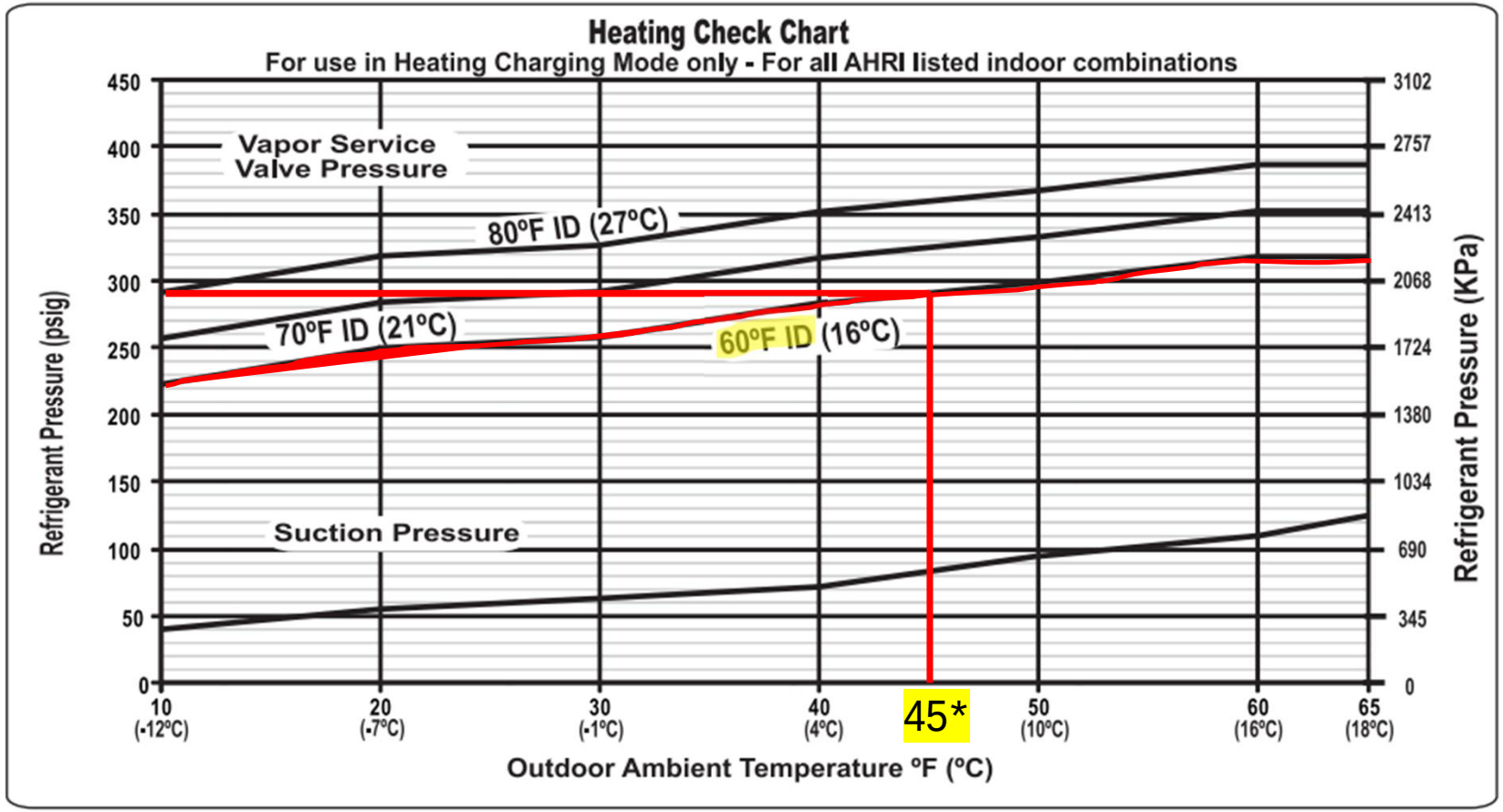
Only to check if charge is correct/do not adjust charge to chart

Indoor temp- 60*

Outdoor temp- 45*

Vapor pressure- 295psig

Pressure taken at vapor service valve-
If taken from liquid service valve add 12psig.
(295+12=308)



Check product literature for specific heating check chart

Indoor txv – outdoor eev

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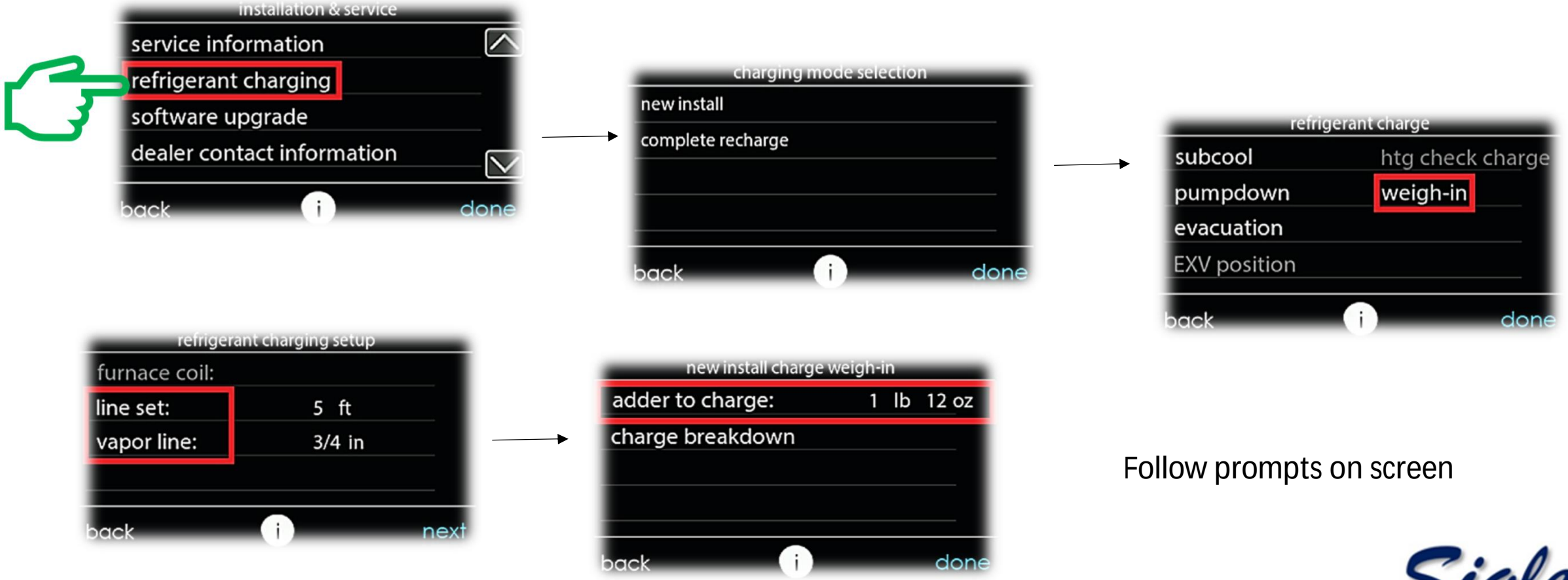
Infinity charging with UI

Touch and hold cap until it turns GREEN

Infinity charging with UI

Input required information



Follow prompts on screen

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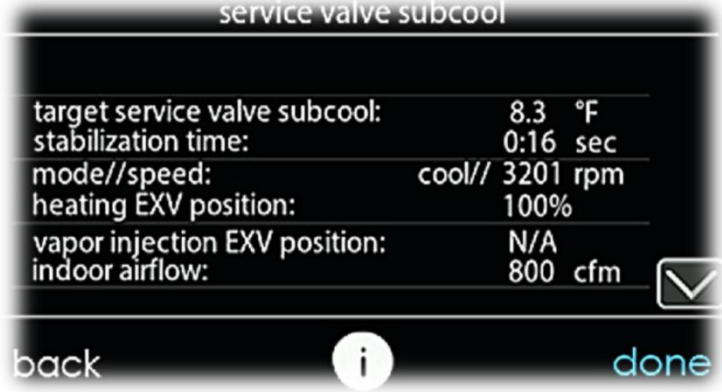
Infinity charging with UI

- Charge can be checked by subcool, ONLY if…….
  - Outside temps between 65 and 100?
  - Indoor temps between 70 and 80?
  - Subcool can only be accurately adjusted when in charging mode



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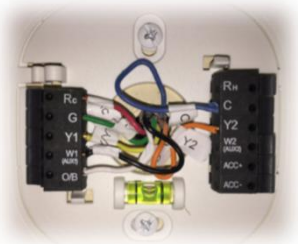
WIRING



24VAC — R

COM — C

FIRST STAGE COMPRESSOR — Y1

SECOND STAGE COMPRESSOR — Y2

REVERSING VALVE/HEATING — B

REVERSING VALVE/COOLING — O

OUTPUT SIGNAL FOR ELECTRIC STRIPS — W2

W2 automatically energizes during defrost cycle

OUTPUT SIGNAL FOR ELECTRIC STRIPS — AUX

Aux heat automatically energizes to assist HP

OUTPUT SIGNAL FOR SECONDARY HEAT — E

Emergency heat is manually switched on at stat

*

Only used when a second heat source is installed (electric strips, gas furnace)

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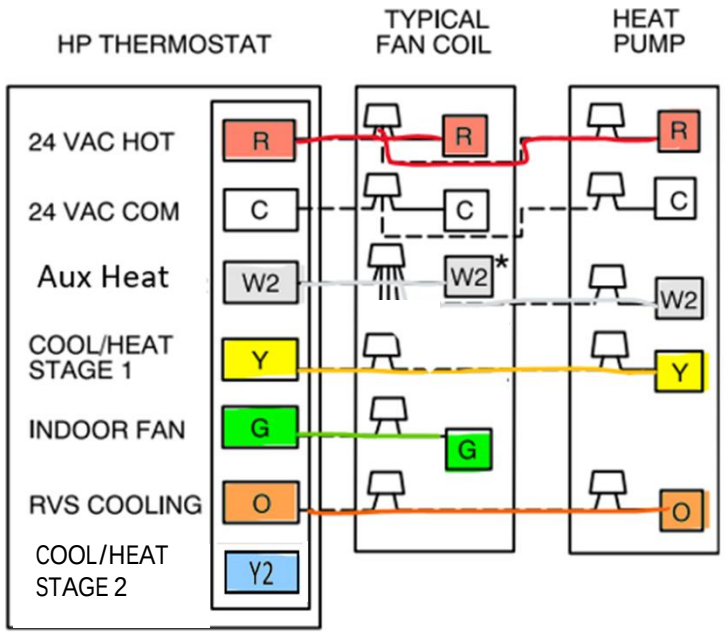
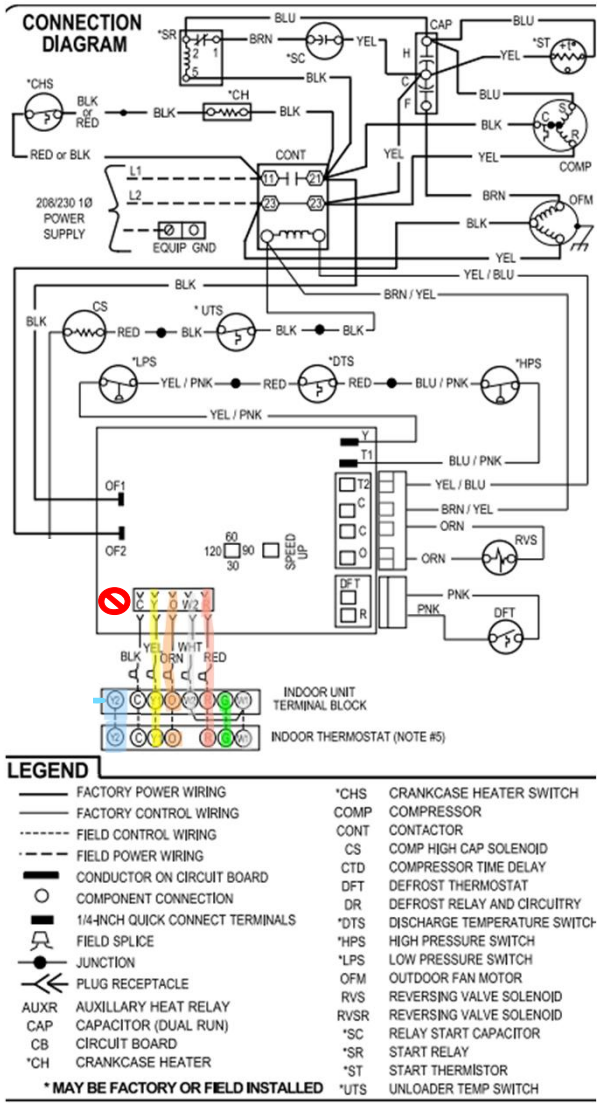
WIRING STAGE 2





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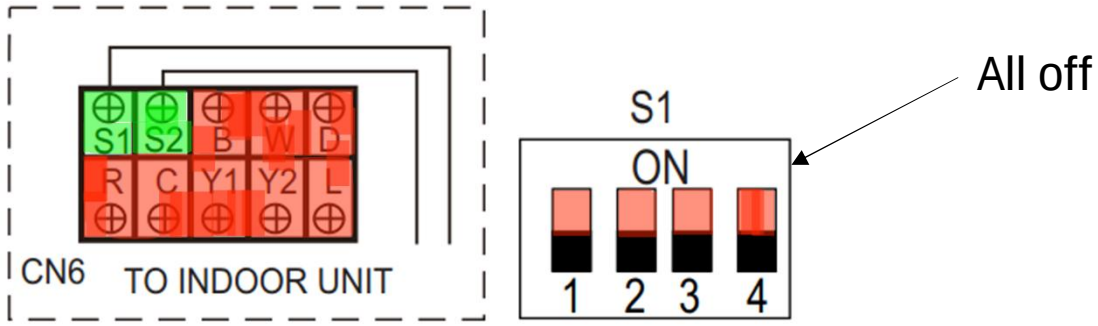
38MURA WIRING

RS485 Communication

Only when using 40MUAA fan coil

16 awg (shielded stranded)



Dip Switch	Function	ON	OFF
SW-1	Metering Device Adjustment	Does not impact this system	
SW-2	Communication Mode IDU-ODU	24V communication	[Default] RS485 communication, S1+S2
SW-3	Recovery Time Enhancement	Increased compressor frequency for quicker recovery to setpoint	[Default] Normal compressor Operation
SW-4	Function not defined/Future use		

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38MURA WIRING

Conventional 24Vac

R	24V Power Connection
C	Common
Y1	Low Demand Slower compressor
Y2	High Demand Faster compressor
B	Heating Reversing Valve
W	Heating Control
D	Defrost - (24V output signal)
L	System Fault - (24V output signal)

Required if using ”D”

Required

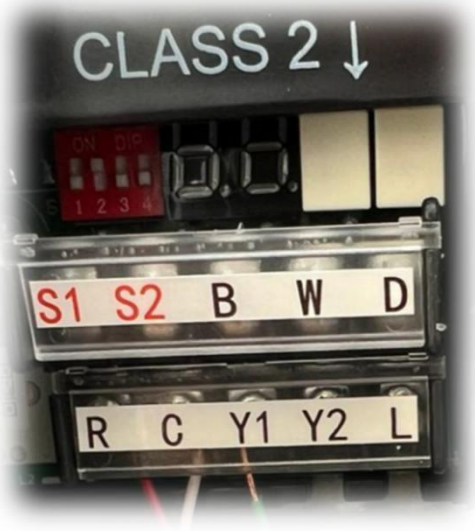
Low stage compressor

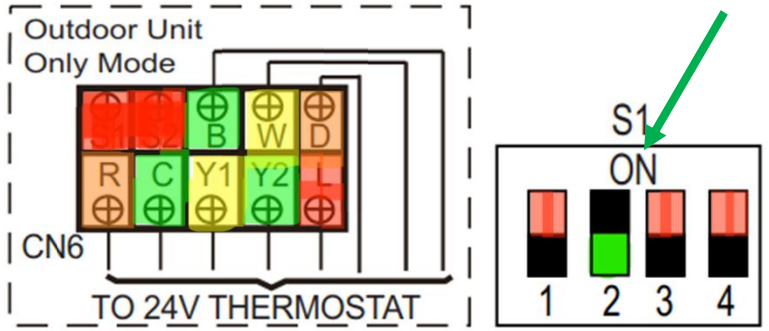
Required

Required

Can be used with conventional t-stat

If using electric heat strips





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R454-B Requirments

Requirement	R410a	R454b
Remove refrigerant safely following local & national codes	Required	Required
Purge circuit with inert gas (nitrogen)	**Best Practice**	Required
Evacuate	**Best Practice**	Required
Purge with inert gas for 5 min.	**Best Practice**	Required
Evacuate again	**Best Practice**	**Required**
Open the circuit by cutting or brazing	Final Step	Final Step
For repairs, purge with nitrogen during brazing	Required	Required
Pressure test	**Best Practice**	Required
Leak test	**Best Practice**	Required
Evacuate system again after service	Required	Required
Charge system	Required	Required

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Important steps to follow when servicing R-454B systems

- Access system for service
- Make repair
- Conduct leak test
- Conduct pressure test
- Evacuate to 500 microns prior to charging (not to rise above 1500 microns in 10 minutes)
- Charge carefully and slowly in liquid state per manufacturer recommendations

Field service procedures with R454-B

If there is no need to access the condensing unit, pump down of the refrigerant into the condensing unit is allowed

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Recovery

- Always recover refrigerants into an approved container
- Clearly mark the container for refrigerant type
- Never mix refrigerant types

R454-B Recovery cylinders

Recovery cylinders

- Yellow Top – A1
- Yellow top with Red band – A2L

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Inert gas purge/Nitrogen

- Sweep system with nitrogen to help release any trapped refrigerant
  - Additional nitrogen sweep required after 1st sweep to ensure trapped refrigerant is pulled out

R454-B piping connections

- Straight stub outs/need to swage if brazing
- Push fit and press fit connections are allowed

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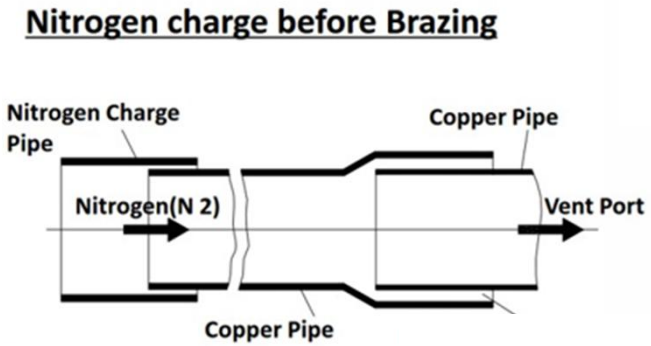
Flow nitrogen when brazing

- Flow nitrogen while brazing
  - Flow nitrogen through system while making brazes



Combustion of refrigerant ==> HF ==> Hydrofluoric acid

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Pressure test

Pressure testing

- Pressure test with nitrogen
- Hold for 1 hour with no drop in pressure
- Required

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Leak check with electronic leak detector

Leak test

- Required after repairs
- Trace gas test for leaks in hard-to-find locations
- Leak test prior to evacuations

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Double Evacuation

- Double evacuation REQUIRED
  - Purge with 2-3 psig nitrogen
  - Evacuate to 500 microns (not to rise above 1500 microns in 10 minutes)
  - Break vacuum with nitrogen to 0 psig
  - Evacuate to 500 microns (not to rise above 1500 microns in 10 minutes)

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Charging

- NEVER exceed maximum allowable charge weight
- Always charge as liquid
- Never mix refrigerants
- Always charge by subcool/superheat
- Weigh in charge during winter as necessary
- Verify charge when temperature exceeds 65° F outside and 70° F inside

Install considerations

- A2L not a “drop-in” refrigerant
- Systems & equipment must be designed for R454-B

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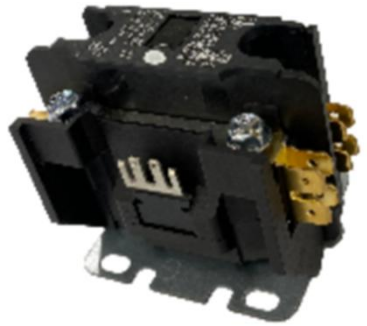
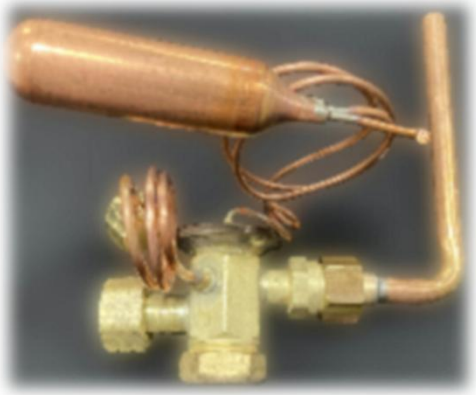
R454-B differences

- Cylinders will have left hand threads
- Split system contactor will be enclosed to prevent spark/coil terminals will be 1/8”
- TXVs will have fully mechanical connections





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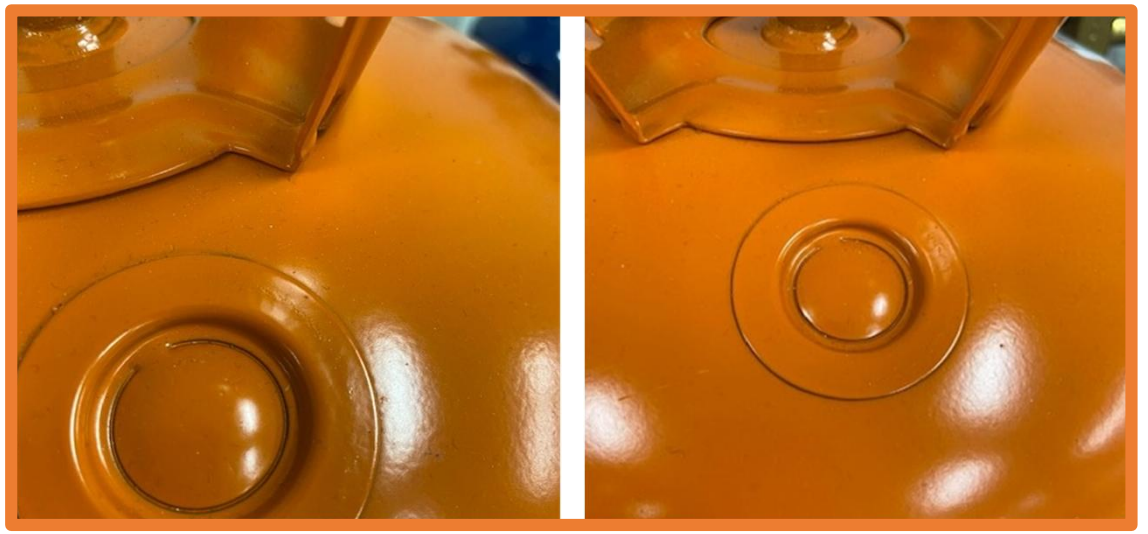
R454-B Cylinder disposal

Pressure safety design features

A1: Rupture disc



A2L: Pressure relief valve

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R454-B Cylinder disposal

Cylinder end of life handling

- A1: Remove or puncture rupture disc

- A2L: Puncture side of cylinder

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R454-B Recap

A2L refrigerant cylinders:

- Red top
- Left-handed thread
- Pressure relief valve
- Flammable and Compressed Gas labels

Worksite safety & best practices:

- Dedicated gauges & hoses
- Refrigerant leak detector for personal protection

  Electronic tools must be spark-proof

  Verify tools and equipment are safe for R454-B

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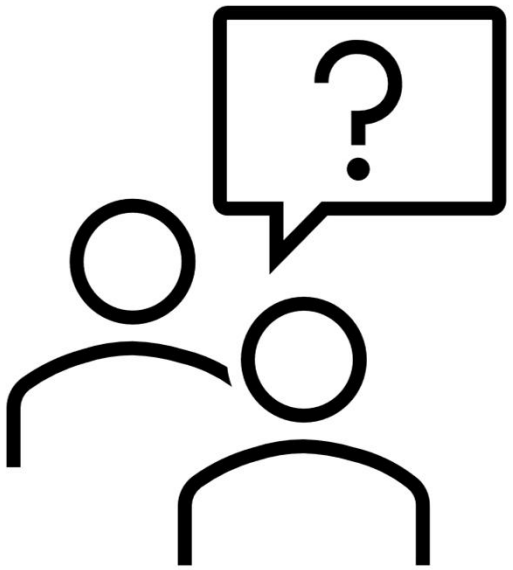
Questions



Comments

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THANK YOU

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