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## Information Installation And Service Manual



3034 SANDBROOK ST.  
MEMPHIS TENNESSEE 38116  
800-228-4138 Fax 901-396-4131

## **Disclaimer**

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# Index

Why did the compressor fail?	Page 2
Good serviceman should know...	Page 5
Identifying Failure Modes	Page 6
Liquid Slugging	Page 6, 7
Liquid Washout	Page 6, 7
Liquid Dilution	Page 6, 8
High Discharge Temperature	Page 6, 8
Lack of Lubrication	Page 6, 9
Motors	Page 7, 9
Typical Three Phase Winding Failures	Page 10
Installation and Startup	Page 13
Superheat	Page 14
About Capacity Control	Page 14
Normal Oil Pressure	Page 15
Operating Temperature Guidelines for Air Conditioning	Page 16
Operating Temperature Guidelines for Refrigeration	Page 17
Brainerd Compressor Startup Sheet	Page 18
Brainerd Compressor Inspection Form	Page 19
Wiring Diagrams	Page 20
Carrier/Carlyle 06D	Page 21, 22
Carrier/Carlyle 06E	Page 23
Carrier/Carlyle 6G, 06G, 6L and 06L	Page 24, 25
Copeland	Page 26
Chrysler Airtemp	Page 27, 28
Dunham-Bush	Page 29, 30, 31, 32
York	Page 33, 34
Trane	Page 35, 36
Capacity Control (Adjusting and Diagrams)	Page 37
Carrier/Carlyle, 06D, 06E	Page 38, 44, 45
Carrier/Carlyle, 5F, 5H, 6G/06G, 6L/06L	Page 40, 46
Trane, A, B, E and F	Page 42, 51
Trane, M and R	Page 43, 52, 53
Copeland	Page 47, 48
Chrysler Airtemp	Page 49, 50
Welcome To Brainerd, About Brainerd Compressor	Page 54
Brainerd Procedures and Testing Manual	Page 58
Procedures and Testing Manual Index	Page 60

## WHY DID THE COMPRESSOR FAIL?

YOU MUST ALWAYS ASK *YOURSELF* THIS QUESTION. IF YOU DON'T FIND THE ANSWER YOU WILL PROBABLY BE CHANGING THE COMPRESSOR AGAIN. THE OLD COMPRESSOR HAS A STORY TO TELL. BY TAKING A LITTLE TIME WE MAY FIND THE ANSWER TO OUR QUESTION. LETS LOOK AT SOME STORIES.

“SHORTED TO GROUND.” 85% of compressor failures include a motor failure, only 5% of them are just “Motor Failures”, the remaining 80% fail for another reason. A large percentage of shorts and/or grounds are caused by lack of lubrication. Pull the end bell off the compressor and look at the rotor and stator. Look at the windings and see what condition they are in. If we see a general burn, all windings burned, we need to check for low voltage, high voltage, voltage and/or current imbalanced or loss of motor cooling. If we see one or two phases burned and the others are not, then we probably had a single-phase condition, either primary single phase or secondary single phase. If we find half of the windings burned and the other half not, one contactor did not pull in and we overheated the other (part winding start). If we find two phases of half the winding burned, check for welded contact points keeping two legs energized in the off cycle. If you find a spot burn at the bottom of the compressor check the clearance between the rotor and stator. Check for up and down or side-to-side movement of the rotor.

If you have a compressor that is locked up, you need to look in the crankcase. Pull the side plate or bottom plate. Look for broken rods, galled bearings or seized pistons. You may also want to look at the valves by pulling the heads. Look for broken or discolored valves, blown head or valve plate gaskets, bent valve backers, loose, missing or broken valve bolts.

Is there any copper plating? Moisture and high temperatures result in acid followed by copper plating.

After installing a new compressor, you will want to use what you found on your inspection of the old compressor to check for system problems. Galled or worn bearings and wrist pins are signs of flooding. Broken valves and rods are signs of a flooded start or slugging from the system.

TAKE TIME TO CHECK THE SAFETIES.

Checking a compressor that is running:

The compressor is running but the oil leaves the compressor. This can be caused by worn pistons, worn rings, bad valves, flooding or worn bearings. The rear main bearing may be severely worn. When checking for flooding, look at the oil sight glass. Does the oil look foamy or clear and then turns foamy and back to clear? Are the heads too hot (sizzle when sprayed with water)? Is the crankcase too hot (105° to 125° F is normal)? Does the oil leave on start up and doesn't seem to come back? Check the suction pressure. Suction or head pressure may be too low to bring the oil back to the compressor. Has the compressor been running unloaded for an extended time? When a compressor unloads the gas velocity decreases and the line sizes are incorrect for the new capacity, this may result in poor oil return. If this is a refrigerant cooled compressor you have also lost some compressor cooling and your compressor may run hotter. Is the crankcase pressure too high? Check the difference between the crankcase and the suction

pressure. The crankcase pressure should be slightly lower than the suction on most hermetic reciprocating compressors. The Carrier/Carlyle O6E is one exception to this with a higher crankcase pressure but should not be more than 2 psig higher.

Does the compressor knock when it is running? Worn bearing, rods, wrist pins, broken rods or valves might be the cause. To check for a worn wrist pin, bring the piston to the top of its stroke and start back down. Now push down on the piston, there should be no movement. This condition is common if the compressor has run with a broken discharge valve. To check for high crankcase pressure, put a gauge on the crankcase fitting and one on the suction of the compressor. While the compressor is running, begin to close the suction service valve. Watch the crankcase pressure. When it stops dropping that is the lowest the suction pressure can be and still have the oil returned to the crankcase. Check the superheat. What do you want it to be? If it's 12° or less it's considered wet and you will at times during system changes bring back some liquid. At the very least you will be washing the lubrication off the upper cylinders and reduce the life of the compressor. Brainerd requires a minimum of 15° to insure a dry vapor, and recommends 20° at the compressor. This is system superheat not evaporator superheat. The suction pressure should be taken at the compressor suction service valve and the temperature taken within 18 inches of this valve. Brainerd's recommendations are for true superheat, not your readings. True superheat is your readings adjusted according to the ambient temperature and how well the temperature probe was insulated. You can expect an error of two to five degrees if the best possible field procedures with a well-insulated temperature probe are followed. This error will most likely be on the unsafe side. Keep in mind that superheated refrigerant is not needed in the evaporator, many evaporators are flooded, but superheat is what protects the compressor. Liquids will not compress, when you try, parts break.

The following information is quoted directly from Copeland's Application Engineering Manual AE-104-R1 page 17-9. It eliminates confusion on WHERE to measure and HOW MUCH superheat you should have.

"A minimum of 15° F superheat at the compressor must be maintained at all times to insure the return of dry gas to the compressor suction chamber, and a minimum of 20° F. of superheat is recommended. Note that this is not superheat at the expansion valve, but should be calculated from the pressure measured at the suction service valve and the temperature measured 18" from the compressor on the bottom of a horizontal run of the suction tubing. Lower superheat can result in liquid refrigerant flooding back to the compressor during variations on evaporator feed with possible compressor damage as a result. Excessively wet refrigerant vapor continually returning to the compressor can reduce the lubricating qualities of the oil and greatly increase compressor wear, as well as resulting in a loss of capacity."

Does the compressor vibrate excessively when running? Common causes are broken valves, blown gaskets, broken rods or crankshaft, and oil trapping, as well as a high oil level and system flooding. Fan cycle switches or defective capacity control valves can cause the TXV to flood the compressor.

Check the discharge temperature within twelve inches of the compressor discharge service valve, 200° F is ok, above 200° is in the danger zone for air conditioning applications. Heat pumps and refrigeration applications may be higher. Valve temperatures are 50° to 75°

above discharge temperature. Oil will break down at 350° F. In systems with refrigerant cooled compressors the compressor is the last thing to get cooling and the first thing to lose it. A low discharge temperature indicates flooding. Discharge temperature should have reached 160° F within one minute of operation. Feel the compressor body. Is it cold up around the heads? It shouldn't be. Check the oil pressure, this can be critical. You cannot always tell when a compressor is not being lubricated. Check the oil failure switch for proper operation and settings. When checking voltage, be aware of the voltage difference between legs. Two percent is the maximum allowed voltage imbalance. The maximum allowable current imbalance is ten percent. Most current imbalance is due to voltage imbalance. Winding temperatures increase rapidly with any current imbalance. A five percent imbalance will result in a twenty five percent increase in winding temperature. This increase is above its normal winding temperature.

If your suction pressure is about the same as your discharge then you could have a broken crankshaft, broken valves or a leaking pressure relief valve. The compressor may run smooth if the crankshaft is broken. A compressor valve check can be done by pumping the compressor down. If it will not pump down, or pumps down slowly, one or more suction valves may be bad. If the compressor pumps down and off but the pressure on the suction side rises rapidly, one or more discharge valves are bad, the pressure relief valve is leaking, or you have a blown gasket. If the compressor is going off on the oil pressure control you may have a broken oil pump shaft or an oil pressure-regulating valve that is stuck. Most low oil pressure problems are a result of worn bearings causing a loss in pressure around the bearing surfaces. Other causes for low oil pressure are high temperature and oil dilution. A broken oil pump shaft results in zero or no oil pressure and maybe a result of a bearing failure allowing the compressor crankshaft to bounce and snap the oil pump shaft.

There is a wide range of air conditioning and refrigeration system designs, refrigerants and configurations. They are far too numerous for me to list all the conditions and causes of compressor failures. The statements made here are by no means meant to be a comprehensive list of faults and remedies. We wish only to impress upon the readers the importance of determining a cause for the compressor failure before installing a replacement and leaving the job half done. Keep in mind that few compressors you replace actually wore out due to age. When you're called to fix a system with a bad compressor, try to remember that the bad compressor is most likely a result. Most of us have seen compressors that have been running for thirty or forty years but most of what we change have less than ten years running time. Most failures fall into just a few categories. Loss of lubrication is probably number one and many things can cause this, most are system faults rather than compressor defects. Any system fault will eventually show up in the compressor. When doing an inspection, remember that what you find, are, for the most part, a result and a clue to the cause of the compressor failure, not the cause itself. The above example of a shorted to ground motor winding is not uncommon. Was this a result of a system fault? If so, it's not the cause of failure. If you do not have time to inspect the compressor do you have time to replace it?

All manufacturers agree that replacement compressors fail at a rate several times higher than original equipment compressors. It is the service technician's responsibility to determine not only the reason the unit isn't cooling, "compressor is shorted to ground", but also what caused it to fail and to correct any system faults. ***Why did the compressor fail?***

## A GOOD SERVICEMAN SHOULD KNOW THE ANSWERS

What should your discharge temperature be within 6" of the compressor?

What should your oil temperature be?

How can you check to see if the rings are worn?

What is superheat and what should the superheat be at the compressor on a TXV system?

What is Subcooling and what should it be at the outlet of the condenser?

What causes most electrical failures?

Broken valves, rods and pistons are caused by?

What should a cold motor sensor read in ohms? Robertshaw \_\_\_\_\_ TI \_\_\_\_\_

Make sure you have the right motor protector module for the sensors you are using.

If you have one solid-state sensor bad and the compressor shows to be ok what can you do?

What would happen if the crankcase pressure rises above the suction pressure?

What path does the refrigerant take inside an air-cooled compressor? A refrigerant cooled compressor?

How would you set the unloader on a Trane or Carrier compressor, with suction pressure controlled hydraulic unloaders? Be careful when you remove the electric unloaders solenoids from a Trane compressor. You can put them on upside down.

Assuming a standard air conditioning application, what suction pressure should the compressor capacity control be set for?

Frost at the compressor and working back towards the evaporator indicates what condition?

What is a normal compression ratio for air conditioning?

How do you determine compression ratio?

How do you check for broken discharge valves?

How can you tell which head has a broken discharge valve?

How do you check for bad suction valves?

What is the oil pressure of a Carrier 06D or 06E compressor? On an 'E' or 'F' model Trane?

How do you check an oil failure switch?

What happens if you don't phase a part winding start motor correctly?

What causes oil to leave a compressor?

What is the maximum voltage imbalance?

How do you determine voltage imbalance?

What causes high oil temperatures?

What is single phasing and how do you check a compressor for single phasing?

Will a TXV valve operate properly on a 30-ton system when the system is at one-third capacity?



## **IDENTIFYING FAILURE MODES**

1. Liquid Slugging - Liquid, either refrigerant or oil, in the compressor cylinders.
  - (a) Broken reeds
  - (b) Loose discharge valve bolts
  - (c) Blown gaskets
  - (d) Broken rods
  - (e) Broken crankshafts
  
2. Liquid Washout - Washing the oil off of loaded surfaces.
  - (a) Worn pistons
  - (b) Worn rings
  - (c) Worn cylinders
  - (d) Scored wrist pins
  - (e) Scored rods
  - (f) Worn bearings
  - (g) Scored crankshafts
  
3. Liquid Dilution - Liquid refrigerant diluting the oil.
  - (a) Dragging rotor
  - (b) Worn bearings
  - (c) Scored and/or broken rods
  - (d) Scored crankshafts
  
4. High Discharge Temperatures - Temperatures thinning the oil.
  - (a) Discolored valve plate
  - (b) Overheated or burned reeds
  - (c) Worn rings and pistons
  - (d) Worn cylinders
  - (e) Scored rods, bearings, and crankshafts
  
5. Lack of Lubrication - Lack of oil or indeterminate.
  - (a) Scored bearings



- (b) Broken rods
- (c) Scored crankshafts

6. Motors

- (a) General burn - entire windings burned
- (b) Single phase - two phases burned
- (c) Half winding single phase - one half of each two windings
- (d) Spot burn - localized burn
- (e) Start winding burn - only start winding burned
- (f) Leads shorted
- (g) Primary single phase

**The first three modes are results of varying amounts of liquid in the compressor.**

1. Liquid Slugging

This is a result of trying to compress liquid in the cylinders. That liquid may be either refrigerant or oil or more likely a combination of both. In the case of air-cooled compressor, any liquid being returned to the compressor comes directly into the cylinders. On a suction-cooled compressor, slugging is a result primarily of refrigerant migration into the oil on the off cycle. Upon start up the lowering of crankcase pressure causes a violent explosion that carries quantities of refrigerant and oil into the cylinders.

The results in either case are:

- (a) Broken reeds - either or both
- (b) Loose discharge valve bolts - stretching or stripping threads
- (c) Blown gaskets - head or valve plate gaskets
- (d) Broken rods - depending on the quantity of liquid in cylinders
- (e) Broken crankshaft - particularly on MR or 9R

2. Liquid Washout

This is a result of refrigerant washing oil off wearing surfaces. On air-cooled compressors, this is usually saturated refrigerant being returned during the running cycle directly to the cylinders and washing the oil off the pistons and cylinders. This is also a possibility on suction cooled compressors, but off cycle migration is more likely the cause. When the compressor starts up with refrigerant in the crankcase, the refrigerant washes the oil off of the pistons and cylinders. Slugging is really just an extreme result of migration.

The results are:

- (a) Worn pistons

- (b) Worn rings if they are used
- (c) Worn cylinders - hard to determine
- (d) Scored wrist pins
- (e) Scored and broken rods
- (f) Worn bearings
- (g) Scored crankshaft

### 3. Liquid Dilution

This is a result of liquid refrigerant being returned to a suction-cooled compressor during the running cycle. If the liquid refrigerant is returned in great enough quantity and for a long enough period of time to cool the motor, it will be returned to the crankcase through the oil check valve. The heat of the oil will vaporize some of the refrigerant, but as the oil cools, it will become so diluted that it cannot properly lubricate. The diluted mixture may be adequate for the oil pump and cover bearing, but as it progresses down the crankshaft, there will not be enough oil left to properly lube the main bearings.

The results are:

- (a) Dragging rotor
- (b) Worn bearings, particularly the center and rear
- (c) Scored and/or broken rods - Scoring first
- (d) Scored crankshaft

### 4. High Discharge Temperatures

This is a result of temperatures in the compressor head and cylinder becoming so hot that the oil loses its ability to lubricate. High compression ratios and inadequate compressor cooling cause this. High compression ratios are the result of operation with too low a suction pressure, too high a discharge pressure or a combination of both. It is important that the system operate with as high a suction pressure and as low a head pressure as possible. Proper selection of equipment and proper setting of pressure switches will help assure this. The temperature of the suction gas returning to the compressor should be as low as practical without having flood back.

The results are:

- (a) Discolored valve plates - color cannot be rubbed off
- (b) Overheated or burned reeds.
- (c) Worn rings, pistons and wrist pins.
- (d) Worn cylinders.
- (e) Scored rods, bearings, and crankshafts.
- (f) Stator spot burned due too debris.

5. Lack of Lubrication

This is a result of lack of enough oil in the crankcase to properly lubricate the load bearing parts. This may be caused by improper piping, oil trapping, inadequate defrosts, loss of charge, short cycling, or low load conditions. Oil must return to the compressor as fast as it is pumped out in order to maintain proper lubrication.

The results are:

- (a) Scored bearings
- (b) Broken rods
- (c) Scored crankshafts

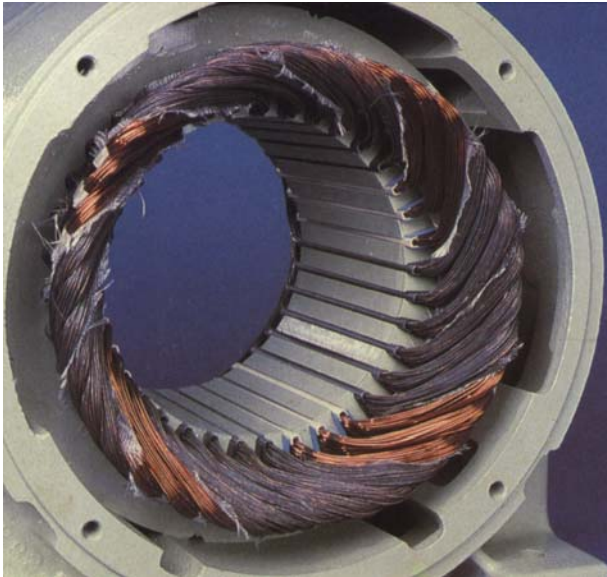
6. Motors

Many motors fail as a result of lubrication related failure. But many also fail without evidence of mechanical problems.

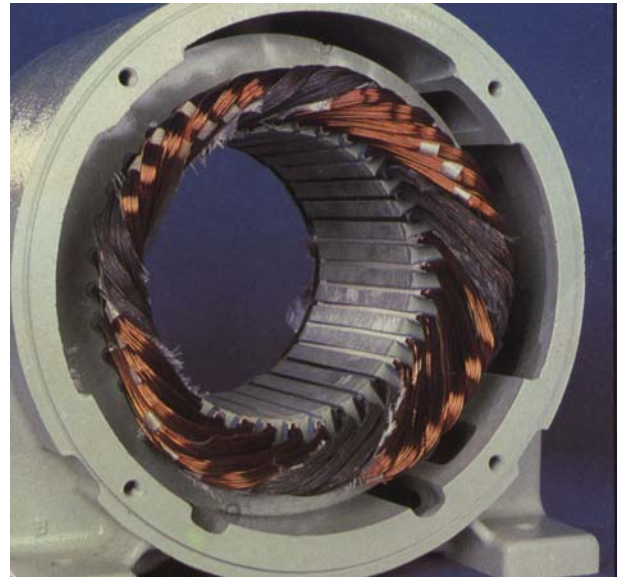
Examples of this are:

- (a) General Burn - The entire windings are overheated or burned. This may be a result of voltage problems, inadequate motor cooling, or unknowns.
- (b) Single Phase Burn - Two phases of a three-phase motor are overheated or burned. This is a result of not having current through the unburned phase and overloading the other two phases.
- (c) Half Winding Single Phase Burn - This occurs on a part winding, two-contactor system when one half of the motor has a single phasing condition. This is usually a contactor problem.
- (d) Spot Burn - This is a short either between windings, between wires, within a winding or to ground. The damage is confined to a small area. Contaminants, vibration, voltage surge or reasons unknown.
- (e) Start Winding Burn - Only the start winding is burned in a single-phase motor. Excessive current has flowed through the start winding from a failure of starting components, miswiring or overloading the motor.
- (f) Leads Shorted - Terminals grounded or lead abrasion.
- (g) Primary Single Phase - As a result of losing a phase in the primary of a  $\Delta$  to Y or Y to  $\Delta$  transformer. This shows as one phase burned.

## Typical three phase winding failures and possible causes.



1 - Single Phase burnout on a 'Y' or Star Connected motor with two burned phases, one good

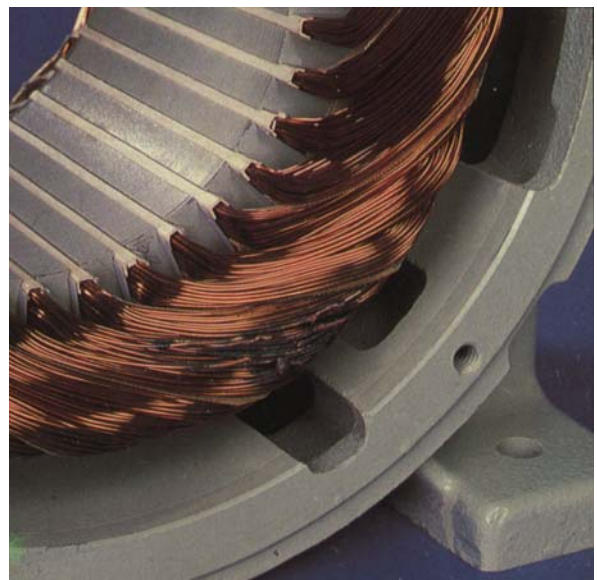


2 - Single Phase burnout on a delta connected motor or a primary single phase. One phase burned, two good.

Pictures 1 & 2 are single phased winding failures. Picture one is of a Y or Star connected motor and picture two is that of a delta connected motor. Single-phase burnouts are a result of losing voltage on one of the phases to the motor. The burnout shown in picture two is also the type burnout you will get on a Y connected motor when you have a primary single phase condition with a Y to  $\Delta$  connected transformer or a  $\Delta$  to Y connected transformer.



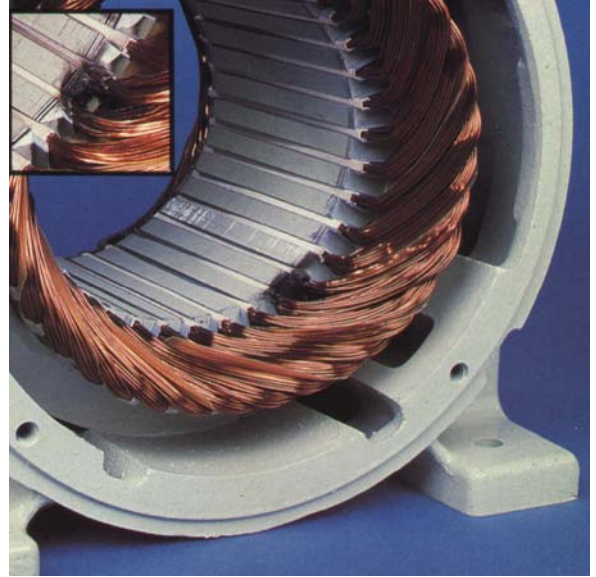
3 - Phase to Phase winding short.



4 - Turn to Turn winding short



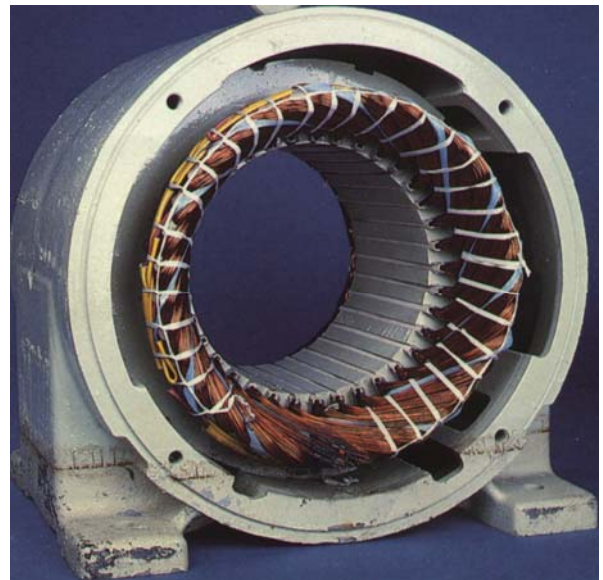
5 - Shorted Coil (sometimes referred to as a 'Hot' coil).



6 - Winding grounded in corner of the slot.



7 - Winding grounded in slot.



8 - Shorted or blown connection.

Pictures three thru eight show insulation failures. These are usually caused by contaminants, abrasion, vibration or voltages surges. Number three is phase to phase short, four is turn to turn short, five is a shorted coil, six is grounded at the edge of the slot, seven is grounded in the slot, and eight shows a shorted connection.

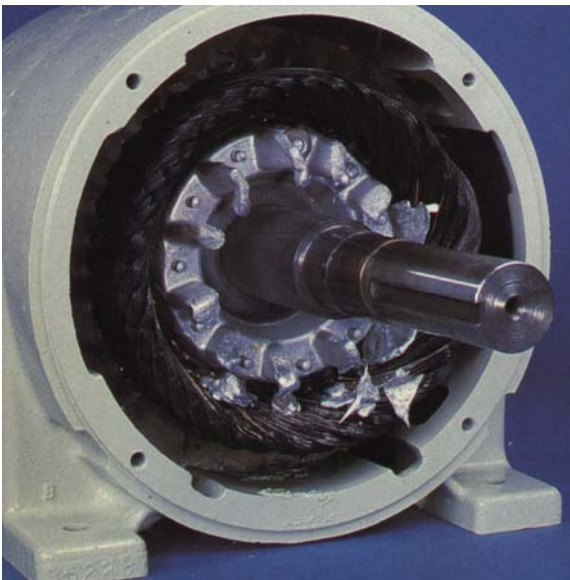


9 - Phase damage, possible voltage unbalance.

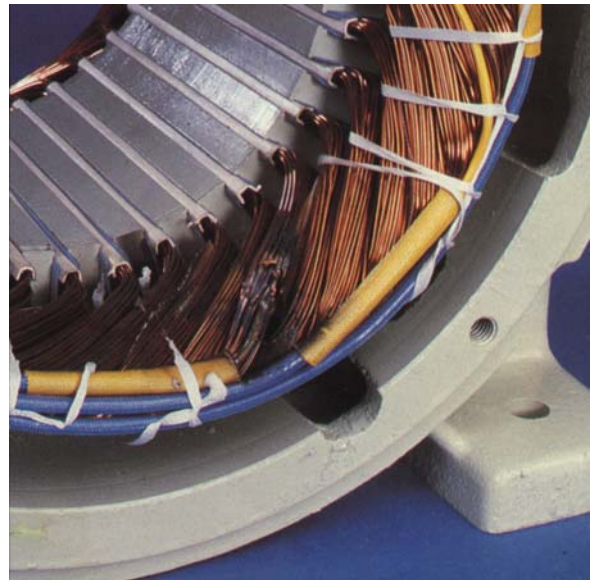


10 - Even burn, loss of cooling, overload, low or high voltage.

Picture nine shows insulation deterioration of one phase as a result of heat. This is often caused by voltage imbalance. A voltage imbalance of 1% can result in a current imbalance of 6 to 10%. Maximum allowable voltage imbalance is 2%. Maximum allowable current imbalance is 10%. Picture ten shows total winding deterioration as a result of heat. This may be caused by loss of compressor cooling, compressor overload, low or high voltage.



11 - Locked rotor.



12 - Winding damaged by voltage surge or contamination.

Picture eleven shows a severe winding burn of all three phases and rotor damage due to high heat. This is usually the result of a locked rotor condition with no working compressor protection. Twelve is a possible voltage surge.

# Installation and Startup

Superheat	Page 14
About Capacity Control	Page 14
Normal Oil Pressure	Page 15
Operating Temperature Guidelines for Air Conditioning	Page 16
Operating Temperature Guidelines for Refrigeration	Page 17
Brainerd Compressor Startup Form	Page 18
Brainerd Compressor Inspection Form	Page 19
Wiring Diagrams	Page 20 - 36
Carrier/Carlyle 06D	Page 21, 22
Carrier/Carlyle 06E	Page 23
Carrier/Carlyle 6G, 06G, 6L and 06L	Page 24, 25
Copeland	Page 26
Chrysler Airtemp	Page 27, 28
Dunham-Bush	Page 29, 30, 31, 32
York	Page 33, 34
Trane	Page 35, 36
Installing/Adjusting Capacity Control	Page 37 - 43
Carrier/Carlyle, 06D, 06E	Page 38, 44, 45
Carrier/Carlyle, 5F, 5H, 6G/06G, 6L/06L	Page 40, 46
Trane, A, B, E and F	Page 42, 51
Trane, M and R	Page 43, 52, 53
Copeland	Page 47, 48
Chrysler Airtemp	Page 49, 50
Capacity Control Diagrams	Page 44 - 53



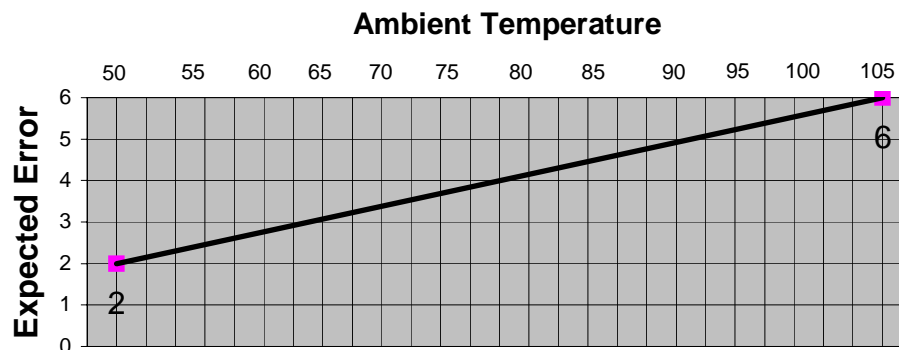
## SUPERHEAT

Recommended superheat setting for air conditioning duty, (TXV, 90 to 125° SCT), is 15 to 20°, taken at the compressor, within 12 inches of the suction service valve, and after you deduct the expected error. This setting should be maintained at all times. Compressors that run unloaded for extended periods may be operating outside the capabilities of the expansion valve. Do not expect a TXV to properly control the superheat if it's operating at 30% of its rated capacity.

Recommended method of taking superheat;

Strap a good electronic temperature probe to a clean suction line within twelve inches of the suction service valve. Replace the Armaflex and add two layers of one-inch fiberglass insulation (or equivalent) over the Armaflex, extending six inches in both directions from the temperature probe. Take suction pressure, line temperature, and ambient temperature.

**SUPERHEAT = Line temperature minus suction pressure, converted to temperature, minus error (see graph)**



## CAPACITY CONTROL

Compressors that run with a low suction pressure or unloaded for extended periods of time when the conditioned air space requires cooling and the temperatures indicate the evaporator load should be high could be a result of a system fault. Faults such as dirty filters, a system restriction such as restricted driers, bad TXV or liquid line solenoid valve, dirty or defective evaporator or chiller, poor air or water flow or a system sized much larger than the load.

Compressors are not designed to run unloaded for extended periods. The more capacity control a compressor has, and the more it runs unloaded, the hotter it runs. This may shorten the compressors life. Compressors also pump a small amount of oil out of the compressor while running which must be returned to the compressor at the same rate of loss to maintain compressor lubrication. Any reduction in compressor pumping capacity also results in a gas velocity and volume reduction. These are used for both oil return and compressor cooling. It may also result in a loss of superheat control followed then by flooding, oil dilution, and/or bearing failure. The majority of compressors that fail with one or more of these conditions show the general cause of failure to be "Loss of Lubrication". Any system fault will eventually show up in the compressor. All system faults such as design, installation, or defective components must be corrected before the compressor is left running, if it's expected to last.



No capacity controls are factory preset. Because of the variation in HVACR system temperature and Freon applications, all compressors that have internal suction capacity control such as 5F, 5H, 6G/06G, 6L/06LH Carrier and Trane A, B, E, and F must be field adjusted to the desired evaporator pressure. Any removable capacity control device that is removed from a defective compressor and installed on the replacement should be checked for proper orientation and operation or replaced if found to be defective. The control for systems using electric solenoids should also be checked.

## **OIL PRESSURE**

The following are expected oil pressures and oil failure switch recommendations for some compressor makes and models. Oil pressures listed are net oil pressure (oil pump pressure minus suction pressure).

The terms "cut in" and "cut out" refer to the warp switch within the oil failure switch.

**Carrier/Carlyle** older 06D & 06E compressors should have a net oil pressure of 12 to 20 psig. Newer 06D & 06CC, 16 to 37 CFM, should have 18 to 26 psig, 06E & 06CC compressors, 50 to 99 CFM have 18 to 34 psig. Oil failure switches should have 11 psig cut out, 4 psig cut in with a 45 second delay, and 120 seconds with POE oils. 5F, 5H and 06G, 06LH compressors typically have 40 to 60 psig net oil pressure. We recommend 25 to 30 psig trip with a 45 second delay. This is minimum needed for proper operation of the capacity control systems on 5F40 thru 5H126 and all 6G/06G and 6L/06LH compressors.

**Chrysler's** recommendations on oil failure protection calls for an oil pressure safety control settings to cut out at 30 psig and cut in at 25 psig with a 45 second delay. This is the minimum for lubrication and proper operation of the capacity control system. Normal oil pressure should be 40 to 60 psig net.

**Copeland** compressors should have 20 to 40 psig net oil pressure. Oil failure switches should have a cut out of 14 psig, cut in of 9 psig, with a 120 second delay.

**Dunham-Bush** D/B metric compressors should have 20 psig net oil pressure, all Big-4 compressors should have 30 to 50 psig net.

**Trane** 'M' & 'R' models should have  $30 \pm 5$  psig net oil pressure, minimum 20 psig. Trane 'E' & 'F' models, open and hermetic, 50 to 60 psig net. These compressors typically have higher than 60 psig. Originally 'E' model cut in was 17 psig but in 1970 this was changed to 30 psig cut in and the oil sensing port was moved from just under the oil pump to a port on the unloader hand hole cover on all 'E' open and hermetic compressors.

**York** 'J' compressors, styles 'A' thru 'D' should have a net oil pressure of 25 to 40 psig. Styles 'E' and later should have a minimum of 60 psig net.

**Never reset the oil failure switch more than once without finding out the reason it's tripping. You are witnessing a "lubrication failure".**



## OPERATING TEMPERATURE GUIDELINES FOR AIR CONDITIONING DUTY

The temperature ranges and guidelines shown below can be considered good for the following conditions:

1. R-22 Systems      2. Air Conditioning Duty (TXV)      3. SCT from 90° to 125° F.  
Reading from other conditions will not fit into all the guidelines.

1. Suction Line Temperature: 15° - 20° above saturated suction temperature.
2. Motor barrel temperature near crankcase: 80° to 100° F.
  - a. Below 80° is a possible indication of flooding.
  - b. Above 100° is a possible indication of motor running too hot from:
    1. Too high superheat
    2. Not enough suction gas with acceptable superheat to cool motor on low load conditions.
    3. Rotor drag - three temperatures at motor barrel are required to find hot spots due to rotor drag on stator if motor end bearing has been lost due to flooding.
3. Underside of Cylinder head: 85° to 115° F
  - a. Below 80° is a possible indication of flooding.
  - b. Above 115° is a possible indication of unloaded cylinder or blown gaskets or broken valves.
4. Crankcase Temperature: 105° to 125° F
  - a. Below 105° is a possible indication of flooding.
  - b. Above 125° is a possible indication that the compressor is running too hot - possibly caused by high oil levels.
5. Hot gas (discharge) temperature: 160° to 200° F.
  - a. Temperature below 160° after one minute run time is an indication of flooding.
  - b. Above 200° is an indication that the compressor is running too hot.
    1. Suction too low
    2. Condensing too high (check for condenser problems)
    3. Superheat too high
    4. Motor overheating (check motor temperature)
    5. Broken discharge valves/blown gaskets
    6. Leaking pressure relief valve (06E - 06LH models only)
6. Liquid line temperature should be 8° to 15° below saturated condensing temperature. (8° to 15° Subcooling)



## OPERATING TEMPERATURE GUIDELINES FOR REFRIGERATION DUTY

The temperature ranges and guidelines shown below can be considered good for the following conditions: Refrigeration Duty, R-12 and R-502 (low & medium temperature), SCT from 95° to 115° F.

### GUIDELINES

1. The preferred return gas temperature of refrigerant at compressor suction service valve is 35° to 50° F. Maximum return gas temperature: 65° F.
2. Motor barrel temperature near crankcase: 80° to 125° F.
  - a. Below 80° F is a possible indication of flooding.
  - b. Above 120°F is a possible indication of motor running too hot from:
    1. Too high superheat
    2. Running too low suction pressures
    3. Voltage or current imbalance
    4. Rotor drag – Motor end bearings failure due to flooding. Three temperatures at motor barrel are required to find hot spots due to rotor drag on stator I.D.
3. Underside of side bank cylinder heads: 80° to 120° F.
  - a. Below 80° F is a possible indication of flooding.
  - b. Above 120° F is an indication of blown gaskets or broken valves.
4. Crankcase temperature of oil compartment (below oil level): 100° to 130° F (Max. allowable temp. 165° F.)
  - a. Below 100° F is a possible indication of flooding
  - b. Above 130° F is an indication of blown gaskets or broken valves.
5. Hot gas (discharge) line temperatures. This is very much a function of refrigerant and suction/discharge pressure range:

R12 Medium temperature	180° to 210° F.
R502 Medium temperature	180° to 210° F
R502 Low temperature	200° to 250° F (Max. allowable 275° F)

  - a. Temperatures below minimum limits after one minute of run time is a possible indication of flooding. Note, though, that low discharge temperatures are evident when floating head pressure designs are used.
  - b. Temperatures above maximum limits is an indication the compressor is running too hot. Possible causes are:
    1. Suction too low
    2. Condensing too high (check for condenser problems)
    3. Superheat too high
    4. Cylinder head cooling fan defective (low temperature system)
    5. Motor overheating (check motor temperature)
    6. Broken discharge valves — blown gaskets
    7. Leaking pressure relief valve

# Brainerd Compressor Start Up Sheet

Date of Start Up \_\_\_\_\_  
 Contractor / Dealer Company Name and Address:

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 Owner / Customer Name and Address:  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

New Model #: \_\_\_\_\_  
 New Serial #: \_\_\_\_\_

Old Model #: \_\_\_\_\_  
 Old Serial #: \_\_\_\_\_

Acid Test Done? Yes \_\_\_\_\_ No \_\_\_\_\_

Results \_\_\_\_\_

Recommended method of taking superheat: Strap a good electronic temperature probe to a clean suction line within twelve inches of the suction service valve. Replace the Armaflex and add two layers of one-inch fiberglass insulation (or equivalent) over the Armaflex, extending six inches in both directions from the temperature probe. Take suction pressure, line temperature, and ambient temperature.

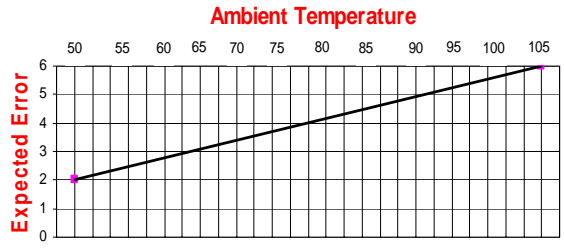
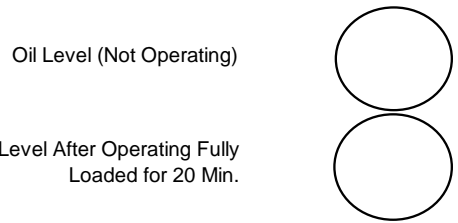


Figure 1

### Start-Up Temperatures

- Ambient Outdoor Temperature
- Evaporator Return Air/Water Temperature
- Conditioned Air Temperature
- Suction Line Temperature @ Compressor
- Discharge Gas Temperature: (6" from Service Valve)
- Liquid Line Temperature
- Crankcase Temperature (Below Oil Level)

### Pre-Start Check

- Crankcase Heater(s) Operating?
- New Dryers/Filters Installed?
- Moisture Indicator Dry?
- Expansion Valve Bulbs Tight?
- Evaporator Coil Clean?
- Contactor Replaced?
- Unit Fuse Size:

### Start-Up Pressures

- Suction Pressure @ Compressor
- Discharge Pressure
- Liquid Line Pressure
- Net Oil Pressure (Suction Pressure - Oil Pump Pressure)
- Capacity Control Set Point
- Capacity Control Differential

### Sub-Cooling Calculations

- Liquid Line Pressure Converted to Temperature (SC)
- Minus Liquid Line Temperature
- = Subcooling

### Superheat Calculations

- Suction Line Temperature @ Compressor
- Minus Suction Pressure Converted to Temperature
- Minus Expected Error: (See Figure 1)
- = System Superheat

### Calculate % of Voltage and Current Imbalance

Amps	Volts	
		Line 1
		Line 2
		Line 3

Sum of Volts (L1 + L2 + L3) =	
Average Voltage (Sum ÷ 3) =	
Voltage Difference (Average - Worst leg) =	
% Imbalance (Difference ÷ Average x 100) =	

### Example

Sum of Voltage Readings (222 + 227 + 215) =	664
Average Voltage (664 ÷ 3) =	221
Voltage Difference (227 - 221) =	6
% Imbalance (6 ÷ 221 x 100) =	2.71

Calculate Current Imbalance in the same way as Voltage Imbalance.  
**Maximum allowable Voltage Imbalance is 2%**  
**Maximum allowable Current Imbalance is 10%**



# BRAINERD COMPRESSOR, INC

3034 SANDBROOK ST  
MEMPHIS TENNESSEE 38116

901-396-4051

FAX 901-396-4131

800-228-4138

## COMPRESSOR INSPECTION REPORT

DATE \_\_\_\_\_ MFG \_\_\_\_\_ MODEL \_\_\_\_\_ SERIAL NO. \_\_\_\_\_

CUSTOMER \_\_\_\_\_ VOLTAGE \_\_\_\_\_ PHASE \_\_\_\_\_

NUMBER THE CYLINDERS IN RELATION TO WHERE IT'S CONNECTING ROD ATTACHES TO THE CRANKSHAFT. WHILE INSPECTING THE PARTS MAKE NOTE OF ANY PATTERN IN THE FAILED PARTS SUCH AS THE BEARING CONDITION AS THE POSITION MOVES DOWN THE SHAFT AWAY FROM, OR TOWARD THE OIL PUMP.

<b>MOTOR</b>	OK <input type="checkbox"/>	GROUNDED <input type="checkbox"/>	BLOWN IN SLOT <input type="checkbox"/>	ROASTED <input type="checkbox"/>	SINGLE PHASE <input type="checkbox"/>	PRIMARY SINGLE PHASE <input type="checkbox"/>
	½ WINDING SINGLE PHASE <input type="checkbox"/>	½ WINDING BURN <input type="checkbox"/>	BLOWN CONNECTION <input type="checkbox"/>	ROTOR DRAGGING <input type="checkbox"/>		

<b>VALVES</b>	OK <input type="checkbox"/>	SUC. VAL. BROKEN <input type="checkbox"/>	DISC. VAL. BROKEN <input type="checkbox"/>	THREADS STRIPPED <input type="checkbox"/>	BACKER BENT/BROKEN <input type="checkbox"/>
	DISCOLORATION <input type="checkbox"/>	LIGHT CARBONIZATION <input type="checkbox"/>	HEAVY CARBONIZATION <input type="checkbox"/>	COPPER PLATING <input type="checkbox"/>	DRY <input type="checkbox"/>
	CYLINDER LOCATION _____				

<b>CYLINDERS</b>	OK <input type="checkbox"/>	WORN <input type="checkbox"/>	SCORED <input type="checkbox"/>	DAMAGED <input type="checkbox"/>	DRY <input type="checkbox"/>	GALLED <input type="checkbox"/>	LOCATION _____
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<b>PISTONS</b>	OK <input type="checkbox"/>	SCORED <input type="checkbox"/>	BROKEN <input type="checkbox"/>	SEVERE WEAR <input type="checkbox"/>	WRIST PIN HOLE OVERSIZE <input type="checkbox"/>	NORMAL RING WEAR <input type="checkbox"/>
	SEVERE RING WEAR <input type="checkbox"/>	RINGS BROKEN <input type="checkbox"/>	LOCATION _____			

<b>RODS</b>	OK <input type="checkbox"/>	BENT <input type="checkbox"/>	BROKEN <input type="checkbox"/>	WRIST PIN HOLE OVERSIZE <input type="checkbox"/>	SCORED THRUST SURFACE <input type="checkbox"/>	_____
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<b>ROD BEARINGS</b>	OK <input type="checkbox"/>	SCORED <input type="checkbox"/>	GALLED <input type="checkbox"/>	COPPER PLATING <input type="checkbox"/>	LOCATION _____
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<b>MAIN BEARINGS</b>	DRIVE/MOTOR	OK <input type="checkbox"/>	GALLED <input type="checkbox"/>	SCORED <input type="checkbox"/>	NORMAL WEAR <input type="checkbox"/>	SLIGHT WEAR <input type="checkbox"/>	SEVERE WEAR <input type="checkbox"/>
	DRIVE/CRANKCASE	OK <input type="checkbox"/>	GALLED <input type="checkbox"/>	SCORED <input type="checkbox"/>	NORMAL WEAR <input type="checkbox"/>	SLIGHT WEAR <input type="checkbox"/>	SEVERE WEAR <input type="checkbox"/>
	OIL PUMP MAIN	OK <input type="checkbox"/>	GALLED <input type="checkbox"/>	SCORED <input type="checkbox"/>	NORMAL WEAR <input type="checkbox"/>	SLIGHT WEAR <input type="checkbox"/>	SEVERE WEAR <input type="checkbox"/>

<b>OIL PUMP</b>	OK <input type="checkbox"/>	SCORED <input type="checkbox"/>	SHAFT BROKEN <input type="checkbox"/>	END CLEARANCE <input type="checkbox"/>	SHAFT BROKEN <input type="checkbox"/>	PUMP BEARING WORN <input type="checkbox"/>
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<b>OIL</b>	OK <input type="checkbox"/>	LOW <input type="checkbox"/>	HIGH <input type="checkbox"/>	MOISTURE <input type="checkbox"/>	WATER <input type="checkbox"/>	DIRTY <input type="checkbox"/>	COMMENT _____
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<b>CASTING</b>	OK <input type="checkbox"/>	DRY <input type="checkbox"/>	CRACKED <input type="checkbox"/>	JUNK <input type="checkbox"/>	RUSTY <input type="checkbox"/>	DIRTY <input type="checkbox"/>	COMMENT _____
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**OTHER COMMENTS** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

<b>POSSIBLE CAUSES OF FAILURE (REFER TO "IDENTIFYING FAILURE MODES")</b>	FLOODING <input type="checkbox"/>	FLOODED START <input type="checkbox"/>	SLUGGING <input type="checkbox"/>	
HIGH DISCHARGE TEMPERATURE <input type="checkbox"/>	LOSS OF LUBRICATION <input type="checkbox"/>	LOSS OF OIL <input type="checkbox"/>	½ WINDING BURN <input type="checkbox"/>	SINGLE PHASE <input type="checkbox"/>
½ WINDING SINGLE PHASE <input type="checkbox"/>	PRIMARY SINGLE PHASE <input type="checkbox"/>			

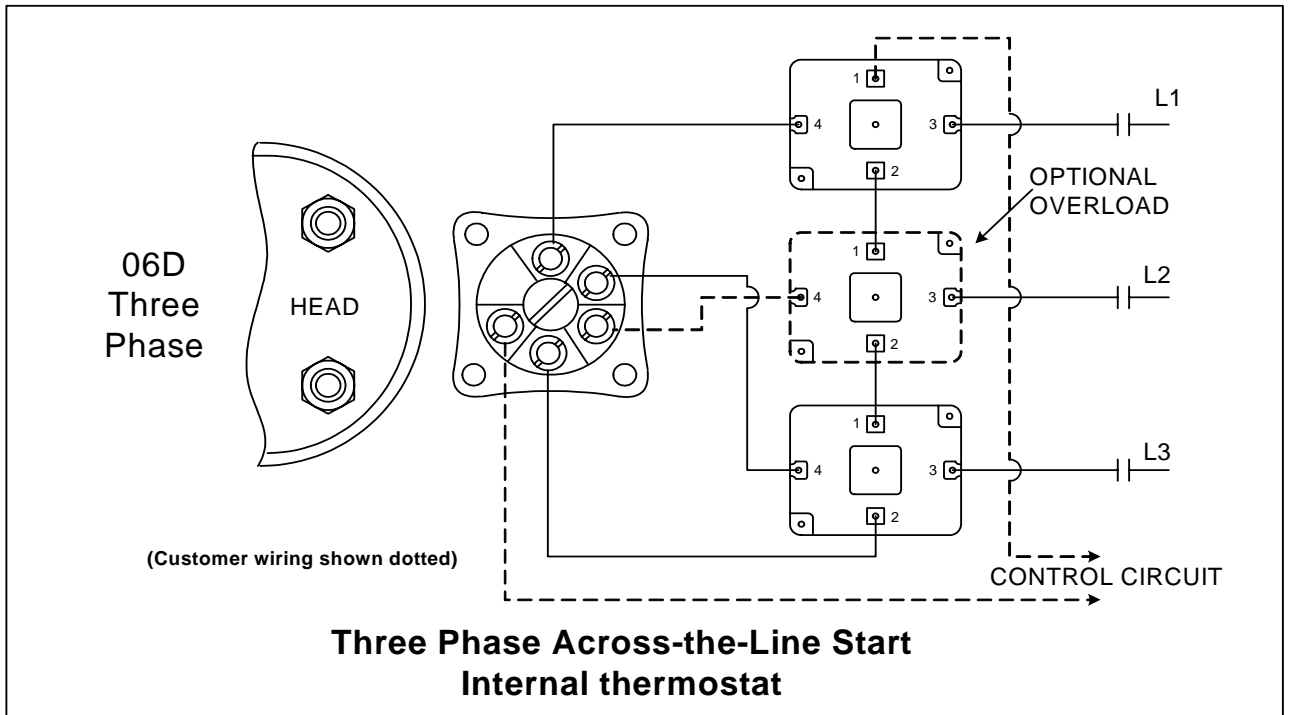
OTHER: EXPLAIN \_\_\_\_\_  
\_\_\_\_\_

INSPECTED BY: \_\_\_\_\_ DATE \_\_\_\_\_

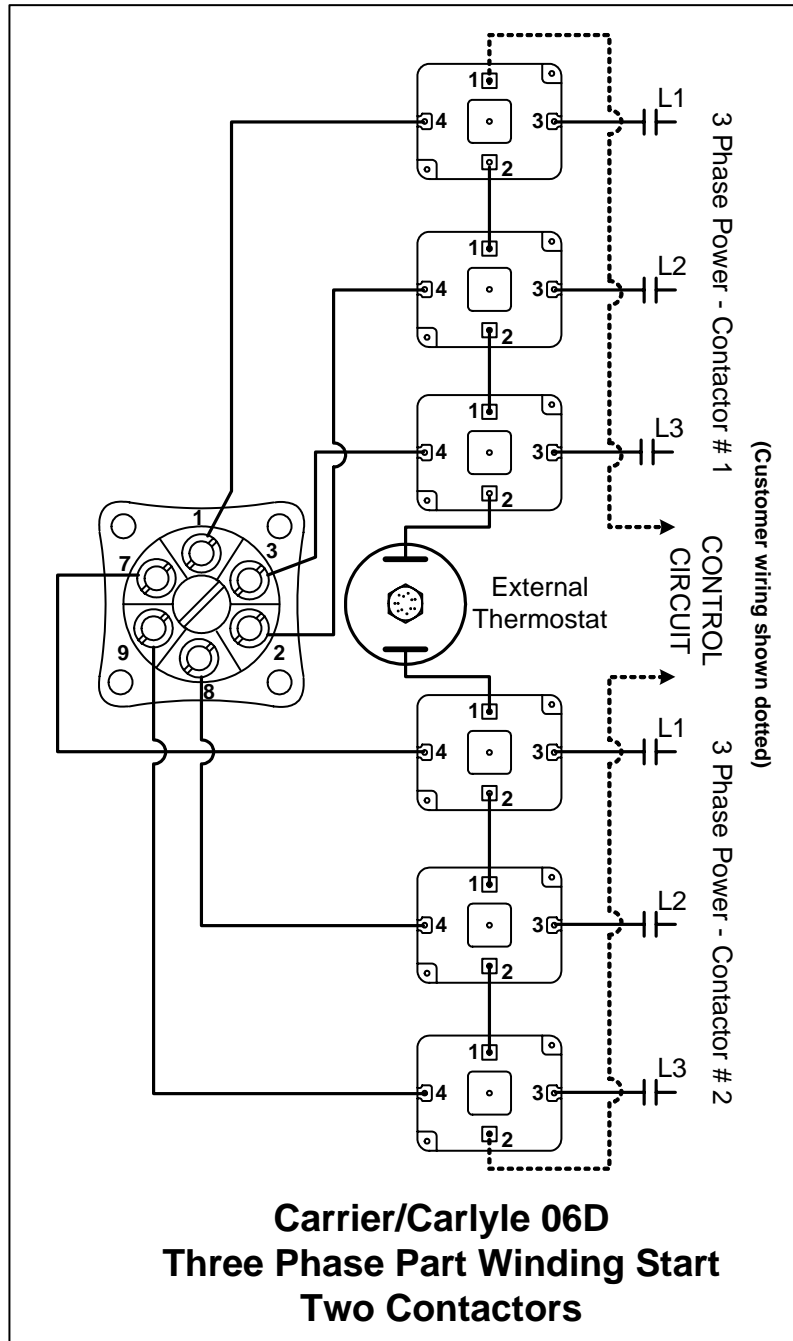
# Wiring Diagrams

Carrier/Carlyle 06D	Page 21, 22
Carrier/Carlyle 06E	Page 23
Carrier/Carlyle 6G, 06G, 6L and 06L	Page 24, 25
Copeland	Page 26
Chrysler Airtemp	Page 27, 28
Dunham-Bush	Page 29, 30, 31, 32
York	Page 33, 34
Trane	Page 35, 36

# CARRIER/CARLYLE 06D SINGLE VOLTAGE THREE PHASE COMPRESSORS WITH INTERNAL WINDING THERMOSTAT



# CARRIER/CARLYLE 06D SINGLE VOLTAGE THREE PHASE COMPRESSORS WITH PART WINDING START AND NO INTERNAL WINDING THERMOSTAT

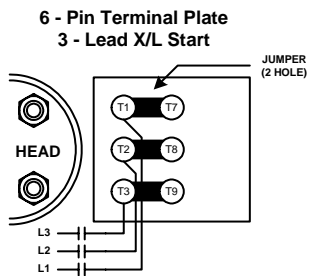




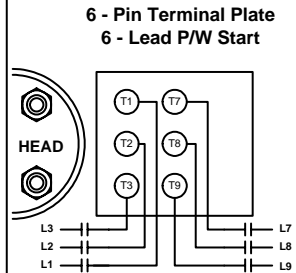
# CARRIER/CARLYLE 06E THREE PHASE COMPRESSORS

## O6E COMPRESSORS

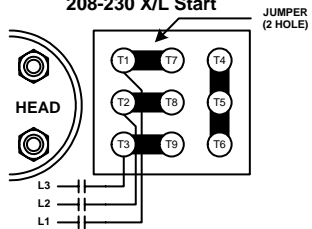
### ACROSS - THE - LINE START (X/L)



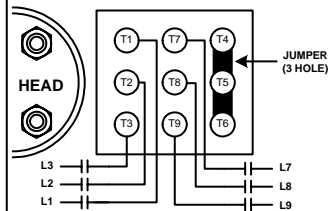
### PART - WINDING START (P/W)



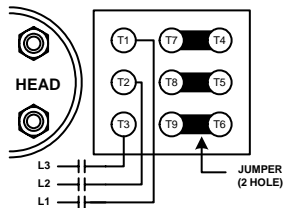
### 9 - Pin Terminal Plate (208-230/460V 300 Series Models 208-230 X/L Start



### 9 - Pin Terminal Plate (208-230/460V 300 Series Models 208-230 P/W Start Only



### 9 - Pin Terminal Plate (208-230/460V 300 Series Models 460V X/L Start

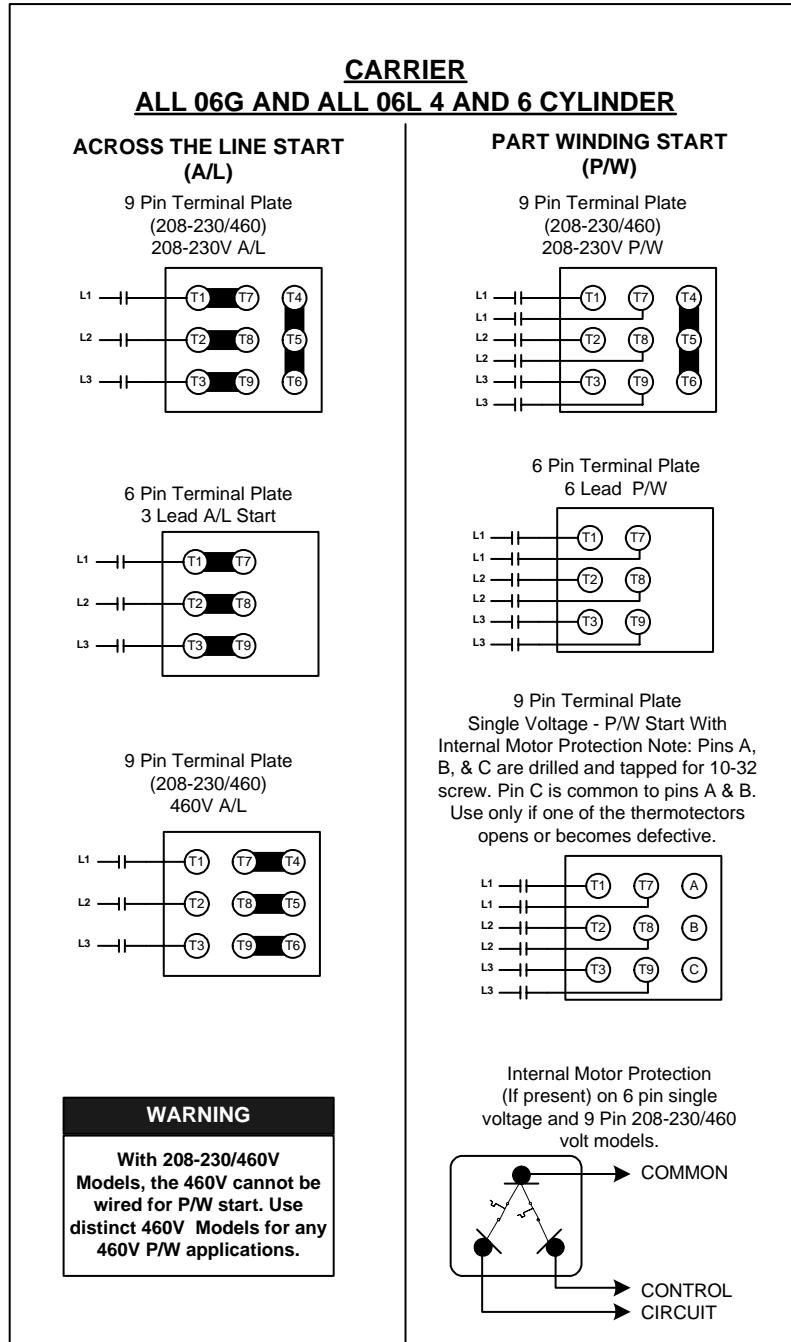


### 9 - Pin Terminal Plate 460V 600 Series Models 460V P/W Start

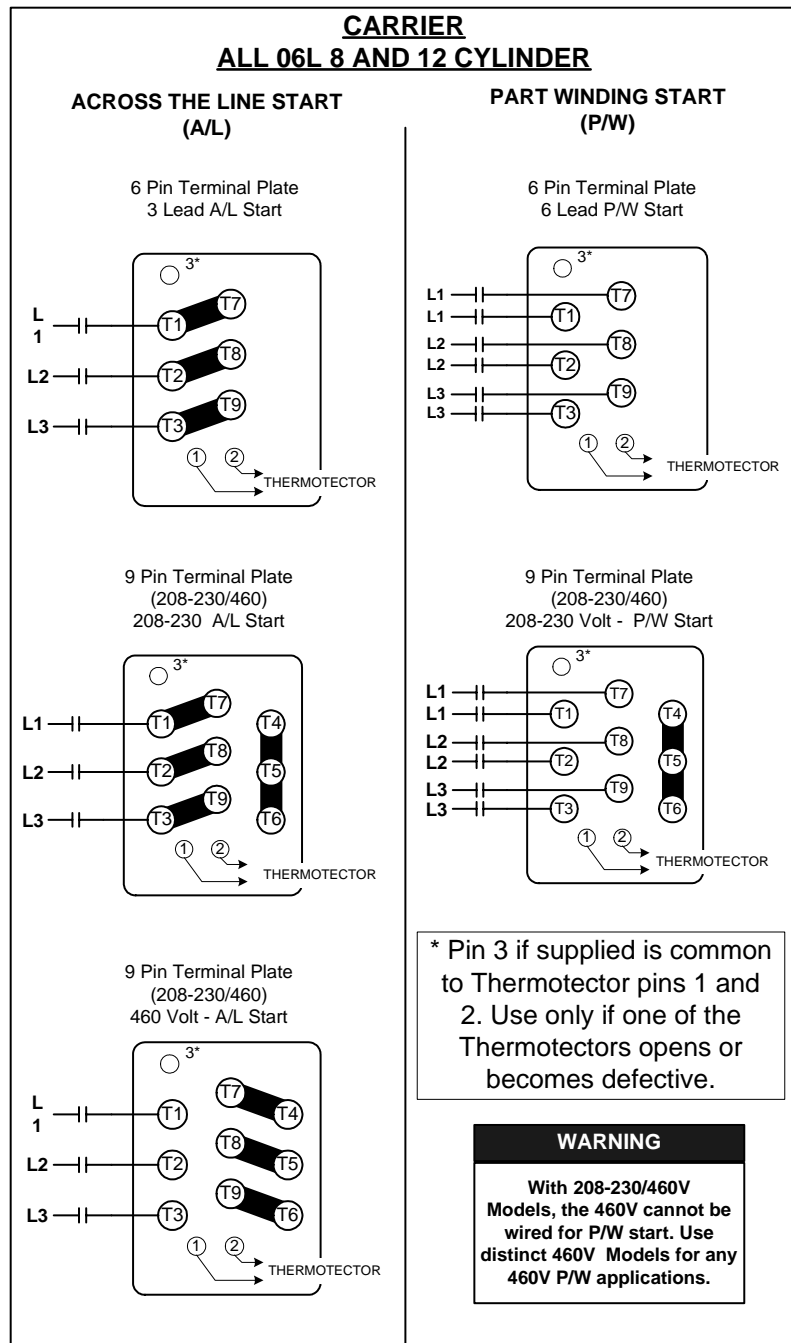
**WARNING**

With 208-230/460V 300 Series Models, the 460V cannot be wired for P/W start. Use distinct 460V 600 Series Models for any 460V P/W applications.

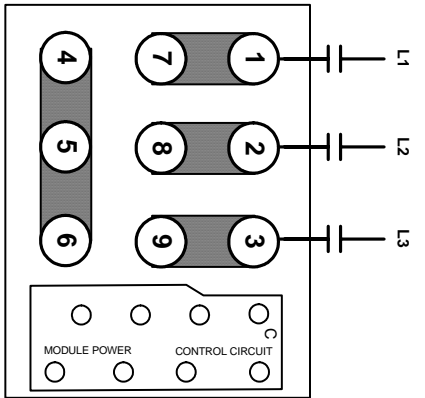
# CARRIER/CARLYLE 6G, 06G, 6L AND 06L 4 AND 6 CYLINDER THREE PHASE COMPRESSORS



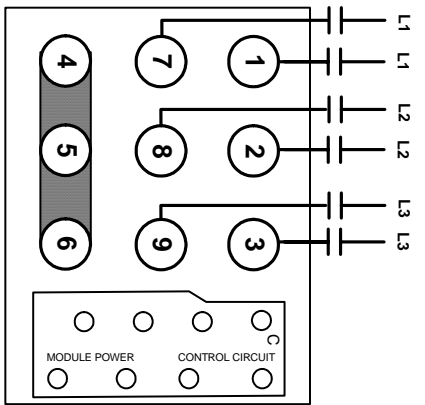
# CARRIER/CARLYLE 6L AND 06L 8 AND 12 CYLINDER THREE PHASE COMPRESSORS



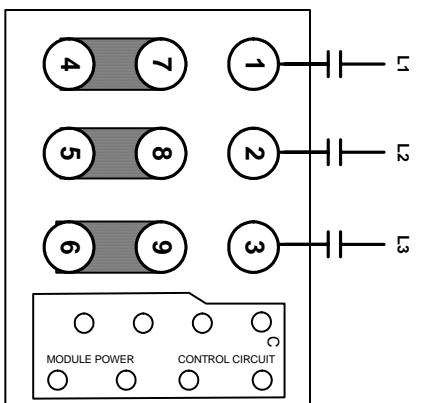
# 4R, 6R, 8R, 4D, 6D AND 8D COPELAND COMPRESSORS



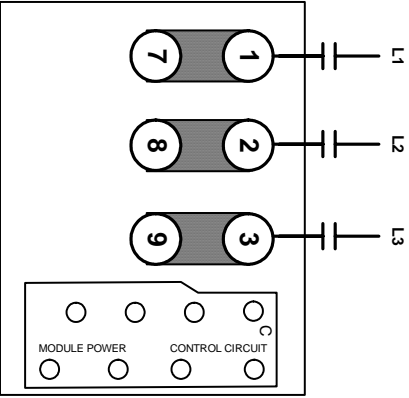
9 - Pin Terminal Plate  
(208-230/460V Models)  
208-230 Across the Line Start



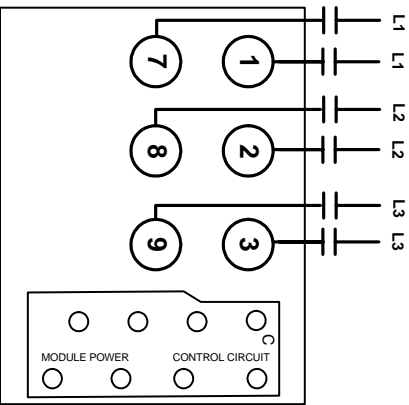
9 - Pin Terminal Plate  
(208-230/460V Models)  
208-230 Part Winding Start



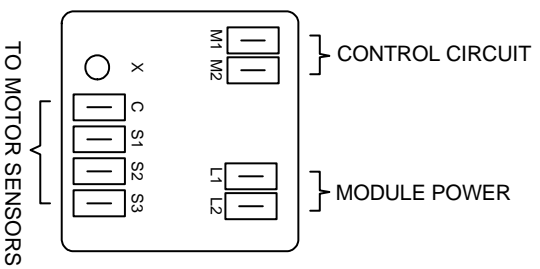
9 - Pin Terminal Plate  
(208-230/460V Models)  
460V Across the Line Start



6 - Pin Terminal Plate  
(460V Models)  
460V Across the Line Start



6 - Pin Terminal Plate  
(460V Models)  
460V Part Winding Start

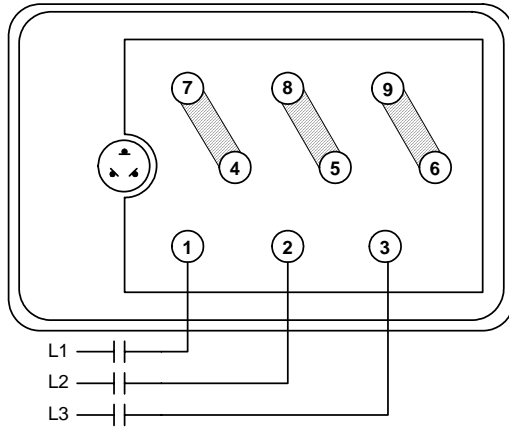


# CHRYSLER AIRTEMP 3050 THRU 3000

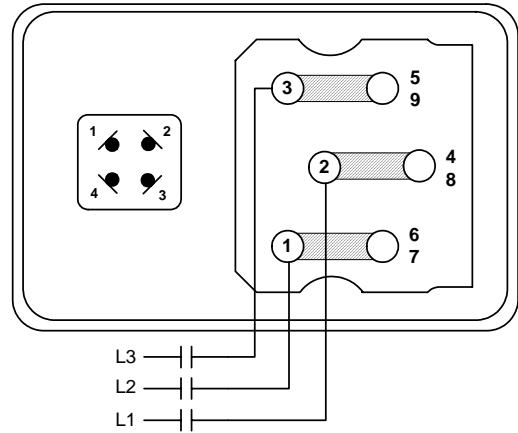
## 00 SERIES COMPRESSORS DUAL VOLTAGE 9 PIN

## 01 & 02 SERIES COMPRESSORS SINGLE VOLTAGE 6 PIN

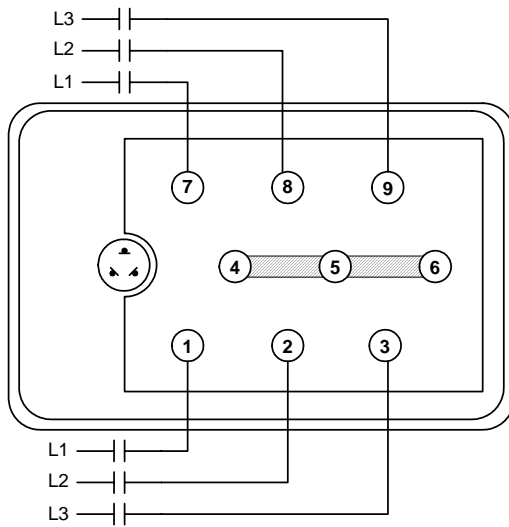
### 440 VOLT A/L START



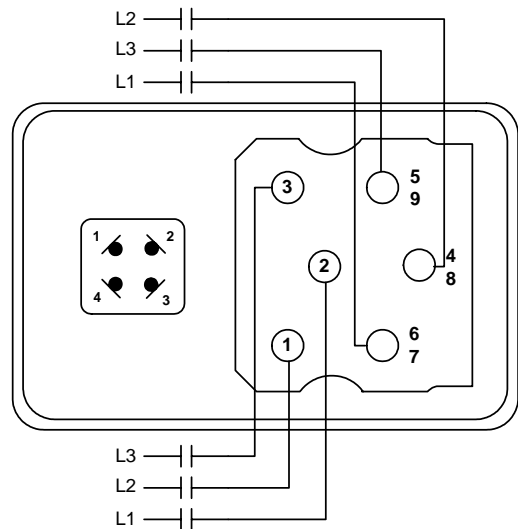
### SINGLE VOLTAGE A/L START 230 OR 460 VOLT MODELS



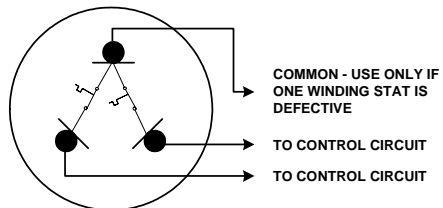
### 208-220 VOLTS P/W START



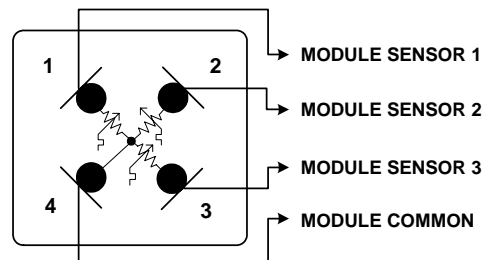
### SINGLE VOLTAGE P/W START 230 OR 460 VOLT MODELS



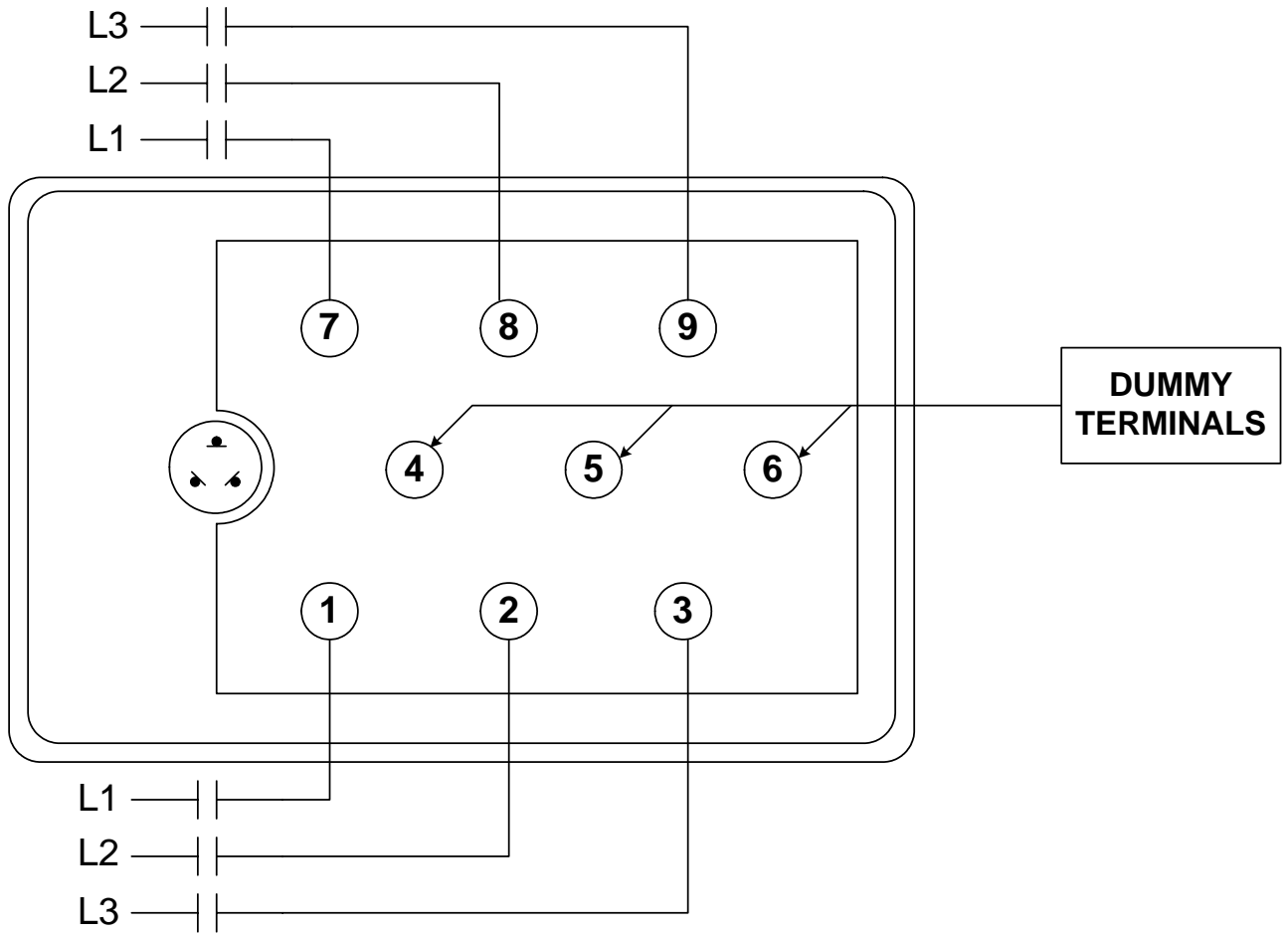
### 00 Series Compressors with 3 Lead Internal Winding Thermostats



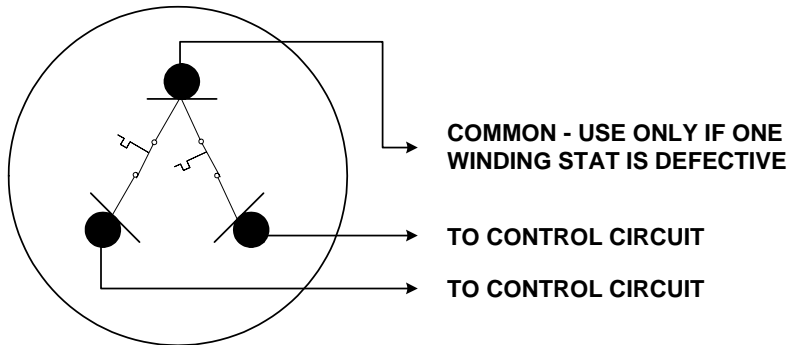
### 01 & 02 Series Compressors with 4 Lead Robert Shaw Motor Protection



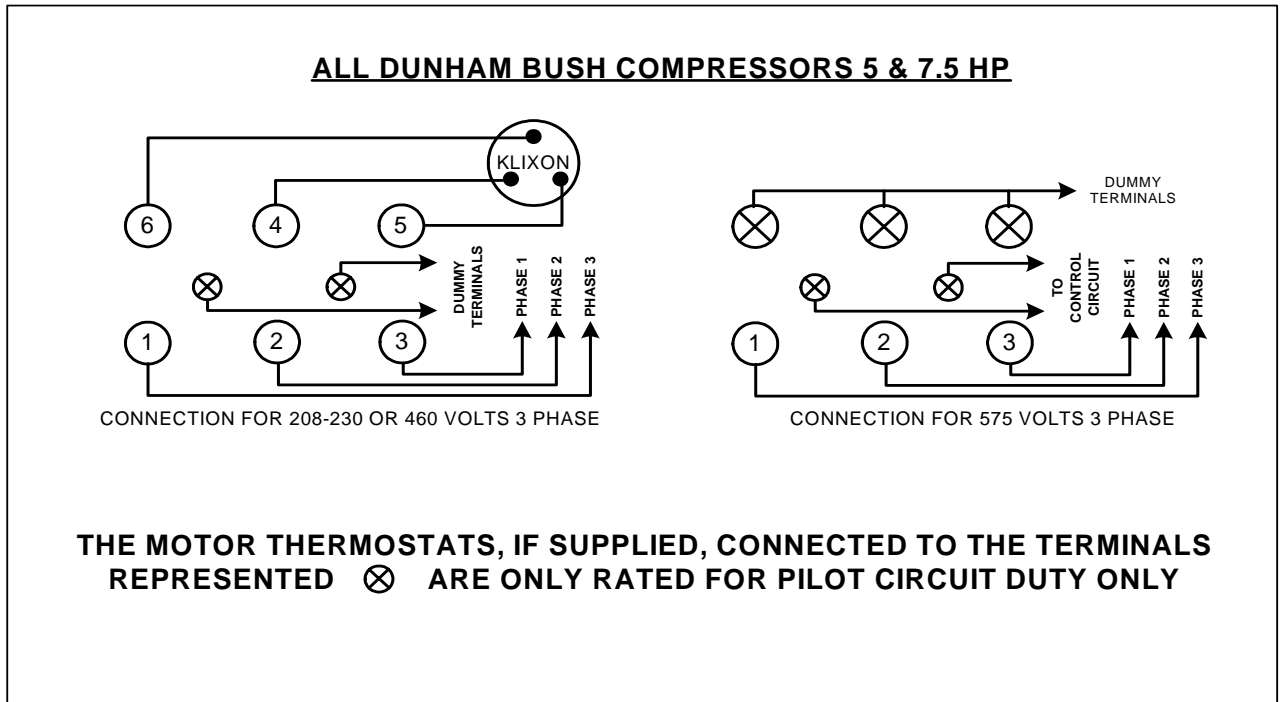
**CHRYSLER 3050-00  
460 VOLTS P/W START**



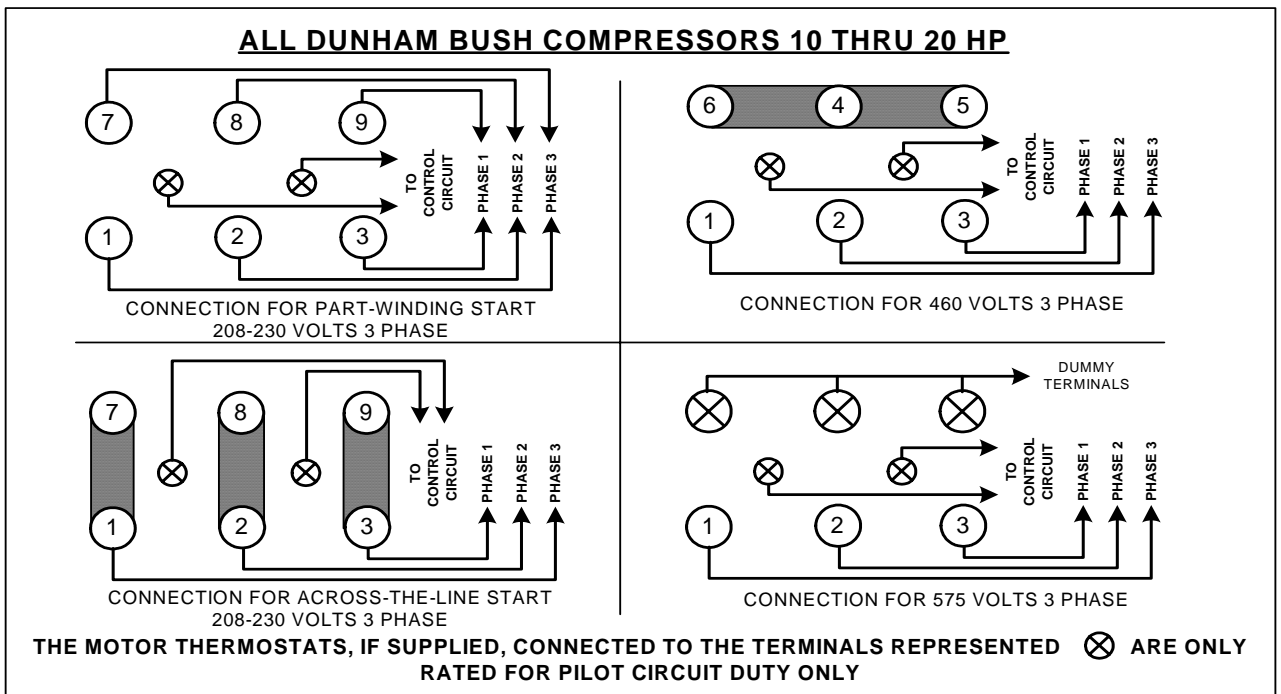
00 Series Compressors with 3 Lead Internal Winding Thermostats



## DUNHAM-BUSH (D/B METIC) 5 AND 7½ HP THREE PHASE SINGLE VOLTAGE

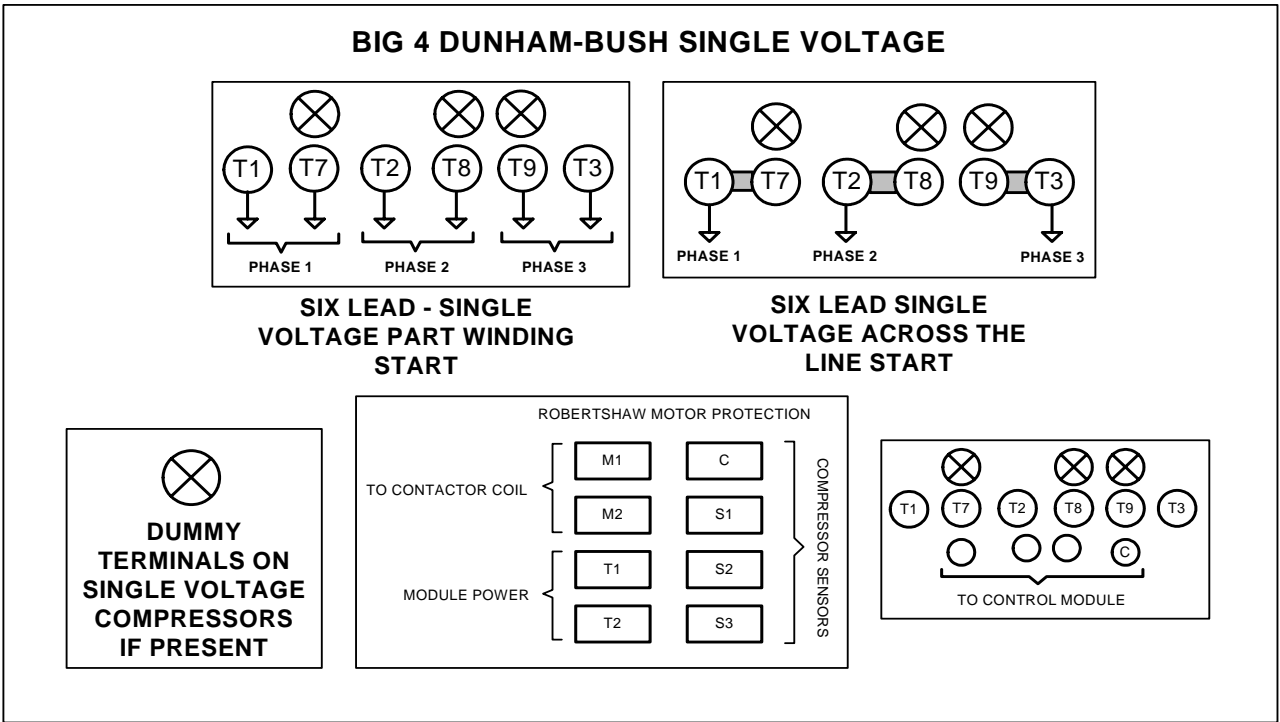


## DUNHAM-BUSH (D/B METIC) 10 THRU 20 HP THREE PHASE SINGLE VOLTAGE

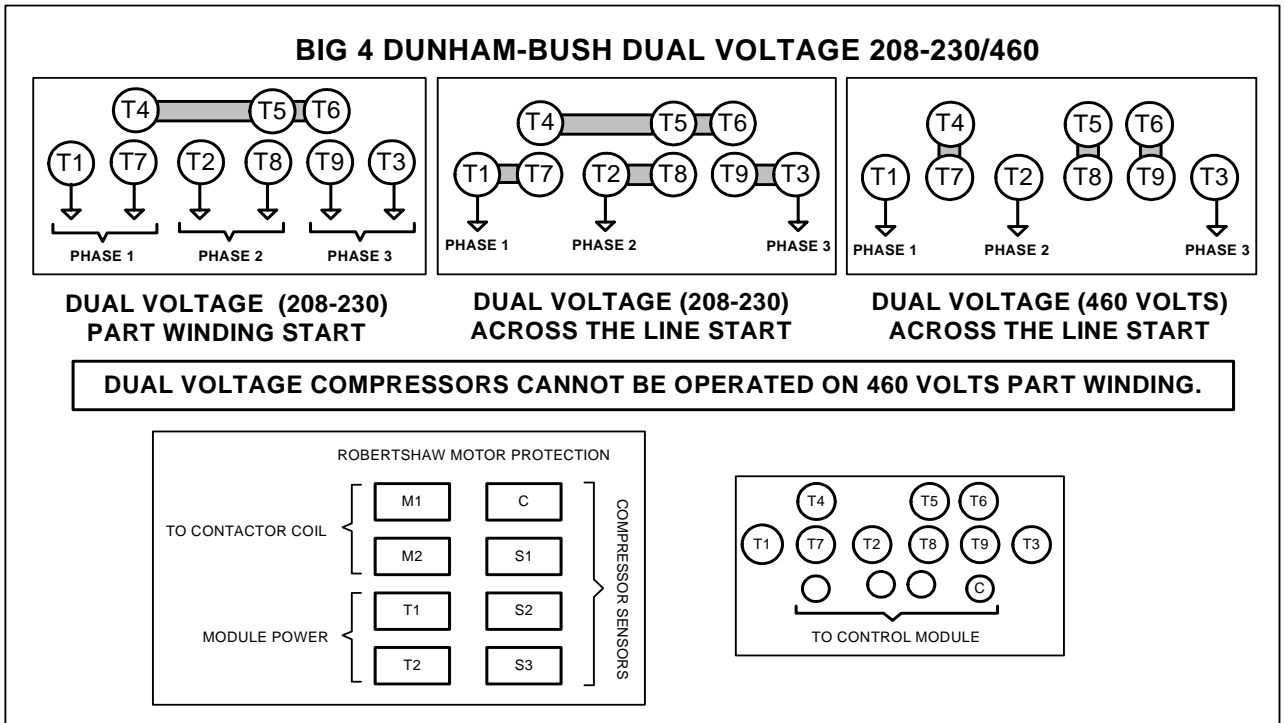




# DUNHAM-BUSH (BIG 4) THREE PHASE SINGLE VOLTAGE COMPRESSORS WITH SOLID STATE ROBERTSHAW MOTOR PROTECTION

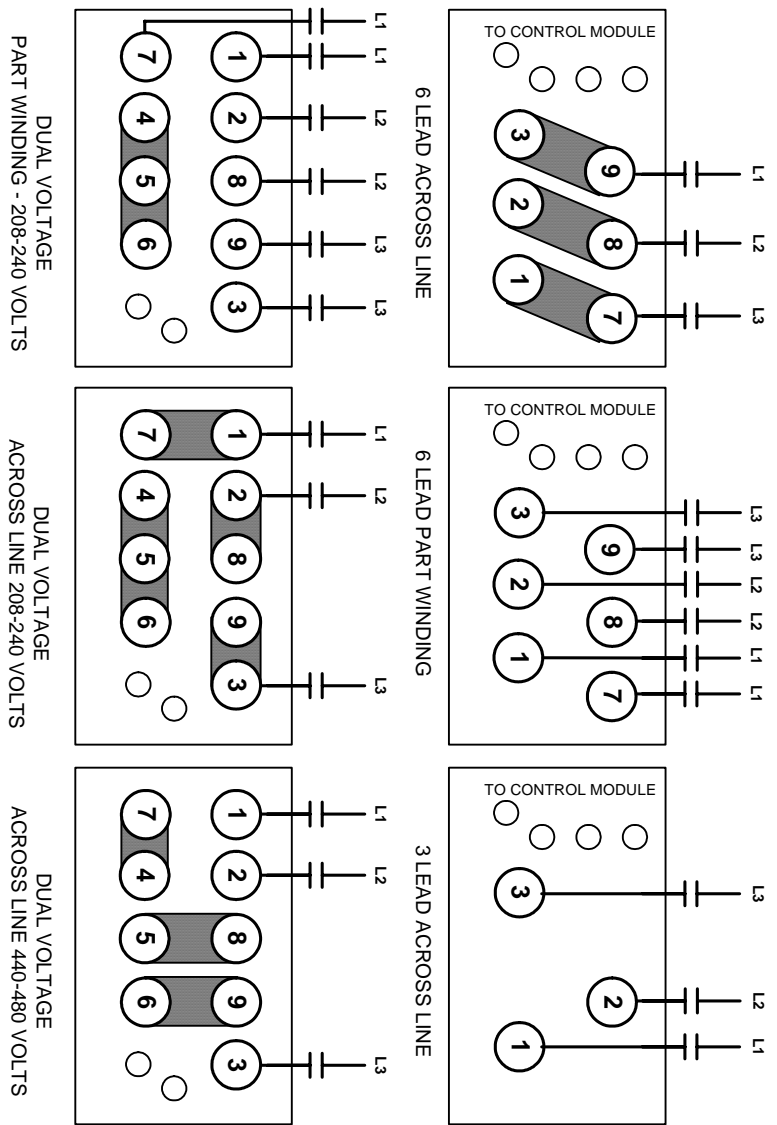


# DUNHAM-BUSH (BIG 4) THREE PHASE DUAL VOLTAGE COMPRESSORS WITH SOLID STATE ROBERTSHAW MOTOR PROTECTION



# ALL 'H' AND 'SS' YORK COMPRESSORS SINGLE AND DUAL VOLTAGE

## SINGLE AND DUAL VOLTAGE 'H' AND 'SS' YORK COMPRESSORS

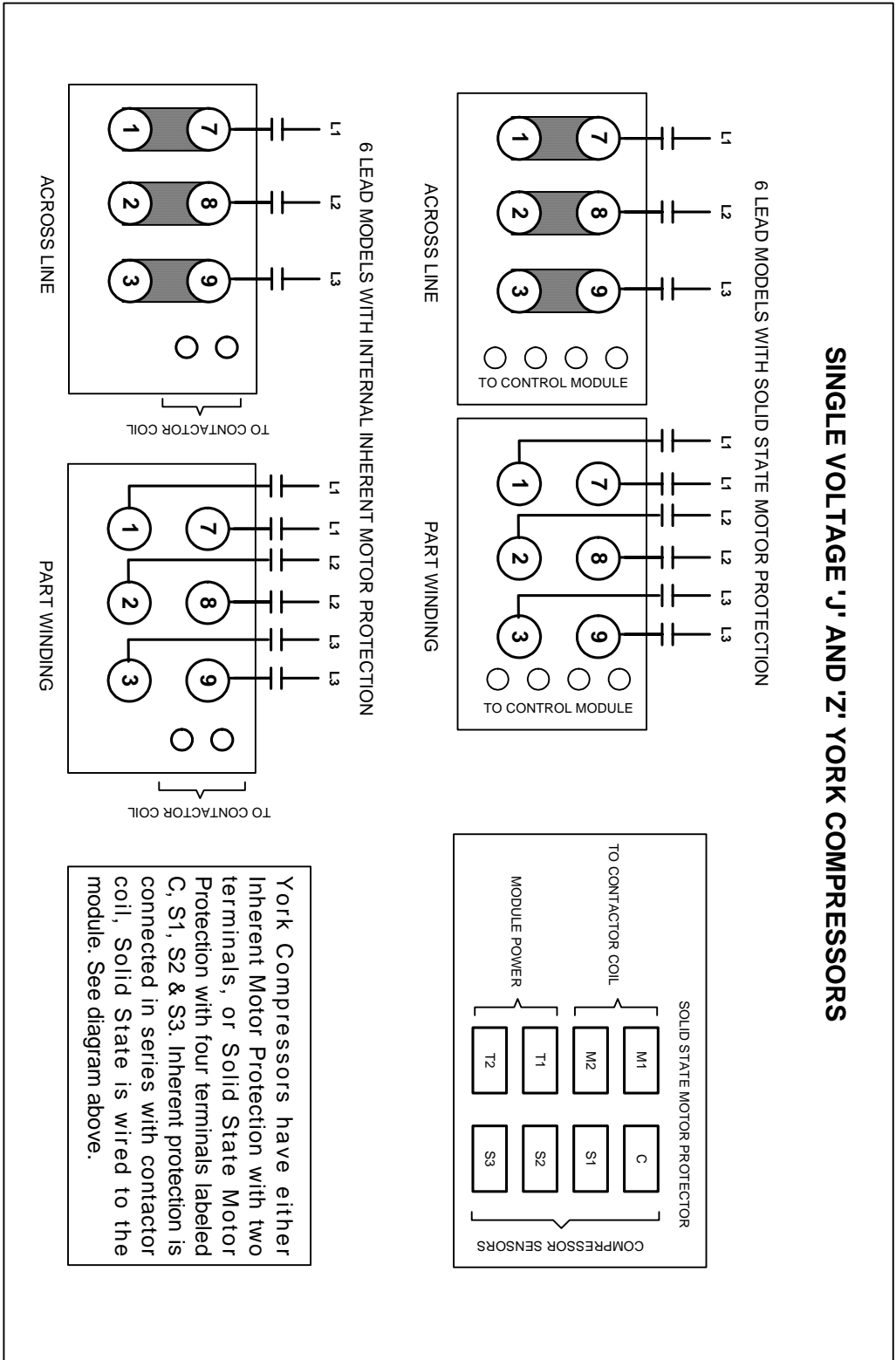


York Compressors have either Inherent Motor Protection with two terminals, or Solid State Motor Protection with four terminals labeled C, S1, S2 & S3. Inherent motor protection is connected in series with contactor coil, Solid State is wired to the module. See diagram reverse side.

DUAL VOLTAGE COMPRESSORS CANNOT BE USED ON 460 VOLTS PART WINDING START

# ALL 'J' AND 'Z' YORK COMPRESSORS SINGLE VOLTAGE

## SINGLE VOLTAGE 'J' AND 'Z' YORK COMPRESSORS

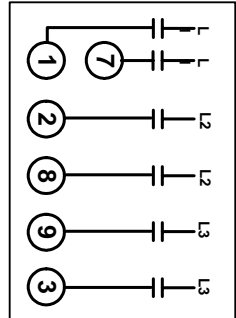


York Compressors have either Inherent Motor Protection with two terminals, or Solid State Motor Protection with four terminals labeled C, S1, S2 & S3. Inherent protection is connected in series with contactor coil, Solid State is wired to the module. See diagram above.

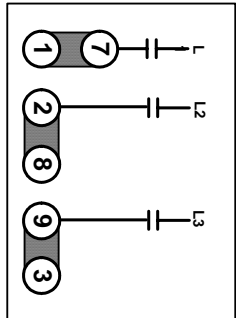
# ALL 'M' AND 'R' TRANE COMPRESSORS SINGLE AND DUAL VOLTAGE

## TRANE M & R MODEL WIRING DIAGRAMS

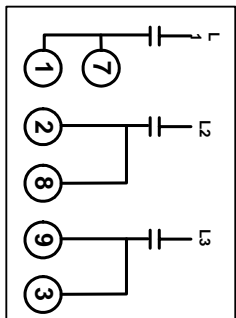
### 6 LEAD SINGLE VOLTAGE CRHR 500,600



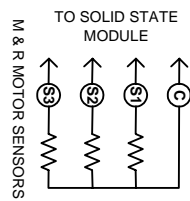
PART WINDING START



FULL WINDING START - 3 WIRE

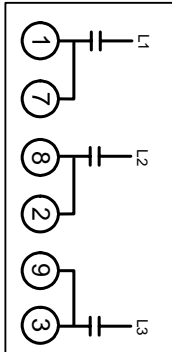


FULL WINDING START - 6 WIRE

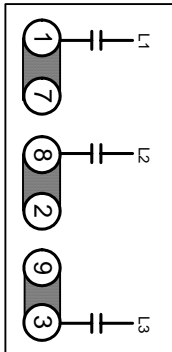


M & R MOTOR SENSORS

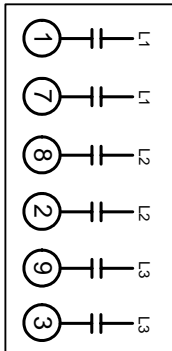
### 6 LEAD SINGLE VOLTAGE CRHR 400 & ALL CRHM



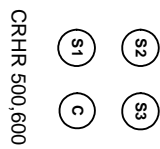
FULL WINDING START - 6 WIRE



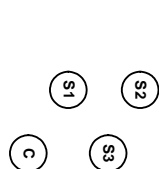
FULL WINDING START - 3 WIRE



PART WINDING START

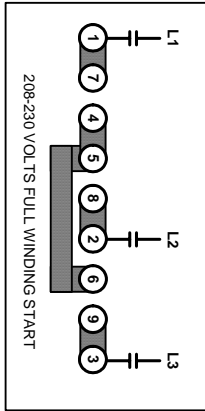


CRHR 500,600

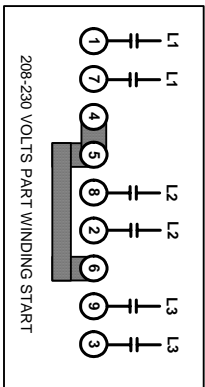


CRHR 400 & ALL CRHM

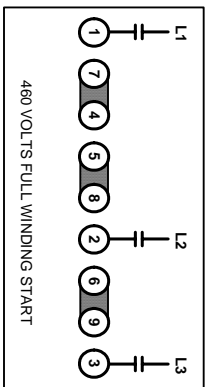
### TRANE DUAL VOLTAGE (208-230/460) CRHR 400 & ALL CRHM



208-230 VOLTS FULL WINDING START



208-230 VOLTS PART WINDING START

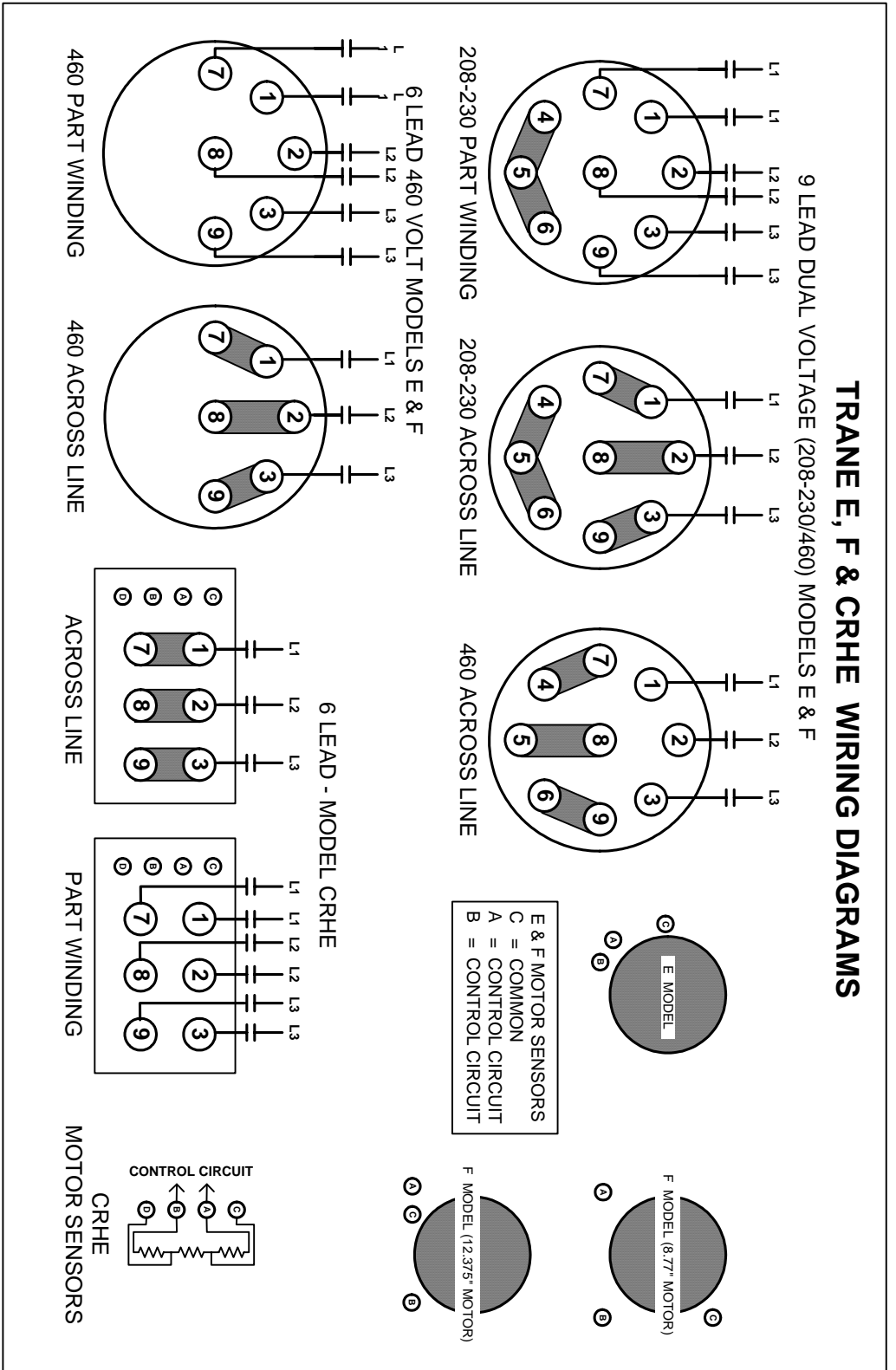


460 VOLTS FULL WINDING START

NOTE:  
DUAL VOLTAGE  
COMPRESSORS  
CAN NOT BE  
OPERATED ON 460  
VOLTS PART  
WINDING START

# ALL 'E', 'F', AND 'CRHE' TRANE COMPRESSORS SINGLE AND DUAL VOLTAGE

## TRANE E, F & CRHE WIRING DIAGRAMS



# Capacity Control

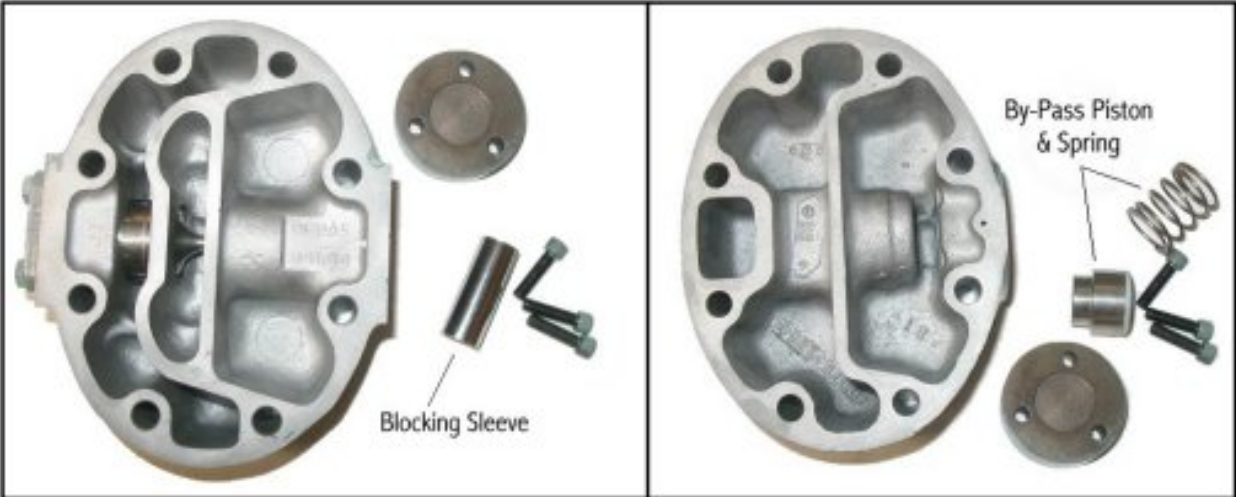
Servicing Carrier/Carlyle, 06D, 06E	Page 38
Diagrams	Page 44, 45
Servicing Carrier/Carlyle, 5F, 5H, 6G/06G, 6L/06L	Page 40
Diagram	Page 46
Servicing Trane, A, B, E and F	Page 42
Diagram	Page 51
Servicing Trane, M and R	Page 43
Diagrams	Page 52, 53
Copeland Diagrams	Page 47, 48
Chrysler Airtemp Diagrams	Page 49, 50

### Carrier/Carlyle 06D and 06E Capacity Control

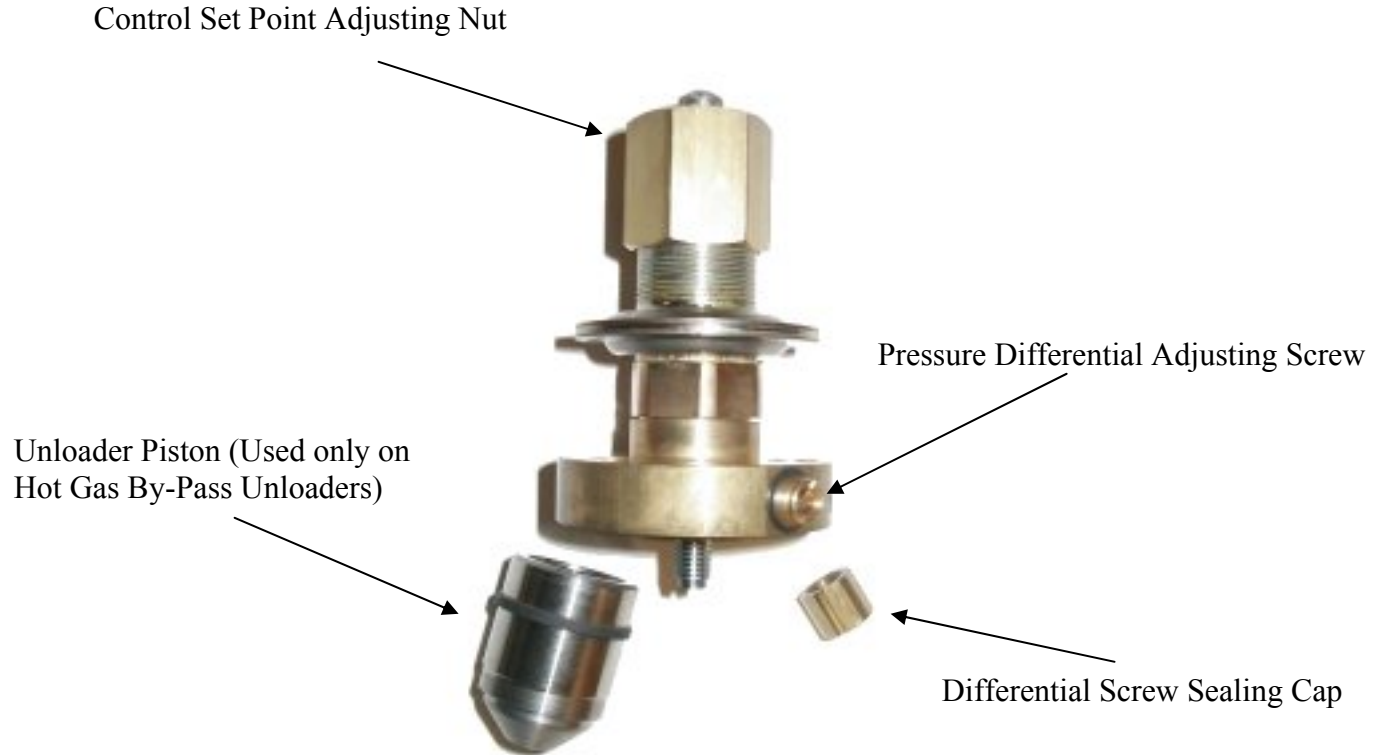
The electric capacity control valve is shown on the left, the pressure capacity control valve, sometimes referred to a mechanical is shown on the right. Both control valve packages are for all 06D and 06E compressors and will work on both the hot gas bypass unloader heads and the suction cut off unloader heads. Each package comes with complete instructions for installation and adjustment.



The 06D and 06E compressors use two designs of capacity control. These compressors are shipped with the heads blocked in the loaded position. If you do not need capacity control no changes are necessary. If you wish to install capacity control you must first remove either the blocking sleeve or the bypass piston, piston seal and spring before installing the capacity control valve. The 06D heads are pictured here with the suction cut off on the left and the hot gas by pass on the right. The 06E capacity control heads look similar. Refer to the drawings in the capacity control sections for information on how these two systems operate.







### INSTALLING AND ADJUSTING 06D OR 06E CAPACITY CONTROL VALVES

Decide which type unloader system your compressor is equipped with, hot gas by-pass or suction cut off. If you're working on the hot gas by-pass system you must first install the unloader piston onto the control valve. Discard this piston if you have the suction cut off unloader system. Remove the unloader flange from the compressor head and remove the blocking sleeve or by-pass piston, piston seal and spring. Install the valve assembly into the head using the screws provided with the unloader. Flange and unloader screws are not interchangeable. Do not use the flange screws to install the unloader.

Electric unloaders are controlled by another device such as a pressure or temperature switch and are not adjustable. Pressure unloaders are adjustable and must be set when installed. The control set point is the pressure the cylinders load and may be set from 0 to 86 psig. Pressure differential between load and unload is adjustable from approximately 6 to 18 psig. To set the unloader turn the control set point nut clockwise to its bottom stop. This is the fully loaded position and each full turn of the adjusting nut counterclockwise will decrease the set point by approximately 7 psig. Approximately 12 turns out will decrease load point to approximately 0 psig. Turn the differential adjusting screw counterclockwise to its backstop. This position sets the differential at approximately 6 psig. Each full clockwise turn raises the differential setting approximately 1 psig. Check all settings with gauges and readjust as needed. Replace differential sealing cap to prevent any refrigerant leakage.

## 5F, 5H, 6G/06G and 6L/06L Installation

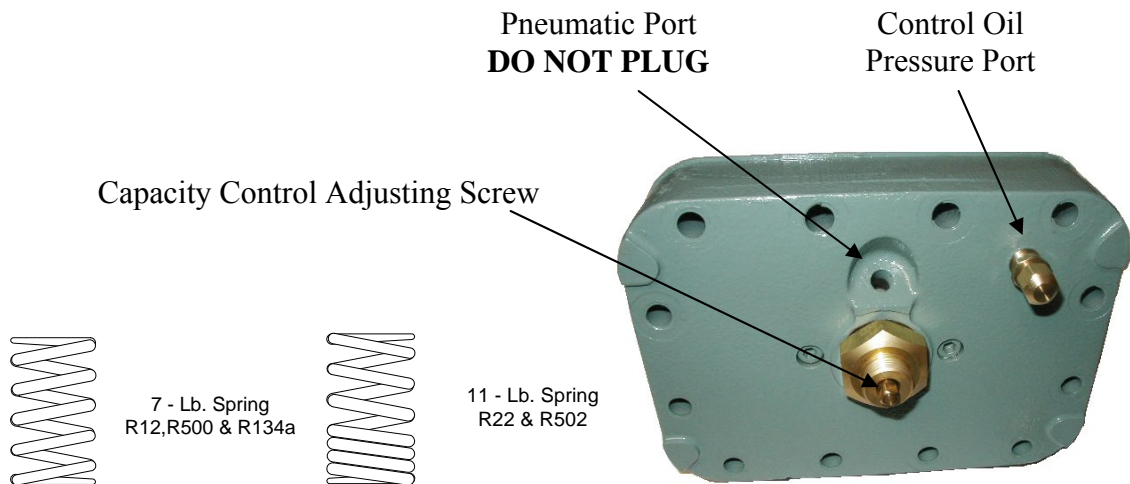
The capacity control valve is equipped with an 11-pound range adjustment spring for use with R-22 and R-502, If R-12, R-500 or R-134a is used in the system replace with the 7-pound range adjustment spring. The 11-pound spring has 3 active coils. The 7-pound spring has 5 active coils.

An external adjusting stem is provided to set control point (suction pressure at which first step of cylinder unloading occurs). Control point is adjustable from 0 to 85 psig for R-22 and R-502, and from 0 to 50 psig for R-12, R-134a and R-500. Turn the adjusting stem one full turn clockwise to raise control point approximately 10 pounds for R-22 and R-502 or 6 pounds for R-12, R-134a and R-500.

### ADJUSTING CONTROL SET POINT

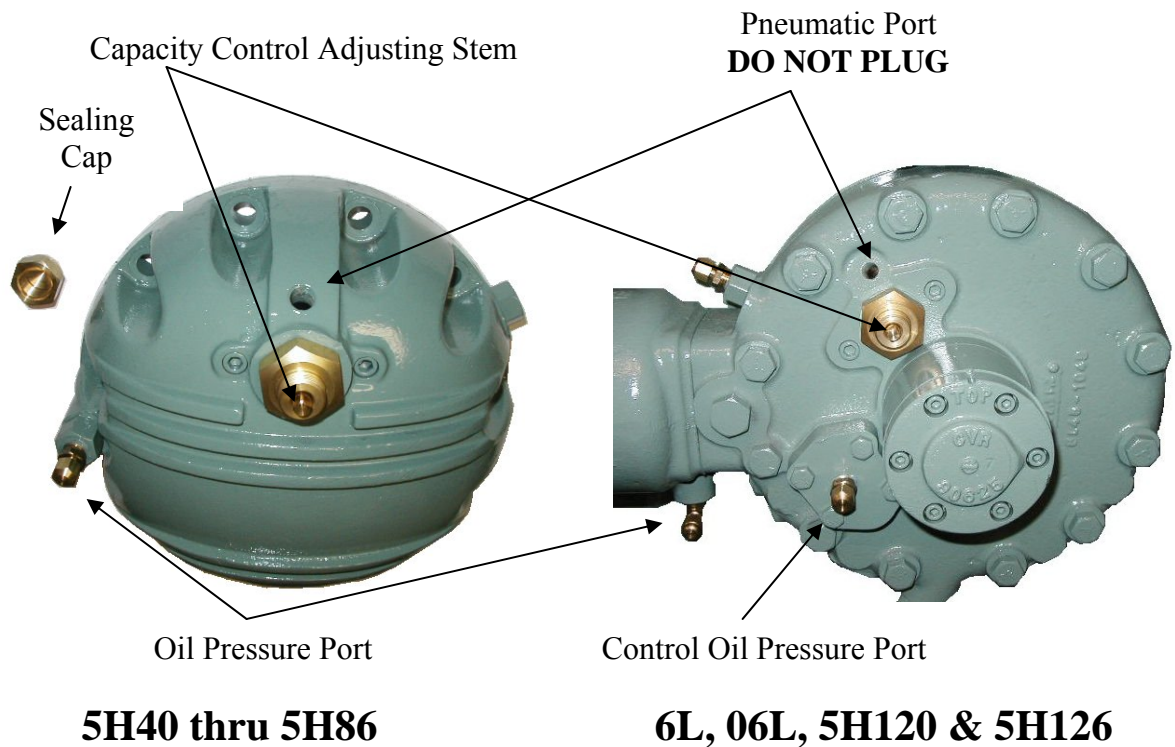
1. Load compressor until suction pressure is above desired control set point.
2. Reduce compressor suction pressure to control point pressure by slowly closing suction valve.
3. At control point pressure, slowly turn adjusting stem in clockwise direction until first step of unloading takes place.
4. After completing step 3 the control point is set. Thereafter, the compressor is fully loaded when suction pressure is 4 psig (3 psig with R-12) above control point, and is fully unloaded when suction pressure is 7 psig (4 psig with R-12) below control point.

These compressors may also have the capacity controlled by pneumatics. Connecting the pneumatic line to the pneumatic port and then controlling the pressure applied to bellows will vary the compressor capacity. If you are not using pneumatics this vent must remain open. Plugging this vent will adversely affect the operation of the capacity control system. A refrigerant leak at this port indicates a defective bellows and internal repairs will be necessary.



**7 and 11 lb Capacity Control Spring**

**6G, 06G, 5F40 & 5F60**



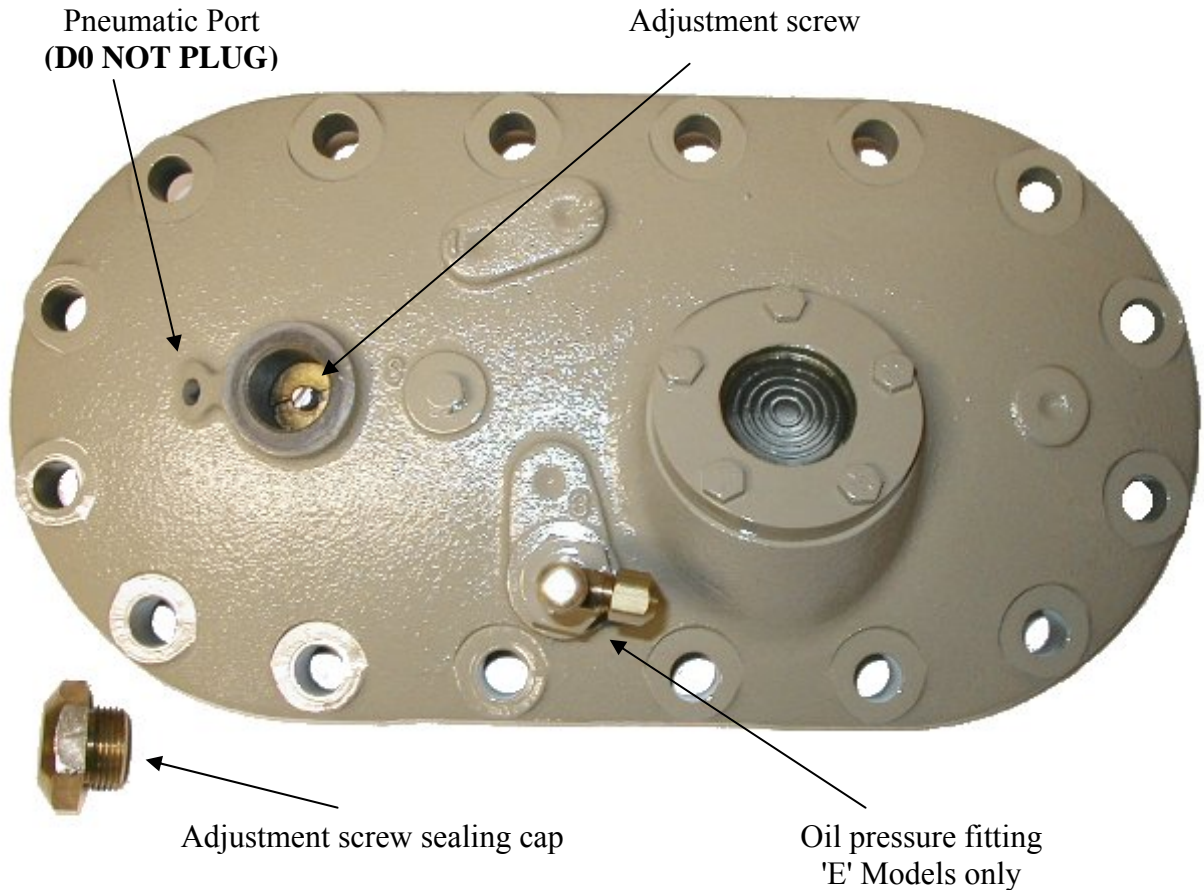
**5H compressors that use an external oil filter must have a 0.030 orifice ell (Carrier Part number DD40CA051) in the bottom of the oil filter. Failure to install the proper ell will result in low oil pressure and may result in compressor failure.**

**5F, 5H and 6L/06L compressors using an external oil cooler must have a blocking sleeve or plug installed in the bearing head to re-route the oil thru the oil cooler. 5H46, 66, 86, & 126 require an oil cooler.**

### NON STANDARD APPLICATIONS

5F, 5H, 6G/06G and 6L/06L compressors are shipped configured internally for R22 air conditioning applications. When these compressors are used for other applications they must be special ordered or field converted. Internal modifications must be made for most other refrigerants or if an external oil cooler, external electric unloading or water-cooled heads are used. These changes require additional gaskets and the removal of parts from the old compressor to be installed on the replacement compressor. Failure to make the necessary changes for any non-standard applications may result in a pre-mature, **non-warranty** compressor failure. Many applications using external oil coolers also require that water cooled heads be installed. Oil coolers are required on all long stroke (5H46, 66, 86 and 126) compressors and these compressors should not be used on belt drive applications. Contact your supplier if you have any questions or need additional information.

## TRANE CAPACITY CONTROL



## TRANE SUCTION PRESSURE CONTROLLED CAPACITY CONTROL

Trane A, B, E, and F model compressors use three types of unloader controls. Two of these are electric versions. One with three solenoids mounted directly to the hand hole cover and the other with remote electric solenoids piped back to the hand hole cover with copper lines. All electric capacity control are operated using some other control such as pressure or temperature, usually temperature on water chillers. Suction pressure (Pictured above) must be set when the compressor is installed. This cannot be factory set for an unknown system using an unknown refrigerant. This capacity control system is set by means of an adjustment screw in the hand hole cover. Turning the screw clockwise will unload or raise control set point. Turning the screw counterclockwise will load the compressor or lower the control set point. These compressors all have three steps of capacity control. Only the first step of capacity control is adjustable, the differential between each step is fixed and cannot be changed. This type capacity control will operate over a 9 to 10 psig range.

These compressors may also have the capacity controlled by pneumatics. Connecting the pneumatic line to the pneumatic port and then controlling the pressure applied to bellows will vary the compressor capacity. If you are not using pneumatics this vent must remain open.

Plugging this vent will adversely affect the operation of the capacity control system. A refrigerant leak at this port indicates a defective bellows and internal repairs will be necessary.



**Figure 1**



**Figure 2**



**Figure 3**

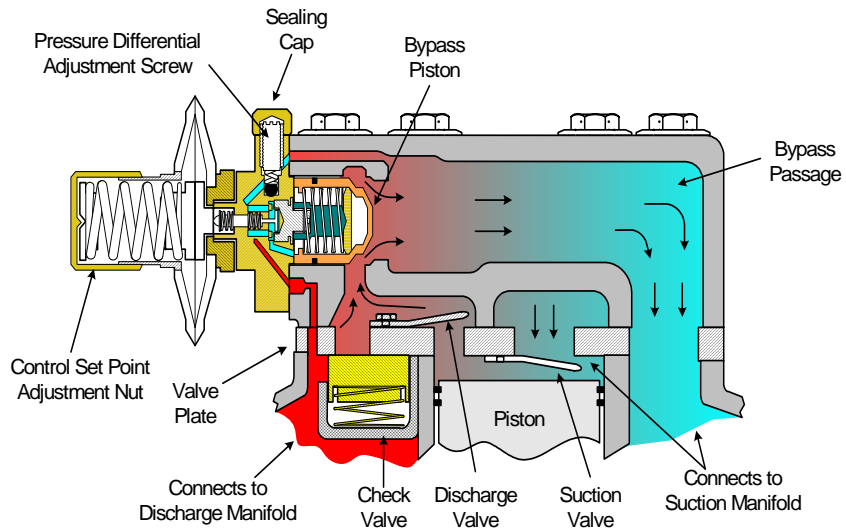
A, B, E, and F models with electric unloading and three hand hole mounted solenoids must have the solenoids installed correctly. Newer solenoids are marked with the word 'top' or 'down' (Figures 1 and 3). Some older solenoids have a small triangle and the word 'form' on the edge of the base, (FORM ▽), this marking is oriented to the top left when installing (Figure 2). Still another design has the letters 'B', 'A' and 'C' stamped into the side of the base (Not shown). Install these so the letters run B, A, C top to bottom. Installing the solenoids upside down may cause a premature compressor failure. A defective or improperly installed solenoid may cause a significant loss in oil pressure. Check all electric stems and coils and replace if needed whenever a new compressor is installed.

### **'M' AND 'R' MODEL TRANE**



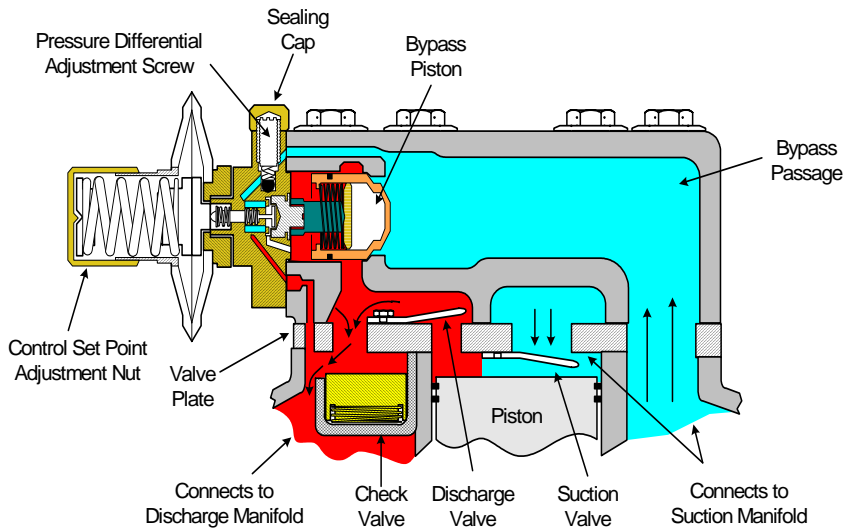
'M' and 'R' model Trane compressors all use electric unloading. This is hot gas by-pass unloading. Maximum number of stages per compressor is two. The number of cylinders that unload is usually one third (one step) or two thirds (two steps), allowing capacity down to 33% of full compressor capacity.

# 06D AND 06E CARRIER/CARLYLE HOT GAS BY-PASS CAPACITY CONTROL



**Unloader Piston in Unloaded Position**

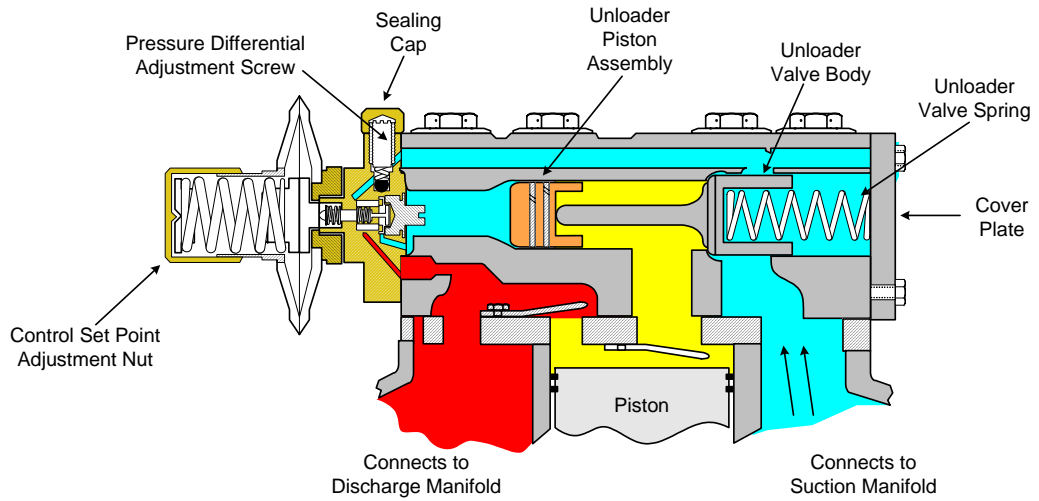
Discharge Pressure
  Suction Pressure



**Unloader Piston in Loaded Position**

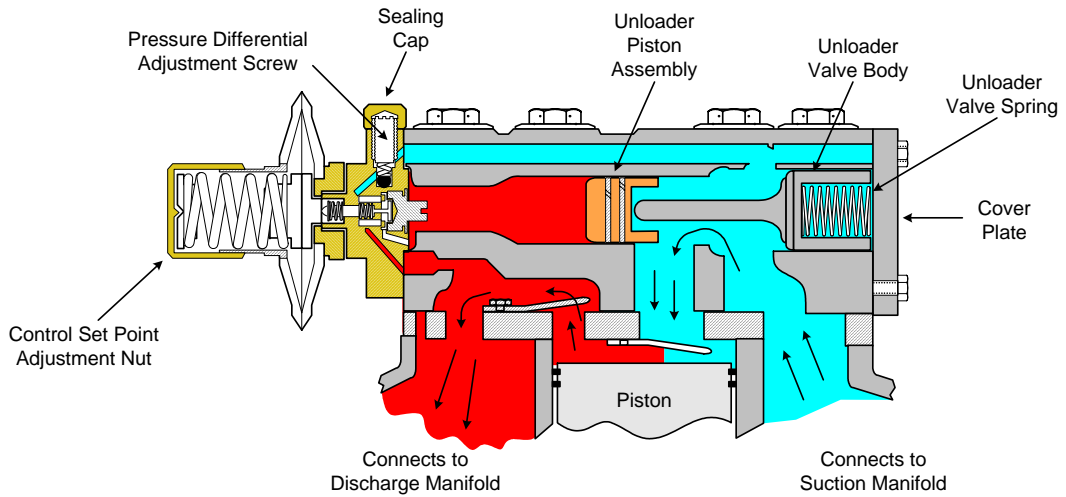
Discharge Pressure
  Suction Pressure

# 06D AND 06E CARRIER/CARLYLE SUCTION CUT OFF CAPACITY CONTROL



**Unloader Piston & Valve Body in Unloaded Position**

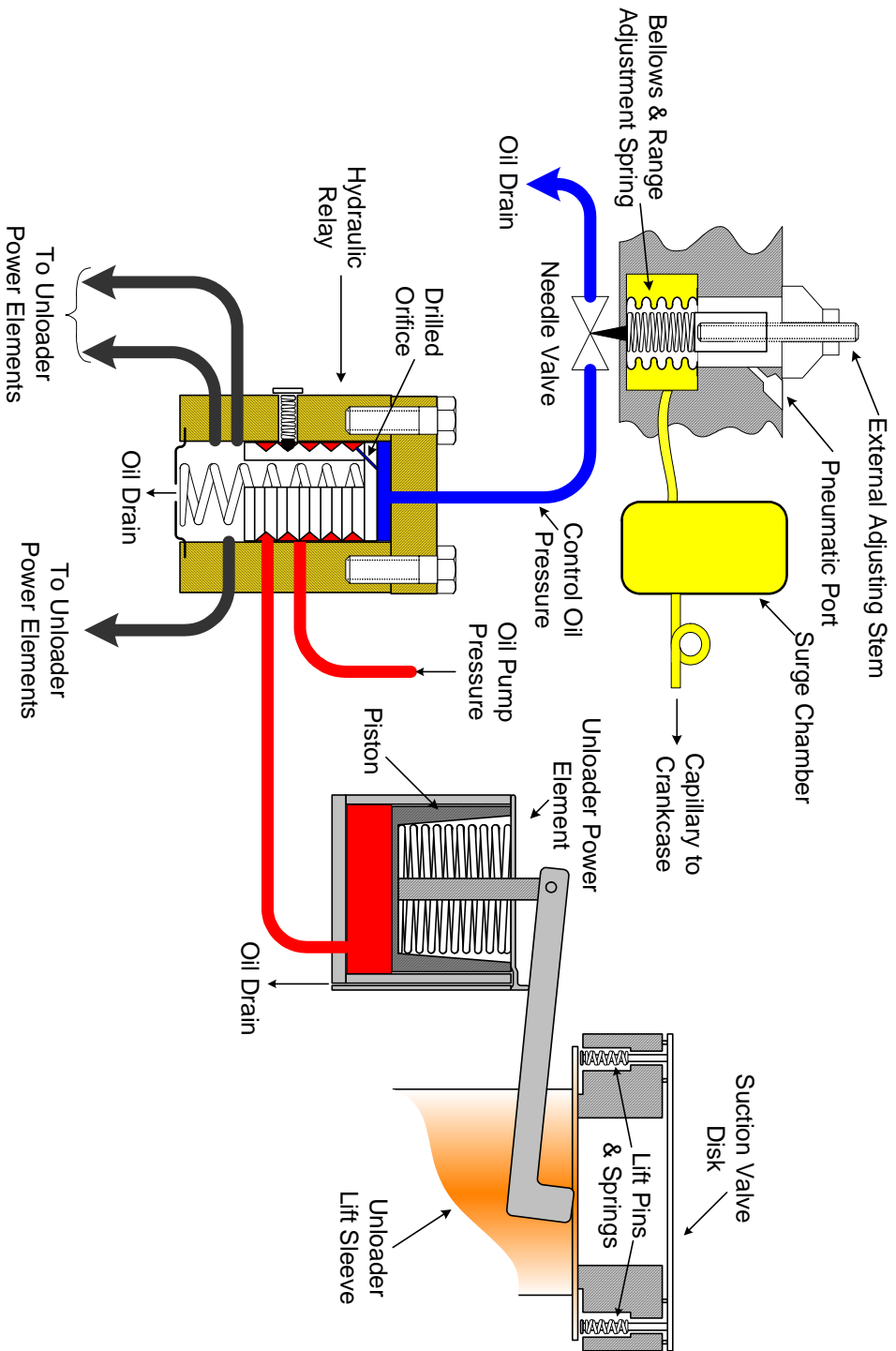
Discharge Pressure
  Suction Pressure



**Unloader Piston & Valve Body in Loaded Position**

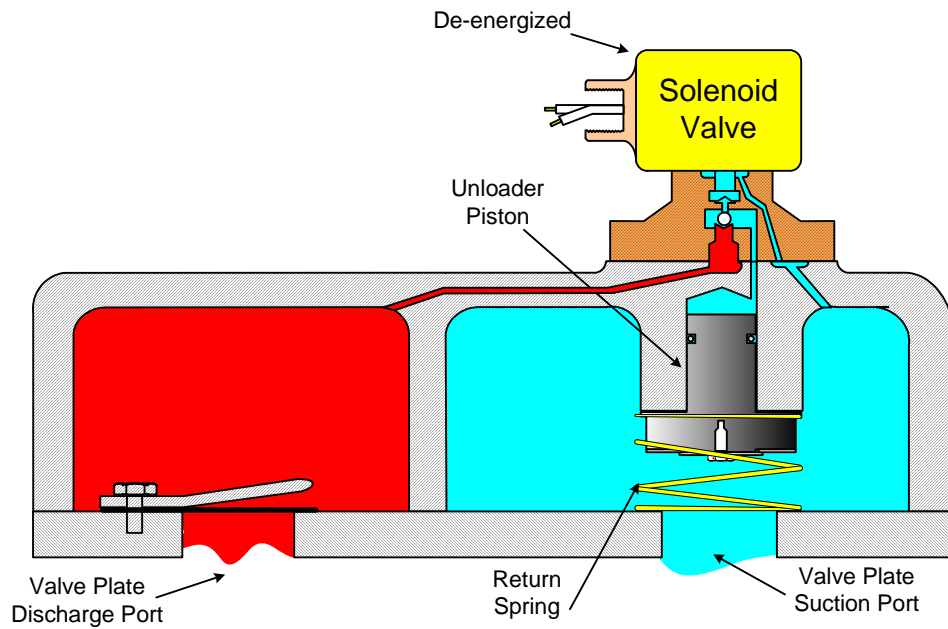
Discharge Pressure
  Suction Pressure

# 5F, 5H, 6L, 06L, 6G AND 06G CARRIER/CARLYLE CAPACITY CONTROL



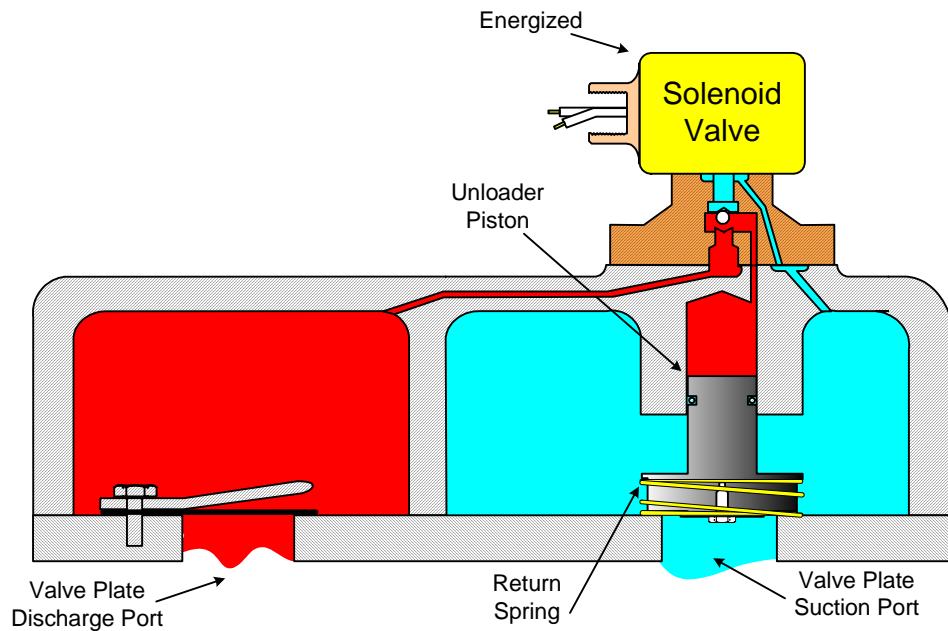


# 4R/6R/8R/4D/6D/8D COPELAND SUCTION CUT OFF



**Unloader Piston in Loaded Position**

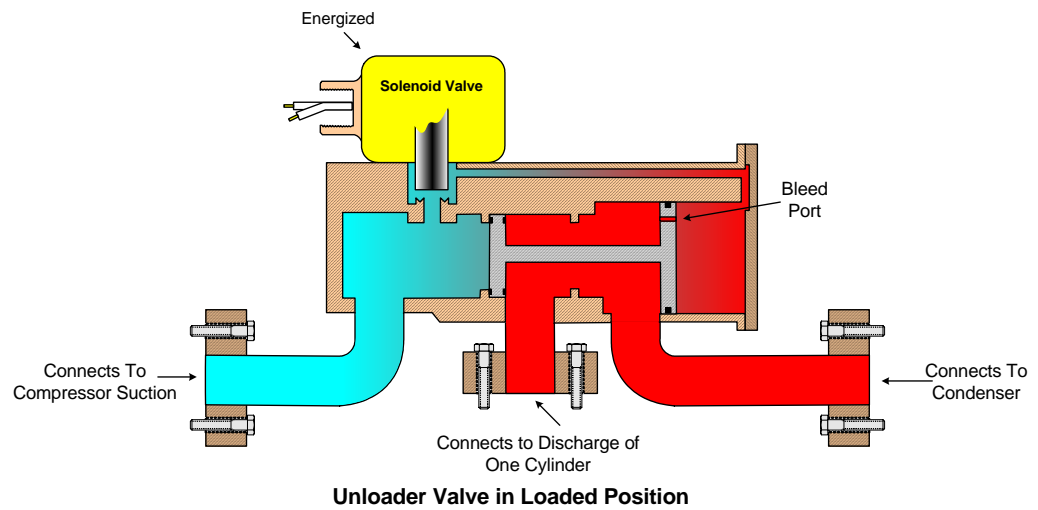
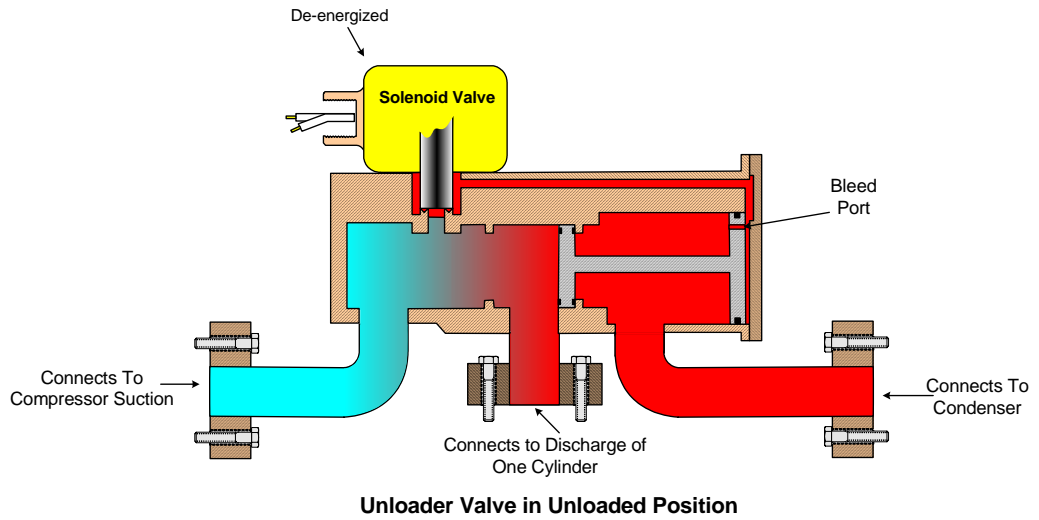
Discharge Pressure
  Suction Pressure



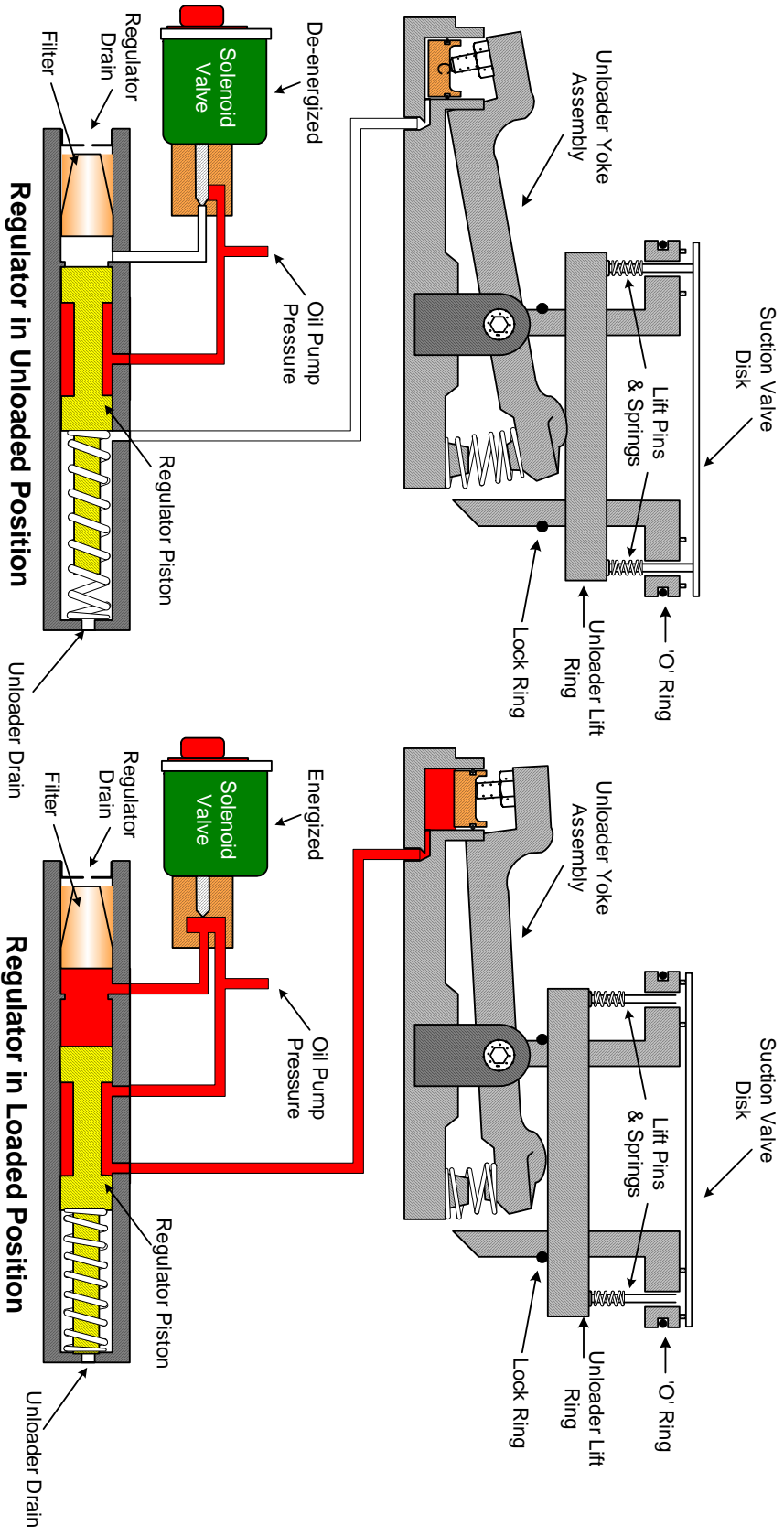
**Unloader Piston in Unloaded Position**

Discharge Pressure
  Suction Pressure

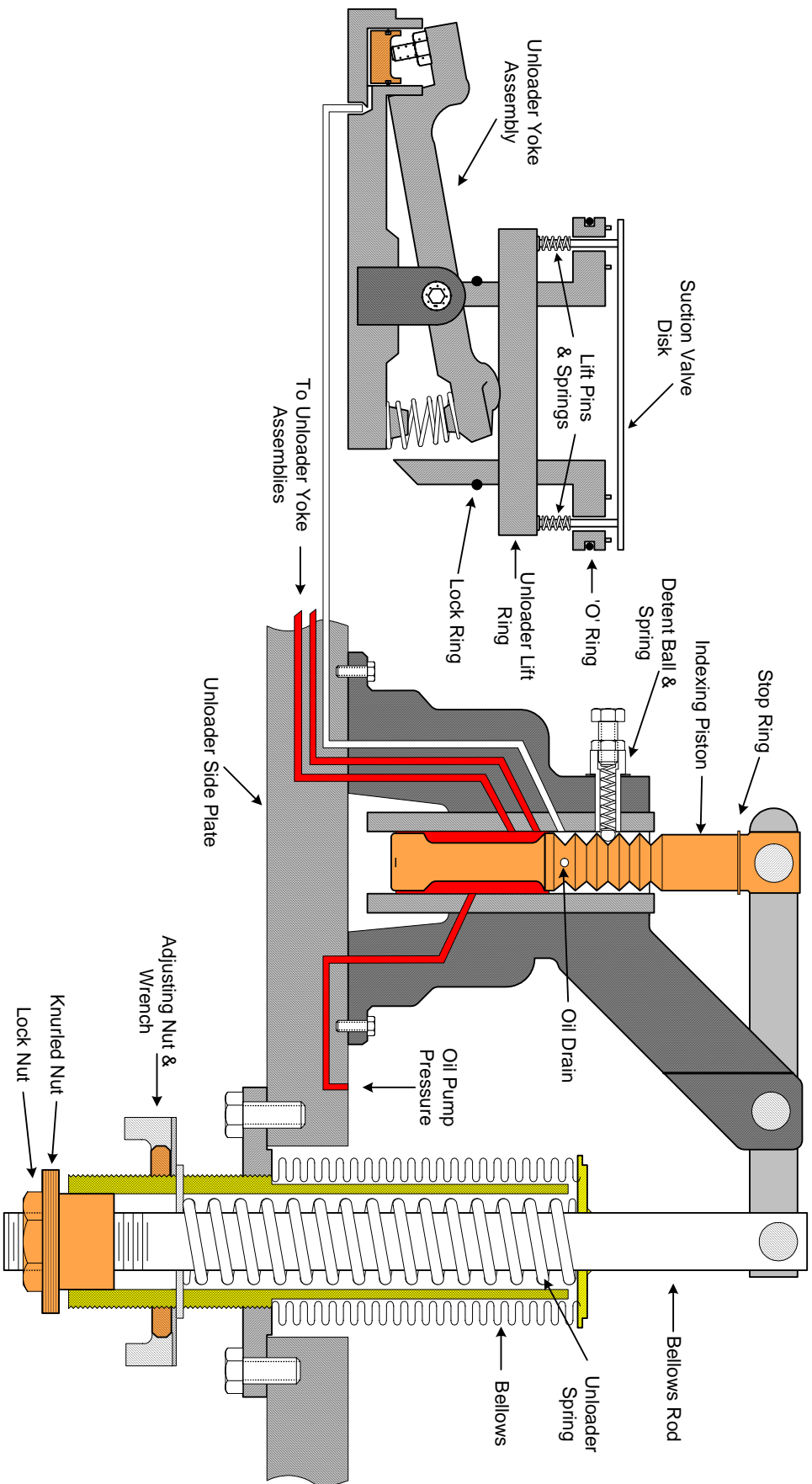
## 9R COPELAND HOT GAS BY-PASS CAPACITY CONTROL



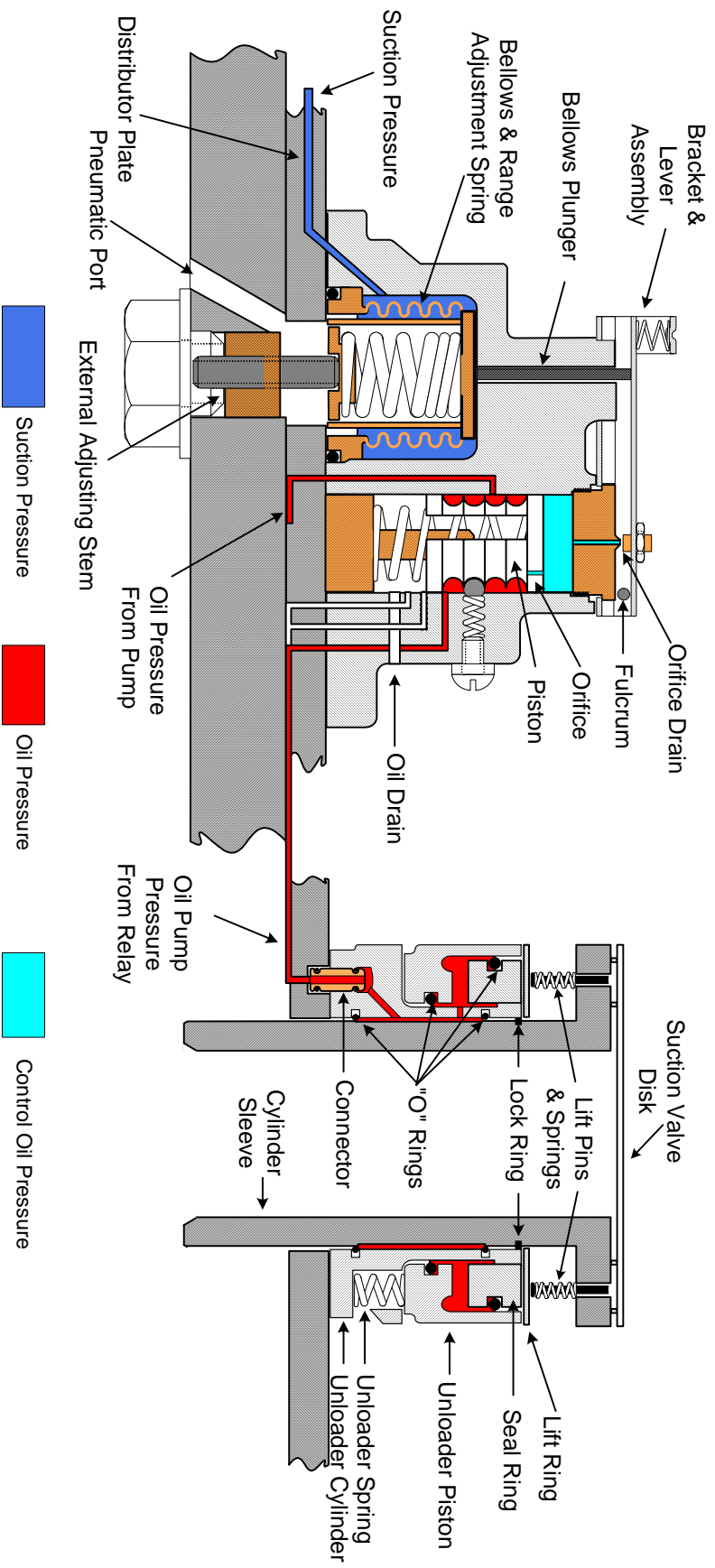
# CHRYSLER AIRTEMP 2000 AND 3000 ELECTRIC CAPACITY CONTROL



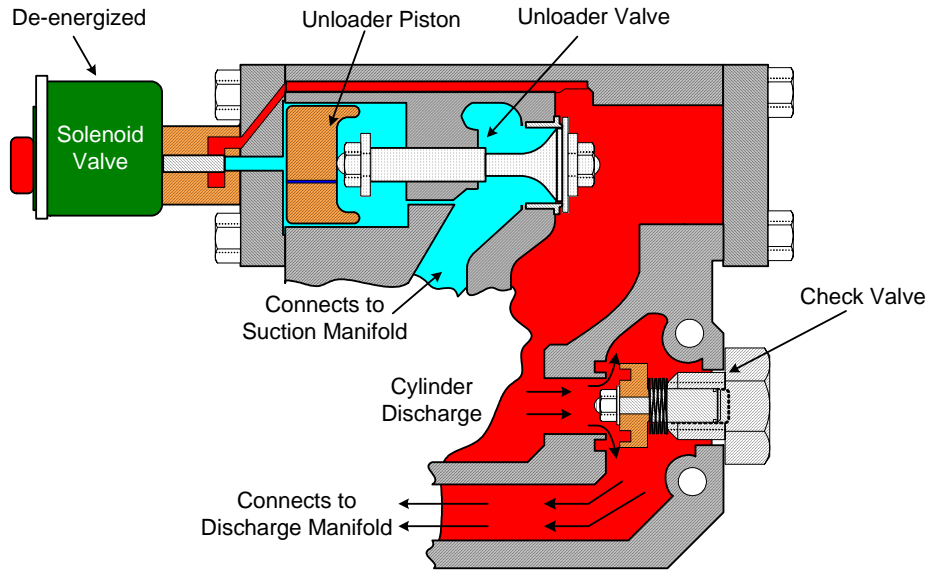
# CHRYSLER AIRTEMP 2000 AND 3000 SUCTION PRESSURE CAPACITY CONTROL



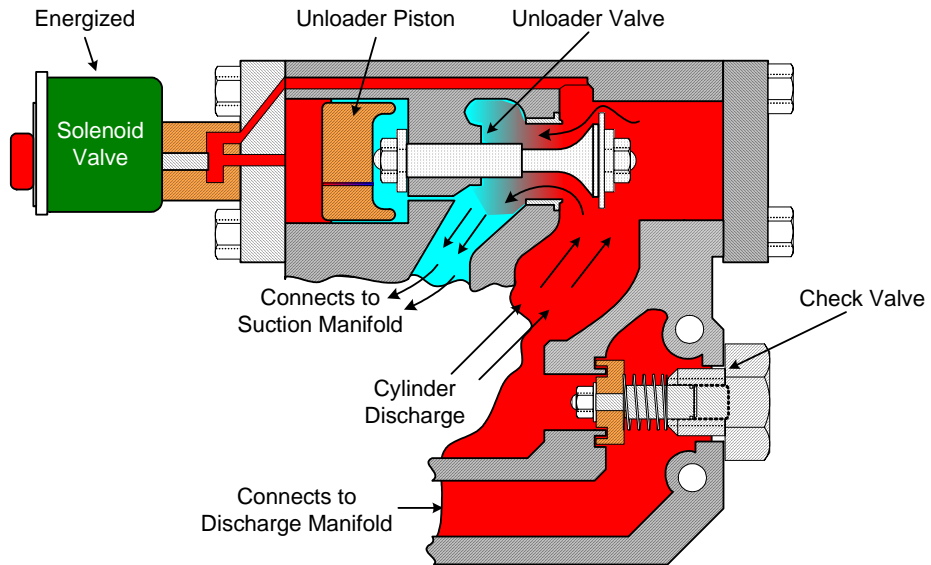
# TRANE A, B, E AND F MODEL SUCTION PRESSURE CAPACITY CONTROL



# TRANE 'M' MODEL HOT GAS BY-PASS CAPACITY CONTROL

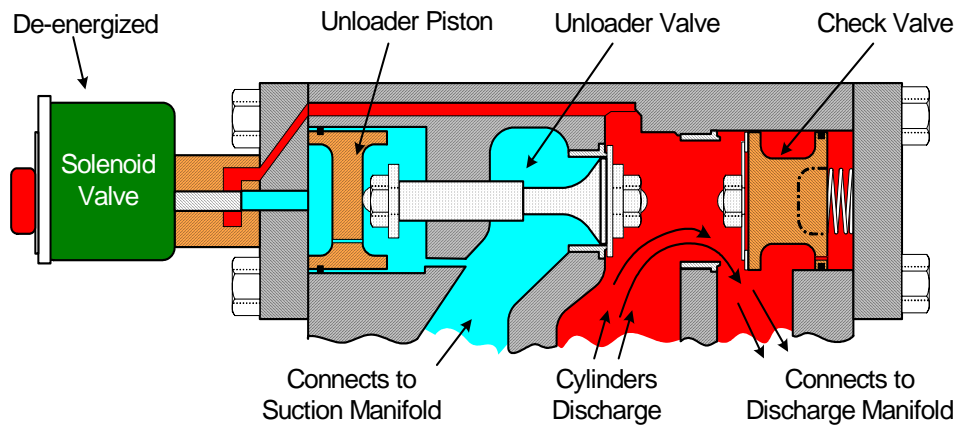


**Unloader Piston & Valve in Loaded Position**

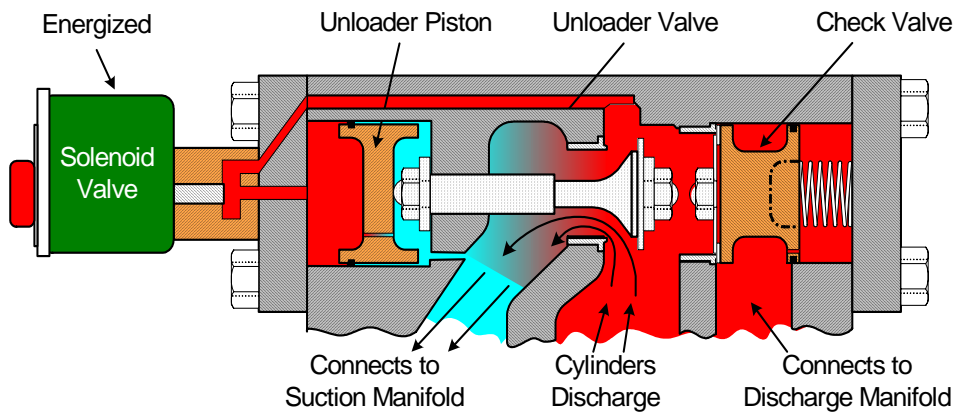


**Unloader Piston & Valve in Unloaded Position**

# TRANE 'R' MODEL HOT GAS BY-PASS CAPACITY CONTROL

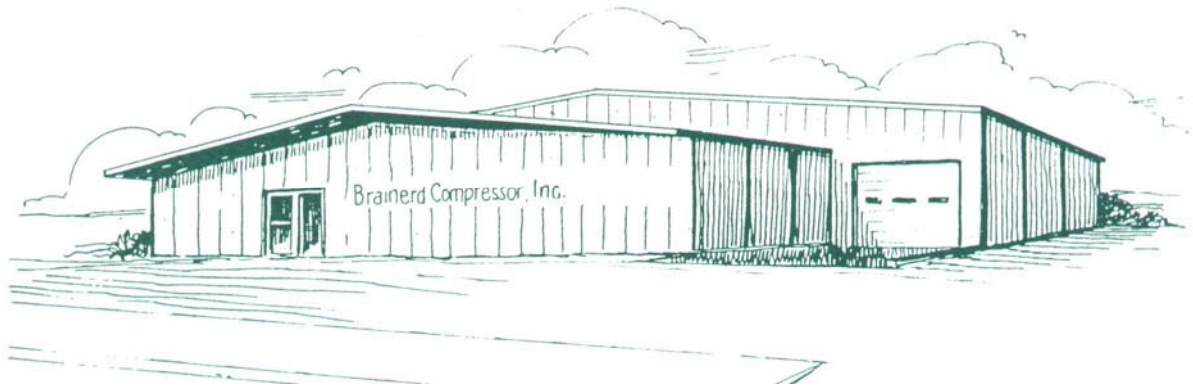


**Unloader Piston & Valve in Loaded Position**



**Unloader Piston & Valve in Unloaded Position**

# Welcome To Brainerd Compressor





Brainerd Compressor neither fixes nor patches compressors, we remanufacture the compressors. That's to say that all compressors are completely disassembled. Each and every part is cleaned and checked to insure it meets industry tolerances. Compressors are then assembled, tested, evacuated, painted and put in our stock for exchange sales.



Brainerd believes that having clean compressor castings and parts is very important. We have invested considerable time and money to insure that all components of each and every compressor are free of any and all contaminants. Pictured above is our AmPro cleaning system. This system consists of four steps, first is the burning process, which burns all paint, oil, grease, or contaminants to carbon dust. The second step is a stainless steel shot blasting process that removes all carbon and paint residue. The third step is a shaker and cool down step to remove excessive shot. The fourth and final AmPro step is a high-pressure wash and dry using a detergent and rust preventive solution followed by a high-pressure air blast to dry the parts. This step removes all remaining dust and leaves a rust protective coating on the parts.



Brainerd generates a large amount of scrap in the form of bad parts. We estimate that 90% of what's in our compressors is new. Any re-qualified part must go thru a rigorous re-qualification procedure starting in tear down. Critical wear parts are not checked, they are always replaced with new, these include, valve reeds, gaskets, 'O' rings, shaft seals, piston rings and bearings. All parts that may be re-used are cleaned, visually inspected and then checked using Mitutoyo digital

test instruments which measure plus or minus a half a millionth of an inch ( $\pm .00005$ ). Parts that are not within specifications are considered scrap.



All cylinders are checked and honed to break the glaze and restore proper cross-hatching. Cylinders may be bored and honed to an acceptable oversize dimension such as .010 or .020. Cylinders that cannot be bored to an oversize dimension are sleeved and returned to the original standard dimension or the casting/part is scrapped. Valve plates are re-ground to insure a parallel seat and all new valve reeds and springs are installed.



Compressors are put on the line with all necessary parts for assembly. The assembled compressors are then leak checked, charged with oil and run tested in a closed loop system simulating system conditions.



All compressors are run tested to insure a satisfactory and trouble free operation when the compressor is received at the job. Suction pressure, head pressure, oil pressure, oil charge, amps on all motor leads, motor resistance, motor dimensions, make motor, voltage, size of cylinders, size of crankshaft, cubic feet displacement and other needed information of each compressor is recorded and logged for future reference.



Compressors are evacuated, charged with a dry nitrogen holding charge, painted and put in stock for exchange sales. Compressors are shipped with all necessary gaskets and service literature for installation.

For further information on our procedures see our procedures and testing section. We welcome you to stop by at any time and tour our facility. You may contact us if you have any questions and we invite you to visit or web site. ([www.brainerdcompressor.com](http://www.brainerdcompressor.com))

**Brainerd Compressor Inc**  
**3034 Sandbrook St.**  
**Memphis TN. 38116**  
**(800) 228-4138 (901) 396-4051 Fax (901) 306-4131**

PROCEDURES AND TESTING MANUAL  
FOR BRAINERD COMPRESSOR INC.



APPROVED BY

PAUL STOKES - QUALITY CONTROL MANAGER

LARRY BARTON - VICE-PRESIDENT

## GENERAL

It is the purpose of this manual to set forth the procedures to maintain consistency and reliability in the receiving and processing of compressor and/or parts orders with satisfactory quality control.

The inspection system in effect at Brainerd Compressor is comprised of a minimum of departments necessary to carry out good inspections procedures and maintain a high level of quality control. These departments consist of:

1. Order Processing
2. Customer Technical Assistance
3. Shipping and Receiving
4. Disassembly and Cleaning
5. Machine Shop
6. Motor Shop
7. Parts
8. Sub-Assembly
9. Assembly and Testing
10. Evacuation and Painting

This manual will be reviewed no less than annually to insure that all procedures and materials used by each department will meet or exceed a high level of industry quality in all products and services provided by Brainerd Compressor Inc.

All changes and/or additions to the quality control program will be submitted to management for review before becoming a part of this manual.

This manual is a reference manual to be used as a source of information to insure all practices and procedures are consistent with high product quality and customer satisfaction.

## INDEX

Order Processing	Section I	Page 61
Scheduling and In-Process Procedures	Section II	Page 62
Receiving Inspection - Materials	Section III	Page 63
Receiving Inspection - Compressors	Section IV	Page 64
Remanufactured Compressor Specification	Section V	Page 65
Final Testing Procedure and Preparation	Section VI	Page 69
Preservation, Packaging, Stocking and Shipping	Section VII	Page 71

## Section I Order Processing

Purpose:

To maintain consistency and reliability in the receiving and process of orders, whether written or oral.

Responsibility:

All sales personnel as designated by the sales manager.

Procedures:

- A. Sales assisting staff will receive orders either by mail, fax, or phone.
- B. A written order in triplicate will be processed that will include, but not be limited to, the following information:
  - 1) Customer name and address
  - 2) Shipping address
  - 3) Purchase order number, date, telephone number
  - 4) Contact name
  - 5) Description of order – quantity, make, model, voltage, phase
  - 6) Shipping date and weight
  - 7) Price
- C. Copies of orders will go to production manager, parts manager, shipping and receiving manager.
- D. Orders on all stock items will be processed as soon as possible by the shipping and warehouse manager.
- E. Orders on all non-stock items will be given to the production manager for processing until completed and will then be given to the shipping manager.

## Section II Scheduling and In-Process Procedures

**Purpose:**

To outline the procedures for production and scheduling of compressors, both on order and for stock.

**Responsibility:**

Production manager and designated staff as assigned by the production manager.

**Procedures:**

- A. Production manager will receive orders from the vice president in charge of production on all stock items and from sales assisting staff on all incoming orders.
- B. Production manager will then proceed with the scheduling of all orders in coordination with management of each department.
- C. Production manager will oversee the scheduling of “remanufacturing process” as outlined in specifications.
- D. After production is finished and compressors have been through their final testing procedures the production manager will turn product over to warehouse manager for final shipping instructions.



### Section III Receiving Inspection – Materials

**Purpose:**

To provide for the control of incoming material furnished by suppliers or contractors.

**Responsibility:**

Quality control manager, parts manager, or qualified representative designated by quality control manager.

**Procedure:**

- A. Quality control manager, parts manager, or designated representative will inspect all incoming materials or supplies for the following characteristics:
  - 1) Quantity
  - 2) Damage – deterioration
  - 3) Conformance to purchase order or factory order requirements. Verification of above conformity will be noted on each shipping document.
- B. Any material or supplies received that do not meet proper purchase order requirements will be held in a designated hold area and notification will be made to vendor.
- C. Upon final approval of all materials or supplies received, certification and test reports, if requested, will be reviewed for adequacy by the quality control manager and so filed.
- D. Prior to acceptance of material or supplies, inspection shall include visual, dimensional, and functional tests. All material will be identified and labeled, listing customer purchase order, factory order, nomenclature and stamped for acceptance.
- E. A transfer will then be made to the material hold storage area. Material will then be controlled on the hold area by authorized employees until request is made by production control for release.

Section IV  
Receiving Inspection – Compressors

Purpose:

To provide for the control of incoming compressor cores, both exchange and remanufacture.

Responsibility:

Receiving clerk or qualified representative

Procedure:

- A. Receiving clerk will inspect all incoming compressors for the following characteristics:
  - 1) Quantity
  - 2) Damage-deterioration
  - 3) Conformance to purchase order or factory order requirements. Verification of exchange compressor or to be remanufactured and returned will be noted on all shipping documents.
- B. Any compressors requesting inspection report will be specially tagged and held in designated area.
- C. Any compressors designated for remanufacture will be tagged and turned over to the production supervisor to be processed.
- D. All other exchange compressors will be tagged for warehouse and held until production supervisor puts them into production.
- E. All compressors will be identified and tagged with a minimum of the following information:
  - 1) Customer name and address
  - 2) Customer order or reference number
  - 3) Compressor make
  - 4) Compressor model
  - 5) Voltage
  - 6) Phase
  - 7) Special accessories on compressor

Section V  
Remanufactured Compressor Specification

General

1. All remanufactured compressors shall be a combination of new and re-qualified parts that meet dimensional and functional specifications of the original manufacturer.
2. Disassembly - All compressors to be remanufactured shall be completely disassembled, including all internal parts and subassemblies. This is to allow each part to be cleaned, inspected, and refurbished.

Cleaning

1. All parts shall be cleaned to remove major amounts of oil, grease, and metal fragments.
2. All larger cast iron and steel parts and housings shall be cleaned as follows:
  - A. Parts are to be loaded into an Am-Pro cleaning rack and placed into the Am-Pro Thermal cleaner unit for a period of 30 to 40 minutes and constantly rotated while at a temperature of 350 degrees Fahrenheit. All oil, grease, acid, and paint shall be burned to a dry carbon.
  - B. Parts rack shall then be moved to the Am-Pro Air-Blaster unit and rotated for best effect while blasting with stainless steel shot for a period of 20 to 30 minutes. This step shall remove all rust and carbon from the parts.
  - C. The parts rack shall then be moved to the Am-Pro Shaker/CoolDown unit where it will be rotated and rocked while cooled by blowers until shot is removed and parts are cooled to 150 degrees Fahrenheit.
  - D. After cool down the rack is to be placed in the Am-Pro hi pressure washer to remove all remaining dust and residue, the parts shall be rotated and hi pressure washed with an anti-rust solution for a period of 10 minutes then will be blown dry with a hi pressure, hi volume blower for a period of 5 minutes.
  - E. The parts shall be thoroughly inspected for cleanliness. Any part that is not completely free of oil, grease, paint, or rust shall be recycled through the cleaning operation a second time.
3. Small aluminum and steel parts are cleaned using the following procedure:  
(includes rods, pistons, unloaders)
  - A. Small steel parts and aluminum parts shall be steam cleaned and/or agitated in a 180-degree caustic solution to remove the majority of oil and grease.

- B. Parts shall be placed in a burnishing machine using a combination of stainless steel medium and special a cleaning detergent to thoroughly clean all parts. Each part shall be burnished a minimum of 25 minutes or until clean. This burnishing shall remove all contaminants without damage to the parts.
  - C. After burnishing, parts shall be treated with an anti-rust preservative and then dried using compressed air.
4. All remaining parts or parts which do not come entirely clean using the above cleaning procedures shall be cleaned individually in a bead blast machine or recycled thru the cleaning procedure.
5. Motors
- A. Motors that require rewinding shall have their old windings burned in a temperature-controlled burnout oven designed for this purpose at a temperature not to exceed 700 degrees Fahrenheit. Ovens shall be designed to prevent flames during the burning process. After stripping the old winding from the stator iron, the iron shall be cleaned by glass bead blasting to remove all contaminants and then inspected for damage.
  - B. All stator cores that are to be rewound shall be subjected to a core loss test. The iron shall be driven at a flux densities of sufficient magnitude to accurately assess the magnetic properties of the metal. Core losses shall be no more than that allowed by the motor manufacturer. Any iron showing shorts or hot spots shall be scrapped. No iron cores shall be rewound that do not successfully pass the core loss test.
  - C. Motor winding materials shall be approved for sealed hermetic use in a Freon application. No material with less than a Class B 125° C rating shall be used. All materials shall meet or exceed the following minimum requirements:
    - 1. Magnet wire shall be GP/MR-200 modified polyester with amid imide overcoat, (Class H, 200° C) or equal.
    - 2. Motor insulation shall be Nomex/Mylar/Nomex, (Class H 180° C) for slot liners and formed wedges or equal.
    - 3. Phase to phase protection shall be Dacron/Mylar/Dacron, (Class C 155° C) or nomex/mylar/nomex, (Class H 180° C).
    - 4. Motor lead insulation shall be polyester fiber and polyester film hermetic motor lead or equal, (Class B 125° C) or greater. Leads connections shall be welded and insulated with Nomex/Mylar/Nomex tubing, (Class H 180° C).
    - 5. Heat shrink Dacron lacing cord shall be used to lace all motor end coils.

6. Windings, leads, and insulation package shall be satisfactory for operation and off season submersion in refrigerant, lubricating oil, and/or a mixtures of refrigerant and oil.
  7. Motors shall be dipped in an epoxy varnish, such as Isopoxy 771 or Dolphon BC-352, which is compatible with refrigerant, and cured at the varnish manufacturer's specified temperature and time.
- D. All motors must pass the following series of electrical tests before qualifying for use in a compressor:
1. Nema hypot – a rewind motor shall be subjected to a voltage equal to two times its rated voltage, plus 1000 volts to verify the integrity of the insulation package. A motor that is re-qualified for use is to be subjected to a reduced voltage NEMA hypot.
  2. Double bridge test – each motor shall be tested by applying voltage to each phase and measuring the resistance from lead to lead. There shall not be more than a two percent variation between resistances of any two phases.
  3. Surge comparison test – each motor shall be subjected to a surge comparison test with the resultant waveform for each phase of the motor compared to one another on an oscilloscope. Variations in the wave form shape of each phase shall be identified to detect winding errors including, but not limited to, phase-to-phase shorts, turn-to-turn shorts, phase to ground, improper connections, or improperly welded connections.

## 6. Machining

- A. All crankshafts shall be gauged to verify proper dimensional and finish specifications as originally intended by the manufacturer of the compressor. Crankshafts may be plated with industrial hard chrome and reground on a precision grinder to original dimensional tolerances. Crankshafts may also be ground to .010, .020, .030 under size as allowed by original manufacturer. Mixing of sizes between journals is not permitted.
- B. All re-qualified rod and pin bores shall be gauged to verify proper dimensions. Dimensions must be within original factory specifications. All scored, galled or otherwise damaged rods are to be scrapped and replaced with new rods.
- C. All parts with sealing surfaces shall be machine lapped or surface ground to insure parallel surfaces and establish required finishes.
- D. Cylinder liners or cylinder bores shall be checked for proper dimension, and honed to break the glaze and establish a crosshatch in the bore.

- E. On models that do not have replaceable liners all cylinders are to be checked for proper dimensions, taper or out of round conditions. Damaged or worn cylinder bores may be bored oversize or sleeved, and re-bored to establish proper cylinder dimensions. All cylinders within factory specifications shall be honed to break the glaze and establish a crosshatch in the bore.
- F. Valve plates shall be ground on a surface grinder to establish new parallel sealing surfaces.

## 7. Subassembly

- A. All subassemblies, such as rod and piston assemblies, valve cage assemblies, hand hole covers, oil pumps, etc., shall be assembled using new or re-qualified parts. No subassemblies shall be reused as removed from exchange compressors.
- B. All main bearings and bearing inserts shall be new. New bearings shall be installed in all bearing head assemblies using a hydraulic press that inserts the bearing in one continuous stroke.
- C. All suction and discharge valves, valve springs, unloader springs and seals shall be new.
- D. Suction pressure unloading actuator controls shall be tested and calibrated prior to assembly into a compressor using air and/or oil pressure to insure proper unloader operation.

## 8. Final Assembly

- A. All compressor housing oil lines shall be inspected and replaced if damaged. All oil lines shall be tested to insure proper lubrication and hydraulic pressure distribution to the unloaders where applicable.
- B. During assembly, the top dead center tolerance of each cylinder shall be verified to be proper.
- C. Crankshaft end play shall be verified to be within original manufacturer's specifications.
- D. All bolts shall be torqued during assembly using a calibrated torque wrench.

Section VI  
Final Testing Procedure and Preparation

Purpose:

To outline the various testing procedures that each compressor will be subjected to in order to maintain a consistent high quality product.

Responsibility:

Quality control manager or qualified representative as designated by the quality control manager.

Procedures:

- A. The compressor is then to be leak tested with a minimum of 125 psi of dry nitrogen.
- B. Each compressor shall receive a full charge of new oil, which has been approved for use by the original manufacturer.
- C. Each compressor shall be given a comprehensive test on a run in stand capable of simulating compressor operation conditions.
- D. Each compressor shall be run at its rated voltage. Part winding start motors shall be operated in the part-winding configuration.
- E. The amperage draw of each motor phase shall be verified to be within the compressor manufacturer's specifications.
- F. The CFM of each compressor shall be verified to be within the compressor manufacturer's specifications.
- G. The oil pressure shall be measured and verified gauge readings to be within acceptable limits. When the compressor has hydraulically operated unloaders, the oil pressure shall be checked at each stage of unloading.
- H. The compressor is then to be run in the reverse direction and the oil pressure, CFM, amperage and unloading again verified to be acceptable.
- I. The discharge valve assemblies shall be placed under a differential pressure to prove the sealing integrity of the discharge valves and internal discharge relief valve.
- J. All head bolts shall be re-torqued, using a calibrated torque wrench.
- K. After final testing, the compressor shall be evacuated to one mm of mercury, and then supplied with a holding charge of dry nitrogen.

L. The compressor shall be painted with a corrosion-resistant paint and mounted on a skid suitable for return of the exchange compressor.



Section VII  
Preservation, Packaging, Stocking and Shipping Procedure

Purpose:

To assure proper and adequate preservation, packaging, stocking and shipping. To assure that all items shipped are in compliance with existing contract data. This data includes all orders, finish specifications and any contract information from the contract administrator.

Responsibility:

Quality control manager, shipping clerk, or qualified representative as designated by quality control manager.

Procedures:

- A. Packaging materials such as crates, boxes, and wraps will be stored in a manner to assure cleanliness and to prevent deterioration or contamination.
- B. Preservation, packaging, and shipping check list is reviewed and marked to assure proper preparation of compressors to be shipped or stored.
- C. A visual examination will follow, to include:
  - 1) Determination of cleanliness and proper painting prior to preservative wrap to be applied.
  - 2) Terminals, nuts and caps on all ports are present and tightened.
  - 3) Sight glass is clear.
  - 4) Comparison of part numbers to match both compressor and applicable purchase order.
- D. All compressors going to stock will be properly wrapped, tagged, and transferred to the various stocking locations for that particular model.
- E. Compressors leaving the BCR warehouse will be properly packed and crated according to contract packing specifications as follows:
  - 1) Shipping cartons in accordance with level of packaging.
  - 2) Pallets are properly constructed – banded together – and are within dimensional requirements.
  - 3) Designated wraps, cushioning and other required material is properly utilized in package fabrication.
  - 4) Required bracing, bolting, and blocking.
  - 5) All shipping containers are properly labeled as marked.
  - 6) Proper execution of bills of lading.
  - 7) All carrier loading is to be accordance with sound loading practices.



## HISTORY OF BRAINERD

In 1951 A.G. Brainerd began what was then known as The Brainerd Company. His business consisted mainly of commercial service and filter changing in Memphis and the Mid-South. In servicing the larger HVAC equipment and in constant need of all types of compressors, Mr. Brainerd began rebuilding his own compressors in-house and soon became an outlet for other service companies.

It was in 1971 that J. Howard Barton purchased The Brainerd Company and merged it with his already existing Barton Service Company. At that time he immediately saw the need and growth potential of the compressor remanufacturing business and separated this into an existing company of its own. His brother Larry already having experience in this business joined him in 1972 and together they developed Brainerd Compressor into one of the largest and most reliable compressor remanufacturers in the country. Now with their vast and unparalleled stock of inventory in three locations, Brainerd has become "The Source" for remanufactured compressors, not only in the United States, but also in countries worldwide.

### Warranty

We warrant our remanufactured or exchange compressor to be free from defect in material and workmanship under normal use for one (1) year from date of original purchase to the original purchaser. Warranty shall be limited to furnishing a replacement, F.O.B. our warehouse, for the compressor which upon our examination discloses to our satisfaction to be thus defective.

Warranty shall not be extended to any compressor that has been subjected to liquid slugging, improper voltage, poor system engineering, or installation of compressors into contaminated systems. We recommend the installation of suction line dryer ahead of the compressor on burnouts.

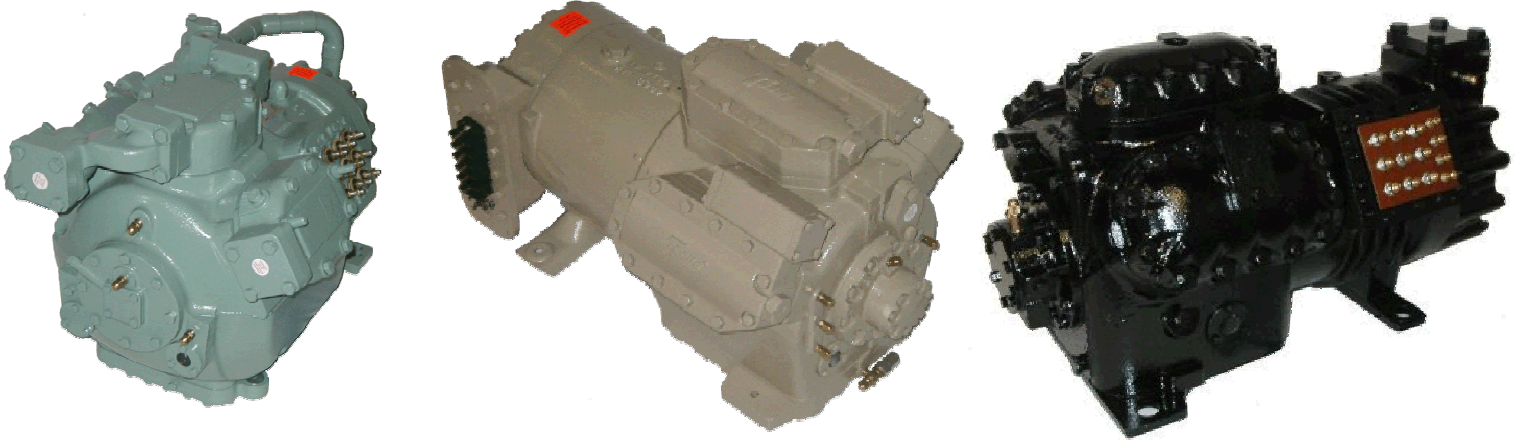
We assume no liability for systems damage or product loss due to a failure of one of our compressors.



# **BRAINERD**

• COMPRESSOR INC. •

[www.brainerdcompressor.com](http://www.brainerdcompressor.com)



**3034 SANDBROOK ST. MEMPHIS TENNESSEE 38116**  
**800-228-4138 Fax 901-396-4131**