Basic Electricity and Troubleshooting for General applications

Instructor: Brian Edmiston
Carrier Enterprise Tech Support
1-800-264-2512

Training will resume in:

10:00

Carrier Enterprise

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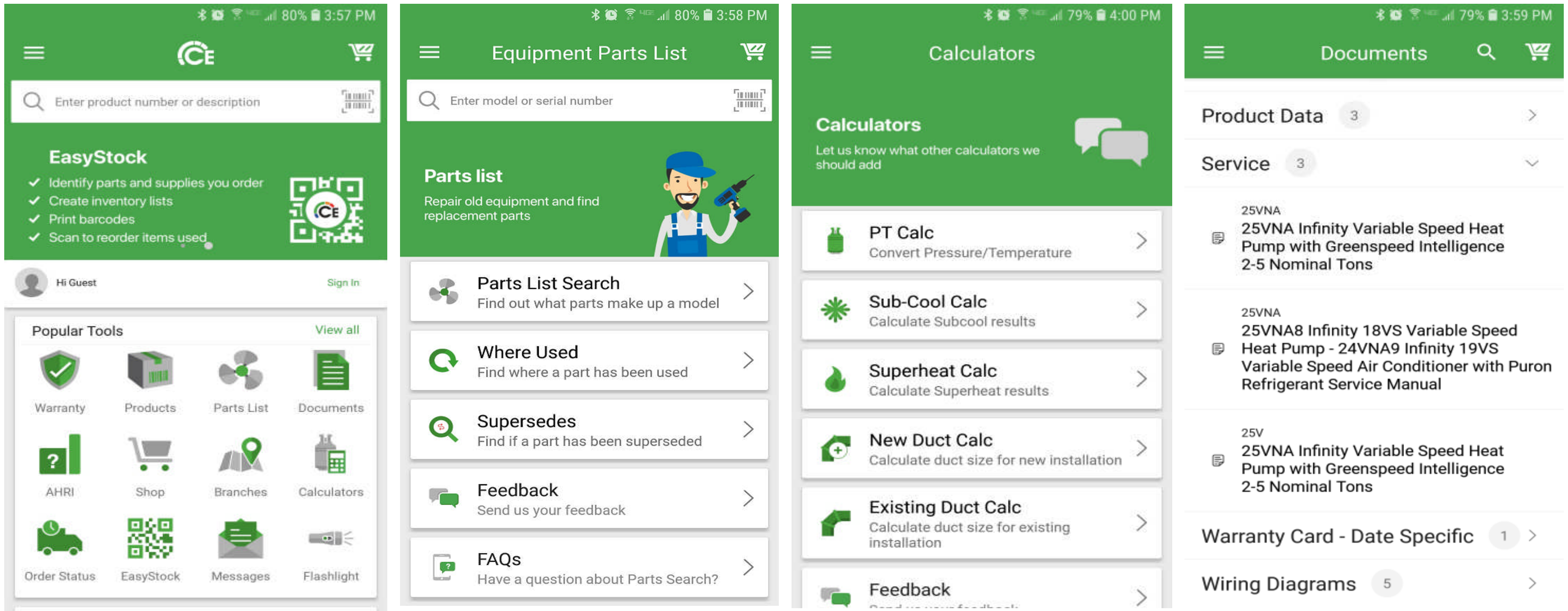
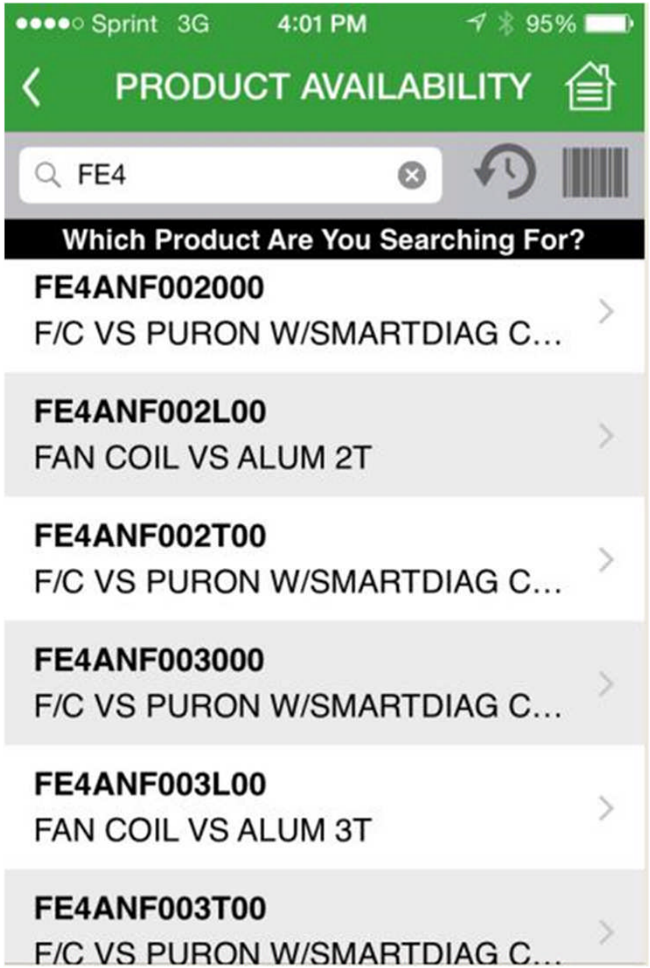
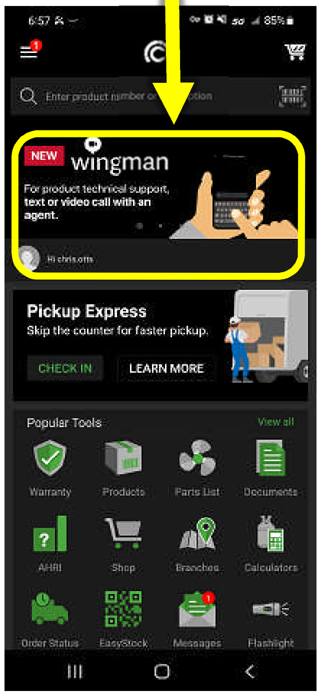
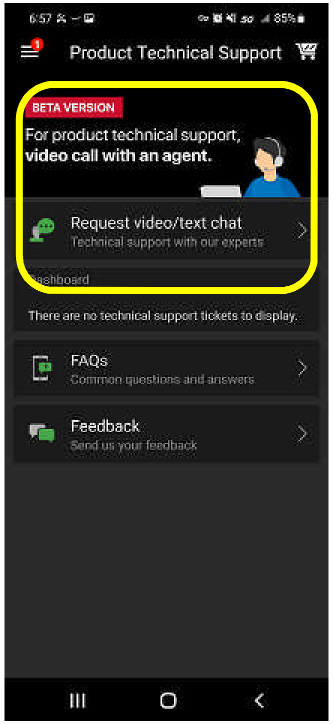


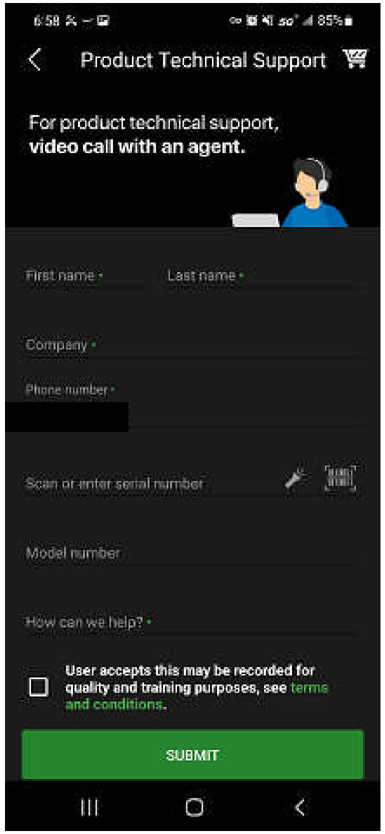

Sprint 3G
4:01 PM
95%
PRODUCT AVAILABILITY
FE4
Which Product Are You Searching For?
FE4ANF002000
F/C VS PURON W/SMARTDIAG C...
FE4ANF002L00
FAN COIL VS ALUM 2T
FE4ANF002T00
F/C VS PURON W/SMARTDIAG C...
FE4ANF003000
F/C VS PURON W/SMARTDIAG C...
FE4ANF003L00
FAN COIL VS ALUM 3T
FE4ANF003T00
F/C VS PURON W/SMARTDIAG C...

Welcome to Wingman!

A better way to request Technical Support!
Next time that you need a little assistance, let us be your WINGMAN!







Please sign in using one of these three methods:

https://tinyurl.com/ycvmxbbv

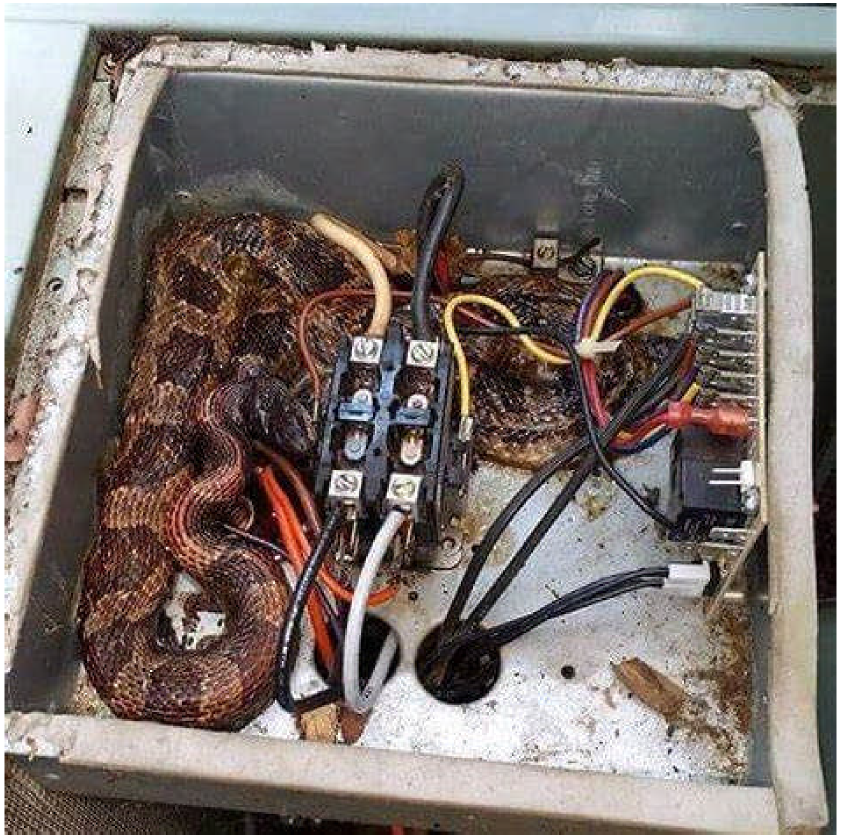
Click on the link in the chat window.

Overview

- Ohms Law (Volt, Ohm, Amp, Watt stuff and how to use it)
- Practical application of Ohms Law
- Device identification and how they are used and where
- Wiring Diagrams
- Identification of power supply
- Using your tools to your advantage
- Testing of devices and motors
- Troubleshooting and not just swapping parts
- Helpful tips to make the task easier.
- Safety
- 10 question quiz

If you have any questions feel free to ask anytime


DANGER
HIGH VOLTAGE
DANGER
DANGER
NOT ONLY WILL
THIS KILL YOU
IT WILL HURT
THE WHOLE TIME
YOU'RE DYING



Ohm's law is one of the few laws of electricity.

As technicians, we can use it to our advantage in troubleshooting and it is not as hard as it looks.

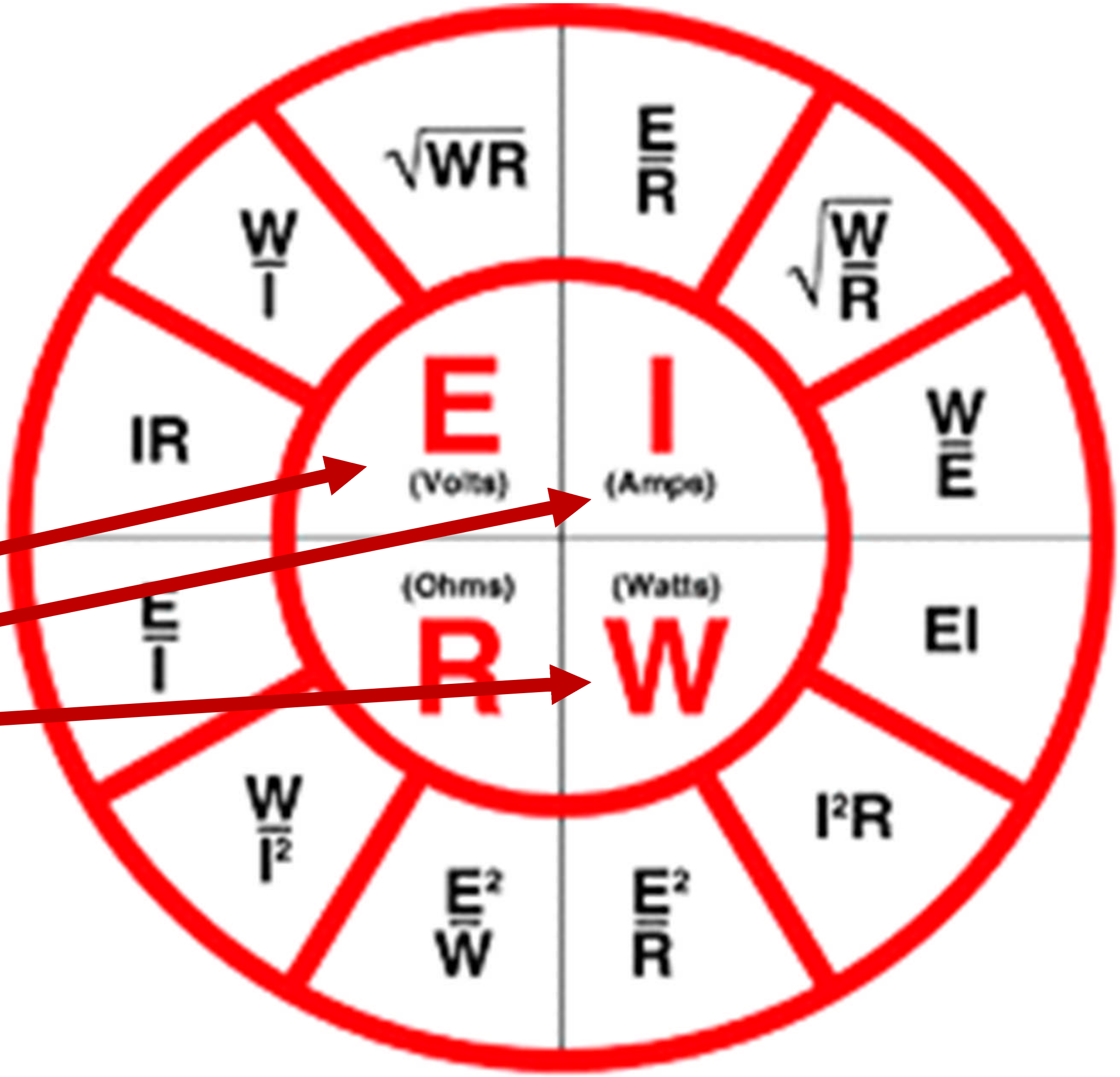
It is taking 2 known values and finding the unknown which takes the guesswork out of electricity and electric operating components.

We will mostly be using:

VOLTS

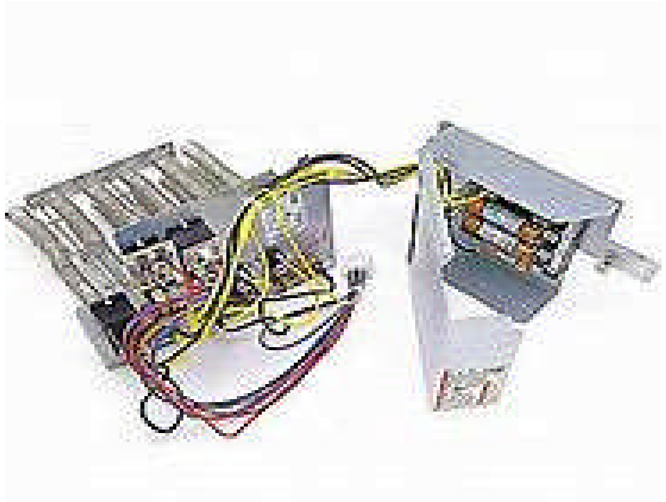
AMPS

WATTS



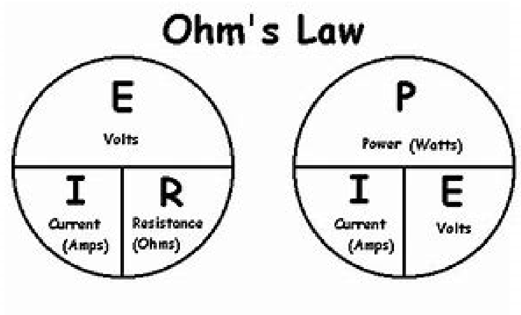
With an electric air handler or fan coil installation, most often an electric heat kit will be installed. All 4 of the needed parts of Ohms law are within the heat kit itself and any of the 4 can be an unknown.

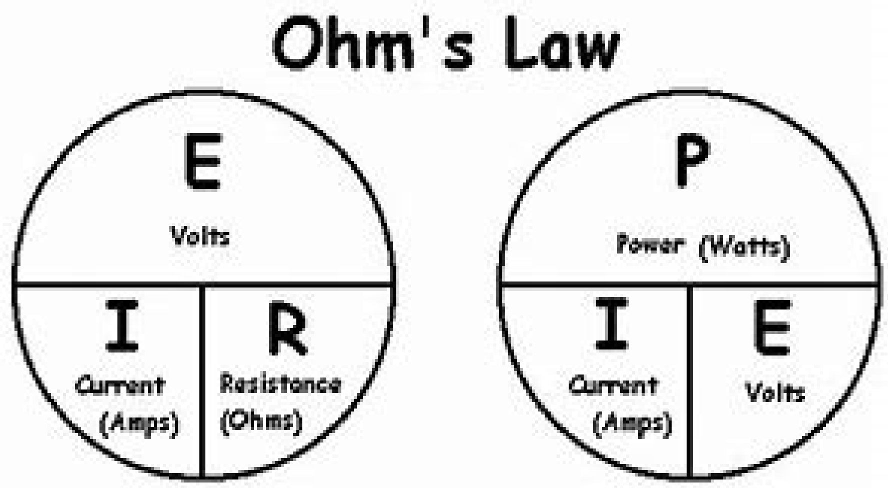
The NOMINAL information that we need is in the instructions and product data with the heat kit. The exact operating data is going to be slightly different depending on our given operating parameters that we will have on each installation. With what we have here, what is the ONLY given operating parameter?



What we need to know and how it works

- With the 4 parts of Ohms law present with an installed heat kit. 3 of them we will use.
- With a multi-meter, we can get our exact given parameters and find just how our system is working and if all of the components are operating correctly. We use Ohms law more than we realize.
- What we need to remember about Ohms law is that when 1 piece of our puzzle changes, all change.
- The rules of Ohms law don't change, that's why it is a law. It can't be proven wrong.
- VOLTS = electromotive force/potential energy = V
- AMPS = Current = amount of charge moving through a conductor = I
- WATTS = Power = the rate at which the work is done = W
- OHM = Resistance = opposition to current flow = R





Volts = Amps x Ohms (not used much for what we do)

Watts = Amps x Volts (used a lot)

Amps = Watts ÷ Volts (used a lot)

Volts = Watts ÷ Amps (used sometimes)

* If the answer does not look right, check the math.

Lets check this out

- We have a FV4B air handler with a 22KW heat kit to install.
- The electrician asks what size circuit we need. How do we find it?
- Amps = Watts ÷ Volts, or kw x 1000 ÷ volts , so now what?
- Amps = 22000 ÷ 230 so 22000 ÷ 230 = ?
- 95 amps for the heat kit plus a motor so right at 100 Amps.
- What about a 208 volt service ?
- When one thing changes, it all changes.

Ohms Law and Data tags

- Ohms law can be used in variation to give us the heat output from an electric source.
- With a drop in voltage, the amperage rises when the given load (motor) stays the same.
- Electricity is a source of heat when consumed. This heat must be managed. Excess heat will be the demise of any electric device.
- All of our electric devices are rated for a specific duty. When this duty is exceeded, the device will soon fail. The device should have this information printed on it.

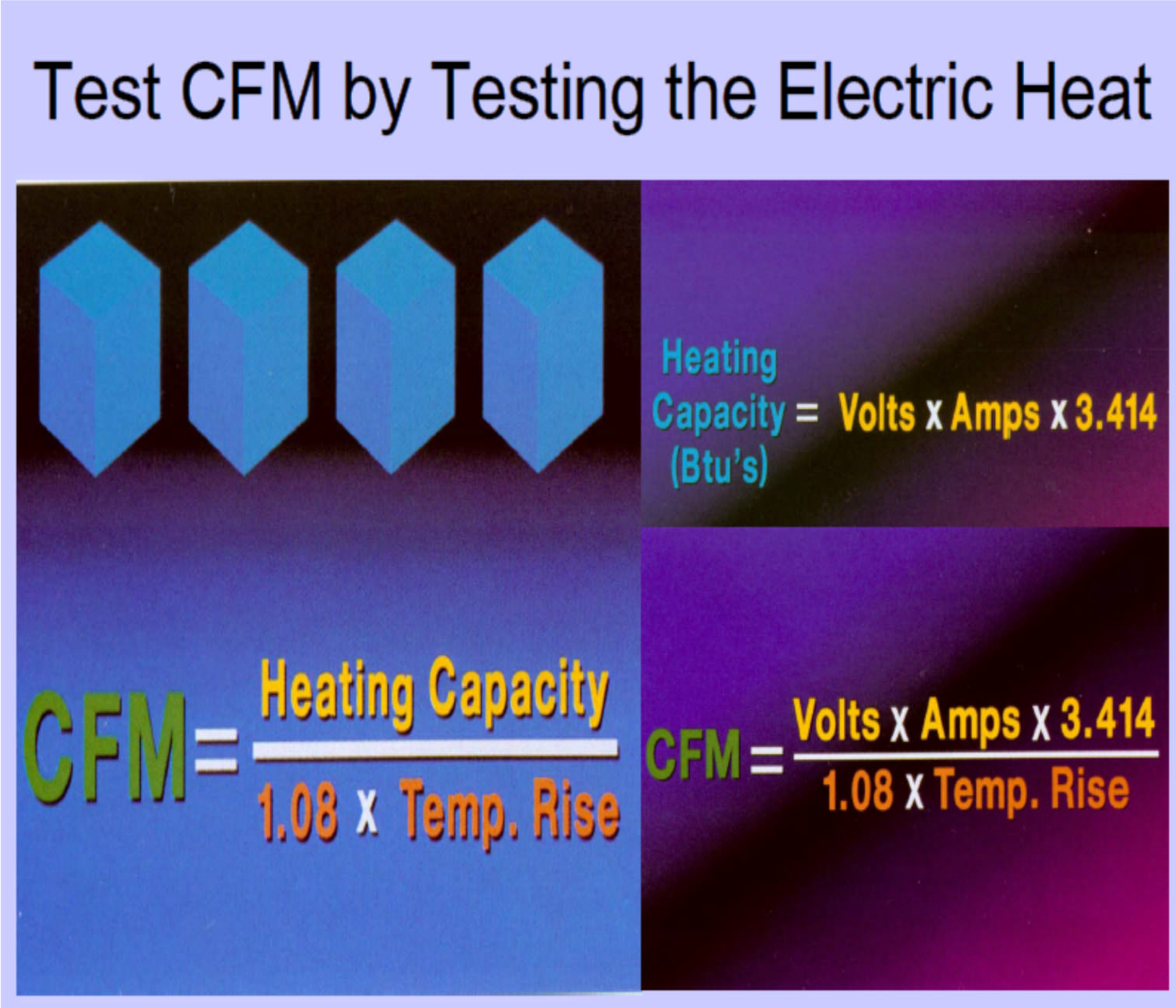
1 watt = 3.414 BTUs of heat

1000 watts = 3414 BTUs of heat

With this we can get our actual CFM from the air handler with accuracy

First find the heating capacity:

All we need is a thermometer and a multimeter and our phone for a calculator.



Volts x Amps x 3.414 = BTHs

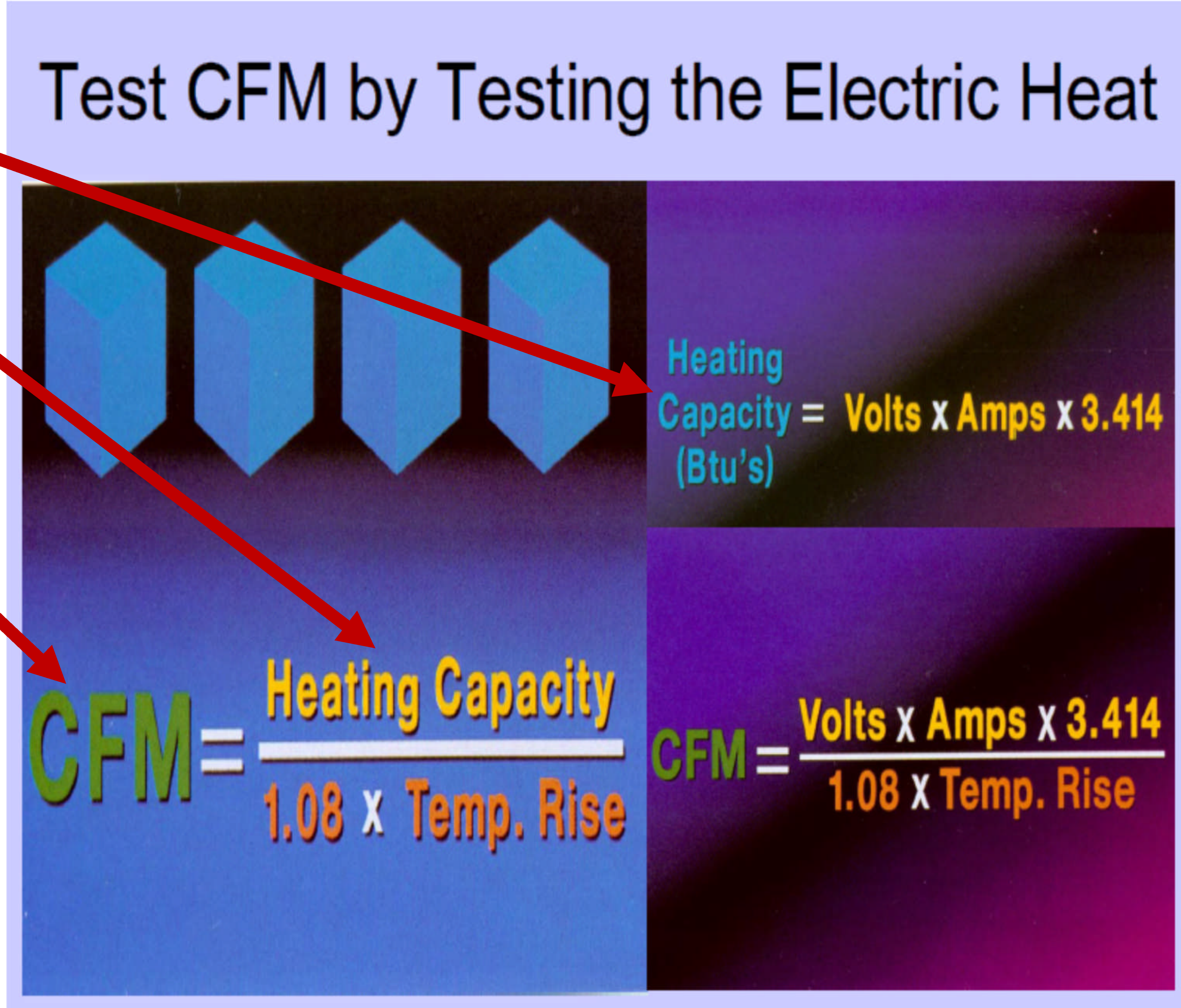
245vac x 58 amps x 3.414 = 48,512

Heating cap. ÷ 1.08 x temp rise

1.08 x 48* ΔT = 51.84

48,512 ÷ 51.84 = **935.8 CFM**

69 degree return and 117 degree supply makes a 48 degree difference or delta T



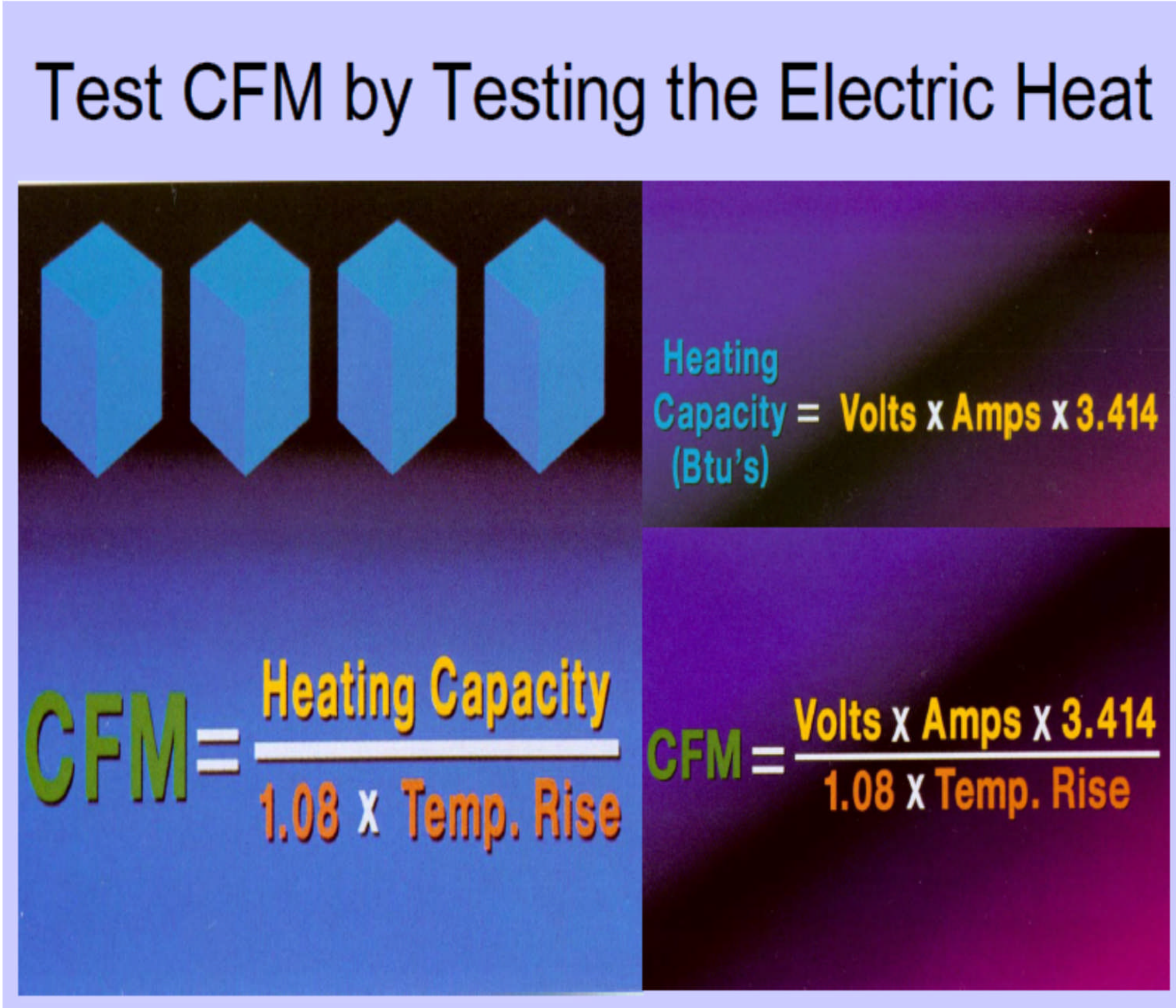
What size heater

Volts x Amps = Watts

245vac x 58 amps = 14,210

14,210 watts

15kw heater



FV4C Product Data

Real heat output we totaled   245vac x 58 amps x 3.414 = 48,512

ELECTRIC HEATERS

HEATER PART NO.	kW @ 240V	VOLTS/ PHASE	STAGES (kW OPERATING)	INTERNAL CIRCUIT PROTECTION	FAN COIL SIZE USED WITH	HEATING CAP. @ 230V‡	INTELLIGENT HEAT CAPABLE†† (kW OPERATING)
KFCEH0501N05	5	230/1	5	None	All	15,700	—
KFCEH0801N08	8	230/1	8	None	All	25,100	—
KFCEH0901N10	10	230/1	10	None	All	31,400	—
KFCEH3001F15	15	230/1	5, 15	Fuses**	All	47,100	5, 10, 15
KFCEH3201F20	20	230/1	5, 20	Fuses**	All	62,800	5, 10, 15, 20
KFCEH2901N09	9	230/1*	3, 9	None	All	28,300	3, 6, 9
KFCEH1601315	15	230/3	5, 15	None	All	47,100	—
KFCEH2001318	18	230/3	6, 12, 18	None	All	56,500	—
KFCEH3401F24	24	230/3†	8, 16, 24	Fuses	005, 006	78,500	8, 16, 24
KFCEH3501F30	30	230/3†	10, 20, 30	Fuses	005, 006	94,200	10, 20, 30
KFCEH2401C05	5	230/1	5	Ckt Bkr	All	15,700	—
KFCEH2501C08	8	230/1	8	Ckt Bkr	All	25,100	—
KFCEH2601C10	10	230/1	10	Ckt Bkr	All	31,400	—
KFCEH3101C15	15	230/1	5, 15	Ckt Bkr	All	47,100	5, 10, 15
KFCEH3301C20	20	230/1	5, 20	Ckt Bkr	All	62,800	5, 10, 15, 20

FV4C Product Data

Product data showing a heating capacity of 47,100 BTUs and a proper airflow of 980 CFM.

Our system is showing an output of 48,512 BTUs and 936 CFM. Where are we lacking?

- **Electric heat is 100% efficient***
- **Excessive heat is the result of low airflow/high static***

AIRFLOW DELIVERY CHART (CFM) — ELECTRIC HEATING MODES

FAN UNIT SIZE	OUTDOOR UNIT CAPACITY BTUH	ELECTRIC HEATER kW RANGE											
		0- 5			0- 10			0- 15			0- 20		
		Lo	Nom	High	Lo	Nom	High	Lo	Nom	High	Lo	Nom	High
002	18,000	625	625	625	675	675	-	-	-	-	-	-	-
	24,000	650	725	835	-	725	835	875	875	875	-	-	-
	30,000	815	905	1040	-	905	1040	900	900	1040	1100	1100	1100
	36,000	980	1085	1250	980	1085	1250	980	1085	1250	1100	1100	1250
003	24,000	675	725	835	875	875	-	-	-	-	-	-	-
	30,000	815	905	1040	875	905	1040	1100	1100	1100	-	-	-
	36,000	980	1085	1250	980	1085	1250	1100	1100	1250	1225	1225	1250
	42,000	1140	1270	1460	1140	1270	1460	1140	1270	1460	1225	1270	1460

Up next: More Stuff

Five minute break

Training will resume in:

05:00

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Ohms law and motors

Ohms law is very present in motors. This data tag is showing a multiple voltage application, which is seen often in commercial and RTUs.

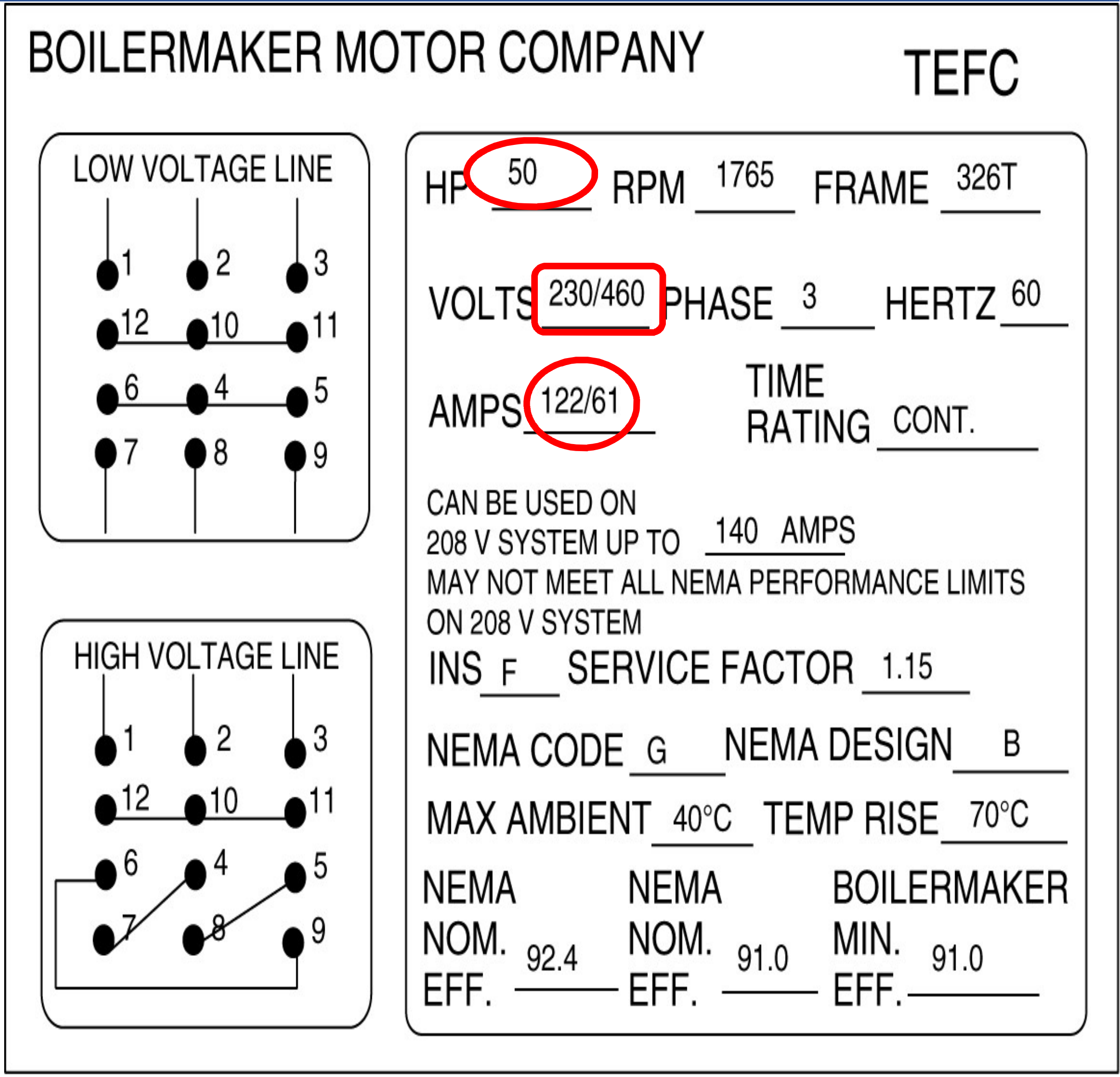
We can have a 230 or 460 volt service to the motor. Being rated at 50 hp at either voltage the load stays the same. When the voltage is changed to the motor, the amperage will change as well.

Remember: When one part of the equation changes, it affects the others.

With this data tag, we can see the Volts, Amps and Watts. The watts are expressed in Horsepower. ****746 watts =1 horsepower****

746 X 50 = 37,300 watts

37,300 ÷ 3.414 = 10,925 BTUs of heat energy



Other information on motors

The data tag contains the information needed about the motor. Understanding the data allows us to select the correct replacement.

Volts- operating line voltage

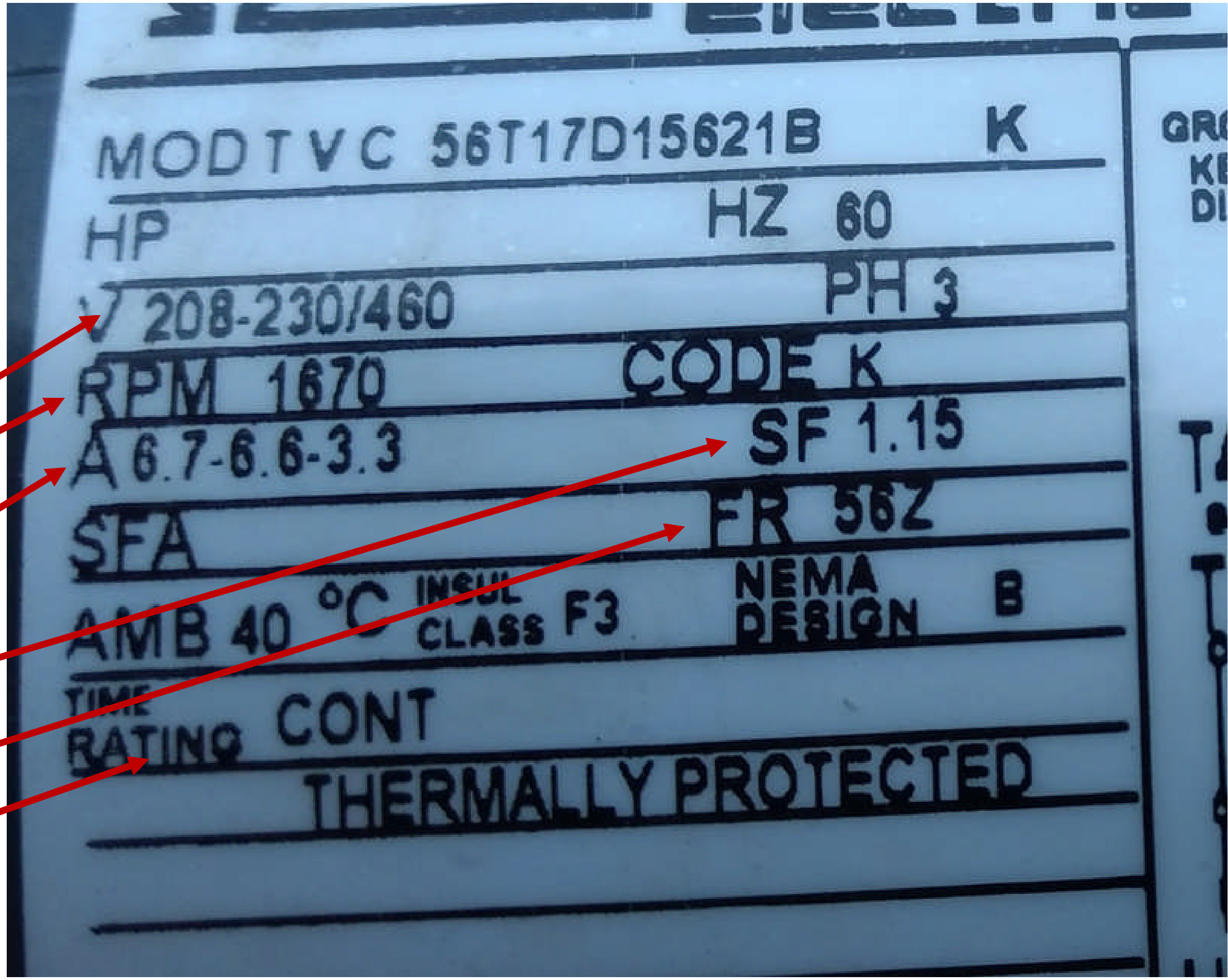
RPM – rotational speed

Amps- Running load amps

SF – Service Factor 100%+____

FR – Frame-Physical measure

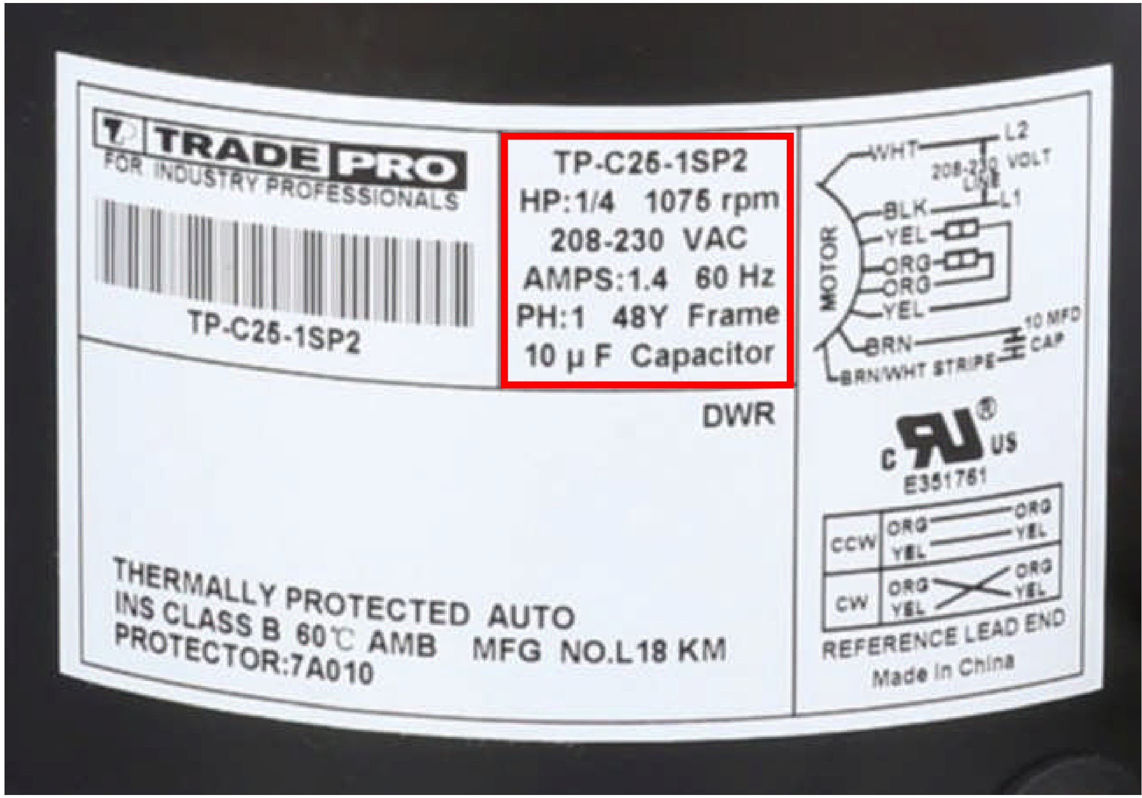
Time/Duty rating-Operating



Residential Motors and Parts

Residential motors are slightly different than commercial 3 phase motors. These motors are single phase and lighter duty motors and they will use capacitors to help with their task.

A capacitor by definition is a torque multiplier. They are needed to keep up the torque to the motor under a load.



Capacitors

Take note that a capacitor's voltage rating is not the voltage that the capacitor will charge up to, but only the maximum amount of voltage that a capacitor should be exposed to and can store safely. For the capacitor to charge up to the desired voltage, the circuit designer must design the circuit specifically for the capacitor to charge up to that voltage. A capacitor may have a 440-volt rating but it will not charge up to 440 volts unless it is fed 440 volts from a power source. The voltage rating is only the maximum voltage that a capacitor should be exposed to, not the voltage that the capacitor will charge up to.

Capacitors

There is no need to replace a 370 volt capacitor with another 370 volt capacitor. A 440 volt capacitor is nothing more than a heavy duty 370 capacitor. Therefore there is no reason to stock both on your truck or make a special trip for a 370 if you have a 440.

Capacitors are rated by microfared and voltage. The microfared is the size that we pay attention to. A motor is designed to operate with a certain size run capacitor. Stay with that size if at all possible. Don’t go down a size. If supplies are limited, go up a size until the correct size can be obtained. Installing a larger capacitor will increase the torque to the motor and can cause overheating.

It is good practice to replace the capacitor when replacing the motor.

Stacking Capacitors

If you need to replace a capacitor and you do not have one with a large enough MFD you can attach multiple capacitors to get the correct MFD. The picture below shows a 20 mfd and a 25mfd wired to make a 45 mfd. The voltage would assume the lower of the 2 capacitors. If you have a 370v and a 440v the voltage would be 370. Two 440v capacitors would be a 440v. A capacitor rating within 10% of required mfd is good.

Start Capacitors

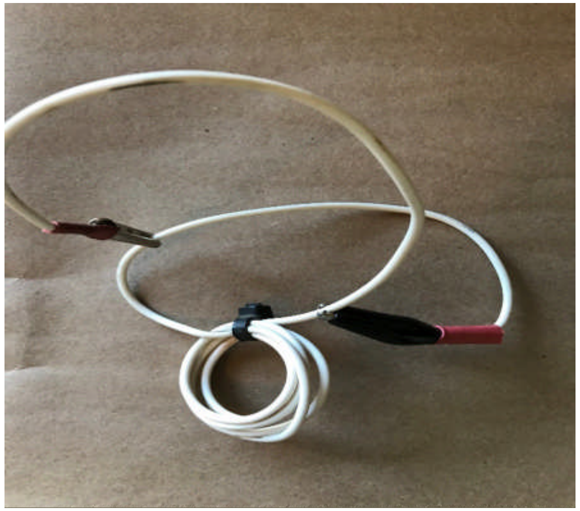
- It is always recommended to change start capacitors and start relays at the same time
- Start relays sticking is the main reason start capacitors blow.
- If a start relay sticks the weakest link is going to blow. That could be the compressor windings or the start capacitor.
- Certain Equipment in the field requires the OEM start kits and will NOT work with a generic kit.
- It is always best to replace with the start kit recommended by the manufacturer

Testing Tools

- Multi-meter / Fluke, Fieldpiece, Sperry, UEI, Simpson, Amprobe
- Ten wrap wire
- "Known to be good" parts

  Peanut relays   User Interface

  Contactor



- Jumper wires with alligator clips. Straight pins from a sewing kit
- In-line fuse holder and spare fuses

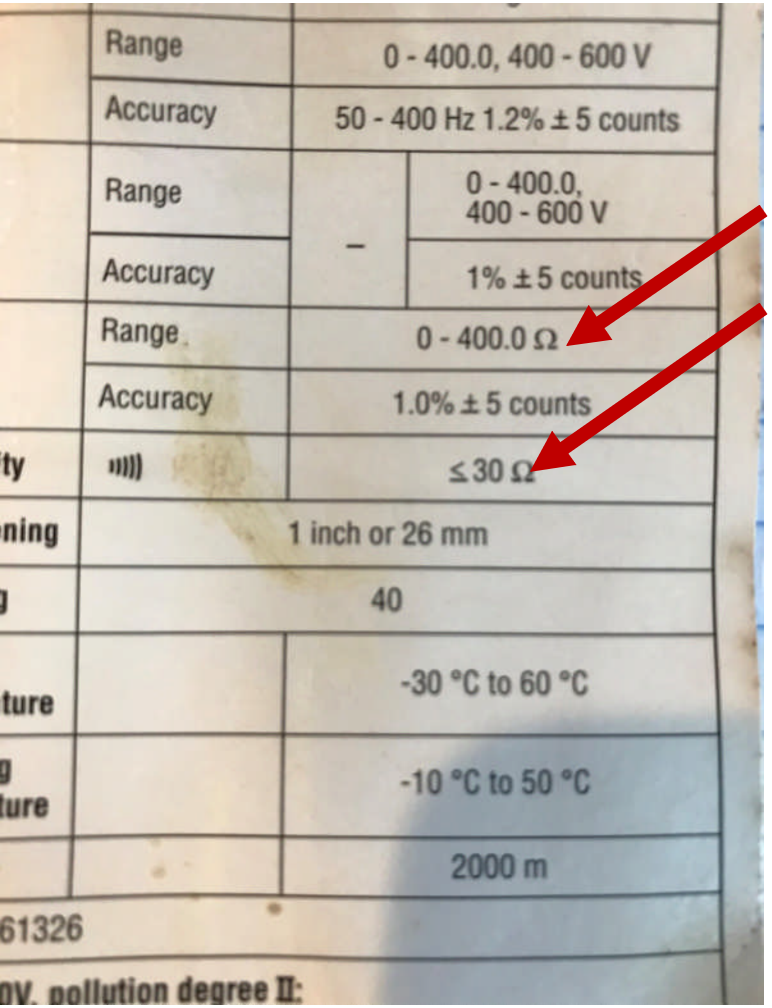
Get to know your meter. Invest wisely

Fluke 322

Klein CL800

Fieldpiece SC640

Get to know your meter. Invest wisely



Fluke 322 multimeter:

Volt range: 600 AC-DC

Ohm range: 400Ω

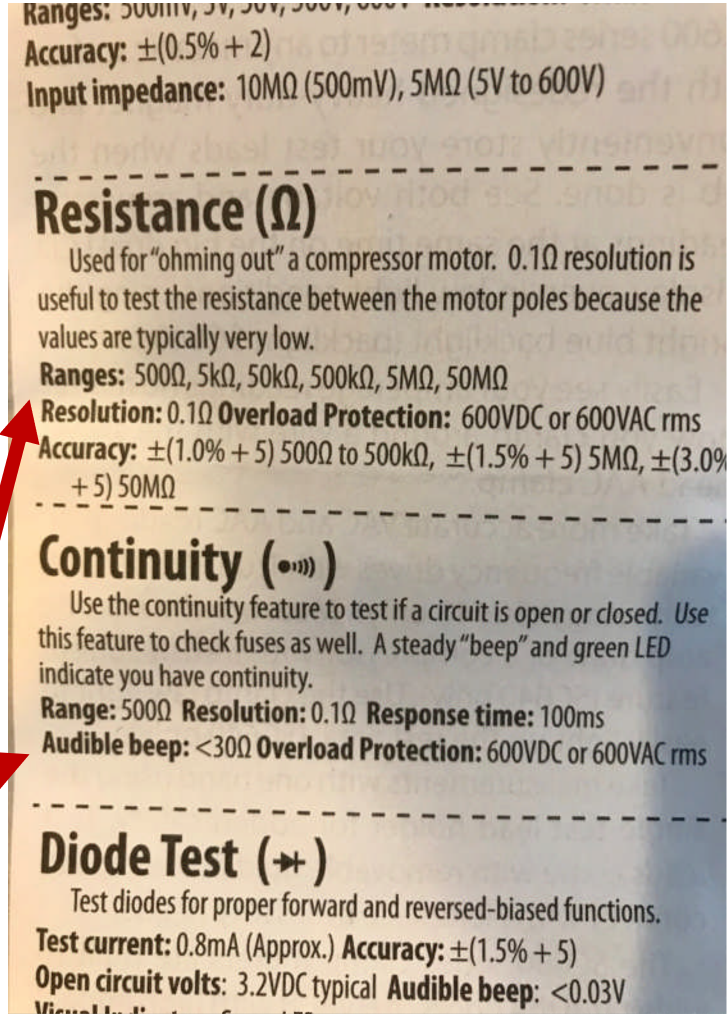
Audible beep: ≤ 30Ω

Fieldpiece SC640 multimeter:

Volt range: 600 AC-DC

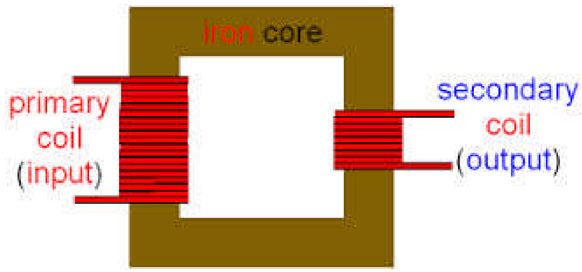
Ohm range: 500,000+

Audible beep: ≤ 30 Ω



Power supply / Voltage

- 120/230 Single phase residential / Lt comm.
- 230 volt Three phase Commercial
- 480 volt Three phase Heavy Comm.
- Control Transformers are made in a way where the coils do not meet
- They use a magnetic field produced by the primary winding to power the secondary winding.

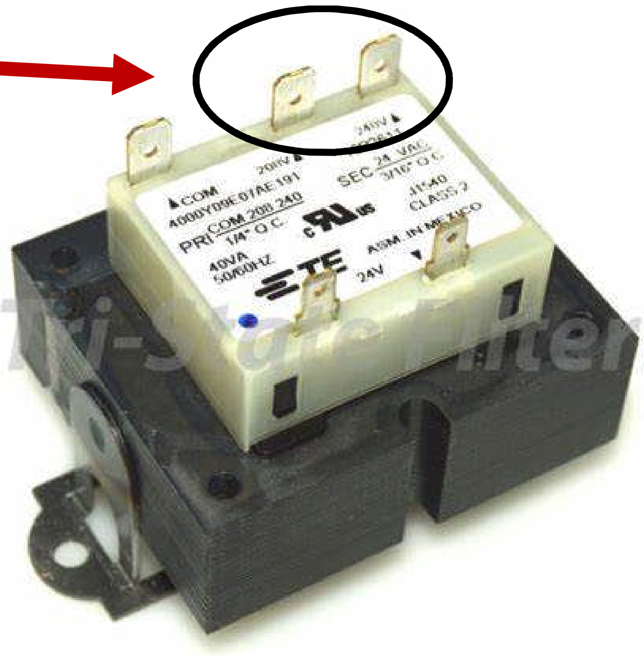


Transformers on new installs

The OEM transformer in the CBP line of fan coils uses a 208/230 primary tap.

Verify the line voltage prior to startup to set the primary voltage correctly. The 208 line voltage is mostly seen in older commercial areas.

With the primary voltage set on 230vac and being served by a 208vac service, control voltage problems will arise.



With a 208 service and transformer set at 230v, there will be a reduced control voltage

Control transformer sizing and load rating

- Control transformers are used to manipulate and reduce the voltage supplied to the controls for safety and reduced load on the primary voltage. This allows the use of smaller and lighter components that pilot larger tasks in the equipment. Contactors, relays and thermostats are by far the most common to perform these tasks.
- 40 VA and 75 VA transformers are the most common with a primary voltage of 120 VAC or 208 or 230 VAC and a secondary voltage of 24 VAC
- The load these transformers can hold is very light. Here is the math.
- The max. load equals the VA rating divided by the secondary voltage.
- 40(VA) / 24(sec vac) = 1.66 amps
- The fuse in a control board is there to help protect the board, not the transformer
- An amp clamp can be used to test for loading. This is where the 10 wrap wire can be used.

Shown here is a 24vac control circuit being tested with a 5 wrap wire. By using the 5 wrap, this multiplies our reading 5 times. AC amps are detected by the clamp-on meter because of the magnetic field produced by the wire. The magnet field can only be measured on one wire at a time. By wrapping the same wire around multiple times, it is still one wire.

Actual 0.33 amps

Device identification

- Types of electric devices: Two basic types
- Power passing; generally called a switch because that is what it is.
- Power consuming; light, motor, magnetic coil, heater element
- Devices can be made together to operate a larger device by a pilot signal from a smaller device.

    Motor starter

    Contactor

    Relay

    Sequencer

Power passing devices

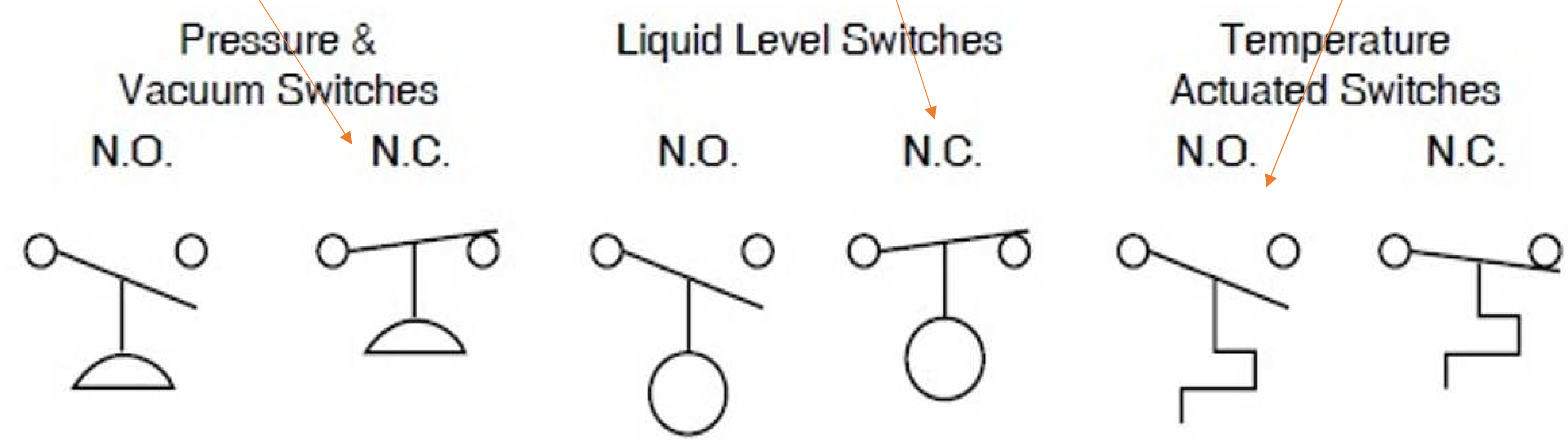
- A power passing device is a switch used to pass power on through it to allow the electric supply/signal to complete its task.
- There should be NO RESISTANCE across a power passing device.
- There should be NO VOLTAGE DROP across the device contacts.
- The device must have contacts heavy enough to hold the load.
- Can have multiple poles. All poles should be equal but separate
- Test by voltage and resistance
- If there is measurable resistance across the contacts, this could be your problem. It can be as little as 5 ohms to cause an issue.
- A switch is designated as Normally Open (N.O.) or Normally Closed (N.C.).

Switches in a diagram

High or low pressure switch.

Float switch

Defrost thermostat



Power passing devices / Switches

Switches are designated by their pole and throw

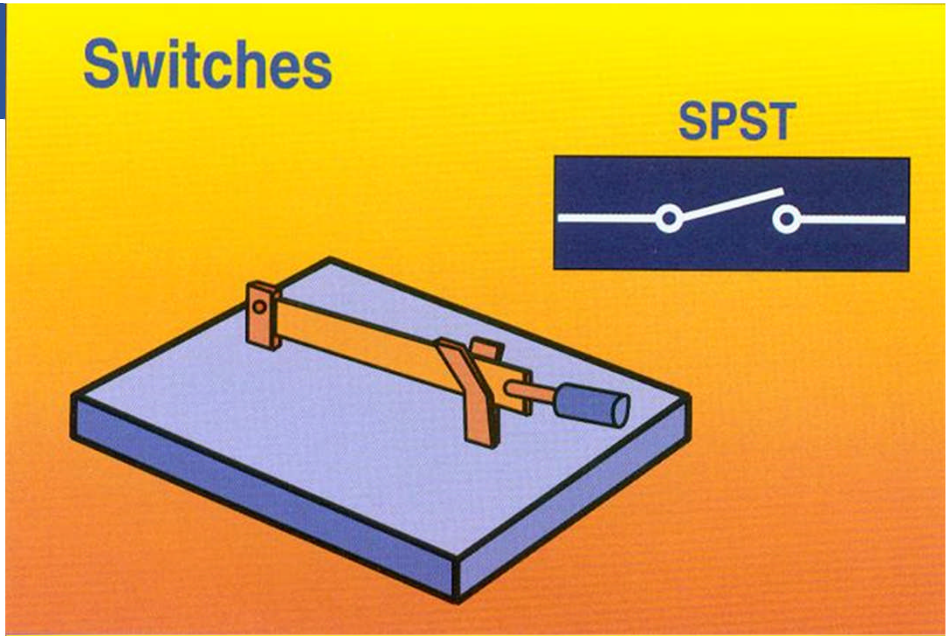
Pole is the leg of power/line of voltage/input

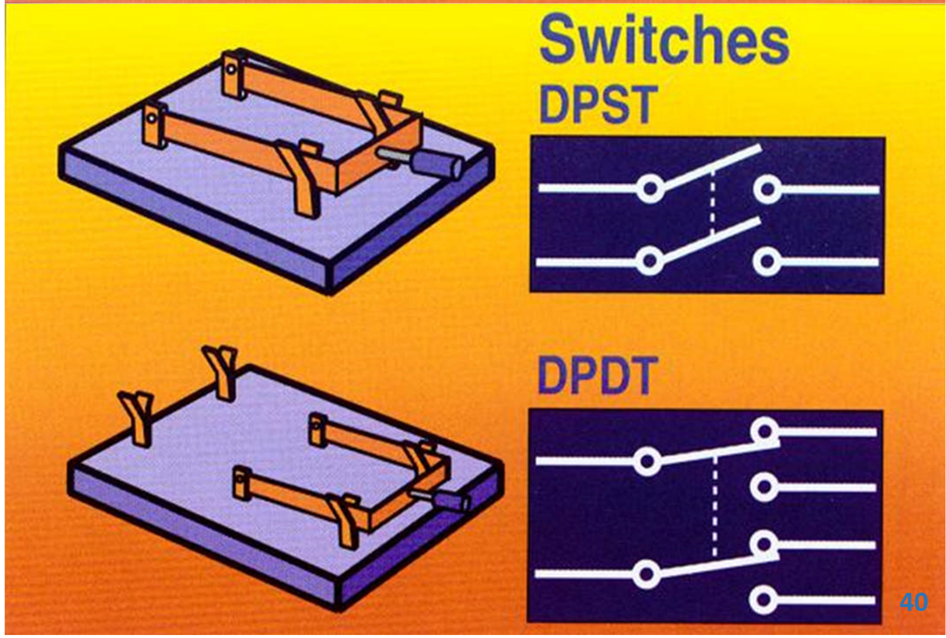
Throw is the point or points of output/contact

Commonly used switches are the single pole and the double pole type, such as contactors.

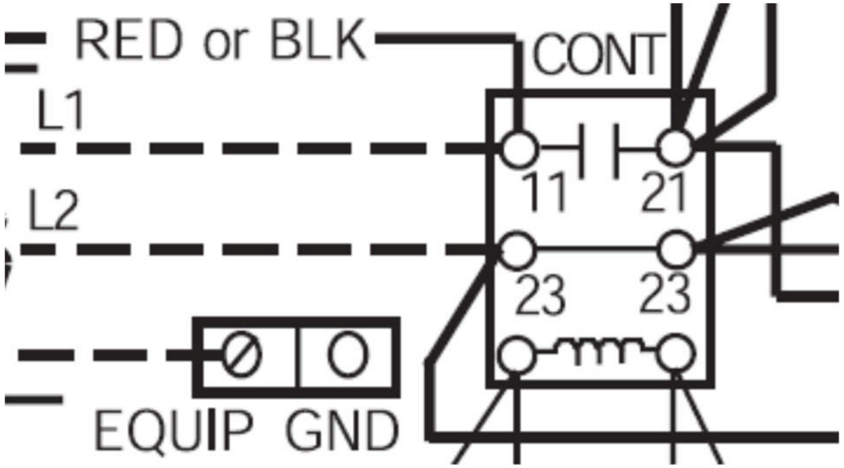
3 poles are commonly seen in commercial equipment due to the 3 phase power supply.

The throw or point of output is usually a single throw. Double throws are seen with 2 speed motors such as a heat/cool fan relay allowing the fan to operate at different speeds.





Single pole Contactor

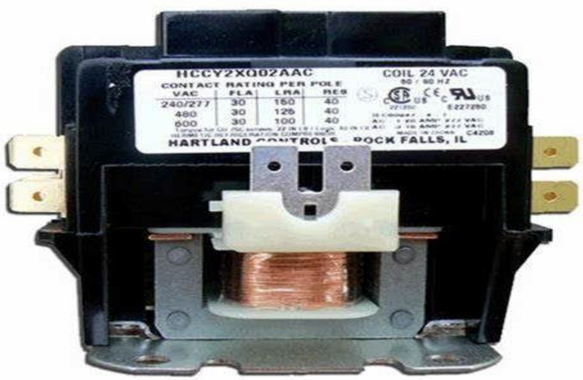


24 ACB condenser

This snapshot is a very common contactor used throughout HVAC equip. Notice the solid bar between 23-23. The other side (11-21) is the switching side. It is drawn this way on purpose and it is crucial to have this installed wire perfect. If a S.P. contactor is not available, jump the switch on the needed side for the same result.

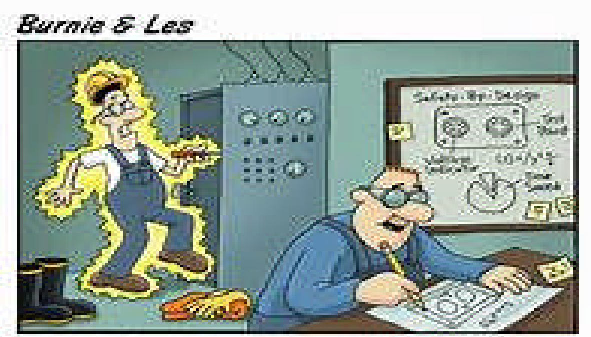
Power Consuming Device

- Consumes/Uses up the electric energy supplied to it in exchange for work to complete the task.   Example: A light bulb, motor, coil
- Can have variables that need to be found/ Voltage or speed
- Can be a little harder to troubleshoot
- Will have measurable resistance
- Test by amperage, resistance
- Can have overload protection built in. Such as a compressor or motor
- The overload simply is a limit switch that opens when overload is measured through heat or amperage.



Power Consuming Devices

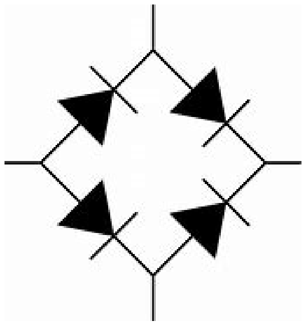
- Power consuming devices can have their work measured with an Amp meter because there is an electric load on the device. Ohm meter with load removed and disconnected.
- Any of these devices must have a complete, unbroken circuit with a measurable amount of resistance. The resistance can vary on the same part depending on several factors.
- Some devices, such as a Hot surface ignitor or a heat strip, have specified resistances that they need to operate correctly.
- Other devices such as contactors and solenoid coils usually don't have a known resistance and the resistance can be different between manufacturers. Still the resistance is measurable and can be compared to a known good part.
- *Safety note: If using an Ohm meter, power must be OFF and the part disconnected.

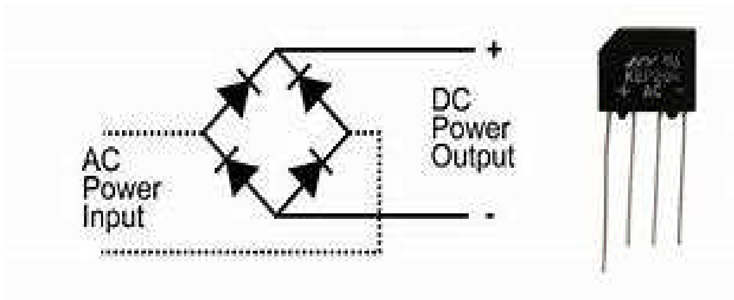


"Hold on Burnie, don't try that yet, I think I figured it out."

Helpful guidelines

- Hot surface igniter 35 – 150 ohms avg. *This is the tolerance @ room temp.
- 24v 30amp 2 pole contactor 10 – 30 ohms avg.
- 120v 30amp 3 pole contactor 110 – 210 ohms avg.
- Fan/switching relay 50 – 100 ohms avg.
- 40 va transformer 24 volt sec 1 – 5 ohms sec side *Test voltage
- EMC/IMC motor windings 20 – 50 ohms
- Solenoid coils can be anywhere. Use ohms law to find resistance
- *If you see a rectifier/pc board be aware of DC voltage
- *Thermistor is a variable resistor. Changes resistance w/temp.





Training will resume in:

10:00

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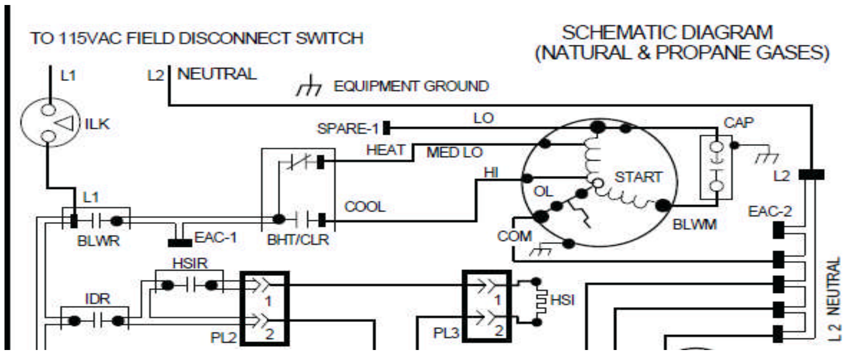
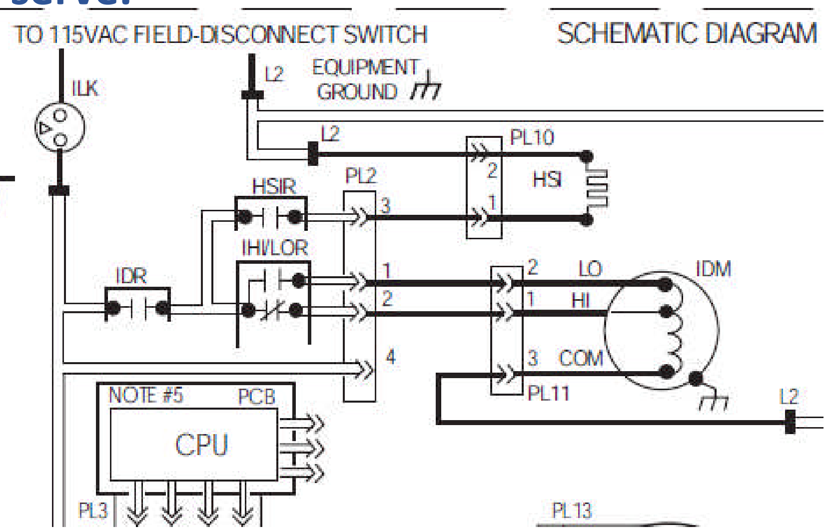
Circuits

- **Two types of circuits: Series circuit / loose one item, loose ‘em all**
- **Parallel circuit / loose one, the rest stay on**
- **Ex. Series circuit.. Safety limits in a heater, furnace, condenser. Found in the control circuit.**
- **Ex. Parallel circuit.. Heat strips, condenser, Air handlers, furnace**
- **Main or large/heavy circuits can split in parallel into branch circuits and have series and parallel circuits working together to perform a needed task.**
- **This is typical of our HVAC equipment. The safeties such as the high and low pressure switch is in series with our contactor coil. If either of the safeties opens we loose 24vac at the contactor. The compressor and fan however are in parallel and are not dependent on each other to operate.**



Wiring Diagrams

- There are several types of diagrams. Two most common are:
- Connection diagram: Shows how the parts are arranged and where the wires land on the parts. Such as control boards and contactors. Color designation is here usually
- Ladder diagram: Shows the component purpose and its relation to the other components. These will be drawn with symbols to indicate the component.
- Also show the series and parallel circuits and what they serve.
- A legend should accompany these diagrams.



LEGEND

A/C	Air Conditioning (Adjustable Airflow -CFM)	ILK	Blower Door Interlock Switch, SPST (N.O.)
ACR	Air Conditioning Relay, SPST (N.O.)	IND	Inductor (Note #7)
ACRDJ	Air Conditioning Relay Defeat Jumper	LED	Light Emitting Diode for Status Codes
BLWM	Blower Motor (ECM)	LGPS	Low Gas Pressure Switch, SPST (N.O.)
BVSS	Blocked Vent Safety Switch, Manual Reset, SPST (N.C.)	LPS	Low-Heat Pressure Switch, SPST (N.O.)
		LS 1, 2	Limit Switch, Auto-Reset, SPST (N.C.)
CF	Continuous Fan (Adjustable Airflow -CFM)	PCB	Printed Circuit Board
COMMR	Communication Relay, SPDT	PL1	12-Circuit Connector
CPU	Microprocessor 7 Circuitry	PL2	4-Circuit HSI & IDM Connector
DHUM	DHUM Connection (24VAC 0.02 Amps)	PL3	4-Circuit ECM BLWM Connector
DSS	Draft Safeguard Sw., Auto-Reset, SPST (N.C.)	PL4	4-Circuit Model Plug Connector
EAC-1	Electronic Air Cleaner Connection	PL7	4-Circuit Communication Connector

Gas furnace ladder diagram

Notice the components and the symbols that represent each and where they are in relation to the unit.

We have: Fuse

Temp Limit switch

Pressure switch

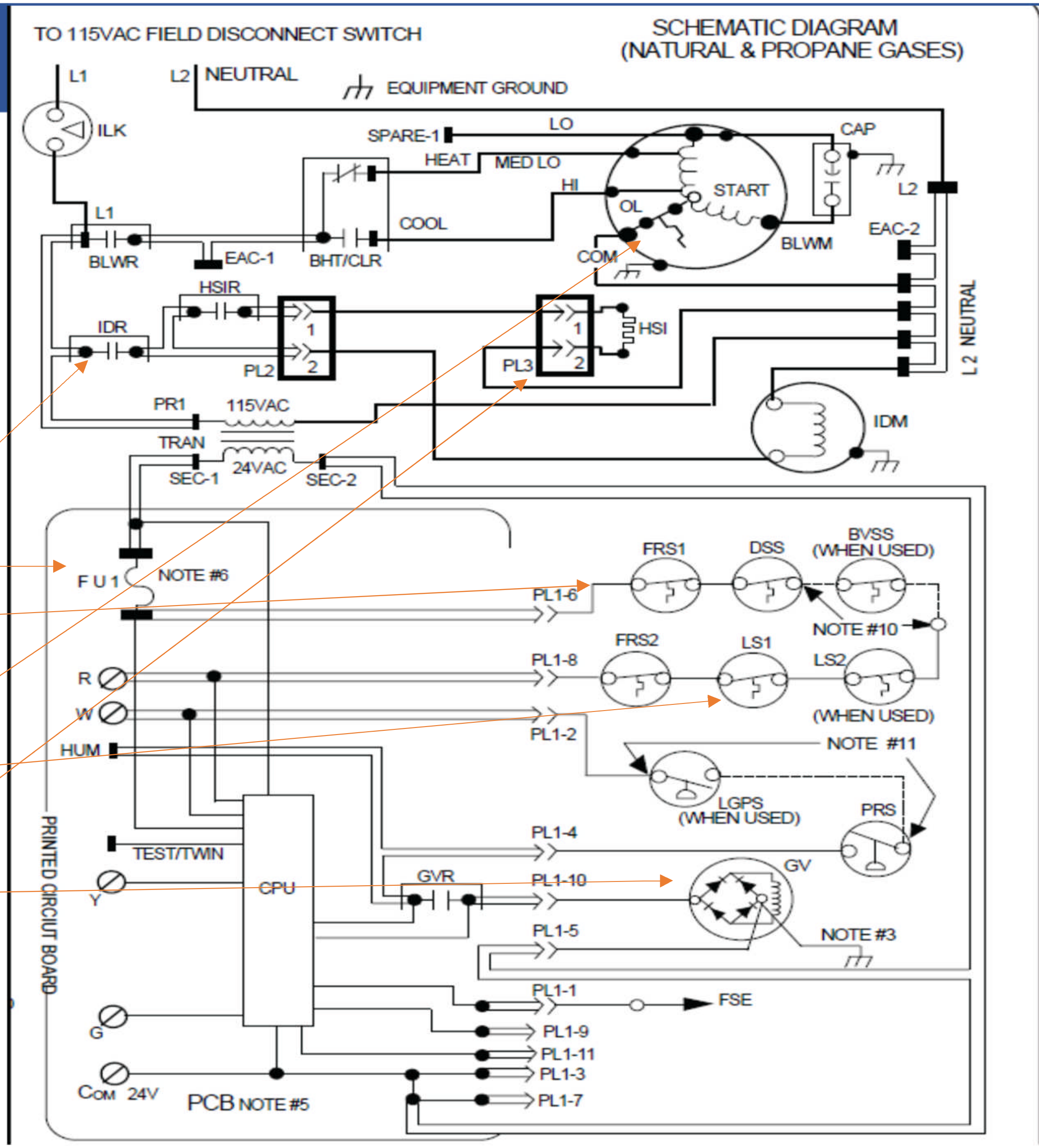
N.O. contact

N.C. contact

Thermal overload

Rectified valve

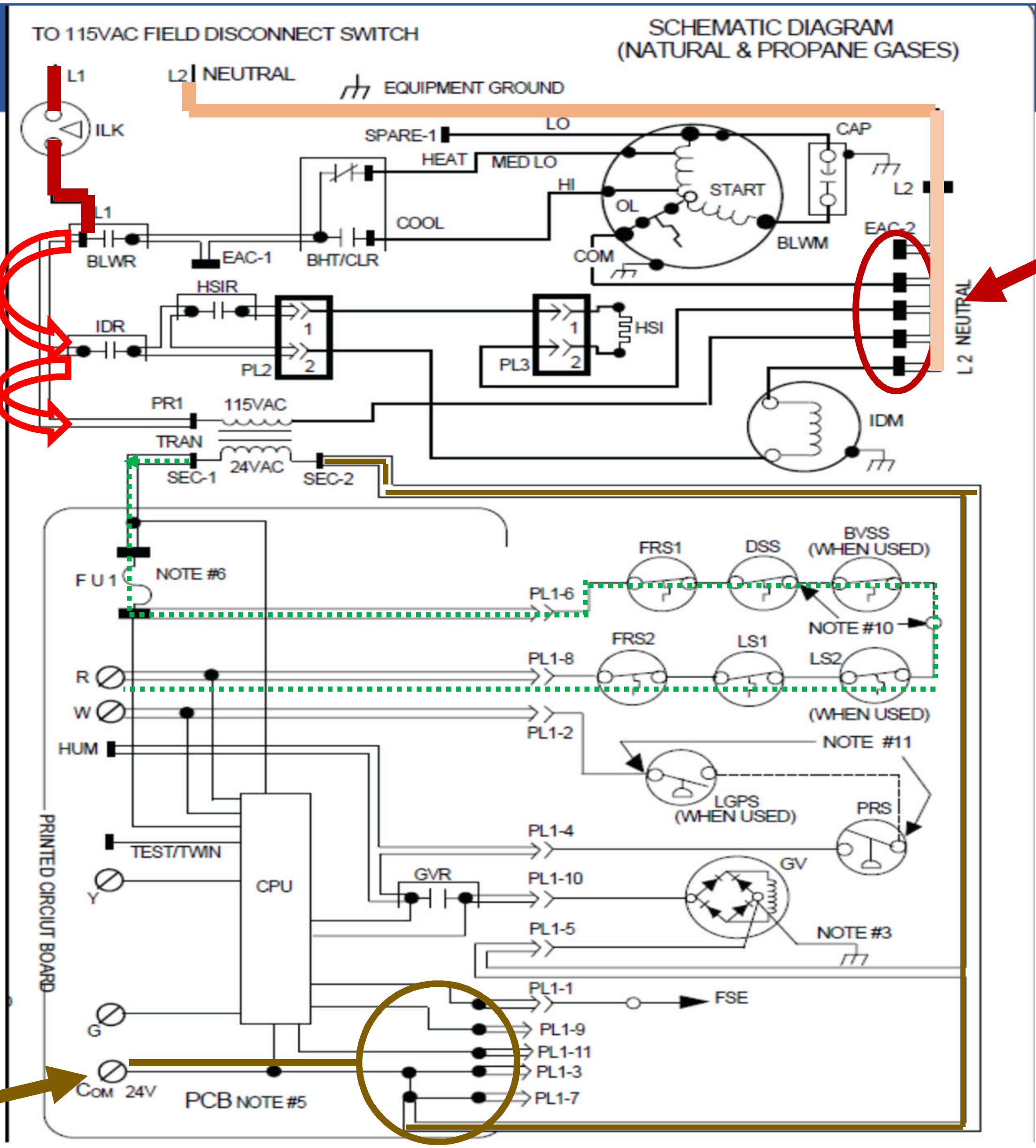
Thermal resistor



Gas furnace ladder diagram

The ladder diagram or schematic, show the high and low volt relationship and the path that the given voltage takes through the system components.

Notice the series and parallel circuits in the high and low voltage



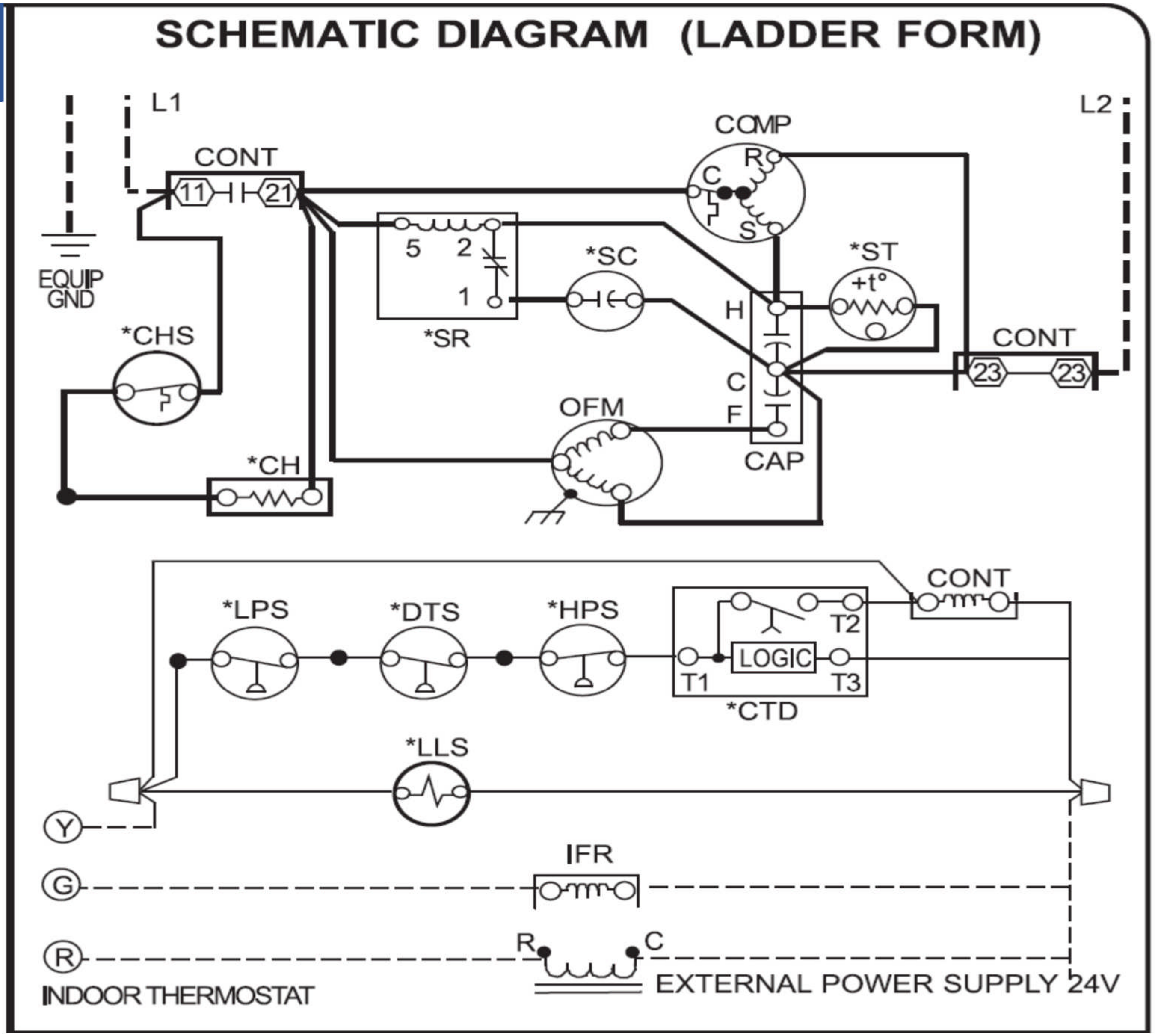
Neutral buss

24 volt common

LADDER DIAGRAM

The ladder diagram or schematic shows the component relationship to the power supply as it is applied to the equipment. The parts and pieces are shown for the purpose that they serve as well as their placement in the circuit

Notice the bold and light lines. This designates the different voltage. The components are shown as a symbol for their purpose in the circuit. Series and Parallel circuits are represented.

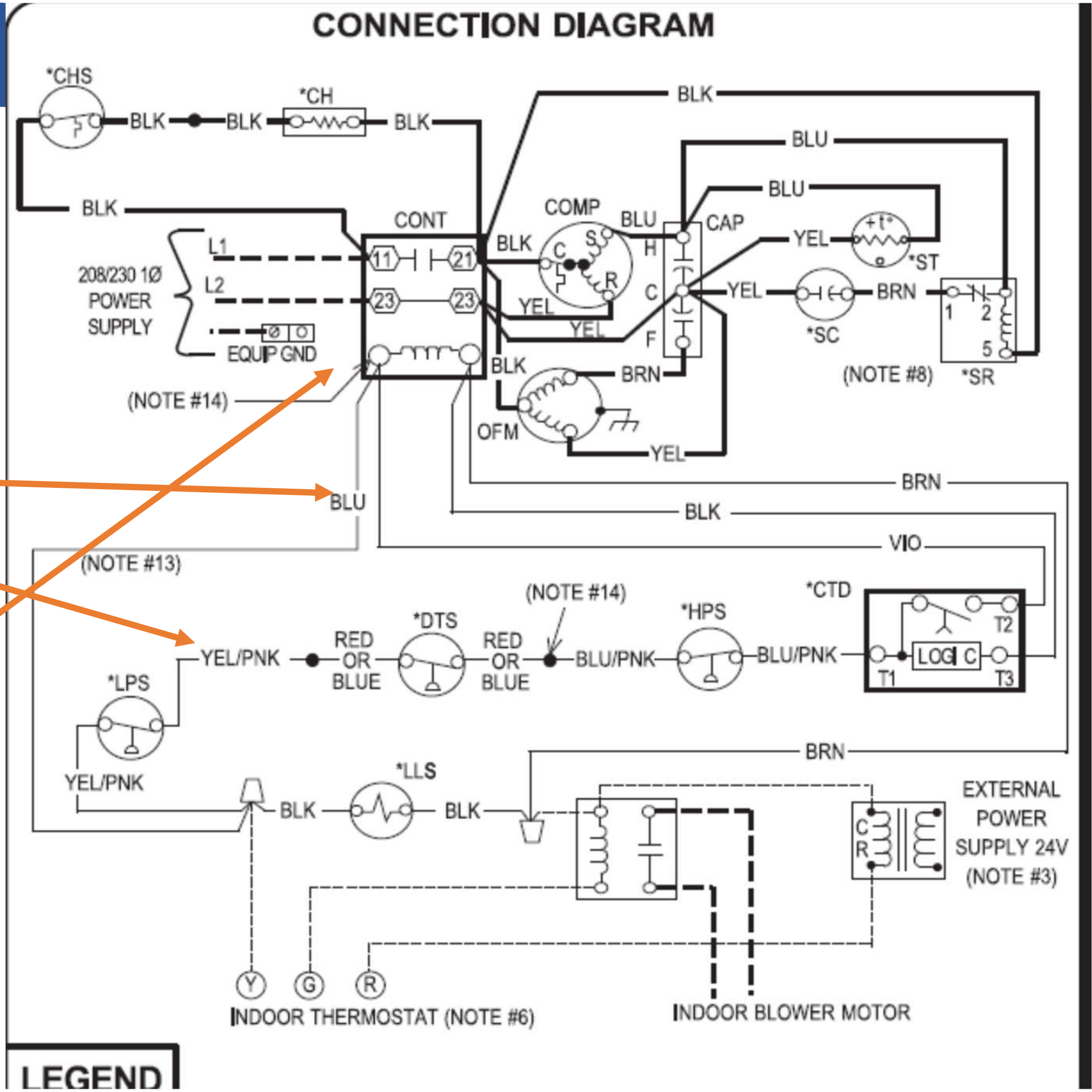


Connection Diagram

The connection diagram is just what it says. It shows the connections of the components to each other and usually has the color coding listed.

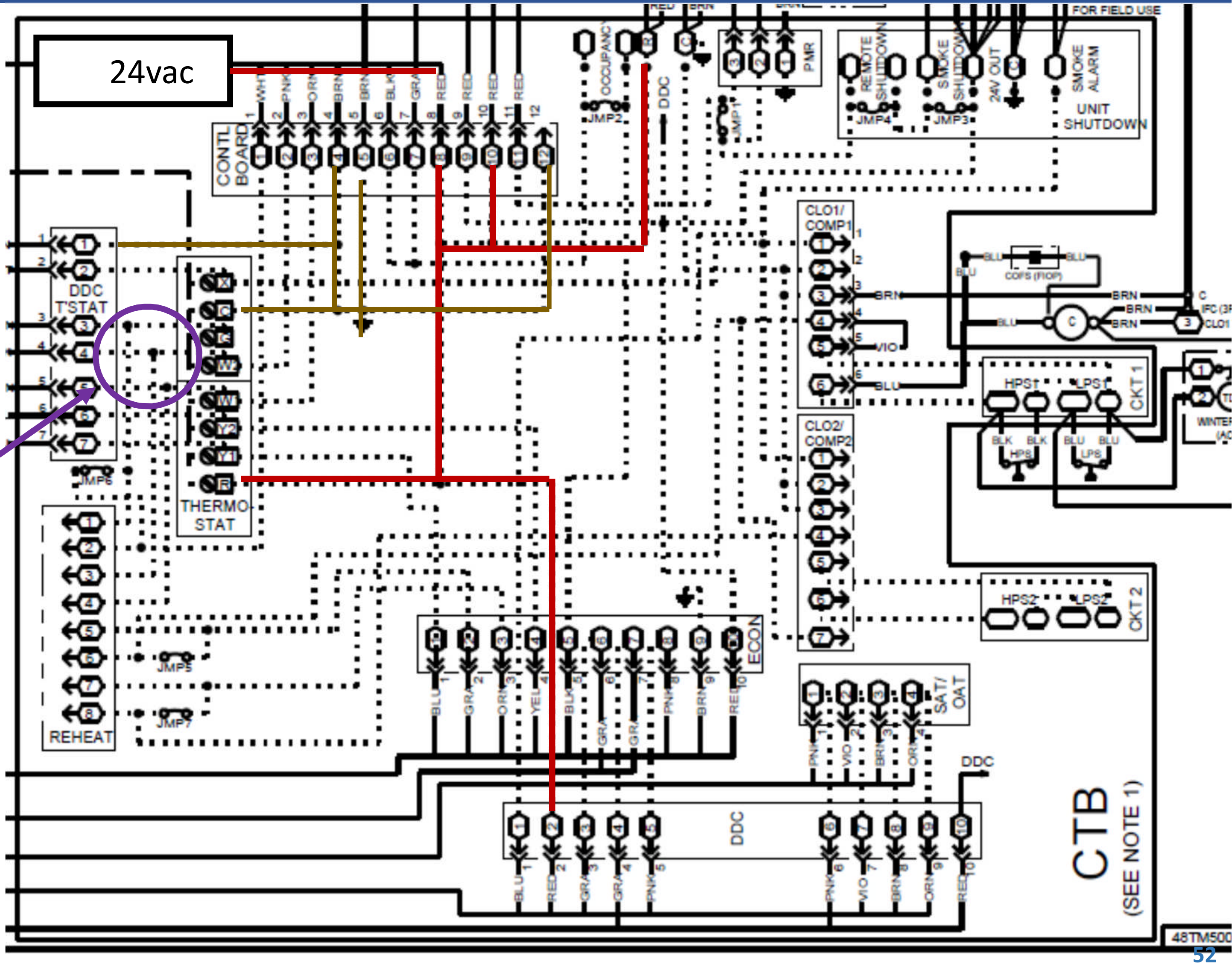
It also shows the relationship between the high and low voltage.

The symbols are still used but it is shown as a complete component



Partial diagram from a RTU.

48-50TC model main terminal board. Notice that there are NO electronics on this board. What is shown is the harness terminal connections and the inner-connecting "wiring" within the board. There can be intersecting lines with a DOT, ● this an internal connection within the board.



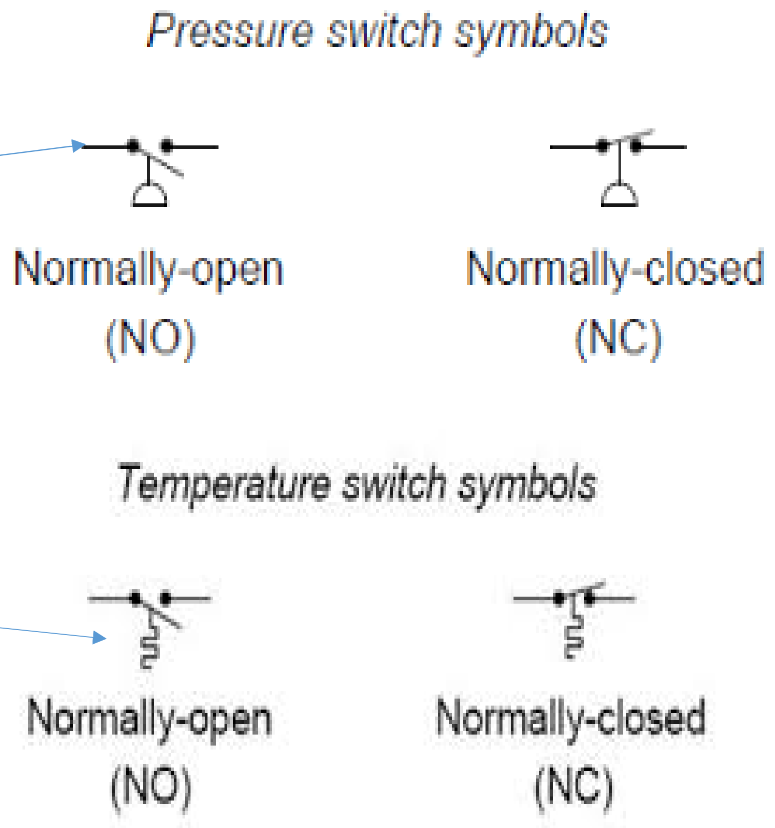
Interpretation

Notice the pivoting arm.

The arm in relation to the contact point tells the " duty" of the switch.

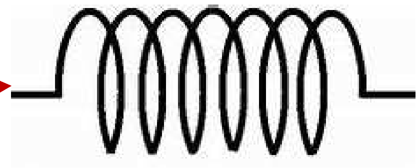
The symbol attached to the arm tells the " actuation " of the switch.

These symbols are the most common that we see in our work

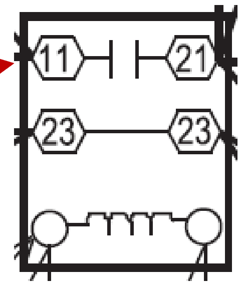


Interpretation of Components and their parts

Magnetic coil: found in contactor or pilot relay. Has measurable resistance, consumes power

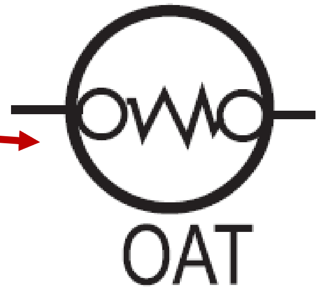


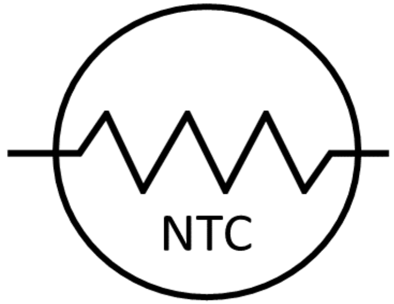
Contactor, Single pole: Shows the shunt side and the switch side with a N.O. contact. No resistance and no voltage drop across the switch when closed



Thermistor: temperature sensitive resistor. 2 types NTC and PTC. 5K ohm, 10k ohm, 50k ohm NTC is what Carrier uses. 10K is the primary one used.

At 77 degrees there will be a 10k ohm resistance to the thermistor. As the temperature increases, the resistance decreases. NTC. Compare the chart readings to assure tolerance.





Thermistors in Carrier equipment

On Carrier equipment, all the thermistors are 10k ohm <u>negative temp. coefficient</u> . Meaning a rise in temp. will result in a fall in resistance. The starting point for all thermistors is 77 degrees.

So

At 77 degrees you have 10k ohms resistance.

10k NTC

Thermistor curve

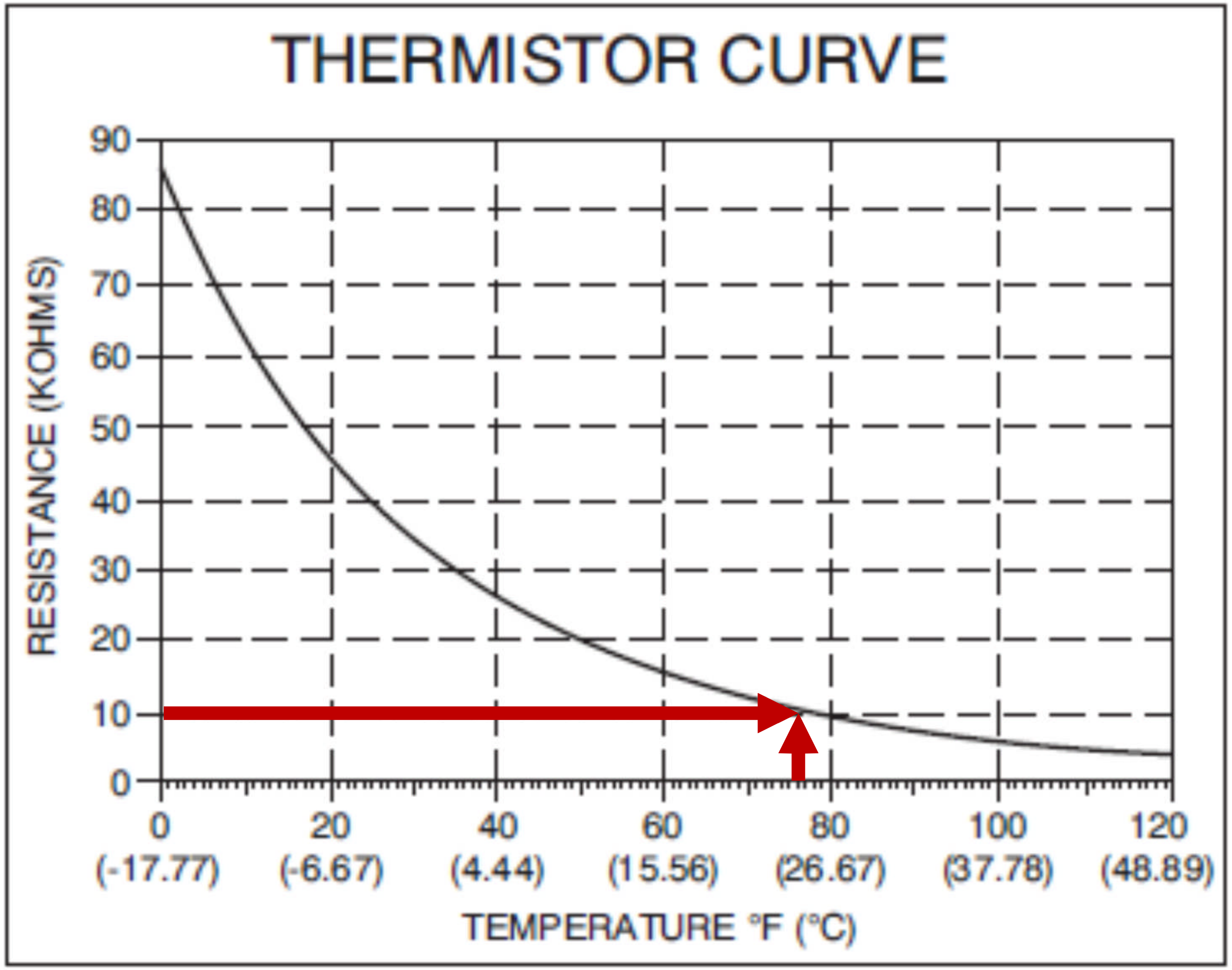


Fig. 8 - Resistance Values Versus Temperature

Table 76 — Thermistor Temperature (°F) vs Resistance/Voltage Drop Values for 10K Thermistors and Sensors (10K at 25 C Resistors)

TEMP (F)	VOLTAGE DROP (V)	RESISTANCE (Ohms)	TEMP (F)	VOLTAGE DROP (V)	RESISTANCE (Ohms)	TEMP (F)	VOLTAGE DROP (V)	RESISTANCE (Ohms)
–25	4.758	196,453	**61**	2.994	14,925	**147**	0.890	2,166
–24	4.750	189,692	**62**	2.963	14,549	**148**	0.876	2,124
–23	4.741	183,300	**63**	2.932	14,180	**149**	0.862	2,083
–22	4.733	177,000	**64**	2.901	13,824	**150**	0.848	2,043
–21	4.724	171,079	**65**	2.870	13,478	**151**	0.835	2,003
–20	4.715	165,238	**66**	2.839	13,139	**152**	0.821	1,966
–19	4.705	159,717	**67**	2.808	12,814	**153**	0.808	1,928
–18	4.696	154,344	**68**	2.777	12,493	**154**	0.795	1,891
–17	4.686	149,194	**69**	2.746	12,187	**155**	0.782	1,855
–16	4.676	144,250	**70**	2.715	11,884	**156**	0.770	1,820
–15	4.665	139,443	**71**	2.684	11,593	**157**	0.758	1,786
–14	4.655	134,891	**72**	2.653	11,308	**158**	0.745	1,752
–13	4.644	130,402	**73**	2.622	11,031	**159**	0.733	1,719
–12	4.633	126,183	**74**	2.592	10,764	**160**	0.722	1,687
–11	4.621	122,018	**75**	2.561	10,501	**161**	0.710	1,656
–10	4.609	118,076	**76**	2.530	10,249	**162**	0.699	1,625
–9	4.597	114,236	**77**	2.500	10,000	**163**	0.687	1,594
–8	4.585	110,549	**78**	2.470	9,762	**164**	0.676	1,565
–7	4.572	107,006	**79**	2.439	9,526	**165**	0.666	1,536
–6	4.560	103,558	**80**	2.409	9,300	**166**	0.655	1,508
–5	4.546	100,287	**81**	2.379	9,078	**167**	0.645	1,480
–4	4.533	97,060	**82**	2.349	8,862	**168**	0.634	1,453
–3	4.519	94,020	**83**	2.319	8,653	**169**	0.624	1,426
–2	4.505	91,019	**84**	2.290	8,448	**170**	0.614	1,400
–1	4.490	88,171	**85**	2.260	8,251	**171**	0.604	1,375
0	4.476	85,396	**86**	2.231	8,056	**172**	0.595	1,350
1	4.461	82,729	**87**	2.202	7,869	**173**	0.585	1,326
2	4.445	80,162	**88**	2.173	7,685	**174**	0.576	1,302
3	4.429	77,662	**89**	2.144	7,507	**175**	0.567	1,278
4	4.413	75,286	**90**	2.115	7,333	**176**	0.558	1,255
5	4.397	72,940	**91**	2.087	7,165	**177**	0.549	1,233
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Testing and Evaluation for Service

The testing and evaluating of the parts in the HVAC system allows us to make a correct diagnosis and repair instead of just swapping parts until we get it found.

Control boards are usually the first thing to get replaced and is the most expensive for the customer. Most of the time, when the control board doesn’t fix the problem is when we in Tech Support get a call just to find the problem to be something that should have been checked first like a contactor or a limit switch burning out.

By making a few checks before condemning a perfectly good control board can same us time and unneeded expense and better at our job.

Also, investing in a quality meter and learning to use it will make the whole process must easier.

Compressor motor testing refresher course

Testing the motor windings of a compressor or any motor is a task that is still the same.

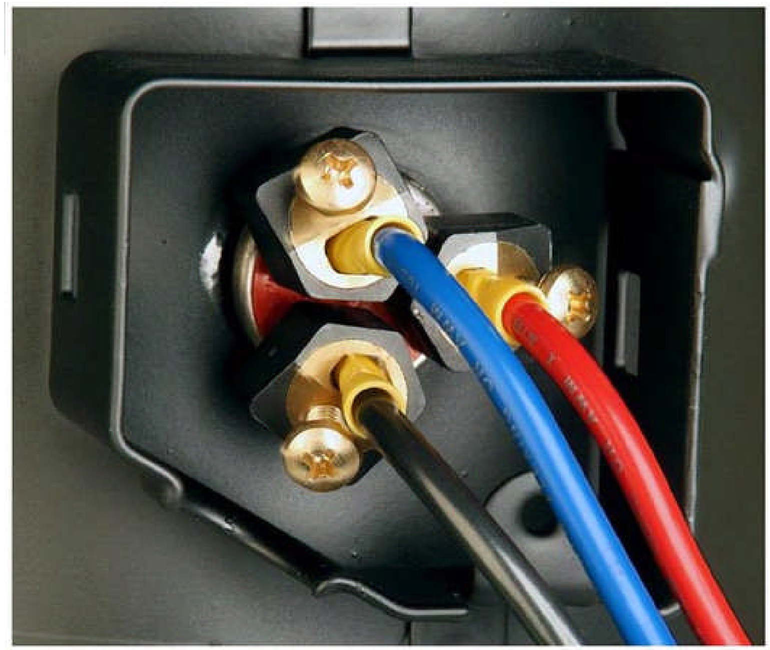
From a basic unit, to a variable speed, to a ductless, the motor is tested the same. Even 3 phase motors.

Needed tools:

Meter that works

Motor

Pencil or pen

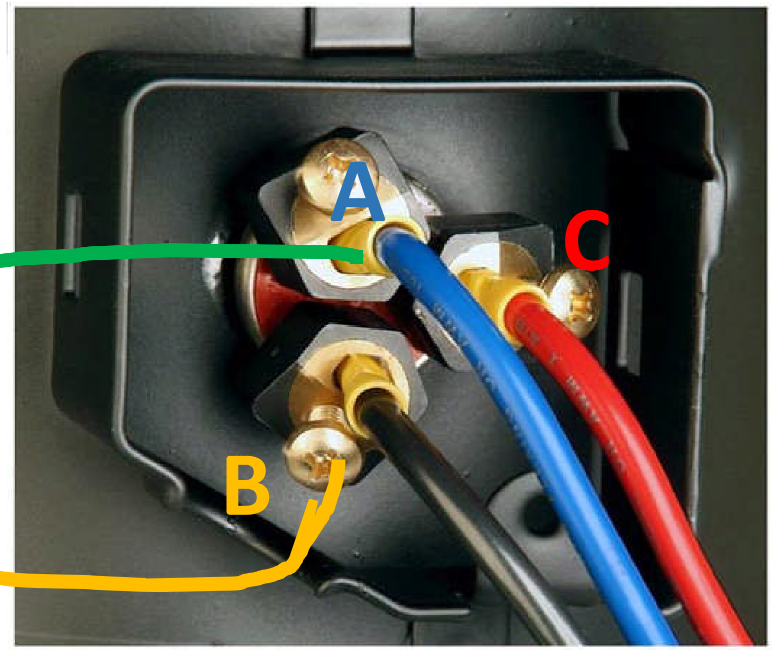


Compressor motor testing refresher course

Label each terminal, A-B-C.

Select a low Ohm scale.

Read A to B --- 3.4

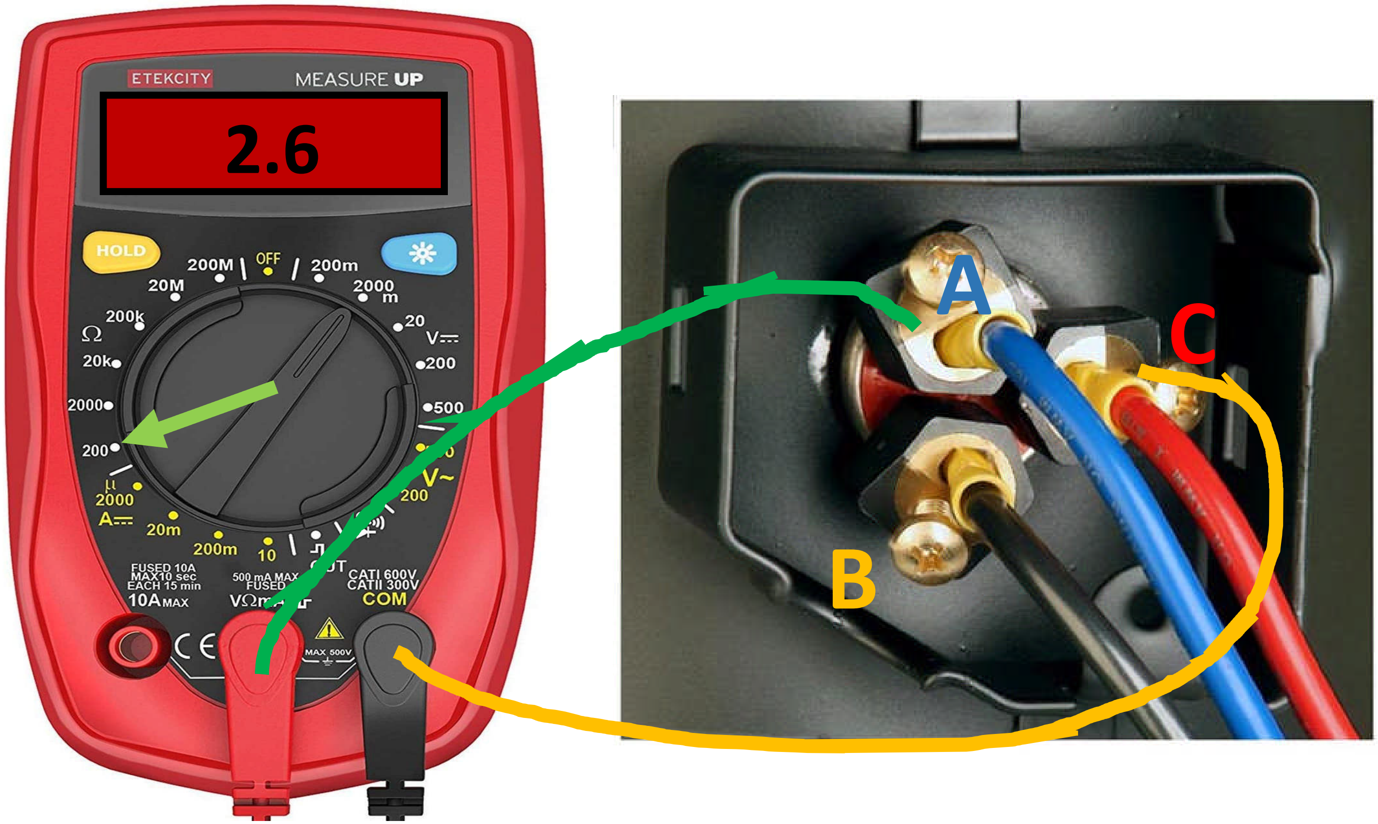


Compressor motor testing refresher course

Label each terminal, A-B-C.

Select a low Ohm scale.

Read A to C ---- 2.6



Compressor motor testing refresher course

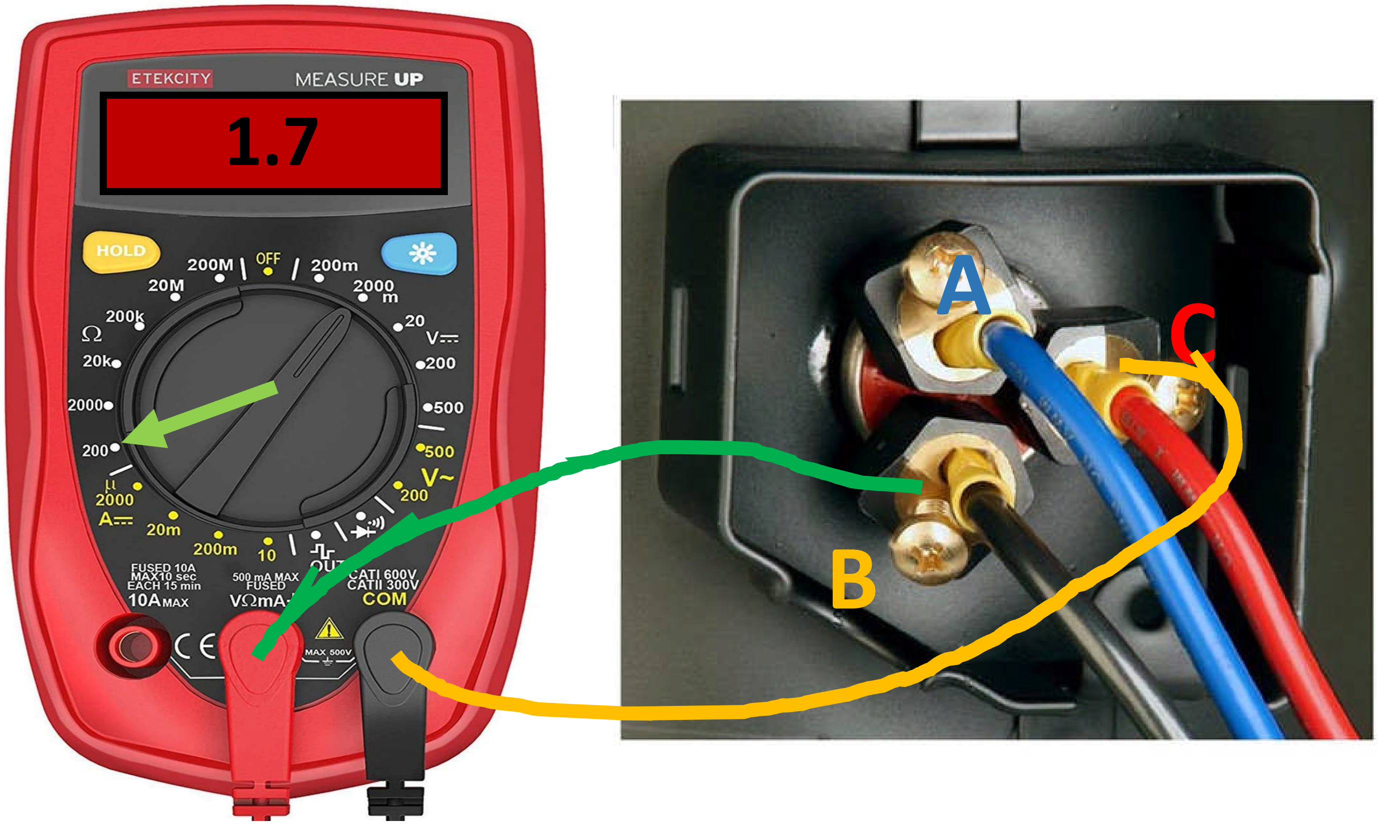
Label each terminal, A-B-C.

Select a low Ohm scale.

Read B to C ---- 1.7

For a single phase motor, the windings appear good.

What are we overlooking?



Compressor motor testing refresher course

Checking each leg to Copper case Ground

Test here should read O.L or 0.00. If there is a reading to ground, failed compressor.

Compressor motor testing refresher course

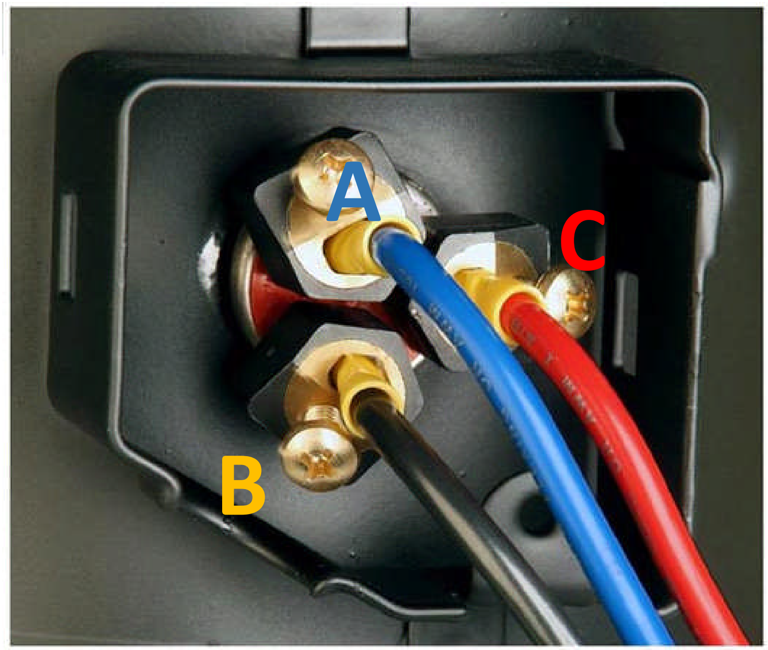
On 3 phase, inverter driven or ductless motors, same thing.

Label each terminal, A-B-C.

Select a low Ohm scale.

All readings will be EQUAL.

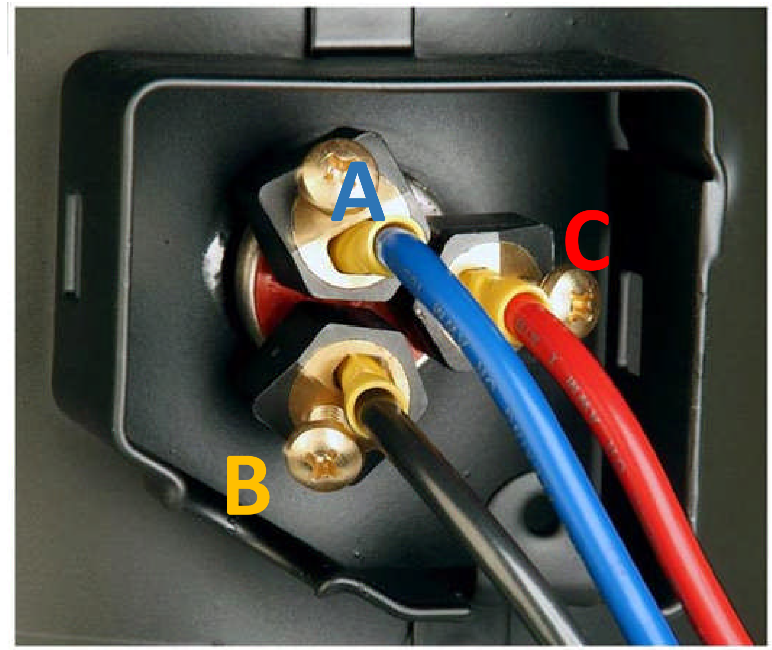
Ohm each leg to copper ground as well.



Compressor motor testing refresher course

The ohm readings will be a low range number, in the single digits, usually.

On inverter driven compressors, they are quite low. As long as they are equal and nothing to ground, the motor winding are good.



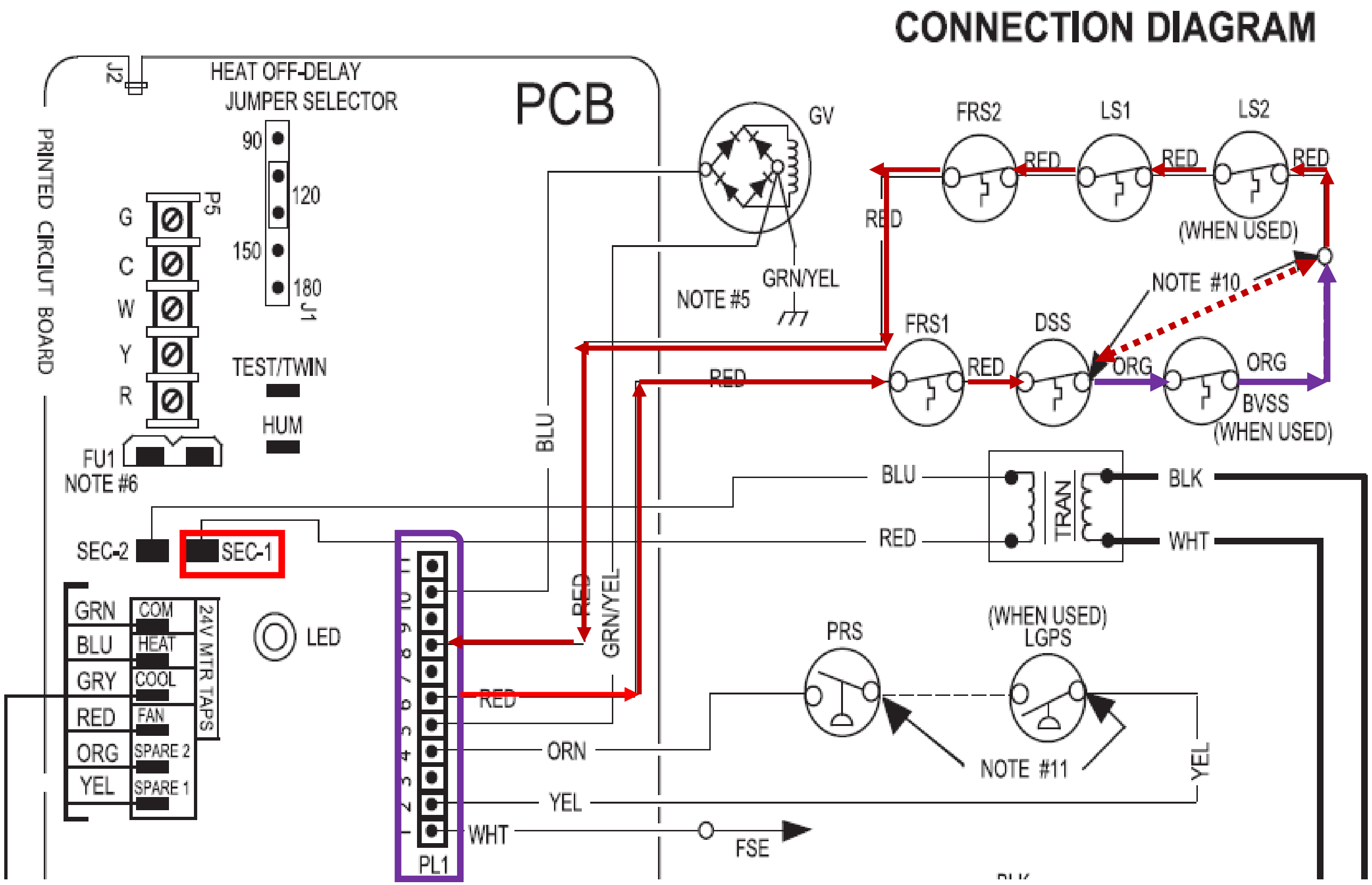
Training will resume in:

05:00

Carrier Enterprise

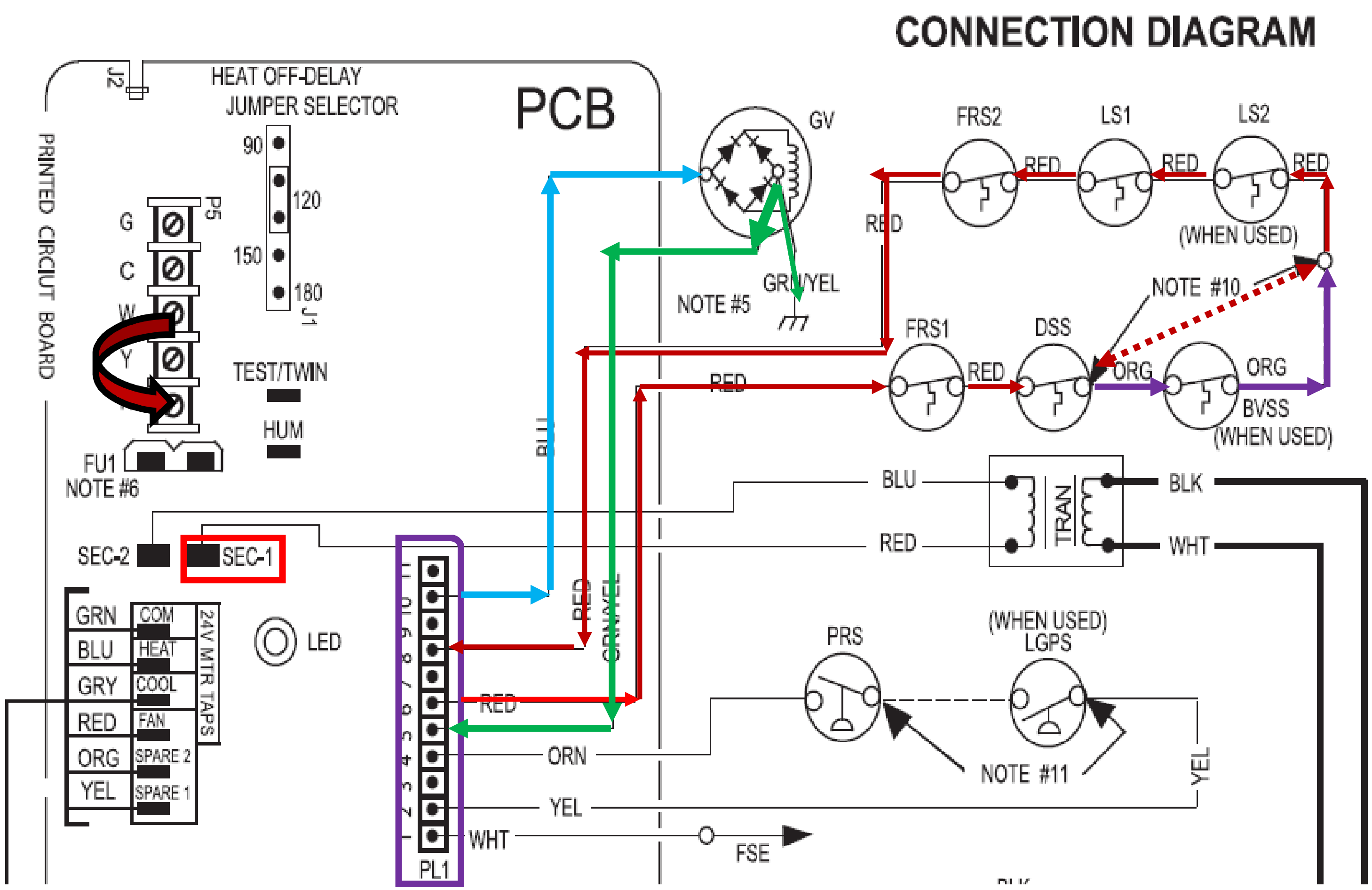
Testing the limit circuit and gas valve : 58SC0A furnace

For the limit circuit test, start by unplugging the PL1 molex from the control board with plug removed, ohm the 2 red limit circuit wires at the plug. This is testing the entire circuit at once. If you see “OL” or any real resistance then start checking the separate limits and connections. *Carrier does not designate a manual or auto reset limit on diagrams.



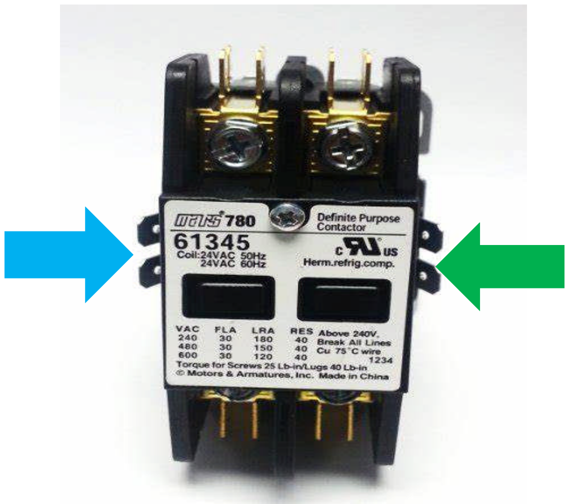
Testing the limit circuit and gas valve : 58SC0A furnace

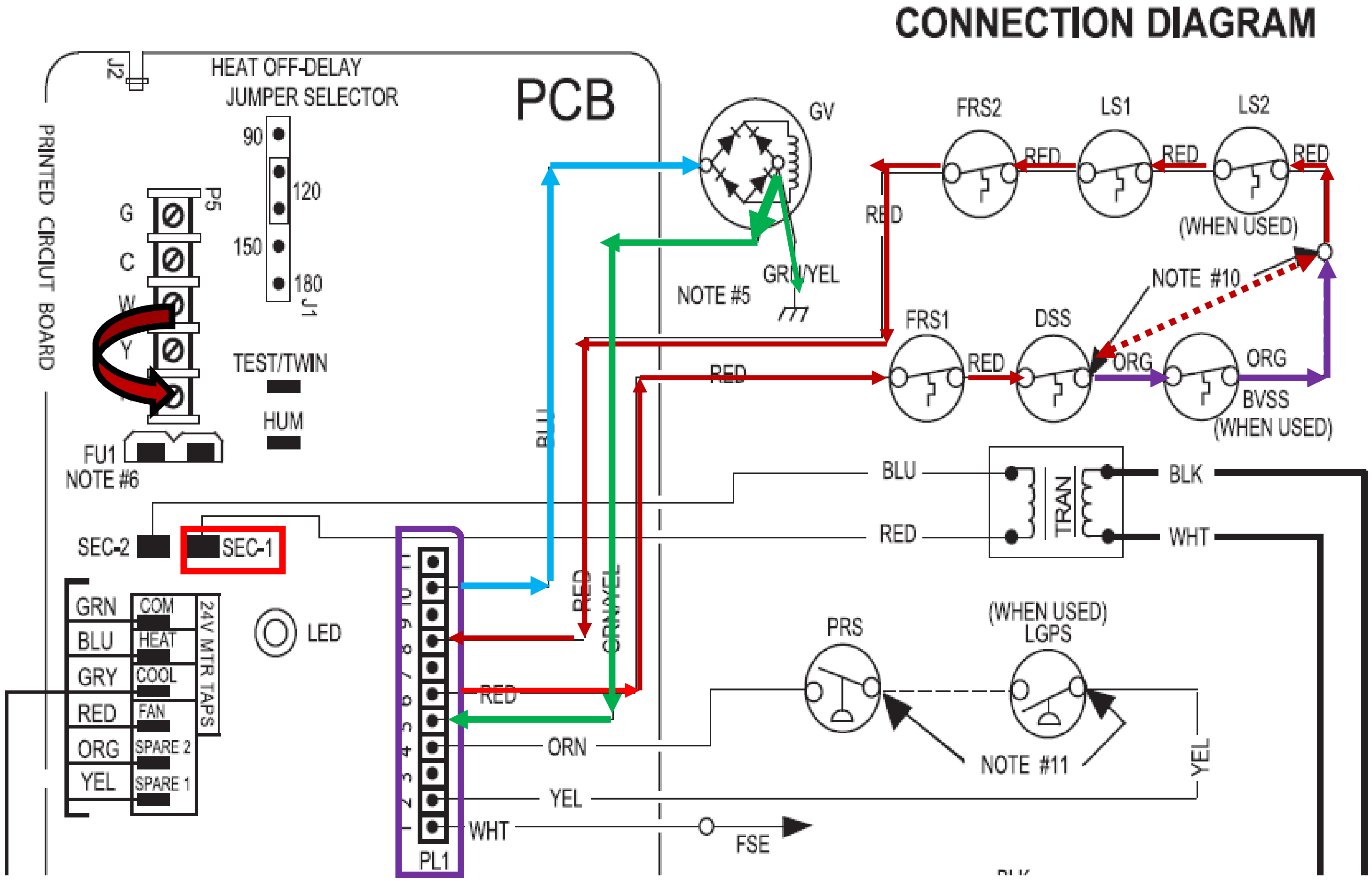
Gas valve testing: This is done with the power on so the signal can be detected. A call for heat is made by jumping R to W. Once the HS Igniter heats to its point the gas valve should get energized. Look for the 24vac signal from blue to ground. To verify this, use a "known to be good" part. In this case we will use a contactor



Testing the limit circuit and gas valve : 58SC0A furnace

Remove the blue and green wire and connect them to the coil on the contactor. Call for heat and see if the coil pulls in.



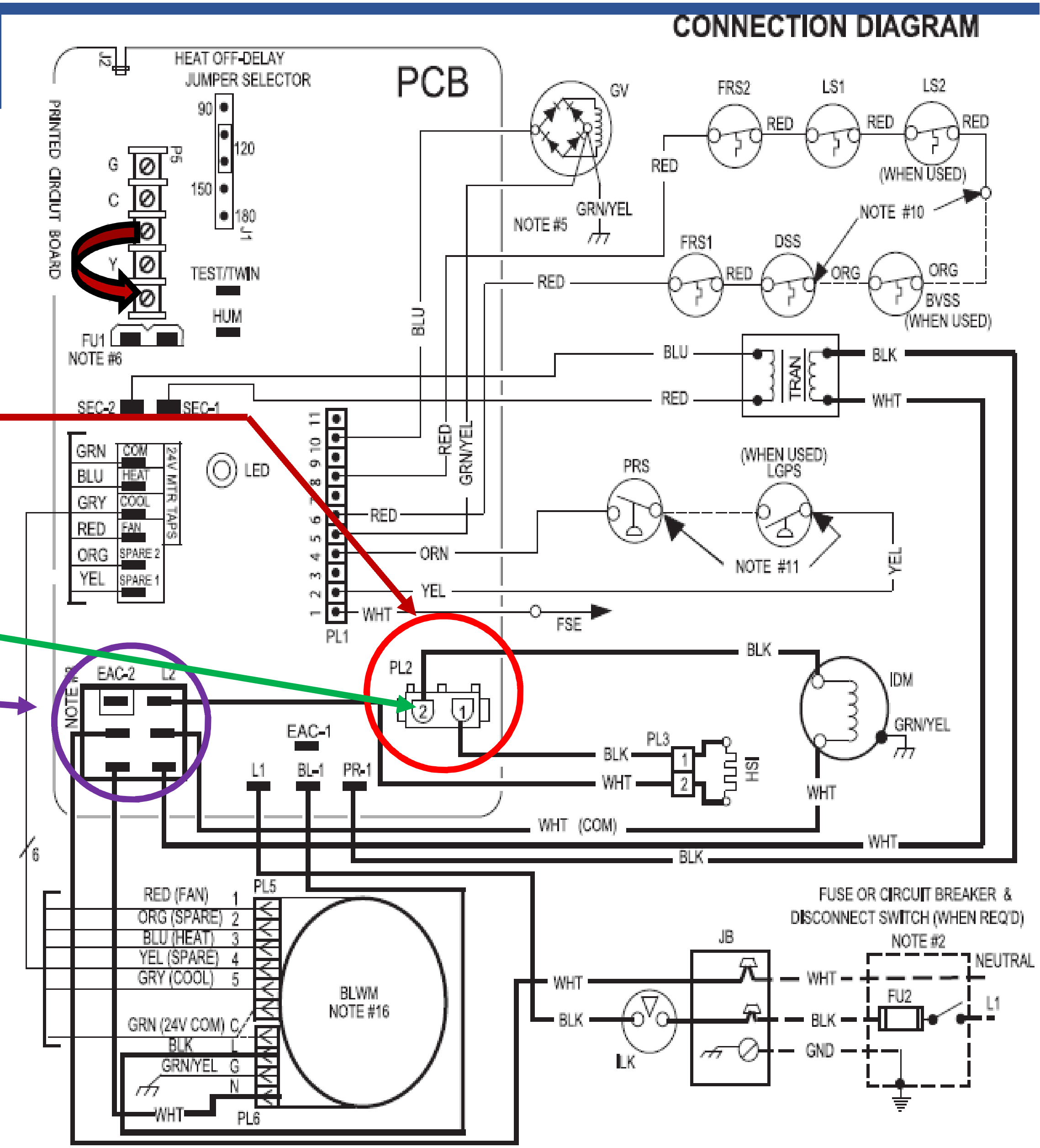


Testing the draft motor : 58SC0A furnace

Draft inducer motor fault could be the draft motor or the control board. Resist the urge to swap the control board before testing.

Locate and unplug the draft motor PL2 plug. Locate the neutral L2 buss on the control board. Call for heat with a jumper. Look for line voltage (120vac) between PL2-2 and L2 neutral.

This test has a short time before a fault will appear. About 10 – 20 seconds



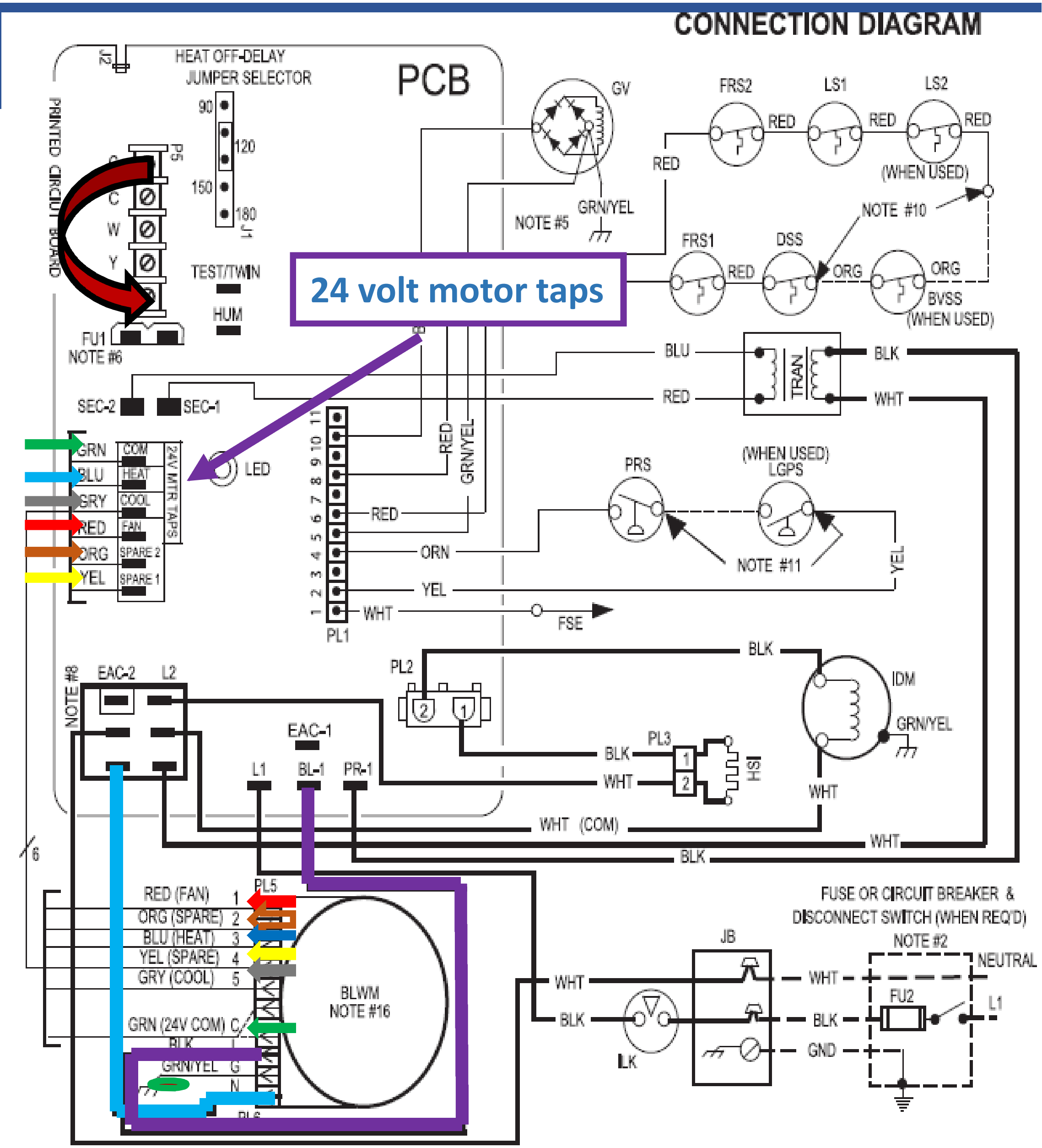
Testing the fan motor : 58SC0A furnace

First, verify the line voltage (120vac) to the motor. Line voltage is always at the motor.

With an operation call (H-C or Fan) test for 24vac at the board. If the 24 volts is there, check the other end of the harness.

It is possible to just loose a single speed and the others still work. The Product Data shows the color/speed relation

070E17−12	Gray	Cooling. Do not use for heating.
	Yellow	Alt Cooling or alt Heating
	Blue	Heating or alt Cooling
	Orange	Alt Cooling or alt Heating
	Red	Alt Cooling. Do not use for heating.



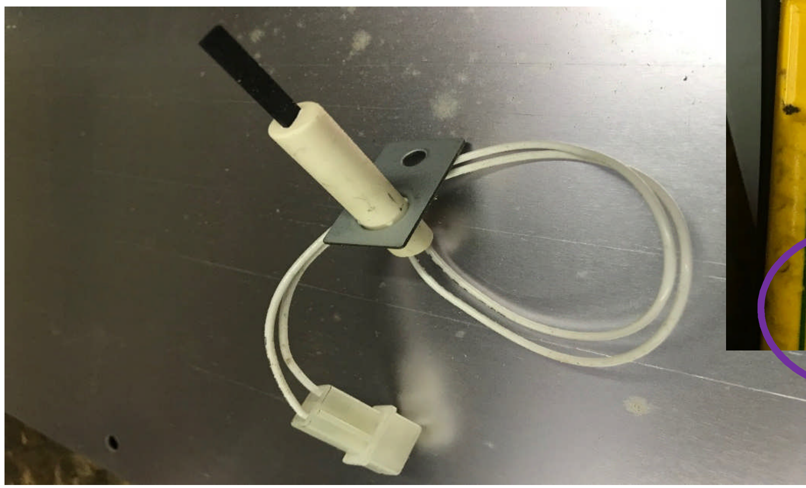
Common HSI

HS Igniter: Test this with the power off and the igniter unplugged from the board but still in place if possible.

Set the ohm meter to a lower range (under 2k).

Data spec state between 35 – 150 ohms is acceptable.

If handling the igniter cannot be avoided, try not to touch or bump the heater element.



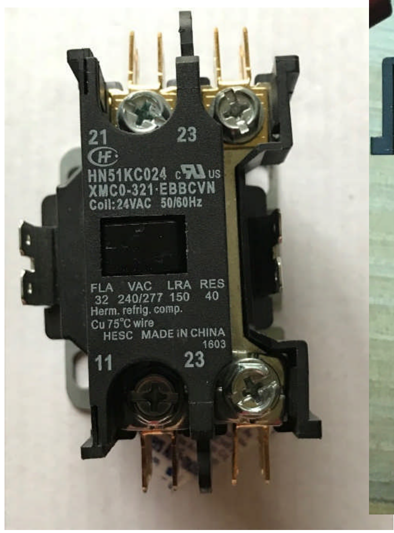
Contactor

Test the coil: Resistance with the power off and all the control wires disconnected.

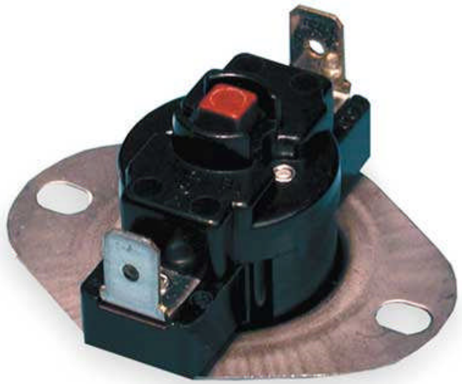
With the meter set to a lower Ohm reading, like on the HSI, measure the resistance. The exact resistance is not known but it should be steady and measurable.

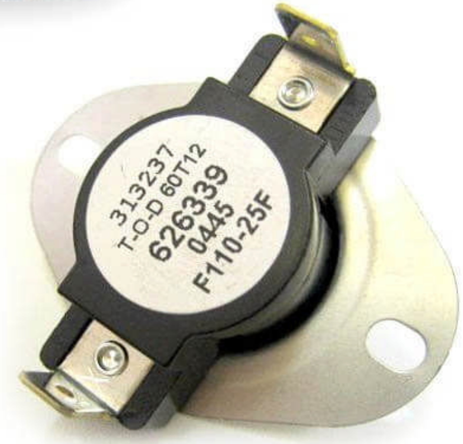
Usually we will see about

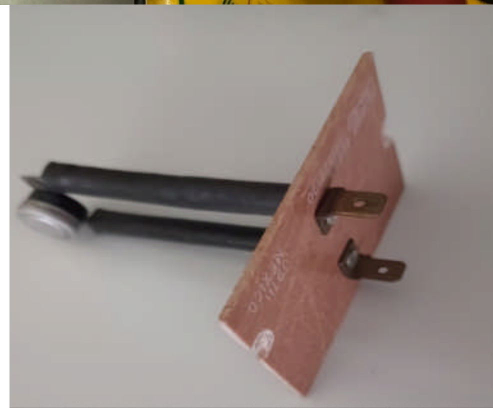
10-30 ohms



LIMIT SWITCHES



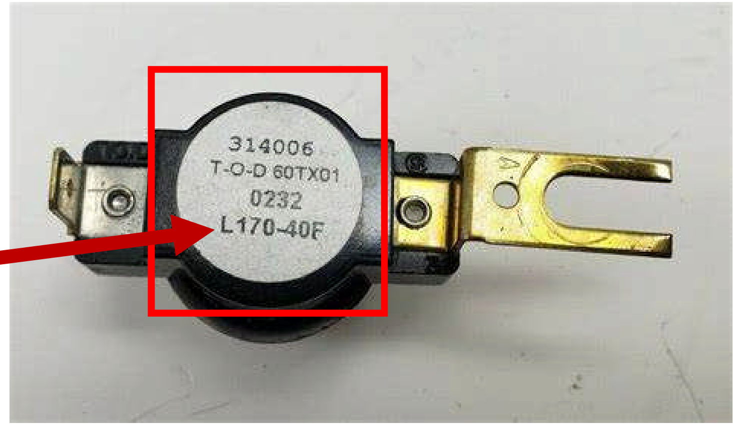




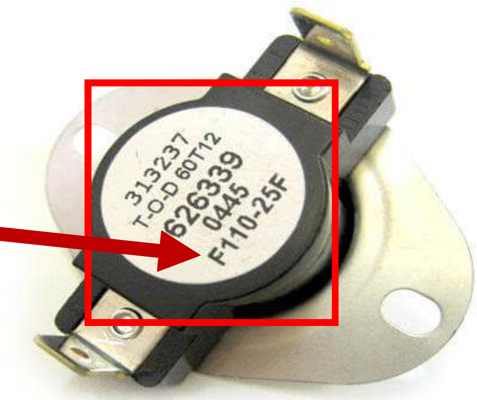
Limit switch actions

Open on rise: Used for safety to break a circuit with a rise in the area that it is sensing. Have a preset temperature to open and a cool down temperature to reset. Designated by an “L” along with the temperature limit and the cool down reset span.

No resistance when closed.



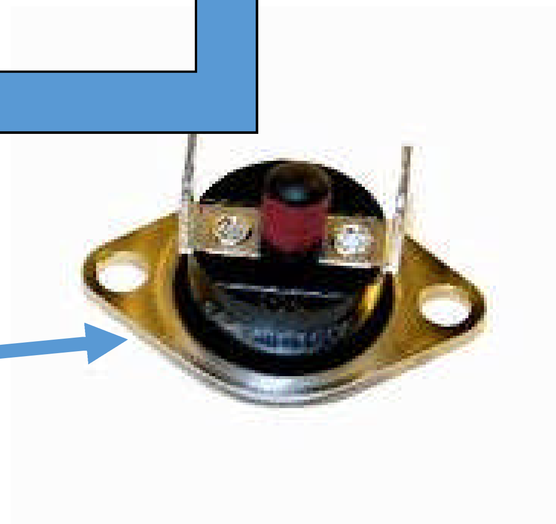
Close on rise: Used as a pilot switch to energize a relay and/or a fan motor. Has a preset temperature and span as well. Designated by an “F” with the temperature. Again, no resistance when closed.



If the markings cannot be read, look at the diagram and determine does it start or stop something.

Limit switches come in a variety of configurations.

They are still all bi-metal snap discs. They are all still classified as “close on rise” and “open on rise”. The way they are used makes the difference. The vast majority are “open on rise” temperature limits like we see in heater safety to prevent excess heat. When the heat reaches a specific temperature, the disc snaps and opens the internal contacts and breaks the heat circuit, switching off the heat source. They can be automatic reset, when they cool they reset without help. They can also be manual reset which require us to push the reset button so that it draws attention to a problem. This is typical of a rollout limit switch.



IDM pressure switch

The pressure switch on a furnace is a simple switch that can be tested fairly easily. First we must understand the operation during a cycle.

With a call for heat, the control board first looks at the pressure switch before it starts the draft motor to see a N.O. switch. If it can see a N.O. switch it will then start the inducer motor. When the inducer motor starts, the control board gives the pressure switch just a few seconds to close. If the switch does not show a closed, completed control signal the H.S. Igniter relay will not be energized to glow and a fault code will appear.

This can all be checked with the wires disconnected and an ohm meter used at the switch terminals

Thermistors in Carrier equipment

On Carrier equipment, most all the thermistors are 10k ohm <u>negative temp. coefficient</u> . Meaning a rise in temp. will result in a fall in resistance. The starting point for all thermistors is 77 degrees.

So

At 77 degrees you have 10k ohms resistance.

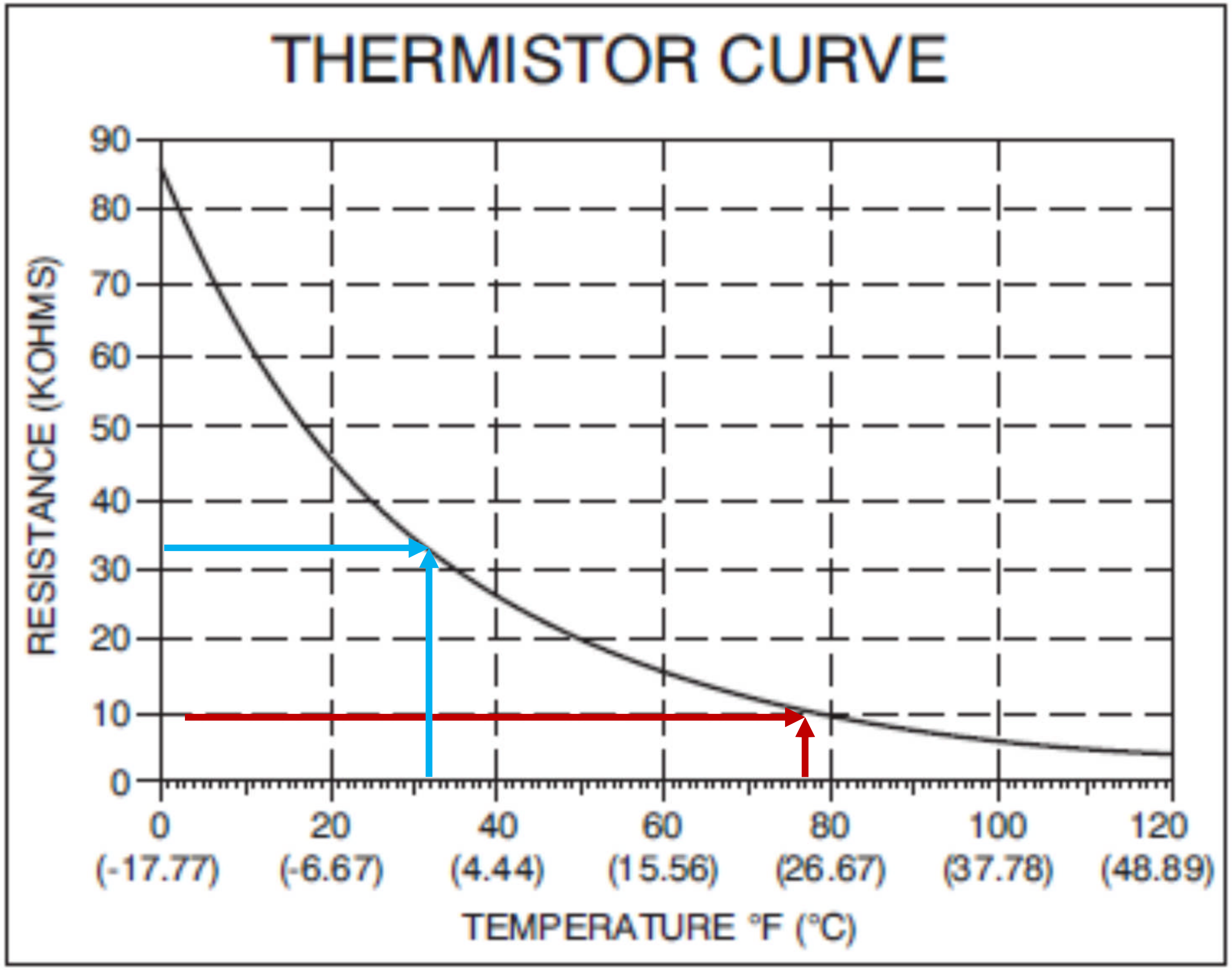


Fig. 8 - Resistance Values Versus Temperature

10K NTC thermistor at 32 degrees is about 32K ohms

10K NTC thermistor at 77 degrees is right at 10k ohms

Table 76 — Thermistor Temperature (°F) vs Resistance/Voltage Drop Values for 10K Thermistors and Sensors (10K at 25 C Resistors)

TEMP (F)	VOLTAGE DROP (V)	RESISTANCE (Ohms)	TEMP (F)	VOLTAGE DROP (V)	RESISTANCE (Ohms)	TEMP (F)	VOLTAGE DROP (V)	RESISTANCE (Ohms)
–25	4.758	196,453	61	2.994	14,925	147	0.890	2,166
–24	4.750	189,692	62	2.963	14,549	148	0.876	2,124
–23	4.741	183,300	63	2.932	14,180	149	0.862	2,083
–22	4.733	177,000	64	2.901	13,824	150	0.848	2,043
–21	4.724	171,079	65	2.870	13,478	151	0.835	2,003
–20	4.715	165,238	66	2.839	13,139	152	0.821	1,966
–19	4.705	159,717	67	2.808	12,814	153	0.808	1,928
–18	4.696	154,344	68	2.777	12,493	154	0.795	1,891
–17	4.686	149,194	69	2.746	12,187	155	0.782	1,855
–16	4.676	144,250	70	2.715	11,884	156	0.770	1,820
–15	4.665	139,443	71	2.684	11,593	157	0.758	1,786
–14	4.655	134,891	72	2.653	11,308	158	0.745	1,752
–13	4.644	130,402	73	2.622	11,031	159	0.733	1,719
–12	4.633	126,183	74	2.592	10,764	160	0.722	1,687
–11	4.621	122,018	75	2.561	10,501	161	0.710	1,656
–10	4.609	118,076	76	2.530	10,249	162	0.699	1,625
–9	4.597	114,236	77	2.500	10,000	163	0.687	1,594
–8	4.585	110,549	78	2.470	9,762	164	0.676	1,565
–7	4.572	107,006	79	2.439	9,526	165	0.666	1,536
–6	4.560	103,558	80	2.409	9,300	166	0.655	1,508
–5	4.546	100,287	81	2.379	9,078	167	0.645	1,480
–4	4.533	97,060	82	2.349	8,862	168	0.634	1,453
–3	4.519	94,020	83	2.319	8,653	169	0.624	1,426
–2	4.505	91,019	84	2.290	8,448	170	0.614	1,400
–1	4.490	88,171	85	2.260	8,251	171	0.604	1,375
0	4.476	85,396	86	2.231	8,056	172	0.595	1,350
1	4.461	82,729	87	2.202	7,869	173	0.585	1,326
2	4.445	80,162	88	2.173	7,685	174	0.576	1,302
3	4.429	77,662	89	2.144	7,507	175	0.567	1,278
4	4.413	75,286	90	2.115	7,333	176	0.558	1,255
5	4.397	72,940	91	2.087	7,165	177	0.549	1,233

Helpful tips

- 746 watts = 1 hp   voltage doesn't matter
- With a given load, amperage rises when voltage drops
- Ampacity of a transformer = VA rating ÷ secondary voltage
- Lock rotor amp are roughly 5 times the running load amps
- Capacitor is a torque multiplier / rated by microfarads / 2 types
- Run capacitor stays in the circuit and rated by specific number
- Start caps <u>do not</u> stay in the circuit / rating is a span of numbers
- Capacitor should be replaced whenever a motor is replaced

EB2

Introducing…………

The new universal

No Trip Breaker Anchor !

The local Fire Dept. loves these

Keeps them on their toes.

EB1

Slide 82

EB1 Edmiston, Brian, 2/15/2019

EB2 Edmiston, Brian, 2/15/2019

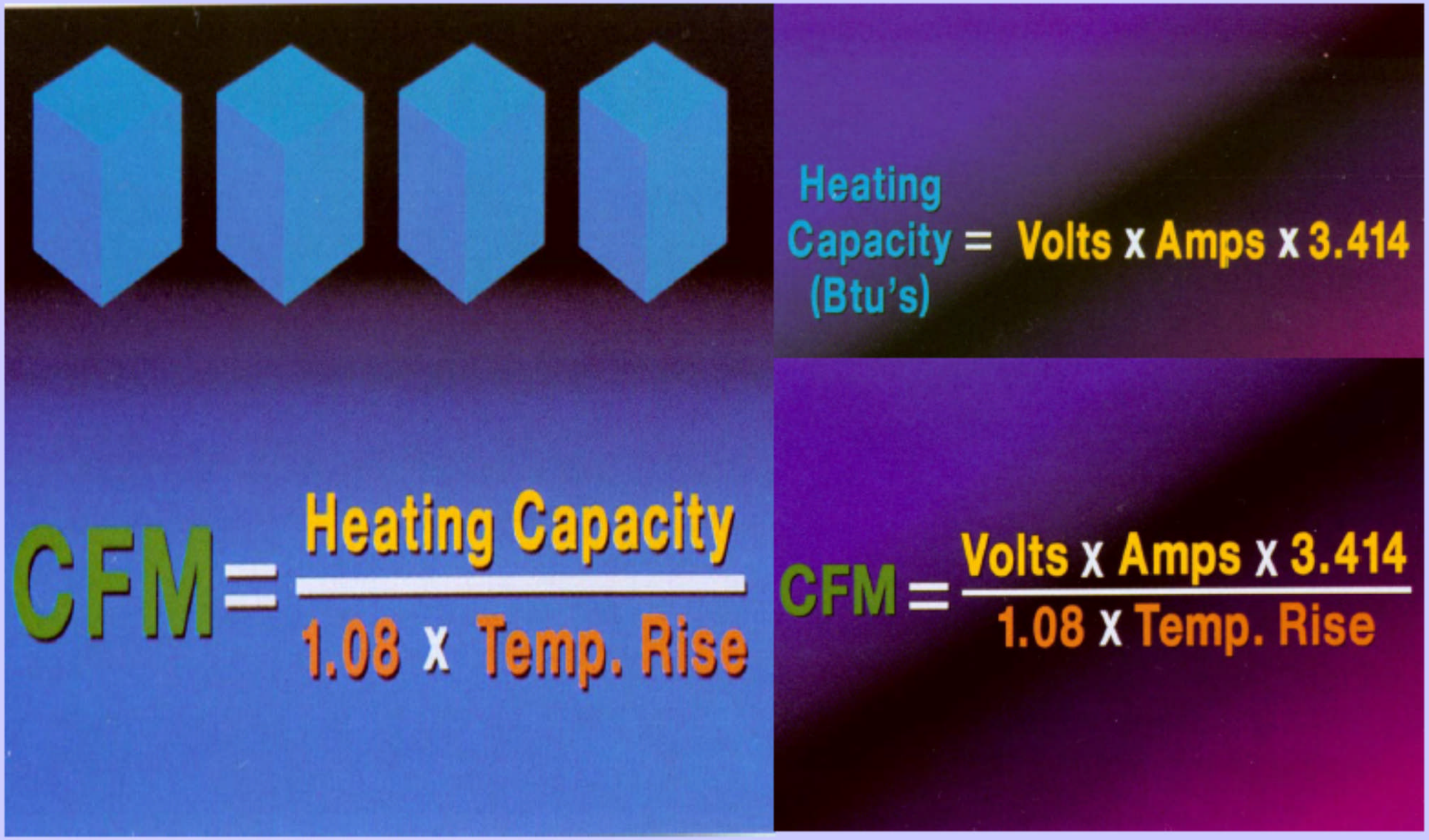
Helpful Formulas

- 1 Watt=3.414 BTU's or 1000 watts=3414 BTU's
- BTU's = volts x amps x 3.414 for elec. Heat capacity

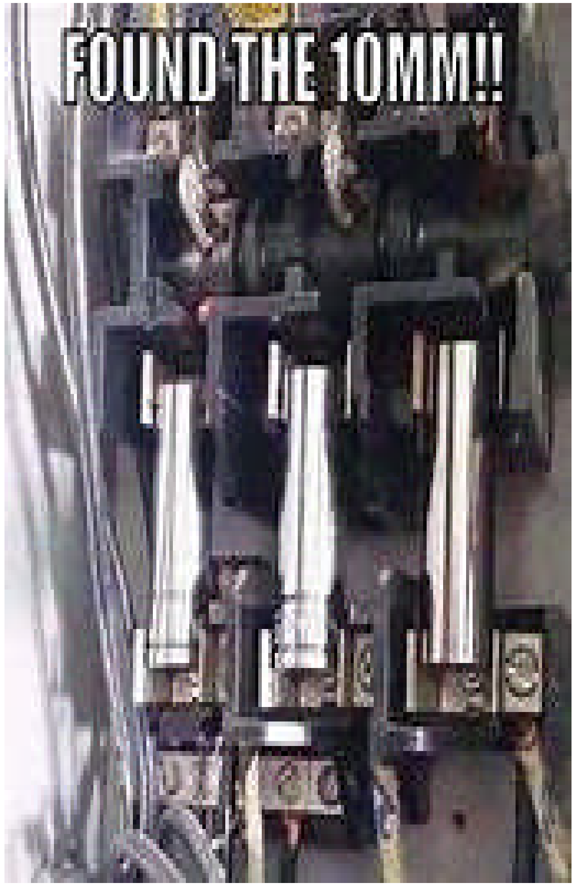
$$\frac{\text{Heat capacity (V x A x 3.414)}}{\text{1.08(given) x Temp. Rise}} = \text{CFM of the unit}$$

- To find ohms (resistance) = $\frac{\text{Volts x Volts}}{\text{Watts}}$
- Or …………………. $\frac{\text{Volts}}{\text{Amps}}$

Test CFM by Testing the Electric Heat




WHEN YOU COME TO FIX
A DIY PROJECT


FOUND THE 10MM!!


TOTALINE
HVAC/R PARTS

Safety

- You can not outrun electricity period.
- The safest way to test anything is to be turned off. Cant always do it.
- Electricity is like most things, it will take the path of least resistance.
- Keep your hands and anything that you love out of the circuit.
- Be aware of grounding yourself, electricity is always looking for it.
- Treat all wiring as if it is on. Check it before you grab it. Don't trust the other guy to keep you alive. Let your meter be your best friend.
- Test resistance(ohms) with the power off. No Exceptions.
- Test volts and amps with the power on.   Be careful.
- Discharge capacitors before removing them. They can hold a charge.

Electric Safety Practice

- **Remember:** High voltage is **ALWAYS** dangerous!
- **Even 40v can be lethal under the right conditions!**
- **Always make certain the power is off before handling high voltage wiring. Double check with volt meter. Never assume a circuit is 'dead', or you could be.**
- **Don't wear jewelry. Always remove rings and bracelets before putting your hands into a unit.**
- **Do not work on high voltage in wet or damp conditions.**
- **Do not work on high voltage in poor lighting conditions.**
- **Do not leave safety switches bypassed any longer than absolutely necessary for circuit or device testing. Operating units with safeties bypassed can be dangerous and potentially lethal.**


QUESTIONS?
COMMENTS?
CONCERNS?

THANK YOU!