Application Engineering

Liquid Refrigerant Control in Refrigeration and Air Conditioning Systems

BULLETIN NO: AE22-1182 R26

Contents

COPELAND

Safety

Important Safety Information

Those involved in the design, manufacture, and installation of a system, system purchasers, and service personnel may need to be aware of hazards and precautions discussed in this section and throughout this document. OEMs integrating the compressor into a system should ensure that their own employees follow this bulletin and provide any necessary safety information to those involved in manufacturing, installing, purchasing, and servicing the system.

Responsibilities, Qualifications and Training

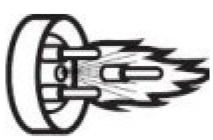
• OEMs are responsible for system design, selection of appropriate components, integration of this component into the system, and testing the system. OEMs must ensure that staff involved in these activities are competent and qualified.

• OEMs are also responsible for ensuring that all product, service, and cautionary labels remain visible or are appropriately added in a conspicuous location on the system to ensure they are clear to any personnel involved in the installation, commissioning, troubleshooting or maintenance of this equipment.

• Only qualified and authorized HVAC or refrigeration personnel are permitted to install, commission, troubleshoot and maintain this equipment. Electrical connections must be made by qualified electrical personnel.

• Observe all applicable standards and codes for installing, servicing, and maintaining electrical and refrigeration equipment.

Terminal Venting and Other Pressurized System Hazards



If a compressor's electrical terminal pin loses its seal, pressurized oil, refrigerant, and debris may spray out. This is called "terminal venting".

The ejected debris, oil, and refrigerant can injure people or damage property. The oil and refrigerant spray can be ignited by electrical arcing at the terminal or any nearby ignition source, producing flames that may project a significant distance from the compressor. The distance depends on the pressure and the amount of refrigerant and oil mixture in the system. The flames can cause serious or fatal burns and ignite nearby materials.

Each compressor has a terminal cover or molded plug that covers electrical connections. The cover or plug helps to protect against electric shock and the risks of terminal venting. If terminal venting occurs, the cover or plug helps contain the spray of refrigerant and oil and reduces the risk of ignition. If ignition occurs, the plug or cover helps contain the flames. However, neither the terminal cover nor the molded plug can completely eliminate the risk of venting, ignition, or electric shock.

See copeland.com/terminal-venting for more details about terminal venting. Additionally, a compressor's refrigerant lines keep refrigerant and oil under pressure. When removing or recharging refrigerant from this component during service, this can pose a pressurized fluid hazard.

Flammable Refrigerant Hazards

If flammable refrigerant is released from a system, an explosive concentration can be present in the air near the system. If there is an ignition source nearby, a release of flammable refrigerant can result in a fire or explosion. While systems using flammable refrigerant are designed to mitigate the risk of ignition if the refrigerant is released, fire and explosion can still occur.

See copeland.com/flammable-refrigerants for more information on flammable refrigerant safety.

Electrical Hazards

Until a system is de-energized, and capacitors have been discharged, the system presents a risk of electric shock.

Hot Surface and Fire Hazards

While the system is energized, and for some time after it is deenergized, the compressor may be hot. Touching the compressor before it has cooled can result in severe burns. When brazing system components during service, the flames can cause severe burns and ignite nearby combustible materials.

Lifting Hazards

Certain system components may be very heavy. Improperly lifting system components or the compressor can result in serious personal injury. Use proper lifting techniques when moving.

POE Oil Hazards

This equipment contains polyol ester (POE) oils. Certain polymers (e.g., PVC/CPVC and polycarbonate) can be harmed if they come into contact with POE oils. If POE oil contacts bare skin, it may cause an allergic skin reaction.

Precautions

- Always wear personal protective equipment (gloves, eye protection, etc.).
- Keep a fire extinguisher at the jobsite at all times.
- Keep clear of the compressor when power is applied.

- IMMEDIATELY GET AWAY **if you hear unusual sounds in the compressor. They can indicate that terminal pin ejection may be imminent. This may sound like electrical arcing (sizzling, sputtering or popping). However, terminal venting may still occur even if you do not hear any unusual sounds.**

• Never reset a breaker or replace a blown fuse without performing appropriate electrical testing

- **A tripped breaker or blown fuse may indicate an electrical fault in the compressor. Energizing a compressor with an electrical fault can cause terminal venting. Perform checks to rule out an electrical fault.**

• Disconnect power and use lock-out/tag-out procedures before servicing.

- Before removing the terminal cover or molded plug, check that ALL electrical power is disconnected from the unit. Make sure that all power legs are open. (Note: The system may have more than one power supply.)

- Discharge capacitors for a minimum of two minutes

- Always use control of hazardous energy (lock-out/tag-out) procedures to ensure that power is not reconnected while the unit is being serviced.

• Allow time for the compressor to cool before servicing.

- Ensure that materials and wiring do not touch high temperature areas of the compressor.

• Keep all non-essential personnel away from the compressor during service.

• For A3 refrigerants (R290) remove refrigerant from both the high and low sides of the compressor. Use a recovery machine and cylinder designed for flammable refrigerants. Do not use standard recovery machines because they contain sources of ignition such as switches, high- and low-pressure controls and relays. Only vent the R290 refrigerant into the atmosphere if the system is in a well-ventilated area. Never use a torch to remove the compressor. Only tubing cutters should be used.

• Never use a torch to remove the compressor. Only tubing cutters should be used.

• Use an appropriate lifting device to install or remove the compressor.

• Never install a system and leave it unattended when it has no charge, a holding charge, or with the service valves closed without electrically locking out the system.

• Always wear appropriate safety glasses and gloves when brazing or unbrazing system components.

• Charge the system with only approved refrigerants and refrigeration oils.

• Keep POE oils away from certain polymers (e.g., PVC/CPVC and polycarbonate) and any other surface or material that might be harmed by POE oils. Proper protective equipment (gloves, eye protection, etc.) must be used when handling POE lubricant. Handle POE oil with care. Refer to the Safety Data Sheet (SDS) for further details.

• Before energizing the system:

1. Securely fasten the protective terminal cover or molded plug to the compressor, and
2. Check that the compressor is properly grounded per the applicable system and compressor requirements.

Signal Word Definitions

The signal word explained below are used throughout the document to indicate safety messages.

DANGER	**DANGER** indicates a hazardous situation which, if not avoided, will result in death or serious injury.
WARNING	**WARNING** indicates a hazardous situation which, if not avoided, could result in death or serious injury.
CAUTION	**CAUTION**, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

INTRODUCTION

Liquid Refrigerant Control in Refrigeration and Air Conditioning Systems

One of the major causes of compressor failure is damage caused by liquid refrigerant entering the compressor in excessive quantities. Improper control of liquid refrigerant in a system can cause a loss of lubrication, as well as excessive stress, on several components in the compressor. Such compressor failures are often classified as lubrication system or component failures, but in reality the problem actually originates with the refrigerant. A well-designed, durable, and efficient compressor for refrigeration, air conditioning, or heat pump duty is primarily a vapor pump designed to handle a small quantity of liquid refrigerant and oil. To design and build a compressor to handle more liquid would require a serious compromise in size, weight, capacity, efficiency, noise, or cost. For any design there are limits to the amount of liquid a compressor can handle, and these limits depend on factors such as internal volume of the crankcase, oil type or charge, type of system and controls, and normal operating conditions. Improper control of liquid refrigerant in a system is an application problem and is largely beyond the control of the compressor manufacturer. The potential hazards to the compressor increase with the size of the refrigerant charge. The cause of damage usually can be traced to one or more of the following:

1. Excessive refrigerant charge for the application.
2. Frosted evaporator.
3. Dirty or plugged evaporator filters.
4. Failed evaporator fan or fan motor.
5. Incorrect capillary tubes or orifice.
6. Incorrect selection or adjustment of expansion

valves.

7. Refrigerant migration during the off cycle.

Refrigerant - Oil Relationship

In order to correctly analyze system malfunctions, and to determine if a system is properly protected, an understanding of the basic relationship between refrigerant and oil is essential.

In refrigeration compressors, oil and refrigerant mix continuously. Refrigeration oils are soluble in liquid refrigerant, and at room temperature they may even mix completely. A small amount of oil is always circulating with the refrigerant. Oil and refrigerant vapor do not mix readily. Oil can be properly circulated through the system and returned to the compressor only if gas velocities are high enough to sweep the oil along through the tubing found throughout the system. If velocities are not sufficiently high, oil will tend to accumulate in the bottom of the evaporator tubing, decreasing heat transfer and eventually cause a shortage of oil in the compressor. As evaporating temperatures are lowered, this problem becomes more critical since the viscosity of oil increases with a decrease in temperature. For these reasons, proper design of piping is essential for satisfactory oil return to the compressor. One of the basic characteristics of a refrigerant and oil mixture in a sealed system is the fact that refrigerant is chemically attracted by oil and will vaporize and migrate through the system to the compressor crankcase even though no pressure difference exists to cause the movement. On reaching the crankcase the refrigerant may condense into a liquid, and this migration will continue until the oil is saturated with liquid refrigerant. The amount of refrigerant that the oil will attract is primarily dependent on the temperature difference between the oil in the crankcase and refrigerant in the system. Refrigerant tends to migrate to cold oil. When the pressure of a saturated mixture of refrigerant and oil is suddenly reduced, as happens in the compressor crankcase on start-up, the amount of liquid refrigerant required to saturate the oil is drastically reduced, and the remainder of the liquid refrigerant “flashes” (evaporates) into vapor, causing violent boiling of the refrigerant and oil mixture. This causes the foaming often observed in the compressor crankcase at start-up, which can drive all of the oil out of the crankcase in a very short period. (Not all foaming is the result of excess refrigerant in the crankcase-normal agitation of the oil will also cause some foaming.) One condition that is often surprising when first encountered by field personnel occurs during the presence of excessive liquid refrigerant in the compressor crankcase. This situation can result in a loss of oil pressure and a trip of the oil pressure safety control even though the level of the refrigerant and oil mixture may be observed to be high in the compressor crankcase sight glass. The high percentage of liquid refrigerant entering the crankcase not only reduces the lubricating quality (viscosity) of the oil, but on entering the oil pump intake may “flash” into vapor which blocks the entrance of adequate oil necessary to maintain oil pump pressure. This condition can continue until the percentage of refrigerant in the oil in the crankcase is reduced to a level which can be tolerated by the oil pump and pressure control.

Typical Effects of Improper Refrigerant Control

Liquid refrigerant problems can take several different forms, each having its own distinct characteristics.

1. Refrigerant Migration

Refrigerant migration is the term used to describe the accumulation of liquid refrigerant in the compressor crankcase during (long) periods when the compressor is not operating. It can occur whenever the compressor becomes colder than the evaporator, since a (small) pressure differential then exists to force refrigerant to the colder area. Although this type of migration is most pronounced in colder weather, it can also exist even at relatively high ambient temperatures with remote type condensing units for air conditioning and heat pump applications.

System designers should recognize that any time the system is shut down and not operative for several hours, migration to the crankcase can occur due to the normal chemical attraction of the oil for refrigerant.

If excessive liquid refrigerant has migrated to the compressor crankcase, severe liquid slugging may occur on start-up, and frequently compressor damage such as broken valves, damaged rods or pistons, bearing failures due to loss of oil from the crankcase, and bearing washouts (refrigerant washing oil from the bearings) occurs.

2. Liquid Refrigerant Flooding

If an expansion valve malfunctions, an evaporator fan fails or air filters become clogged, liquid refrigerant may flood through the evaporator and return through the suction line to the compressor as liquid rather than vapor. During the run cycle, continuous liquid flooding can cause excessive wear of the moving parts because of dilution of the oil, loss of oil pressure resulting in trips of the oil pressure safety control, and loss of oil from the crankcase. During the “off” cycle after running in this condition, since the compressor is often very cold, migration of refrigerant to the crankcase can occur rapidly, resulting in liquid slugging when restarting.

3. Liquid Refrigerant Slugging

Liquid slugging is the term used to describe the passage of liquid refrigerant through the compressor suction and/or discharge valves. It is evidenced by a loud metallic clatter inside the compressor, often accompanied by extreme vibration of the compressor. Depending upon the amount of liquid upstream of the compressor suction valve, slugging can last for as much as several seconds.

Slugging often results in broken valves, blown gaskets, broken connecting rods, or other major compressor damage.

Slugging frequently occurs on start-up when liquid refrigerant has migrated to the crankcase. On some units, because of the piping configuration or the location of components, liquid refrigerant can collect in the suction line or evaporator during the off cycle, returning to the compressor as pure liquid with high velocity on start-up. The velocity and weight of the liquid slug may be of sufficient magnitude to override any internal anti-slug protective features of the compressor. Serious compressor damage often results.

4. Tripping of Oil Pressure Safety Control

A common field complaint arising from a liquid flooding condition is tripping of the oil pressure safety control after a defrost period on a low temperature unit. System design on many units allows refrigerant to condense in the evaporator and suction line during the defrost period, and on start- up, this refrigerant floods back to the compressor crankcase, causing a loss of oil pressure and recurring trips of the oil pressure safety control.

One trip or a few trips of the oil pressure safety control may not result in serious damage to the compressor, but repeated short periods of operation without proper lubrication are almost certain to result in compressor bearing failure. Trips of the oil pressure safety control under such circumstances are frequently viewed by the serviceman as nuisance trips, but it cannot be stressed too strongly that they are warning trips, indicating the compressor has been running without oil pressure for two minutes and that prompt remedial action is required to ensure durability. (See AE8-1095 andAE-1275 for additional discussion of oil pressure safety controls.)

Recommended Corrective Action

The potential hazard from liquid refrigerant to a refrigeration or air conditioning system is in almost direct proportion to the size of the refrigerant charge. It is difficult to determine the maximum safe refrigerant charge of any system without actually testing the system with its compressor and other major components. Compressor manufacturers can determine the maximum amount of liquid the compressor will tolerate in the crankcase without endangering the working parts but have no way of knowing how much of the total system charge actually will return to or reside in the compressor under all conditions. The maximum amount of liquid a compressor can tolerate depends on its design, internal volume, and oil charge. Where liquid migration, flooding, or slugging can occur, corrective action should be taken, the type normally being dictated by the system design and the type of liquid problem.

Table 1 lists refrigerant charge limits for Copeland compressors used in systems without some means of off cycle liquid refrigerant control. It is possible that on systems where large quantities of liquid can flood to the compressor on start-up, some protective action may be required even though the system contains a refrigerant charge smaller than the limits listed in Table 1.

Compressor Model	Crankcase Heater or Pump down Cycle Required
Copeland semi-hermetic	
H	2.0 lbs
K	4
E	6
3	8
L	8
N	10
M	15
2D	15
9	17.5
3D	17.5
4	23
6	28
8	11
Copeland hermetic	
JR	1.75 lbs
RR*2	3
RR*4	4
CRA-CRK, CRL&CRM3	6
CRL1,CRM1,CRP&CRN	8
CR*4 & CR6	See AE4-1276
BR	See AE4-1240
ZR (Compliant Scroll)	See AE4-1280

Table 1 Refrigerant Charge Limits

Minimize Refrigerant Charge

The best compressor protection against all forms of liquid refrigerant problems is to keep the charge within the compressor limits listed in Table 1. Even if this is not possible, the charge should be kept as low as reasonable possible. Use the smallest practical size tubing in condensers, evaporators, and connecting lines. Receivers should be as small as possible.

Charge the system with the minimum amount of refrigerant required for proper operation. Beware of bubbles showing in the sight glass caused by small liquid lines and low head pressures. This can lead to serious overcharging.

Pumpdown Cycle

The most positive and dependable means of properly controlling liquid refrigerant off-cycle migration is by means of a pumpdown cycle. By closing a liquid line solenoid valve, the refrigerant is pumped into the condenser and receiver, thereby isolating the refrigerant during periods when the compressor is not in operation and preventing migration to the compressor crankcase.

Two basic types of pumpdown systems are commonly used today:

Continuous Pumpdown

Recommended for use in all refrigeration systems and in air conditioning systems where long (several weeks or months) off periods are not expected. Compressor operation is controlled by a low-pressure control set to pumpdown the system whenever the suction pressure is above the set point. Should refrigerant leak past the solenoid valve during the off cycle, suction pressure increases thereby restarting the compressor; hence the term “continuous pumpdown”.

One Time Pumpdown

Recommended for use only on Discus equipped commercial air conditioning systems where long off periods are expected. With this type of system, pumpdown will occur only once after the liquid line solenoid is closed. This prevents the possibility of continually short cycling in order to clear the low side of refrigerant that has leaked past the solenoid or compressor valves. Short cycling over extended periods may result in crankcase oil pump-out since this oil is prevented from returning to the compressor by the closed solenoid valve. When after several weeks or months the solenoid valve finally opens, much of the oil is brought back to the compressor quickly which could result in compressor damage.

When One Time Pumpdown is used, a crankcase heater is also recommended.

Copeland engineering tests have demonstrated the superior flooded start capability of the Discus™ compressor compared to conventional reed compressors. An occasional flooded start is therefore deemed preferable to continual cycling with limited oil in the crankcase and the potential for large oil returns during start-up.

During pumpdown the crankcase pressure is rapidly reduced. If the crankcase pressure is reduced low enough, the oil will foam due to the outgassing of the refrigerant trapped in the oil. This will cause oil to be rapidly pumped out of the crankcase and increases stress on the valves and running gear as well as causing an oil shortage during the next run cycle. In order to minimize this effect, Copeland recommends setting the low-pressure control cut-out point as close as possible to the lowest saturated suction pressure expected while the unit is running.

Although the pumpdown cycle is the best possible protection against migration, it will not protect against liquid flooding during operation. A suction accumulator is recommended if flooding is expected. See Section 4.

When a pumpdown cycle is used, an approved start capacitor and relay must be used on all compressors having single phase PSC motors since the compressor will be starting against unbalanced pressures.

Superheat Requirements

To assure that liquid refrigerant does not return to the compressor during the running cycle, attention must be given to maintaining proper superheat at the compressor suction inlet. Copeland recommends a minimum of 20°F (11°C) superheat, measured on the suction line 6 inches

(152mm) from the suction valve, to prevent liquid refrigerant floodback.

Another method to determine if liquid refrigerant is returning to the compressor is to accurately measure the temperature difference between the compressor oil crankcase and the suction line. During continuous operation we recommend that this difference be a minimum of 50°F (27°C). This “crankcase differential temperature” requirement supersedes the minimum suction superheat requirement in the last paragraph. To measure oil temperature through the compressor shell, place a thermocouple on the bottom center (not the side) of the compressor shell and insulate from the ambient. During rapid system changes, such as defrost or ice harvest cycles, this temperature difference may drop rapidly for a short period of time. When the crankcase temperature difference falls below the recommended 50°F (27°C), our recommendation is the duration should not exceed a maximum (continuous) time period of two minutes and should not go lower than a 25°F (14°C) difference.

Contact your Copeland representative regarding any exceptions to the above requirements.

Crankcase Heaters

On some systems, operating requirements, cost, or customer preference may make the use of a pumpdown cycle undesirable, and crankcase heaters are frequently used to retard migration.

The function of a crankcase heater is to maintain the oil in the compressor at a temperature higher than the coldest part of the system. Any refrigerant entering the crankcase will be vaporized and driven back into the system through the suction line. However, in order to avoid overheating and carbonizing of the oil, the wattage input of the crankcase heater must be limited, and in ambient temperatures approaching 0°F., or when exposed suction lines and cold winds impose an added load, the crankcase heater may be overpowered, and migration can still occur.

In no event should a compressor be started in a system with a crankcase heater unless it has been energized for a period of a least four hours immediately prior to compressor startup.

Crankcase heaters are effective in combating migration if conditions are not too severe, but they will not remedy slugging or liquid floodback.

Crankcase heater elements will burn out if overheated and historically, crankcase heaters have not had a good reliability record in the field. Past studies indicate that overvoltage may be a major cause of crankcase heater failure. Traditionally, heaters have been specified at nominal 220 volt and 440-volt conditions, but modern electrical transmission systems may operate at 10 to 15 percent above those voltages. Motors are designed to withstand wide swings in supply voltage without damage, but high voltage on the heater increases current, power input, and temperature, resulting in heater burnout.

To improve heater reliability, Copeland specifications for crankcase heaters have been established at nominal voltage ratings of 120, 240, 480, and 600. These coincide with the standardized nominal service voltage specified by ARI and NEMA. The heaters listed in Tables 2 and 3 reflect these voltage ratings.

Suction Accumulators

On systems where liquid flooding may occur, a suction accumulator should be installed in the suction line. Basically, the accumulator is a vessel which serves as a temporary storage container for liquid refrigerant which has flooded through the system, with a provision for metered return of the liquid refrigerant (and oil) to the compressor at a rate which the compressor can safely tolerate. (See AE11-1147 and AE11-1247.)

Flooding typically can occur on heat pumps at the time the cycle is switched from cooling to heating, or from heating to cooling, and a suction accumulator is mandatory on all heat pumps unless otherwise approved by the Copeland Application Engineering Department. (For Copeland Scroll™ compressors, see AE4-1280 and CR*4 & CR6 compressors see AE4-1276.)

Flooding can occur on an air conditioning system during short off cycles in high ambients. This is especially true on capillary tube or fixed orifice systems with large condenser volumes and high refrigerant charges. During the off cycle, the hot condenser will drive a majority of the system charge (liquid) back to the compressor crankcase. Should the amount of refrigerant exceed the charge limit for the compressor, dangerous start up slugs can result.

To guard against this situation, Copeland recommends testing any air conditioning system with a charge greater than those listed on Table 1 for floodback which would require an accumulator. (See following section, “Air Conditioning Accumulator Test.’’)

Systems utilizing hot gas defrost are also subject to liquid flooding either at the start or termination of the hot gas cycle. Compressors on low superheat applications such as liquid chillers and low temperature display cases are susceptible to occasional flooding from improper refrigerant control. Truck applications often experience extreme flooding conditions at startup after long non-operating periods.

On two stage compressors the suction vapor is returned directly to the low stage cylinder without passing through the motor chamber, and a low stage suction accumulator should be used to protect the compressor valves from liquid slugging.

Since each system will vary with respect to the total refrigerant charge and the method of refrigerant control, the actual need for an accumulator and the size required is largely dictated by the individual system requirement. If flooding can occur, an accumulator must be provided with sufficient capacity to hold the maximum amount of refrigerant flooding which can occur at any one time, and this can be well over 50 percent of the total system charge. If accurate test data as to the amount of liquid floodback is not available, then 50 percent of the system charge normally can be used as a conservative design guide.

Air Conditioning Accumulator Test

To test for need of an accumulator, obtain a sample compressor with a vertical sight tube.

Elevate the evaporator five feet above the condensing unit, and use 25 foot line lengths with no traps in the suction line. If the system is field charged, Copeland recommends testing with a 10 to 20 percent system overcharge.

Operate the system for one hour in a 95°F outdoor and 75°F indoor ambient. Shut the compressor and condenser fan off. Keep the evaporator fan running. Observe the compressor sight tube after a five-minute off cycle.

If the liquid level rises above a predetermined point, (obtained from Application Engineering) an accumulator is required. This test should be repeated several times.

Accumulators for systems with long lines should be considered separately.

Oil Separators

Oil separators cannot cure oil return problems caused by system design, nor can they remedy liquid refrigerant control problems. However, in the event that system control problems cannot be remedied by other means, oil separators may be helpful in reducing the amount of oil circulated through the system and can often make possible safe operation through critical periods until such time as system control returns to normal. For example, on ultra-low temperature applications or on flooded evaporators, oil return may be dependent on defrost periods, and an oil separator can help to maintain the oil level the compressor during the period between defrosts.

WARNING - Extreme care must be taken in starting compressors for the first time after system charging. At this time all of the oil and most of the refrigerant might be in the compressor, creating a condition which could cause compressor damage due to slugging. Activation of the crankcase heater for several hours prior to start-up is recommended. If no crankcase heater is present, then directing a 500-watt heat lamp or other safe heat source on the lower shell of the compressor for approximately thirty minutes will be beneficial in eliminating this condition which might never reoccur.

TABLES

Table 2 Crankcase Heaters Copelaweld Compressors

J Models

Watts	Volts	Copeland Part No.		Tutco Part No.
		Heater Kit	Heater Only	
35	120	518-0020-00	018-0039-00	CH135-2
35	240	Not Available	Not Available	CH135

*kit includes Reference drawing

R, S Models

Watts	Volts	Copeland Part No.		Part No.	Tutco Part No.
		Heater Kit	Heater Only		
42	120		018-0015-01	GAGN-1	
	240		018-0015-00	GAGN-1	
45	120	518-0022-00	018-0038-00		CH103-2
	208	Not Available	Not Available		CH103-1
	240	518-0022-02	018-0038-02		CH103

*kit includes Reference drawing

B Models

Watts	Volts	Copeland Part No.		Tutco Part No.
		Heater Kit	Heater Only	
70 Wrap around	120	518-0019-01	018-0036-01	CH202-02
	240	518-0019-00	018-0036-00	CH202
	460	518-0019-02	018-0036-02	CH202-03
	575	518-0019-03	018-0036-03	CH203-06

*kit includes Reference drawing and insulator

C Models

Watts	Volts	Copeland Part No.		Tutco Part No.
		Heater Kit	Heater Only	
Wrap Around (CR*4 only)				
54	120	518-0021-00	018-0037-00	CH101-2
	208	518-0021-01	018-0037-01	CH101-1
	240	518-0021-02	018-0037-02	CH101
	480	518-0021-03	018-0037-03	CH101-3
Round				
40	240/480/600		018-0031-02	S.W. SO-111 T.I. 9HT5-13

*kit includes Reference drawing

H, K Models

Watts	Volts	Copeland Part No.	Part No.	Part No.
		Heater Kit		
50 clip on	12	998-0118-07		13RO115-1-AL-1
	120	998-0118-05		13RO115-2-AL-1
	240	998-0118-06 (kit includes clips)		13RO115-3-AL-1
50 Bolt on	420	998-0118-02	66-12976-7-30C24-C	
	480	998-0118-03 (kit includes bolts & reference drawing)	66-12976-4-30C24-C	

2D, E, 3R, L, M, N, 9, 3D, 4, 6 Models

Watts	Volts	Copeland Part No.		Acra Part No..	Hot Watt Part No.
		Heater Kit	Heater Only		
65	120	518-0009-00	018-0034-00	ARB6215	13J0600-1-ERC1-1
	240	518-0009-01	018-0034-01	ARB6215	13J0600-2-ERC1-1
	480	518-0009-02	018-0034-02	ARB6215	
	600	518-0009-03	018-0034-03	ARB6215	
	12	518-0009-04	018-0034-04	ARB6215	13J0600-5-ERC1-1

*kit includes Bolts and Reference drawing

2D, M Models, Internal Immersion Type For Deep Oil Sump
9, 3D Models, Internal Immersion Type For Flat Bottom Plate or Deep Oil Sump

Watts	Volts	Copeland Part No.	Hot Watt Part No..	Acra Part No.
65	120	518-0001-03	13A0054-4-EB1J-1	IBW-375
	240	518-0001-02	13A0054-4-EB1J-1	IBW-375
	480	518-0001-01		IBW-375
	600	518-0001-00		IBW-375

4, 6 Models, Internal Immersion Type For Flat Bottom Plate

Watts	Volts	Copeland Part No.	Hot Watt Part No..	Acra Part No.
65	120	518-0002-03	13A9996-4-EB1J-3	IBW-625
	240	518-0002-02	13A9996-3-EB1J-3	IBW-625
	480	518-0002-01		IBW-625
	600	518-0002-00		IBW-625
	420	518-0002-04		IBW-625

4,6,8 Models Internal Immersion Type for Deep Oil Sump

Watts	Volts	Copeland Prt No.	Acra Part No.
200	120	998-0518-00	ARCW901-500
	240	998-0518-01	ARCW901-500

Revision Tracking R26

The document format has been updated to the new Copeland format

All occurrences of "Emerson" have been removed

A note regarding A3 and R290 venting has been updated