ISSUE 2

ThermaCom

FIELD COMPRESSOR GUIDE

Contents Page No.

Commissioning Guide

Please read before <u>Connecting</u> a compressor

As the dynamic component of a fridge system, the compressor will exhibit faults from other regions of the system. If a compressor were considered the 'Fuse' it will 'Blow' as a result of any underlying fault conditions leading to operation outside safe design parameters.

The key approaches to compressor fault diagnosis are ...

	An open mind	**A systematic approach**
1	What is the initial fault report?	
2	Check the obvious	Is it switched on? Are the fuses OK, is the Contactor OK? Are the system valves open?
	What are the system conditions?	Suction Pressure Discharge Pressure Oil Pressure System charge State - Sub-cooling Suction condition - Superheat
	What is the Standing pressure?	Is air present in the system (High standing pressure).
	What is the Oil Level? Are any leaks apparent? Is the compressor Noisy? Is it safe to leave running? Has any other work been done recently? - rule out coincidence	
3	After checking the relevant points above, effect the field test routine below	
4	Trips and noises are the most obvious initial faults ...	

Motor Overload Internal Type	Is motor case hot? - allow to cool before re-start When cool check with Megger before re-start. Are all terminals tight? What is internal overload resistance? - Does overload resistance rise steadily before a trip? - motor getting too hot Does resistance jump about? - loose connection
Motor Overload External Type	What is overload set at, is this correct? Check fuses Any blown? - change all three Effect field tests - Page 4 Are all phases present? - Load voltage even
Oil Pressure	What is net pressure? What is the Oil Level? Does pressure start high & drop off? - Blocked filter

4	Trips & Noises cont.	Liquid returning Liquid in sump	Low pressure fluctuating Faulty TEV Incorrect system charge Evaporator flooded, faulty Solenoid Vv Crankcase heater not working
		Internal leak Faulty pump Oil too thin	Faulty relief valve; Broken valves (surprisingly rare) Try a thicker grade
	Noises	Tinkling	Liquid / hydraulic effect - check system
		Rumbling	Partial phase loss, perhaps to only 1 part wind, Worn bearings Overloaded Broken internally
		Rattling	Are Feet Bolts tight Broken Internally Broken valve reed - Effect Pump test Liquid return
		Bag of Nails	Full / Partial Phase Loss Broken Internally Counter Rotation of Part winds (normally fatal for motor)
	Note the comments re: Phase Loss.		This one is always overlooked when a noise is present. **We look for this one first.**
	And Finally ...		Have you made a mistake ? Have you overlooked something?

Remember the Re-manufacturing Industry runs on 2 things

Liquid Refrigerant Return & Single Phasing

If you have not identified the Root cause of failure the replacement compressor will be endangered.

In our experience most repeat failures will occur within the 1st 48 hours running. Close attention to all running conditions at initial commissioning is therefore essential.

If you require further advice upon use and running of Single Phase Compressors please call ThermaCom technical help or visit our website.

Compressor Testing Guide

Please use this guide if you suspect a faulty compressor

To verify basic compressor function in a field environment the following will demonstrate whether further investigation will be necessary or not.

1	**Earth Test**	Using a 1000v Megger check each field winding to earth. 1st check the earth connection is sound by an earth to earth test & repeat this following the motor test.
	If reading < than 2 MΩ	Stator probably burnt out, but do not rule out a contaminated / damp terminal plate.
	Reading 2 MΩ - 20 MΩ	Probably not burnt out, terminal plate contaminated or damp. Separate terminal plate from main casting & repeat check to casting. If fault clears then terminal plate is faulty.
	Reading > 20 MΩ	No earth Fault
	<u>Precautions</u>	Do not effect Megger checks under deep vacuum. Do not Megger overloads.
2	**Field Balance** 3ø motors only	Using an Ohmmeter set on Ohms verify balance of motor field coils. If balance is out by more than 10 % suspect motor is defective. Separate terminal plate & repeat measurements, if readings do not improve rewind is probably required.
3	**Pump Test**	This is the best check of compressor function reasonable or not.
	Whilst effecting these tests keep head pressure low	Close in the compressor suction valve tight, & link out LP control switch. Attach a compound gauge with a coarse Vacuum scale and operate compressor. Allow machine to pump down to below 24” Hg. If at least 18” Hg not achieved suspect valves are faulty. Do not allow compressor to run in Vacuum for more than 1 minute. If 24” Hg achieved stop compressor & monitor vacuum rise rate. Normal criterion for a new / re-manufactured compressor is not more than 5” Hg rise / minute. A reasonable field machine should not rise more than 10”/ minute.

4 **Voltage Balance Under Load** — The motor should receive a balanced voltage across all terminals.

Maximum deviation must not exceed 1% from the mean voltage.

If voltage does vary compare with levels at supply point. Any variation indicates a break down along the supply to the compressor, most likely points being blown fuses, or defective contactors

5 **Dry Fuse** — A fairly common fault easily overlooked is a dry fuse.

When a fuse blows the wire within the fuse casing explodes throwing molten wire around the interior casing. If these particles form a conductive path, the fuse may seem OK, however when the motor attempts to run the affected phase will become effectively open circuit. The obvious consequence of this is a phase loss to the motor with the distinct possibility of motor burnout.

Always renew all three fuses whenever one fuse of a set is found blown.

6 **Current Balance** (Amps) This should be measured in conjunction with Test 4 - Voltage Balance Under Load.

Running current is proportional to compressor load, this in turn is a function of the suction pressure (evaporating temperature) and discharge pressure (condensing temperature). System design, refrigerant type & compressor selection should take account of the maximum loading to be expected upon the compressor. The running current should not exceed the Nameplate Full Load Amps (FLA).

Providing the current is within the FLA figure (ignore start up conditions) the most important measurement is the current balance between phases. This should not exceed 10% at any load condition. Any deviation greater than this amount suggests either a partial phase loss or an imbalance in the supply voltage (> 1%).

Supply Rotation — Supply imbalance can sometimes be reduced by "Rotating" the supply. That is moving the supply phases around one notch i.e. Red / Yellow / Blue becomes Blue / Red / Yellow or Yellow / Blue / Red.

Important Note — If rotating the supply upon a Part Wind Start motor care must be taken to move both ½ motor field groups the same.

7 **Oil Pressure** — Because the oil in the compressor crankcase (sump) is subject to low side system pressure the actual oil feed pressure to the bearings is the difference in pump output pressure and the low side pressure, referred to as Net Pressure.

Low net oil pressure is a symptom of many other defects, and rarely is the oil pump the culprit.

Is it Low Pressure or No Pressure ?	Desired pressure depends upon model, but most like at least 2 Bar / 30 psi net pressure. Carrier range function quite happily on less than 1 Bar, but this is really an exception. In general reckon on 2 - 3 Bar as good.
Low Pressure	Liquid return / diluted oil; Partially blocked pick up filter; Low oil level; worn bearings; Faulty Relief valve; Internal oil Leak; Oil too thin.
No Pressure	Fully blocked filter; Broken pump drive; Very low oil level; Dry pump; Extremely worn bearings.

If you require further advice on field testing of Compressors please call ThermaCom technical help or visit our website.

Single Phase Motor Connections

Please read this before Connecting a Single Phase compressor

To prevent premature failure of the motor it is essential the motor is connected correctly first time to the power supply. Correct function and connection of both *Start & Run Capacitors* is also vital.

If in doubt follow the simple guide below ...

1. Identify the correct motor Terminals ...

Run - Common	(R - C)	Lowest resistance
Run - Start	(R - S)	Highest resistance
Common - Start	(C - S)	Intermediate resistance

Also **R S** = **C S** + **R C** & **C S** is normally 3 - 4 times resistance of **R C**

2 *Start Capacitor* — This is the larger value capacitor in microfarads (MFD or mFd), typically 100 - 300 mFd. The Start Capacitor connects between the Run Terminal and the *Start Terminal* via the *Start Relay*.

3 *Run Capacitor* — This is the smaller value capacitor, typically 5 - 30 mFd. It is connected in Parallel with the *Start Capacitor*, but not via the *Start Relay*, hence this capacitor provides power to the Start Terminal all the time the motor is running.

The name *Run Capacitor* is misleading because it in fact provides power to the Start Terminal & Start Winding Coil from the power lead to the Run Terminal.

Important Note — On any machine having several smaller Capacitors added to make a final total they MUST ALWAYS be group connected in PARALLEL to achieve the desired value. DO NOT CONNECT CAPACITORS IN SERIES.

4 *Start Relay* — The high value *Start Capacitor* would overload the small Start Winding Coils if left connected permanently, hence it is normal to disconnect it once the motor has started. The *Start Relay* senses the voltage across the Main Run Winding Coils, which naturally increases when the motor increases to normal speed. At a pre-set level it switches the *Start Capacitor* off, leaving only the *Run Capacitor* in circuit to the Start Terminal.

Single Phase Motor Running Checks

Please read this before Connecting a Single Phase compressor

Final Checks before starting

1 Live & Neutral should connect directly to the Run & Common Terminals.

2 The Run Terminal should connect to the Start Terminal via the Run Capacitor.

3 A second connection to the Start Terminal should be made via the Start Relay & Start Capacitor.

Once Running

1 Take current reading on Start Capacitor Lead this should show a brief rise for about 1 - 2 seconds, then drop to zero. Motor tone should become sweeter.

2 Take current reading on Common Terminal lead this should be equal to or less than Full Load Current on nameplate.

3 Take current on Run Capacitor lead, this should be about 1/4 - 1/3 Common Lead current.

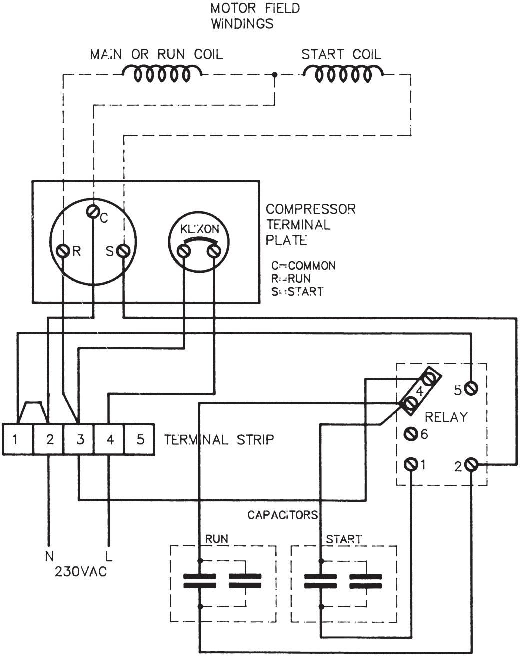
Single Phase Motors actually operate by using two separate field coil windings, Start Coil and Main Run Coil. To achieve a rotating magnetic field it is necessary to cause a phase shift in the current drawn by the two windings when connected in parallel to the same supply.

Different size coils naturally have a slight difference in phase shift due to coil induction, however use of a capacitor considerably exaggerates this phase shift. Most motors require a small capacitor permanently connected upon the supply to the smaller start winding, however those motors requiring a higher starting torque, such as a compressor, require a far greater level of phase shift to achieve initial rotation. Use of a switching relay and second and much larger capacitor achieves this.

If you require further advice upon use and running of Single Phase Compressors please call ThermaCom technical help or visit our website.

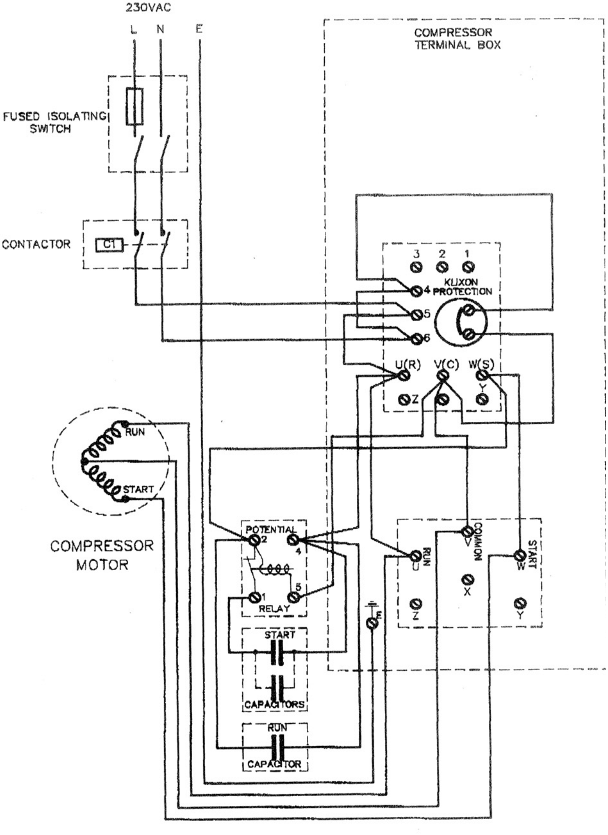
PRESTCOLD 1Ø

K50 TO K150 & L200 TO L300



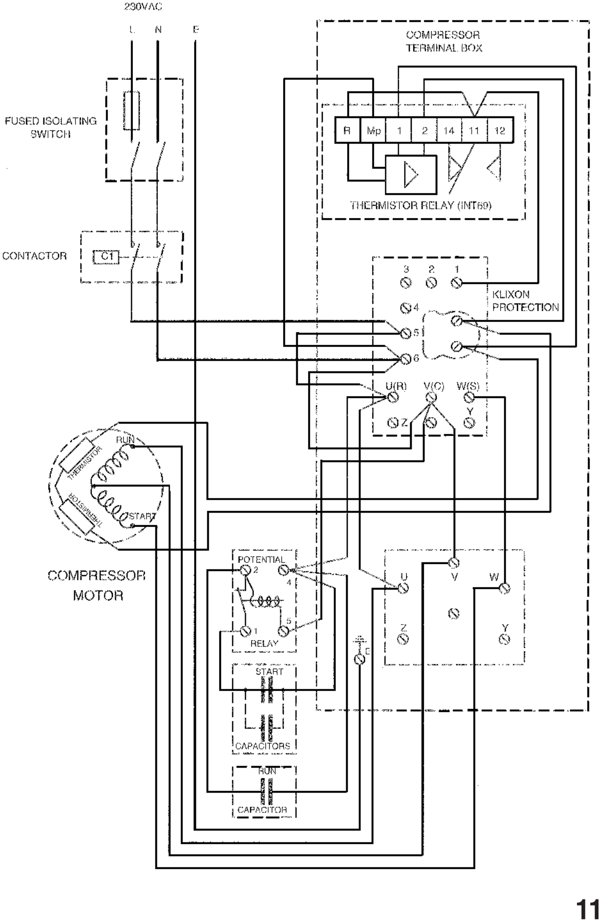
COPELAND DK SERIES

0.5 - 1.5 HP COMPRESSORS 230V AC SINGLE PHASE



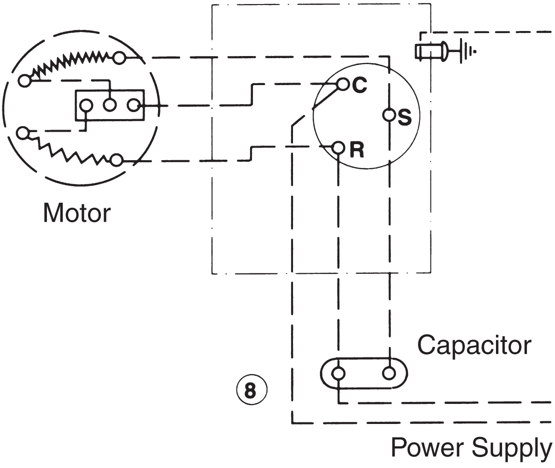
COPELAND DL SERIES

2 &3 HP COMPRESSORS 230V AC SINGLE PHASE WITH THERMISTOR OVERLOAD PROTECTION



COPELAND SCROLL

ZR**K1-PFJ:



Copeland Part Wind Motor Connections

Please read before <u>Connecting</u> a compressor

Copeland Part Wind Start Compressors AWM 67 : 33 BWM 60 : 40

Copeland Part-wind Start compressors use varying ratios of motor part-wind to allow improved starting torque without compromising reduced in-rush current. However it is important that the motor is correctly connected to ensure ...

1 Correct phase polarity to each part-wind as each part of the motor must rotate in the same direction and in phase synchronisation

2 That the larger part of the motor starts first.

<u>Phase Synchronisation</u>

Incoming phases must split to feed the following terminal pairs…

Phase	Red	Yellow	Blue
	1 O	2 O	3 O
Terminals	7 O	8 O	9 O

If in doubt trace the leads back to the split point from each terminal connector to verify correct connection.

<u>Contactor Operating Sequence</u>

The Larger Part wind must start first …

Terminals 1 - 2 - 3 are the larger part-wind and thus have a lower resistance.

Check the leading contactor is definitely connected to this set of terminals.
The 2nd contactor should lag the 1st by 0.5 - 0.75 seconds.

<u>Contactor & Fuse Condition</u>

Have you checked Contactors and Fuses?

'Volts only' checks of contactors & fuses are very unreliable without normal running current passing through

ALWAYS VISUALLY INSPECT THE CONTACT FACES

If only 1 or 2 supply fuses have failed then the 3rd will be damaged

ALWAYS RENEW FUSES AS SET OF 3

Copeland Part Wind Starting Checks

Please read before <u>Starting</u> a compressor

<u>Final Checks before starting</u>

1 We always recommend new contactors with a new compressor.

2 Have you renewed all three fuses or checked out the MCCB.

3 Is the Delay timer correctly set 0.5 - 0.75 seconds

4 Close in Suction Service Valve to prevent liquid surge. On initial start up throttle to maintain minimal suction pressure, gradually open valve until suction pressure stabilises, then fully open valve.

<u>Once Running</u>

1 Take note of contactor sequence. Ensure the lead contactor is correct. Check time delay for 2nd contactor.

2 Immediately check oil pressure starts to build up. Listen for clicking noises - liquid slugging. If present throttle suction.

3 Monitor amps on each phase lead in turn. T1 - T2 - T3 should all balance as should T7 - T 8 - T9.
T1 - T2 - T3 should be higher than T7 - T8 - T9 etc. Balance must be < 10%.

Monitor all Phase to Phase Voltage levels T1 - T2; T2 - T3; T3 - T1; T7 - T8; T8 - T9; T9 - T7. All voltages must read within 1% i.e. 4 volts.

Any greater variation strongly indicates a Partial Single Phase - Stop & Investigate

4 How does compressor sound. A Partial Single Phase can produce heavy mechanical noise.

Throughout the Set to Work it is essential to eliminate what may have caused the previous compressor failure.

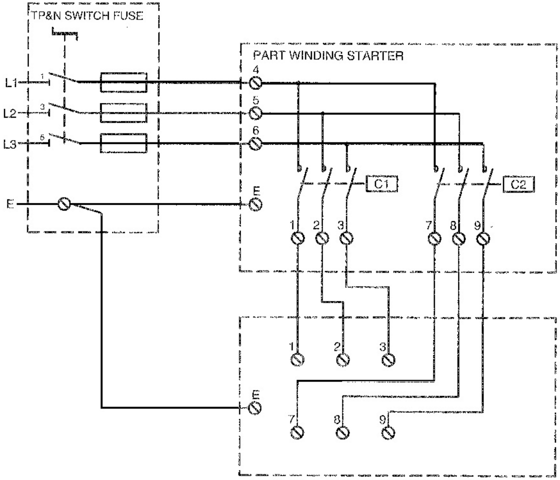
If you have not identified the Root cause of failure the new compressor will be endangered.

In our experience most repeat failures will occur within the 1st 48 hours running. Close attention to all running conditions at initial commissioning is therefore essential.

If you require further advice upon use and running of Part Wind Start Compressors please call ThermaCom technical help or visit our website.

COPELAND 5-40HP. PART WINDING START

(AWM/FWM) 415V 3PH 50Hz



NOTE- FOR AWM C1 MUST CLOSE FIRST

Part-Wind Motor Connections 50 : 50 Split

Please read before Connecting a compressor

Part-Wind Start Compressors with 50 : 50 motor ratio

e.g. Carrier ; York ; Copeland FWM / FSM ; Trane ; Bitzer

Most Part-Wind Start compressors use 50 : 50 split ratio of motor part-wind.

The only exception are the Copeland AWM & BWM covered on Page 13.

However it is important that the motor is correctly connected to ensure correct phase polarity to each part-wind as each part of the motor must rotate in the same direction and in phase synchronisation

Phase Synchronisation

Incoming phases must split to feed the following terminal pairs…

Phase	Red	Yellow	Blue
	1 O	2 O	3 O
Terminals	7 O	8 O	9 O

If in doubt trace the leads back to the split point from each terminal connector to verify correct connection.

Contactor Timing

The 2nd contactor should lag the 1st by 0.5 - 0.75 seconds.

Contactor & Fuse Condition

Have you checked Contactors and Fuses ?

‘Volts only’ checks of contactors & fuses are very unreliable without normal running current passing through

ALWAYS VISUALLY INSPECT THE CONTACT FACES

If only 1 or 2 supply fuses have failed then the 3rd will be damaged

ALWAYS RENEW FUSES AS A SET OF 3

Part-Wind Motor - 50 : 50 ratio Starting Checks

Please read before <u>Starting</u> a compressor

<u>Final Checks before starting</u>

1 We always recommend new contactors with a new compressor.

2 Have you renewed all three fuses or checked out the MCCB.

3 Is the Delay timer correctly set 0.5 - 0.75 seconds

4 Close in Suction Service Valve to prevent liquid surge. On initial start up throttle to maintain minimal suction pressure, gradually open valve until suction pressure stabilises, then fully open valve.

<u>Once Running</u>

1 Take note of contactor sequence. Check time delay for 2nd contactor.

2 Immediately check oil pressure starts to build up. Listen for tinkling noises -

liquid slugging. If present throttle suction.

3 Monitor amps on each phase lead in turn. T1 - T2 - T3 should all balance as should T7 - T 8 - T9. T1 - T2 etc. should be about equal to T7 - T8 etc. Balance must be < 10%.

Monitor all Phase to Phase Voltage levels T1 - T2; T2 - T3; T3 - T1; T7 - T8; T8 - T9; T9 - T7.
All voltages must read within 1% i.e. 4 volts.

Any greater variation strongly indicates a Partial Single Phase - Stop & Investigate

4 How does compressor sound. A Partial Single Phase can produce heavy mechanical noise.

Throughout the Set to Work it is essential to eliminate what may have caused the previous compressor failure

If you have not identified the Root cause of failure the new compressor will be endangered.

In our experience most repeat failures will occur within the 1st 48 hours running. Close attention to all running conditions at initial commissioning is therefore essential.

If you require further advice upon use and running of Part Wind Start Compressors please call ThermaCom technical help or visit our website.

Star / Delta Motor Connections

Please read before <u>Connecting</u> a compressor

Star / Delta Start Compressors e.g. Prestcold > 4 HP ; Copeland EWM

In order to reduce premature failure it is important to effect certain checks to the starting equipment.

<u>Phase Synchronisation</u>

Internal motor coils are	U - X	V - Y	W - Z

Incoming phases must split to feed the following terminal pairs…

From Main Contactor	Red	Yellow	Blue
Terminal set A	U O	V O	W O
From Delta Contactor	Yellow	Blue	Red
Terminal set B	X O	O	Z O
Or	Blue	Red	Yellow
Terminal set B	X O	Y O	Z O

If in doubt trace the leads back to the split point from each terminal connector to verify correct connection.

Do not mix terminal group A & B

<u>Contactor Timing</u>

The Star to Delta change over timing should be 1.5 - 3 seconds.

<u>Contactor & Fuse Condition</u>

Have you checked Contactors and Fuses ?

'Volts only' checks of contactors & fuses are very unreliable without normal running current passing through

ALWAYS VISUALLY INSPECT THE CONTACT FACES

If only 1 or 2 supply fuses have failed then the 3rd will be damaged

ALWAYS RENEW FUSES AS A SET OF 3

Star / Delta Starting Checks

Please read before Starting this compressor

Final Checks before starting

1 We always recommend new contactors with a new compressor.

2 Have you renewed all three fuses or checked out the MCCB.

3 Is the Star / Delta timer correctly set 1.5 - 3 seconds

4 Close in Suction Service Valve to prevent liquid surge. On initial start up throttle to maintain minimal suction pressure, gradually open valve until suction pressure stabilises, then fully open valve.

Once Running

1 Take note of contactor sequence. Check time delay for Delta change over.

2 Immediately check oil pressure starts to build up. Listen for tinkling noises - liquid slugging.If present throttle suction.

3 Monitor amps on each incoming phase lead in turn. R - Y - B should all balance within 10%.

Monitor all Phase to Phase Voltage levels R - Y ; Y - B ; B - R.
All voltages must read within 1% i.e. 4 volts.

Any greater variation strongly indicates a Partial Single Phase - Stop & Investigate

4 How does compressor sound. A Partial Single Phase can produce heavy mechanical noise.

Throughout the Set to Work it is essential to eliminate what may have caused the previous compressor failure

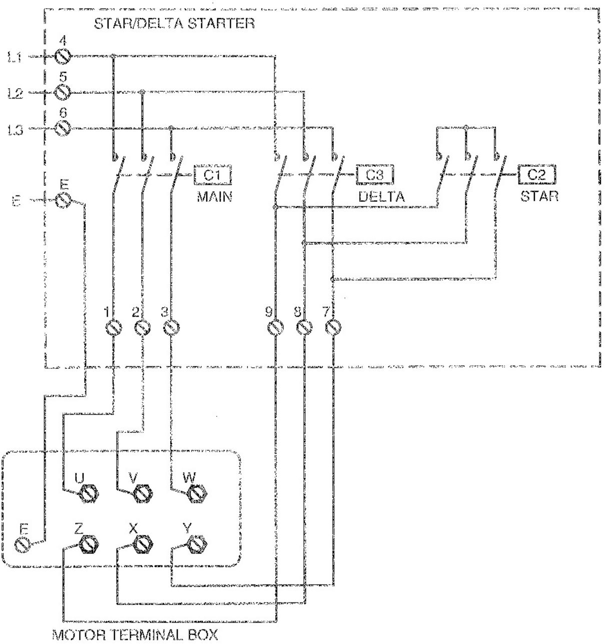
If you have not identified the Root cause of failure the new compressor will be endangered.

In our experience most repeat failures will occur within the 1st 48 hours running. Close attention to all running conditions at initial commissioning is therefore essential.

If you require further advice upon use and running of Star Delta Compressors please call ThermaCom technical help or visit our website.

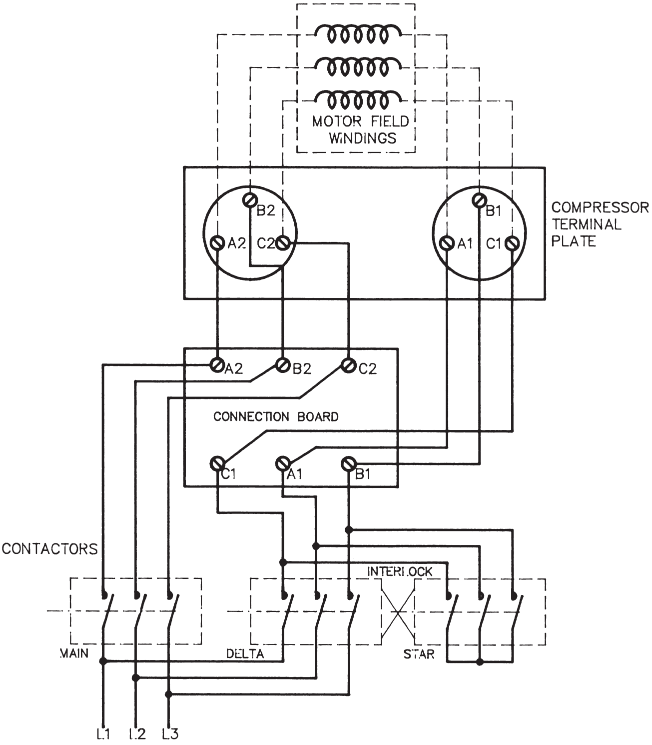
COPELAND STAR/DELTA

5 - 40 HP. 415V 3PH 50Hz (EWM)



PRESTCOLD

L400 TO R1500 STAR/DELTA STARTING



Direct-On-Line Motor Connections

Please read before <u>Connecting</u> this compressor

Direct-On-Line ***Star*** <u>or</u> ***Delta*** Start Compressors *(NB Not Star / Delta)*
e.g. Prestcold > 4 HP ; Copeland EWM

In order to reduce premature failure it is important to effect certain checks to the starting equipment.

<u>Phase Synchronisation</u>

Internal motor coils are	U - X	V - Y	W - Z

Delta connected ***Incoming phases must split to feed the following terminal pairs…***

From Contactor	Red	Yellow	Blue
Terminal set A	U O	V O	W O
Interconnect 2nd terminal set as follows	Yellow	Blue	Red
Terminal set B	X O	Y O	Z O
Or	Blue	Red	Yellow
Terminal set B	X O	Y O	Z O

If in doubt trace the leads back to the split point from each terminal connector to verify correct connection.

Do not mix terminal group A & B

<u>Contactor & Fuse Condition</u>

Have you checked Contactors and Fuses ?

'Volts only' checks of contactors & fuses are very unreliable without normal running current passing through

ALWAYS VISUALLY INSPECT THE CONTACT FACES

If only 1 or 2 supply fuses have failed then the 3rd will be damaged

ALWAYS RENEW FUSES AS A SET OF 3

Direct-On-Line Starting Checks

Please read before Starting this compressor

Final Checks before starting

1 We always recommend new contactors with a new compressor.

2 Have you renewed all three fuses or checked out the MCCB.

3 Close in Suction Service Valve to prevent liquid surge. On initial start up throttle to maintain minimal suction pressure, gradually open valve until suction pressure stabilises, then fully open valve.

Once Running

1 Immediately check oil pressure starts to build up (machines with pumps only)

2 ***Do Not*** charge Liquid refrigerant direct to the compressor suction.

3 Monitor amps on each incoming phase lead in turn. R - Y - B all should balance within 10%.

Monitor all Phase to Phase Voltage levels R - Y ; Y - B ; B - R. All voltages must read within 1% i.e. 4 volts.

Any greater variation strongly indicates a Partial Single Phase - Stop & Investigate

4 How does compressor sound. A Partial Single Phase can produce heavy mechanical noise.

Throughout the Set to Work it is essential to eliminate what may have caused the previous compressor failure

If you have not identified the Root cause of failure the new compressor will be endangered.

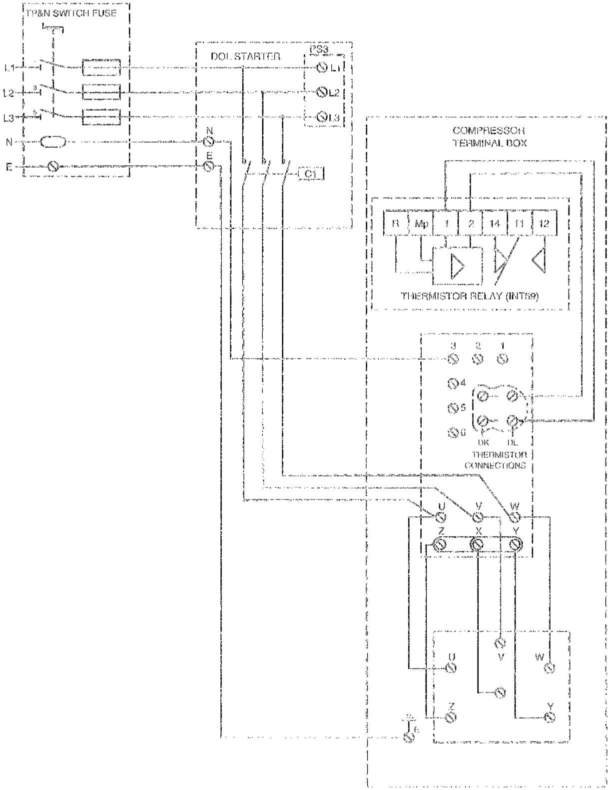
In our experience most repeat failures will occur within the 1st 48 hours running. Close attention to all running conditions at initial commissioning is therefore essential.

If you require further advice upon use and running of Three Phase Compressors please call ThermaCom technical help or visit our website.

COPELAND DK & DL SERIES (EWL)

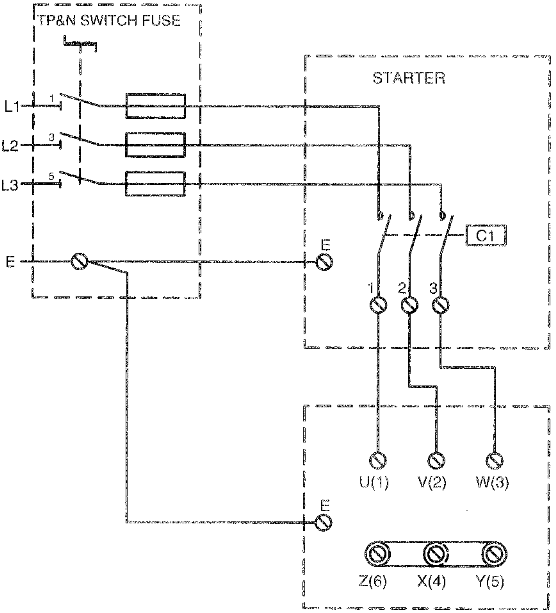
0.5 - 1.5 HP COMPRESSORS AND CONDENSING UNITS
415V 3PH 50Hz DIRECT ON LINE STARTING

WITH THERMISTOR OVERLOAD PROTECTION



COPELAND D4, D6 10 - 40HP (EWL)

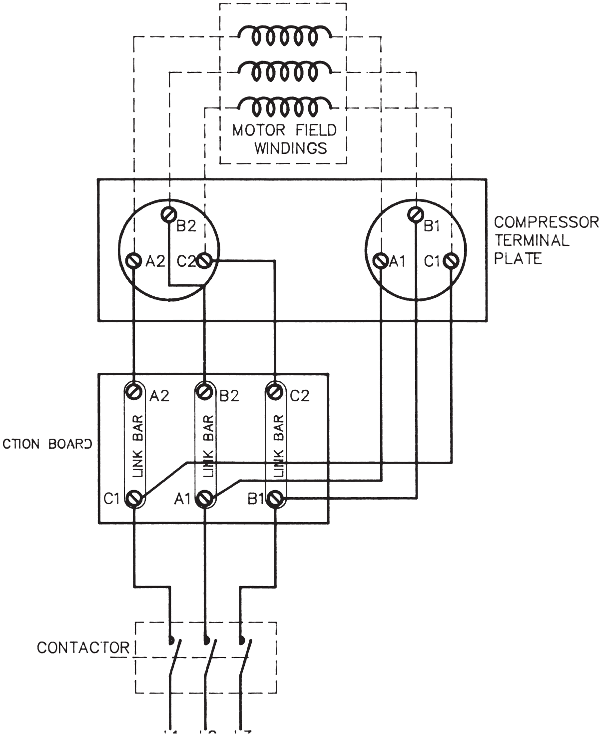
DIRECT ON LINE START 415V 3PH 50Hz



PRESTCOLD

L400 TO R1500

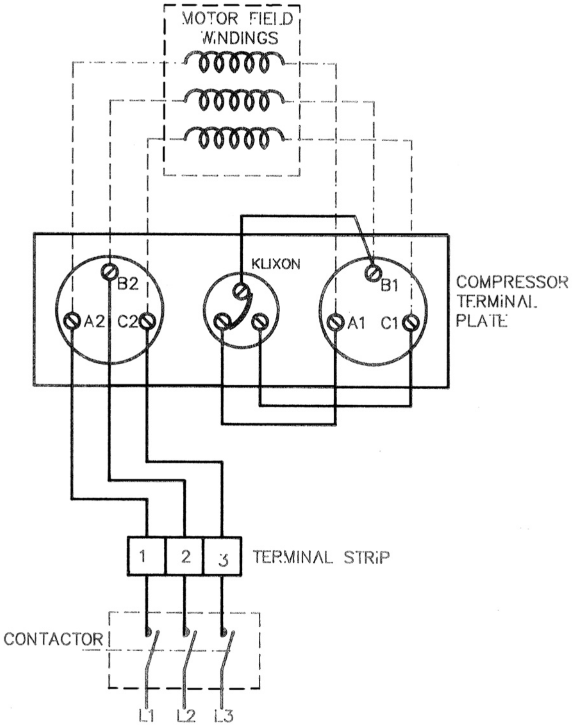
DIRECT ON LINE STARTING (DELTA CONNECTION)



PRESTCOLD 3Ø

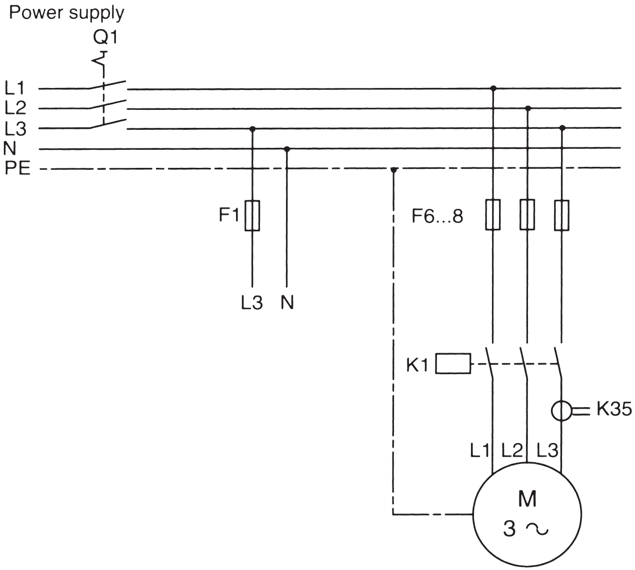
K50 TO K150 & L200 TO L300

DIRECT ON LINE STARTING (STAR CONNECTION)



COPELAND SCROLL

DIRECT ON LINE



Open Drive Compressors

Open Drive Compressors i.e. hose with an external drive motor e.g. Carrier 5F / 5H; Copeland Comef 6CC; Bitzer 6G

Open drive compressors are commonly driven by Star delta or DOL start motors, for details of electrical connections the notes provided for these elsewhere generally applies. The critical factors to consider with open drive compressors are those areas associated with the shaft sealing integrity.

<u>Shaft Seal or Mechanical Seal</u>

This is a delicate, close tolerance component, installed to seal the internal pressurised region of the compressor from the outside atmosphere. Because on occasion, particularly under minor fault conditions, the interior can reach a vacuum condition the shaft seal must also be capable of sealing in opposite conditions, i.e. when the external atmospheric pressure is higher than the compressor interior.

Correct adherence to recognised installation and commissioning procedures is vital if the shaft seal is to maintain it's integrity.

1 Direction of rotation	Certain makes of shaft steel require a certain direction of rotation. Because the preload on the seal is provided by a coil spring, incorrect rotation tends to wind the spring up causing it to loosen in service, this will lead to leakage. Notably the Copeland Comef seal requires an anti clockwise rotation when viewed from the shaft end.
2 Alignment	Correct alignment of the driver and driven shafts is vital. Alignment occurs in two planes - Axial and angular alignment. Both aspects must be within the specified tolerance for the particular coupling type.
Axial alignment	Imagine two lines drawn along the axis of the driver and driven shafts. If either is offset to the other such that the two lines do not form an imaginary continuous line within the specified tolerance, then alignment is unsatisfactory.
Angular alignment	If two imaginary discs were mounted to the end of each shaft adjacent to where they meet at the coupling the two discs should lay parallel to one

another, within the acceptable tolerance for the coupling type. If an angle exists between the two discs then the alignment is unsatisfactory.

General Rule for Alignment tolerance

Axial alignment	The maximum distance apart for the two lines is 0.125mm (0.005")
Angular alignment	The maximum angular misalignment is 1o, but this is awkward to measure, instead allow a maximum of 0.125mm (0.005") per 100mm of coupling radius.

Open Drive Compressor

3 Prevention of Contamination

Shaft seals are very sensitive to contamination, particularly dirt or moisture. Even trace quantities of moisture can lead to leakage as the result of Electrolytic copper plating on the seal. The moisture reacts with the refrigerant to form a mildly acidic refrigerant, this in turn forms an electrolyte, the electrolysis deposits a layer of copper on the fine seal face, leading to leakage.

Always ensure the oil in the compressor is fresh, and if topping up or oil change is required, the oil must only come from a freshly unsealed container, preferably metal not plastic. The trace quantity of moisture in air can occasionally be sufficient to damage a seal face. Always thoroughly evacuate the compressor whenever the interior has been disturbed, even for the simplest task.

Dirt from outside the machine gathering in the vicinity of the seal can penetrate and cause leakage. Fine particles of debris, perhaps from a previous failure, attack the seal from within. In particular oil return reservoirs and float control valves are notorious for holding significant quantities of such debris, and must be rigorously flushed out before being attached to a replacement compressor.

4 Minimise Vibration — Excessive vibration can cause the seal to fail. Pay attention to the power supply to the drive motor, and compressor bearings, and shaft alignment.

Final Checks before starting

1. Have you checked the alignment both Axial and Angular
2. Is the oil clean and from a fresh container.
3. Has the machine been thoroughly evacuated ?
4. Is the refrigerant you are adding clean, pure and dry.
5. Close in Suction Service Valve to prevent liquid surge. On initial start up throttle to maintain minimal suction pressure, gradually open valve until suction pressure stabilises, then fully open valve.

Once Running

1. Immediately check oil pressure starts to build up. Listen for tinkling noises - liquid slugging. If present throttle suction.
2. Monitor motor amps are balanced.
3. Is vibration level acceptable.
4. How does compressor sound. A Partial Single Phase can produce heavy mechanical noise.

If you have not identified the Root cause of previous failure the new compressor will be endangered.

In our experience most repeat failures will occur within the first 48 hours running. Close attention to all running conditions at initial commissioning is therefore essential.

Screw Compressors
Please read before <u>Connecting</u> this compressor

Screw Compressors e.g. Hitachi 6002SC-H; Fu Sheng SR4H

Screw compressors are generally driven by Star delta or Part wind start motors, for details of electrical connections the notes provided for these elsewhere in this guide apply. The critical factors to consider with Screw compressors are those areas associated with initial Direction of Rotation, ensuring a good Head Pressure is established and System Cleanliness.

<u>Direction of Rotation</u>

Screw compressors only work when operated in a particular direction. However, with no external shaft, establishing Direction of Rotation can only be done by close monitoring of the gauges.

Because most Screw compressors utilise a discharge non return valve, if they do rotate the wrong way the reversed pumping effect is minimal. The most reliable method to establish correct DOR is to monitor the suction gauge, which should fall immediately the compressor starts. IF IT REMAINS LEVEL OR SHOWS ANY INCREASE STOP THE MACHINE IMMEDIATELY, then reverse direction (see below) and repeat the attempt.

Reversing Direction of Rotation

Part wind starters	Both part wind must be kept synchronised, so swap matched pairs as follows....	
	In terminal box	<u>1 with 2 & 7 with 8</u> or <u>2 with 3 & 8 with 9</u> <u>or 3 with 1 & 9 with 7</u>
Or	At starter	Swap any two incoming phases before they split off to the individual partwind contractors.
Star delta starters	Phase fields must remain synchronised, or major motor running problems will ensure. Ideally reverse two incoming phases before they split off to the main & delta contactors.	

In terminal box Pay strict attention to leads to be swapped as follows...

Firstly check field continuity as follows U-X V-Y W-Z
then verfiy that the Main contractor is feeding U V W or X Y Z
Swap U with V & Z with X or V with W & X with Y or W with U & Y with Z

Installed Phase Rotation Device (if fitted)
Many Screw compressors incorporate phase rotation sensors to prevent reversed running. However, if the compressor has a rewound stator there is a 50% probability the compressor will still rotate the wrong way. This is because the motor connection at the stator itself could have been reversed during the rewind process, thus whereas the phase rotation meter shall detect correct rotation of the supply, the motor may still reverse.

IF PHASE REVERSAL IS NECESSARY THEN THE PHASE ROTATION SENSOR SHALL ALSO REQUIRE TWO OF IT'S THREE LEADS SWAPPING.

Establishing Head Pressure

Screw compressors rely solely upon the discharge head pressure to provide differential pressure required for lubrication. The oil used in most Screw compressors is very viscous (typically ISO 220), this is needed to provide an effective seal where the rotor tips marry with the root of the opposing rotor. However, this thick oil requires an effective differential to ensure the proper oil flow. The rolling elements bearings in most semi hermetic screws can run for several minutes on the oil film provided at assembly, but any longer and they will suffer.

If possible try to allow the machine to run for several minutes at first start up and allow the head pressure to rise above 175 psi / 12 bar. In cold ambient conditions consider overriding condenser fan controls to establish the head pressure as soon as feasible. Once this is established the compressor will generally run quieter, and the new bearings will really appreciate the plentiful supply of oil to allow them to run in smoothly.

System Cleanliness

Screw Compressors are very sensitive to contamination, particularly dirt or moisture. Even trace quantities of moisture can lead to excessive Electrolytic Copper Plating. The moisture reacts with the refrigerant o form a mildly acidic refrigerant, this in turn forms an electrolyte, the electrolysis deposits a layer of copper on the close running components, which can lead to binding and eventual seizure.

Always ensure the oil in the compressor is fresh, and if topping up or oil change is required, the oil must only come from a freshly unsealed container, preferably metal not plastic. Always thoroughly evacuate the compressor whenever the interior has been disturbed, even for the simplest task.

Final Checks before starting

1. Have you checked the connections?
2. Are you ready to check the Suction Gauge?
3. Has the machine been thoroughly evacuated?
4. Is the refrigerant you are adding clean, pure and dry? Save your recovered gas for non screw plant !
5. Have you overridden fan controls to establish good head pressure as soon as possible after start?

Once Running

1. Immediately check Suction pressure falls. Listen for tinkling noises - liquid slugging.
2. Monitor motor amps are balanced. Is vibration level acceptable ?
3. How does compressor sound ? Once the head pressure establishes the oil flow should make the compressor run quieter.

Throughout the Set to Work it is essential to eliminate what may have caused the previous compressor failure.

If you have not identified the Root cause of previous failure the new compressor will be endangered.

In our experience most repeat failures will occur within the first 48 hours running. Close attention to all running conditions at initial commissioning is therefore essential.

Compressor Oil

Technical misunderstandings affecting refrigeration engineering fall into two broad camps, electrical & mechanical. Mechanical problems of misunderstanding most commonly concern lubrication, although Liquid Refrigerant causes far more failures in actual practice, the Oil and the tasks it performs is far less understood.

The oil in most machines performs one basic requirement: Lubricates-Protects

Lubrication

When any two solid surfaces bear and move against each other, friction, i.e. resistance to movement, will arise. This is due to minute imperfections upon adjacent surfaces interlocking against each other. This rubbing action will produce debris which can further interfere with the smooth running of adjacent surfaces, and in generating the debris a quantity of energy is absorbed and converted to heat, sound etc.

For any bearing surface to have a reasonable life span it becomes necessary to physically separate the two solid surfaces. By use of a suitable liquid to make the separation happen, the simplest solution therefore would be to take a common form of liquid and pump it in between the adjacent surfaces to provide a liquid shear film. Thus to provide an effective lubrication the medium must have 'body' to it, this is referred to as viscosity, also the medium must not have an effect of surface tension, allowing the medium to stay in place over an extended surface without being forced to remain there mechanically. **Oil provides this function.**

Cooling - by allowing the lubricating oil to flow through the bearing parts the oil absorbs locally generated heat and carries it away to a suitable point where it can be rejected. In refrigeration systems the cold refrigerant entering the compressor provides the secondary cooling to the oil within the compressor.

How Lubrication Happens

When the viscous oil is introduced between two bearing surfaces the forces propelling the solid parts together will attempt to force the lubricant away, this force is resisted by the viscosity of the oil. Close attention to the working clearances and allowable tolerances within the bearings is vital to controlling the effective lubrication. In rotating bearings the lubrication occurs locally by formation of an 'Oil Wedge' at the point where the two surfaces come closest. When rotation occurs the shaft within the bearing will try to climb over the adjacent oil wedge, thereby suspending the shaft in an oil film.

After several revolutions the shaft and journal settle into an equilibrium where the two are equally separated around the whole bearing. Lubrication and cooling supply balance is maintained by admitting a continuous supply of lubricant to the running bearing. In smaller bearings by splash effect, or in larger bearings by forcing a continuous flow into the bearing through appropriate drillings and oilways using a pump.

Viscosity & Viscosity Index

By varying the thickness of the oil used in a particular machine the balance of oil flow against effective pressure can be altered. Generally, larger bearings will require a more viscous oil to reduce excessive flow through relatively large clearance areas at the end of bearings, whereas smaller bearings require thinner fluids to maintain acceptable cooling rates. Conveniently most lubricants ranges considerably overlap each other. the ISO standard measurement for viscosity as used by our industry is the Centistoke.

Common viscosity levels are ISO 32; ISO 46 and ISO 68, where the listed viscosity is the viscosity at 40^{o}C. Polyolester oils have higher viscosity indexes (more stable) and thus it is common to use thinner oils on R134a based systems, where use of a thinner oil marginally improves systems efficiency by reduced lubricative energy absorption.

Oil will tend to thicken at low temperature, therefore due consideration must be given to ensure the lubricant chosen for a particular application will not thicken too much in the cold regions of the system otherwise it will stop flowing around the system and back to the compressor (see oil containment). the low point temperature at which an oil thickens to a point where reasonable flow will cease is referred to as Floc Point. Viscosity Index refers to the rate of alteration in viscosity with temperature variations. This is also referred to as stability and is an important consideration for machines which have wide temperature differentials adjacent to their rotating bearings. In particular screw compressors all have rotating bearings at their hottest ends, lubricated by the same oil as that at the cold end.

Oil Containment

Retaining the oil within a fast rotating machine creates numerous engineering problems, particularly in machines designed to pump gas in close confinement with the lubricant oil. However, as afridge systems are closed loop systems, development technology has exploited this. Why contain the oil within the compressor, simply allow it to flow around with the refrigerant.

For this effect to work efficiently the oil must be able to be carried effectively and this requires an easy mixing relationship (miscibility) between the oil and the refrigerant. This was a convenient relationship between traditional CFC refrigerants and simple mineral based lubricating oils. The advent of CFC replacements posed a problem because the new HFC gases do not mix with the simple mineral type lubricants. However, it was found another group of lubricants, synthetic (man-made) Polyolester oils do mix well with these gases and these are now the commonest used oils for the new gases.

It is important to understand that miscibility problems occur only at relatively low temperatures when the oil tends to thicken (as described in the previous section), thus the greatest problems of separation occur at the coldest point of the system, i.e. the evaporator. An excess of oil build up here could cause several problems ....

a. In order to maintain a balance the oil must be returning to the compressor at a similar rate to it’s leaving.
b. Build up of oil in the evaporator will reduce the effectiveness of the evaporator and system efficiency will reduce.
c. Pudding of the oil can lead to mass return of oil at the suction of the compressor where it will attempt to compress the incompressible oil which can cause hydraulic failure of the mechanical parts.

F A Qs Mixing of Oils

In this regard you may regard Mineral & Alkyl Benzene's as 'Sugar' and Polyolester's as 'Salt'. Mixing any of the same broad type will not effect the overall performance, although the resultant viscosity will charge proportional to the mix ratio. It is important is not to mix Mineral with Polyolester unless using with traditional HCFC refrigerants or blends of these gases. Do not use Mineral on any system using R134a or a derivative.

Mineral Oils: These are simple refined products made direct from crude oil. Most mineral oils utilised in refrigeration are Napthenic type oils. Viscosities are normally rated at 32; 46 & 68 for use on most systems from -40°C to + 15°C. Thinner viscosities are also available for very low temperature systems.

Common Grades of Mineral Oil...	Sunisco	3GS (ISO 32); 4GS (ISO 68): 5 GS (ISO 100)
	Texaco	Capella WF (I) 32; 68
	Shell	Clavus 32; 46; 68
	Castrol	Icematic 266 (ISO 32); 299 (ISO 68)
	Mobil	155 (ISO 32); 300 (ISO 68)

Alkyl Benzenes: These are synthetically produced oil with very similar characteristics to mineral oils, however they are claimed to have improved lubricative qualities.

Common Grades are...	Texaco	ROLT 46 (ISO 46 is a common mid-grade)
	Shell	SD (this is actually a mixture of mineral and AlkylBenzene)
	Mobil	Arctic SHC424 (ISO 46)
	Esso	Zerice S46; S68; S100

Polyolester Oils: These are fully synthetic oils produced in a totally different manner to synthetic Mineral oils. These are the commonest lubricants for HFC based gases. These oils use the same ISO grading system as Mineral / AB types. however they tend to be more viscosity stable and may offer improved lubricative qualities to the compressor in extreme situations.

Typical Grades are	ICI	Emkarate	RL32s
	Mobile	EAL Arctic	22; 32; 46; 68 (EAL - Environmental Awareness Lubricant) ThermaCom do not recommend Arctic 22 for use with metalled bearings.
	Castrol	Icematic	SW 32; 68; 100

Common Torque Setting?

Torque Settings for common size bolts

Normal Bolt Size		No Gasket		CAF Gasket		Other Gasket	
Metric	Imperial	Nm	Ft Lbs	Nm	Ft Lbs	Nm	Ft Lbs
M6	1/4”	9	6	11	8	16	12
M8	5/16”	23	17	28	20	40	30
M10	3/8”	42	31	60	44	80	60
M11	7/16”	60	40	82	55	105	70
M12	1/2”	75	55	90	65	125	90
M16	5/8”	190	140	228	170	220	160

Tolerance for all above settings +- 10%
however the above should be regarded as an outline torque guide.
If in doubt please refer to manufacturers own data if available

Conversion Factors?

Unit	X	To convert to	Unit	X	To convert to
Length					
Inches	25.40	mm	Feet	0.3048	Metres
Inches	2.54	cm	Yards	0.9144	Metres
Area					
Square Inches	645.16	Sq. mm	Sq. Feet	0.0929	Sq. Metres
Square Inches	6.4516	Sq. cm	Sq. Yards	0.8361	Sq. Metres
Volume					
Cubic inches	16.3781	CC	Cubic feet	0.02832	Cubic Metres
Mass					
Pounds	0.4536	Kilograms	Tons (UK)	1016.047	Kilograms
Mass/unit area					
Pounds/Sq ft	4.8824	Kg/Sq.Metre	Pounds/ Cu.Ft	16.0185	Kg/Cu.Metre
Capacity					
Gallons	4.5461	Litres	US Gallons	3.785	Litres
Energy					
BTU/Hr	0.2931	Watts	Watts	3.4121	BTU/Hr
BTU/Pound		Kjoules/KG	Watts	0.8598	Kilocals/Hr

Unit	X	To convert to	Unit	X	To convert to
BTU/Sq.Ft/Hr U-BTU/SqFt/H DegF	3.155 5.6783	Watts/Sq. Metre Watts/Sq MDegC	Tons Refrig (12,000 BTU/Hr)	3516.85 3516.85	Watts Watts
K-BTU In./Sq.Ft.Hr. K-BTU	0.1442	Watts/ Metre Deg.	Horse Power	745.70	Watts
1 Therm = 100,000 BTU = 25,200 Kcals = 29.30 KwHr = 39.28 HP Hr = 105.5 MegaJoules					
Water 1 Gall(UK) @ 60 F	Occupies 0.1604 Cu. Ft	= 10LB of Water (10.022 LB)	1 Cu Ft Water 1 Liter Water	@ 60 F	= 62.344 LB = 1 Kilogram
Fahrenheit to Celcius (F - 32) x 0.55			Celcius to fahrenheit (C x 18) + 32		
1 Lt/Sec = 3.6001 Cu.Mtr/Hr = 2.1189 CuFt/Min = 13.1986 (UK) Gall/Min					
1 Bar = 14.5038 PSI = 33.4553 Ft Water = 750.062 mm Mercury = 0.9869 Atms					

What are the Copeland Motor Codes?

Code	Voltage	Phase / Frequency	Start type
CAS	220 v	1 ϕ 50 Hz	1 ϕ
CAG	220-230 v	1 ϕ 50 Hz	1 ϕ
EWD/ESD	440-480 v	3 ϕ 60 Hz	Star Delta
EWK/ESK	220-240 / 380-420 v	3 ϕ 60 Hz	Star (Dual Volt)
EWL/ESL	220-240 / 380-420 v	3 ϕ 50 Hz	Star (Dual Volt)
EWM/ESM	380-420	3 ϕ 50 Hz	Star Delta
EWN/ESN	250-280 / 440-480 v	3 ϕ 60 Hz	Star (Dual Volt)
FWD/FSD	440-450 v	3 ϕ 60 Hz	Part Wind 50:50
FWM/FSM	380-420 v	3 ϕ 50 Hz	Part Wind 50:50
TFD	460 v	3 ϕ 60 Hz	DOL
TAD			
AWM /D	380-420 / 440-480 v	3 ϕ 50 Hz	Part Wind 67:33
BWM	380-420 v	3 ϕ 50 Hz	Part Wind 60:40

Notes:	Overload Protection	aWm eSm	W = PTCR Thermistors S = Robertshaw Sensors

Robertshaws are now obsolete in Europe and a simple conversion is available at rewind.

Motors with spec. for 380-420 v 50 Hz are identical to 440-480v 60Hz.

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Visit our web site and participate with the "Compressor Doctor" - view our interactive trouble shooting pages.

See our published article on the trouble shooting section or contact our web editor. Remember this area is interactive and is designed for your needs, so don't forget that your problems, views and opinions are of interest to us.

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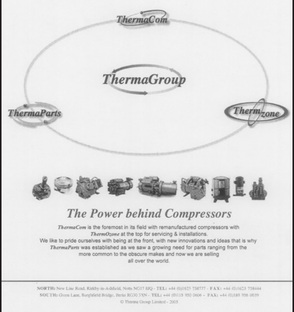
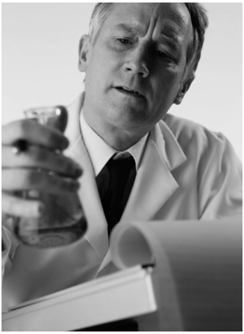
Sales@ThermaCom.com



COMPRESSOR DOCTOR



Log on to our Web Site and look through our library of common compressor failures

Our interactive site allows you to share your problems with others and perhaps find solutions - so join in now!!

Add to our database any suggestions on failures and remedies

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ThermaCom

SOUTH:

Tel: 0118 950 0606

Fax: 0118 956 0039

Green Lane, Burghfield Bridge,

Reading, Berkshire RG30 3XN

MIDLANDS:

Tel: 01623 661133

Fax: 01623 662277

Unit 7B, Kirkland Ave, Ind.Park

Mansfield Notts. NG18 5QP

Email: sales@thermagroup.com

wWebsite: www.thermagroup.com