Copeland scroll compressors

Multiple-compressor assemblies in air-conditioning applications

1. Introduction

This technical information describes the operating characteristics, design features and application requirements for air conditioning and reversible heat pump multiple scroll assemblies. Multiple compressors are paralleling with two compressors (Tandem), three compressors (Trio) with equal capacity (Even) or different capacity (Uneven).

Copeland Tandem and Trio scroll compressors make it possible for greater flexibility in system design for a wide range of applications.

This technical information is referring to paralleling compressors with R407C and R410A.

For individual compressor information, please refer to Copeland Select software or to the compressor application guidelines at www.copeland.com/en-gb. Some of the operating characteristics and design features described below are different from those of the single Copeland scroll compressor models.

2. Nomenclature

The model designation contains the following technical information about the compressor:

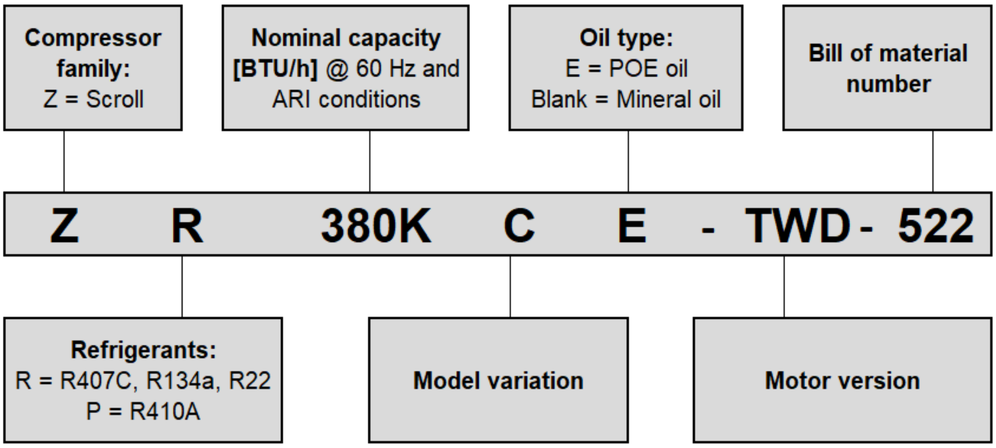


Figure 1: Nomenclature

ARI conditions:

Evaporating temperature .... 7.2 °C	Liquid sub-cooling............. 8.3 K
Condensing temperature .... 54.4 °C	Ambient temperature .... 35 °C
Suction gas superheat .... 11 K	

The model designation contains the following information about the multiple-compressor assembly:

Type	Even	Uneven
Tandem	ZRT, ZPT	ZRU, ZPU
Trio	ZRY, ZPY	ZPM

Table 1: Multiple nomenclature

3. Approved multiple-compressor configurations

3.1. Tandem configurations

HP	ZP Tandem compressors	50Hz	60Hz	ZR Tandem compressors	50Hz	60Hz
6	ZPT72K*E = 2 x ZP36K*E	x	x			
7	ZPT84K*E = 2 x ZP42K*E	x	x			
8	ZPT108K*E = 2 x ZP54K*E	x	x	ZRT96 K*E = 2 x ZR48K*E	x	x
10	ZPT122K*E = 2 x ZP61K*E	x	x	ZRT122K*E = 2 x ZR61K*E	x	x
12	ZPT144K*E = 2 x ZP72K*E	x	x	ZRT144K*E = 2 x ZR72K*E	x	x
12.5	ZPU152K*E =ZP91K*E+ZP61K*E	x	x			
13	ZPT166K*E = 2 x ZP83K*E	x	x	ZRT162K*E = 2 x ZR81K*E	x	x
15	ZPT182K*E = 2 x ZP91K*E	x	x			
15	ZPT180K*E = 2 x ZP90K*E	x	x	ZRT188K*E = 2 x ZR94K*E	x	x
16.5	ZPU195K*E= ZP91K*E+ZP104K*E	x	x			
17.5	ZPU213K*E = ZP91K*E+ZP122K*E	x	x			
18	ZPT206K*E = 2 x ZP103K*E	x	x	ZRT216K*E = 2 x ZR108K*E	x	x
18	ZPT208K*E = 2 x ZP104K*E	x	x			
19	ZPU223K*E = ZP103K*E+ZP120K*E	x	x			
19	ZPU226K*E = ZP104K*E+ZP122K*E	x	x			
20	ZPT240K*E = 2 x ZP120K*E	x	x	ZRT250K*E = 2 x ZR125K*E	x	x
20	ZPT244K*E = 2 x ZP122K*E	x	x			
21	ZPU240K*E = ZP103K*E+ZP137K*E	x	x			
22	ZPU257K*E = ZP120K*E+ZP137K*E	x	x			
22	ZPU258K*E = ZP104K*E+ZP154K*E	x	x			
23	ZPU272K*E = ZP90K*E+ZP182K*E	x	x	ZRU285K*E = ZR160K*E+ZR125K*E	x	x
23	ZPU276K*E = ZP122K*E+ZP154K*E	x	x			
23	ZPU274K*E = ZP120K*E+ZP154K*E	x	x			
24	ZPT274K*E = 2 x ZP137K*E	x	x			
24	ZPU285K*E = ZP103K*E+ZP182K*E	x	x	ZRT288K*E = 2 x ZR144K*E	x	x
24	ZPT286K*E = ZP143K*E+ ZP143K*E	x	x			
25	ZPU302K*E = ZP182K*E+ZP120K*E	x	x	ZRU315K*E = ZR190K*E+ZR125K*E	x	x
26	ZPT308K*E = 2 x ZP154K*E	x	x	ZRT320K*E = 2 x ZR160K*E	x	x
27	ZPU319K*E = ZP137K*E+ZP182K*E	x	x	ZRU334K*E = ZR190K*E+ZR144K*E	x	x
28	ZPU336K*E = ZP182K*E+ZP154K*E	x	x	ZRU350K*E = ZR190K*E+ZR160K*E	x	x
30	ZPT364K*E = 2 x ZP182K*E	x	x	ZRT380K*E = 2 x ZR190K*E	x	x
35	ZPU417K*E = ZP235K*E+ZP182K*E	x	x	ZRU440K*E = ZR250K*E+ZR190K*E	x	x
33	ZPU386K*E=ZP154K*E+ZP232K*E	x	x			
35	ZPU414K*E=ZP182K*E+ZP232K*E	x	x			
38	ZPU449K*E = ZP154K*E+ZP295K*E	x	x			
38	ZPU446K*E=ZP154K*E+ZP292K*E	x	x			
40	ZPT470K*E = 2 x ZP235K*E	x	x	ZRT500K*E = 2 x ZR250K*E	x	x
40	ZPU477K*E = ZP295K*E+ZP182K*E	x	x	ZRU500K*E = ZR310K*E+ZR190K*E	x	x
40	ZPT464K*E=2 x ZP232K*E	x	x			
40	ZPU474K*E=ZP182K*E+ZP292K*E	x	x			
45	ZPU567K*E = ZP182K*E+ZP385K*E	x	x	ZRU580K*E = ZR310K*E+ZR250K*E	x	x

HP	ZP Tandem compressors	50Hz	60Hz	ZR Tandem compressors	50Hz	60Hz
45	ZPU524K*E=ZP232K*E+ZP292K*E	x	x			
50	ZPT590K*E = 2 x ZP295K*E	x	x	ZRU571K*E = ZR380K*E+ZR190K*E	x	x
50	ZPU620K*E = ZP235K*E+ZP385K*E	x	x			
50	ZPT584K*E=2 x ZP292K*E	x	x			
50	ZPU617K*E=ZP232K*E+ZP385K*E	x	x			
55	ZPU680K*E = ZP295K*E+ZP385K*E	x	x			
55	ZPU677K*E=ZP292K*E+ZP385K*E	x	x			
60	ZPT770K*E = 2 x ZP385K*E	x	x	ZRT760K*E = 2 x ZR380K*E	x	x
60	ZPU717K*E=ZP232K*E+ZP485K*E	x	x			
65	ZPU777K*E=ZP292K*E+ZP485K*E	x	x			
70	ZPU870K*E = ZP385K*E+ZP485K*E	x	x			
80	ZPT970K*E = 2 x ZP485K*E	x	x			
90	ZPU111M*E =ZP725K*E+ZP385K*E	x				
100	ZPU121M*E = ZP485K*E+ZP725K*E	x				
120	ZPT145M*E = 2 x ZP725K*E	x				

Table 2: Tandem configurations

3.2. Trio configurations

HP	ZP Trio compressors	50Hz	60Hz	ZR Trio compressors	50Hz	60Hz
22.5	ZPY273K*E = 3 x ZP91K*E	x	x			
27	ZPY309K*E = 3 x ZP103K*E	x	x	ZRY324K*E = 3 x ZR108K*E	x	x
30	ZPY360K*E = 3 x ZP120K*E	x	x	ZRY375K*E = 3 x ZR125K*E	x	x
36	ZPY411K*E = 3 x ZP137K*E	x	x	ZRY432K*E = 3 x ZR144K*E	x	x
36	ZPY429K*E = 3 x ZP143K*E	x	x			
39	ZPY462K*E = 3 x ZP154K*E	x	x	ZRY480K*E = 3 x ZR160K*E	x	x
45	ZPY546K*E = 3 x ZP182K*E	x	x	ZRY570K*E = 3 x ZR190K*E	x	x
60	ZPY705K*E = 3 x ZP235K*E	x	X (BST*)	ZRY750K*E = 3 x ZR250K*E	x	X (BST*)
60	ZPY696K*E= 3 x ZP232K*E	x	x			
75	ZPY885K*E = 3 x ZP295K*E	x	X (BST*)	ZRY930K*E = 3 x ZR310K*E	x	X (BST*)
75	ZPY876K*E= 3 x ZP292K*E	x	x			
90	ZPY1155*E = 3 x ZP385K*E	x	X (BST*)	ZRY114K*E = 3 x ZR380K*E	x	(BST*)
100	ZPM125M*E = 2 x ZP385K*E + 1 x ZP485K*E	x	X (BST*)			
110	ZPM135M*E = 1 x ZP385K*E + 2 x ZP485K*E	x	X (BST*)			
120	ZPY145M*E = 3 x ZP485K*E	x	X (BST*)			
140	ZPM169M*E = 2 x ZP485K*E + 1 x ZP725K*E	x	-			
160	ZPM193M*E = 2 x ZP725K*E + 1 x ZP485K*E	x	-			
180	ZPY217M*E = 3 x ZP725K*E	x	-			

***Table 3**: Trio configurations (BST* = Bigger Suction Tubing)*

***NOTE:* ZR compressors in Tandem and Trio configurations are released with R407C. ZP compressors in Single, Tandem and Trio configurations are released with R410A. All other applications must be reviewed and approved by Application Engineering at Copeland.**

4. Design

Copeland puts all Tandem/Trio designs through a rigorous design testing qualification process prior to release. The design process leverages years of experience and includes the latest technological tools such as computational fluid dynamics analysis. Testing qualification includes strain gauging, oil management evaluation, and complete reliability testing to confirm design life under challenging conditions.

The assemblies outline drawing (piping and rail) are available from Application Engineering at Copeland. The Copeland drawings must be rigorously applied and tested in the system.

4.1. Features of multiple-compressor assemblies

Multiple-compressor applications offer advantages over single compressors with equivalent or bigger capacity:

- Efficient capacity control – by cycling one or two compressors to match multiple-load points in application.
- Increased seasonal efficiency – by running the correct number of compressors.
- Increased reliability – fewer starts/stops than a single large compressor.
- Reduced load starting, whereby individual compressors in Tandem/Trio can be started with time delay
- Redundancy – part-load capacity if one compressor fails, reduced replacement costs
- Compressor replacement in Tandem or Trio design can be cheaper and quicker than one large compressor

4.2. Piping

The system piping must be carefully designed to ensure that the gas velocity is sufficiently high under all circumstances so that oil is returned to the compressors and does not remain in the refrigerant cycle components. High oil content in the evaporator leads to a loss of cooling and efficiency plus a lack of oil in the compressor. With a modulated Tandem unit running on one compressor the gas velocity will be 50 % of when both compressors are running. Minimum velocities of 4 m/s in horizontal lines and 8 m/s in vertical lines are recommended.

For systems with a refrigerant charge greater than indicated a suction accumulator should be installed to protect compressors from liquid refrigerant flood-back.

The discharge line connection of each compressor is provided with a non-return system. This prevents build-up of liquid refrigerant in the idle compressor during long periods of shutdown if this compressor is colder than the condensing temperature.

4.3. Oil and gas management on multiple-compressor assemblies

When compressors are operating in a Tandem or Trio design the return gas and oil enter the suction header and the flow is divided towards the running compressors. Either an oil-equalization line or an oil-and-gas-equalization line is required to achieve good balancing between each compressor under all operating conditions.

Different balance schemes of tubing connections to each compressor are used:

- Three-pipe scheme: suction tube, discharge tube, oil-equalization tube
- Four-pipe scheme: suction tube, discharge tube, oil-equalization tube, gas-equalization tube

4.3.1 Three-pipe scheme

In this balance scheme, there are three tubing connections to each compressor. The three pipes are the suction tube, the discharge tube and the oil-equalization tube. For oil equalization between compressors, oil sumps are used:

- **TPTL – Two-phase Tube Line (Fig. 2)**: By centring the TPTL on the oil level line, both gaseous refrigerant and liquid oil can flow through the pipe. Simultaneous balance of internal gas pressure and oil level is intended.
- **OEL – Oil Equalization Line (Fig. 3)**: By centring the OEL on the oil level line allowing for the free flow of oil between compressors. No gas balancing is intended.

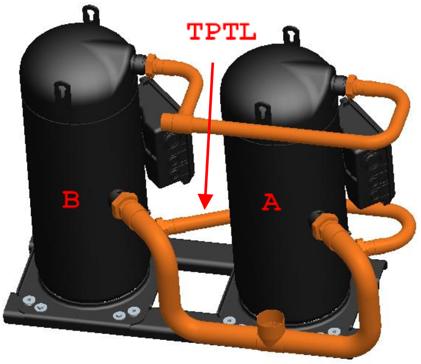


Figure 2: Tandem with 3-tube design (TPTL)

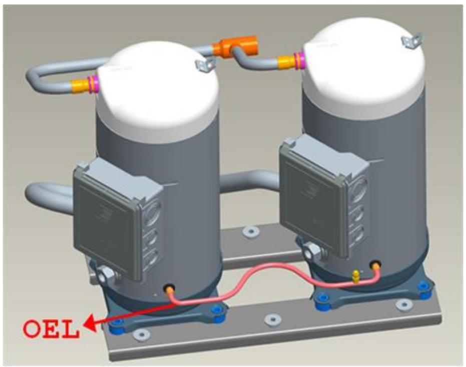


Figure 3: Tandem with 3-tube design (OEL)

4.3.2 Four-pipe scheme

The four-tube scheme uses separate tubes for gas and oil balancing (**Fig. 4**). The dedicated GEL (gas-equalization line) ensures pressure balancing.

Figure 4: Tandem with 4-tube design

When only one compressor is running, the suction pressure in the shell is slightly lower than that of the idle compressor. Since there is still a flow of refrigerant vapour through the shell of the idle compressor and due to the pressure differences, oil can migrate, if required, via an oil-equalization line (OEL) into the shell of the running compressor. When the shell pressure difference between the two compressors is higher, an oil-equalization line alone is not sufficient and an oil-and-gas-equalization line is required. An oil-and-gas-equalization line is also called Two-Phase-Tube-Line (TPTL).

In a Trio assembly, suction and gas/oil-equalization tubing of a symmetrical design is necessary to ensure low tubing stress, proper gas/oil equalization and compressor operation.

Tandem models	**ZRT188K*E to ZRT380K*E / ZRU285K*E** **ZPT180K*E, ZPT206K*E, ZPT208K*E, ZPT240K*E, ZPT244E*K, ZPT274E*K, ZPT308E*K, ZPT364K*E** **ZPU195K*E, ZPU213K*E, ZPU223K*E, ZPU240 to ZPU285K*E, ZPU302K*E to ZPU336K*E**
Common oil-and-gas-equalization line	1 1/4" thread at sight glass position 1 1/8" tube diameter
Oil-equalization line only	3/8" brazing connection
Tandem models	**ZRT500K*E to ZRT760K*E / ZRU440K*E to ZRU690K*E** **ZPT470K*E to ZPT145M*E / ZPU386K*E to ZPU121M*E**
Common oil-and-gas-equalization line	1 3/4" thread at sight glass position 1 3/8" tube diameter

Table 4: 3-pipe models

Tandem models	**ZRT96K*E to ZRT162K*E** **ZPT72K*E to ZPT182K*E, ZPU152K*E & ZPU226K*E**
Gas-equalization line	7/8" brazing connection
Oil-equalization line	9.5 mm brazing connection

Table 5: 4-pipe models

Tandem configurations ZRT188K*E to ZRT380K*E and ZPT180/206/240/274/308/364K*E can be paralleling either by Oil-Equalization Line (OEL) or by Two-Phase Tube Line (TPTL).

Compressor Tandem/Trio models above ZP182K* use the same models for paralleling as the standard single scrolls.

On 3-pipe schemes, TPTL connection is made via the sight glass of each compressor even when the compressors are of different tonnage capacity.

The Schraeder valve connection is a fitting with an internal thread to screw in the valve. To use this connection for oil balancing, remove the Schraeder valve and braze 3/8" copper equalization line to each fitting. The fitting is copper-plated in order to allow an easy soldering process. Before removing the Schraeder valve in each compressor, the Tandem unit is required to be tilted backwards to avoid oil spillage. Before brazing the oil-equalization line, the connections should be cleaned thoroughly and be free of oil. The copper-coated steel tubes on scroll compressors can be brazed in the same manner as any copper tube. Any Silfos material is recommended, preferably with a minimum of 5 % silver. However, 0 % silver is acceptable too.

Figure 5: Oil equalization

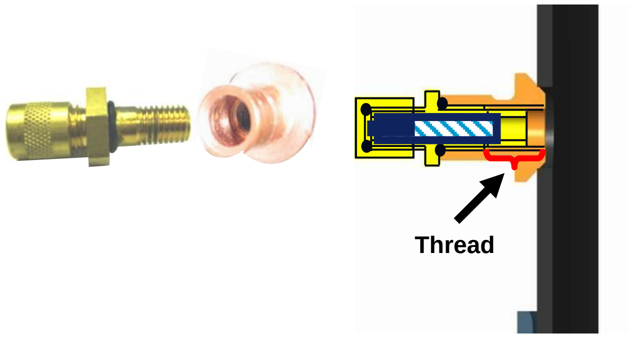


Figure 6: Schraeder valve fitting

The oil/gas-equalization line should be equipped with an oil sight glass to check the oil level. The oil level should be checked at initial system start-up and periodically, when all compressors are off, to ensure that it is within 1/3 to 2/3 of the sight glass. Use the Schraeder valve connection to adjust the oil level as needed, since the compressors are shipped with the oil level above the sight glass position.

When fitting a Two-Phase-Tube-Line to a Tandem unit, care must be taken to prevent oil spillage when removing the sight glass from the compressor. Therefore, it is suggested to put the complete unit onto an arrangement which allows tilting of both compressors until the sight glasses are free of oil. Remove the external sight glasses and the seals and fit the Two-Phase-Tube-Line and new Teflon seals. The Two-Phase-Tube-Line needs to be preassembled for an easier assembling procedure and in order to avoid extended exposure of the hygroscopic POE oil to the atmosphere. A drawing package about how to preassemble the oil balance line for the individual combinations is available upon request from Copeland.

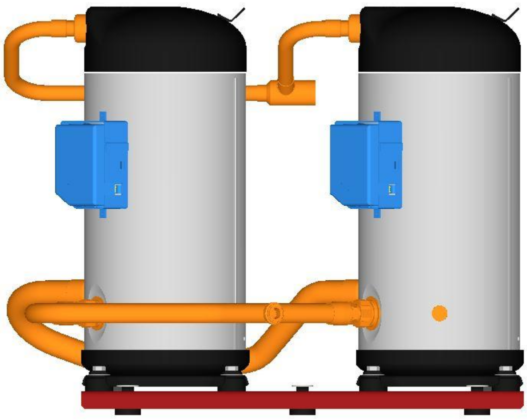


Figure 7: ZRT / ZPT Even Tandem with TPTL

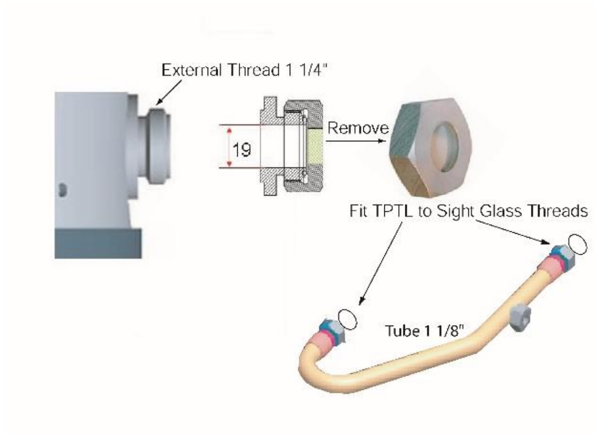


Figure 8: Sight glass adapter for Tandem with TPTL

***NOTE:* Assembly outline drawings (piping and rail) are available from Application Engineering at Copeland for multiple-compressor combinations. The Copeland drawings must be rigorously applied and tested in the system.**

4.4. Multiple-compressor assembly recommendations

4.4.1. General

Uneven multiple combinations have compressors of different sized displacements. The different mass flow rate of each compressor may have an impact on the internal pressures inside the compressor shells and may affect the correct balance of gas and oil. To achieve proper balance across the entire operating envelope a gas flow restrictor is required and is positioned inside the suction line connection or T-fitting of the smallest compressor. Copeland has tested this design extensively and has determined the size of the restrictor required for each compressor model and optimum design configuration.

Attention must be paid to the pipework configuration and to the positioning of flow restrictors. It is essential to follow the design advice as shown in the Copeland drawings to ensure proper oil return to all compressors.

The height of the straight suction collector line from the tee towards the bend is required to be at minimum 450 mm (**Figure 11**) and 580 mm (**Figure 16**) on ZP725K* multiple assemblies.

Depending on the flow direction of the main suction line, one or two flow washers with individual inner diameters must be placed into the suction fitting(s) of the compressor(s) as indicated on the following pages. The flow washers can be supplied by Copeland and have to be placed into the suction or T-fitting(s) or as shown in the following drawings.

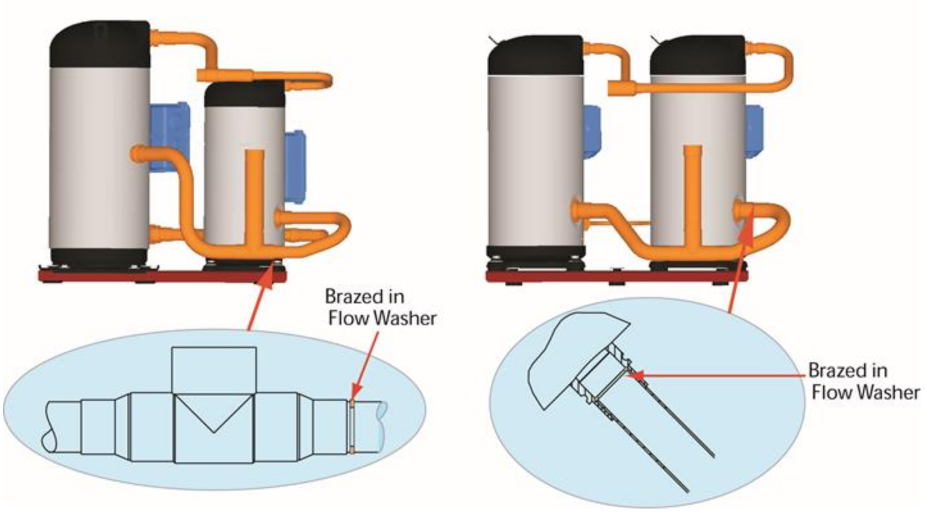


Figure 9: Position of the flow washer in the T-Fitting or at suction port

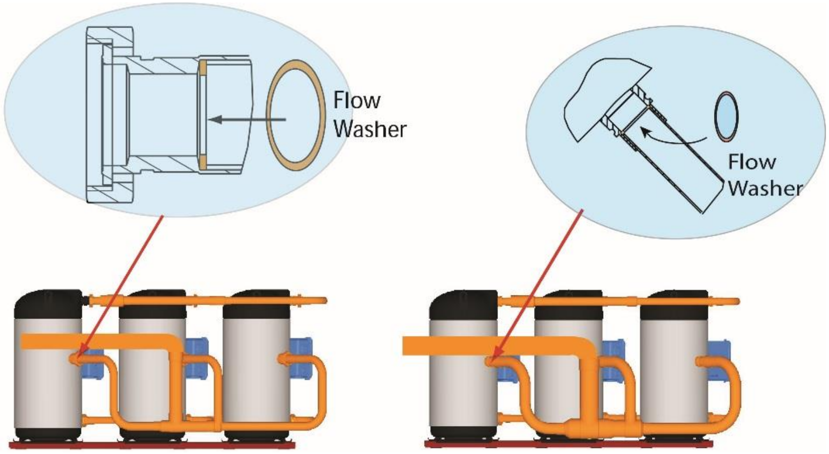


Figure 10: Position of the flow washer depending on connection

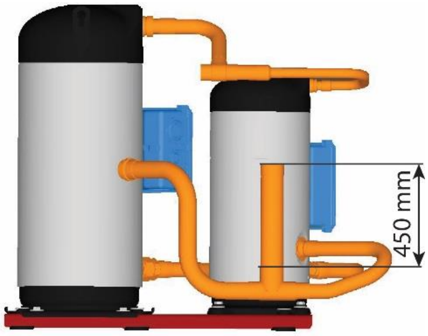


Figure 11: ZRU/ZPU (up to ZP485K*) suction/discharge minimum height of the straight suction

4.4.2. Flow washer recommendation for Tandem assemblies

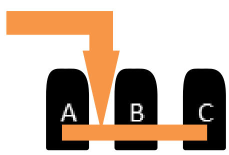
Tandem model	Flow washer position	Flow washer dimensions OD / ID (mm)
ZRU500K*E	In T-fitting towards smaller compressor	34.93 / 27.50
ZRU560K*E	At suction of smaller compressor	41.15 / 35.00
ZRU571K*E	In T-fitting towards smaller compressor	34.93 / 21.30
ZRU690K*E	At suction of smaller compressor	41.15 / 30.00
ZPU449K*E	In T-fitting towards smaller compressor	34.93 / 26.65
ZPU477K*E	In T-fitting towards smaller compressor	34.93 / 27.50
ZPU530K*E	At suction of smaller compressor	41.15 / 35.00
ZPU567K*E	In T-fitting towards smaller compressor	34.93 / 21.30
ZPU620K*E	At suction ZP235K*E	41.15 / 28.00
ZPU680K*E	At suction ZP295K*E	41.15 / 30.00
ZPU870K*E	At suction of smaller compressor	41.15 / 30.00
ZPU617K*E	At suction of smaller compressor	41.15 / 29
ZPU677K*E	At suction of smaller compressor	41.5 / 30
ZPU777K*E	At suction of smaller compressor	41.5 / 28

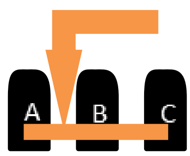
Table 6: Flow washers for Tandem assemblies

NOTE: **The contents of the table above are for informational purposes. Please refer to the assembly outline drawings available from Application Engineering at Copeland. The Copeland drawings must be rigorously applied and tested in the system.**

4.4.3. Flow washer recommendations for Trio assemblies

Table 7 below shows which flow washers are required on Trio models. For models ZPM125M*E and ZPM135M*E see **Figure 12**, for models ZPY145*E/705M*E/885M*E/1115M*E see **Figure 13**.





	Combination	Flow washer ID / Flow direction						
		Opposite (left) flow			Towards (right) flow			
Model	A+B+C	A	B	C	A	B	C	Frequency
ZPM125M*E	ZP385+ZP485+ZP385	28		28	28		28	50 Hz
		33		33	33		33	60 Hz*
ZPM135M*E	ZP485+ZP385+ZP485		32			32		50 Hz
			33			33		60 Hz*
ZPY705M*E	ZP235+ZP235+ZP235	32			32		32	50 Hz
ZPY885M*E	ZP295+ZP295+ZP295	32			32		32	50 Hz
ZPY1115M*E	ZP385+ZP385+ZP385	32			32		32	50 Hz
ZPY145M*E	ZP485+ZP485+ZP485	32			32		32	50 Hz
								60 Hz*

** Larger suction manifolds required for 60 Hz operation*

Table 7: Flow washer for Trio assemblies

ZPM125M*E

ZPM135M*E

Figure 12: Flow washer position and dimensions in mixed and even Trio assemblies ZP385K*E + ZP485K*E

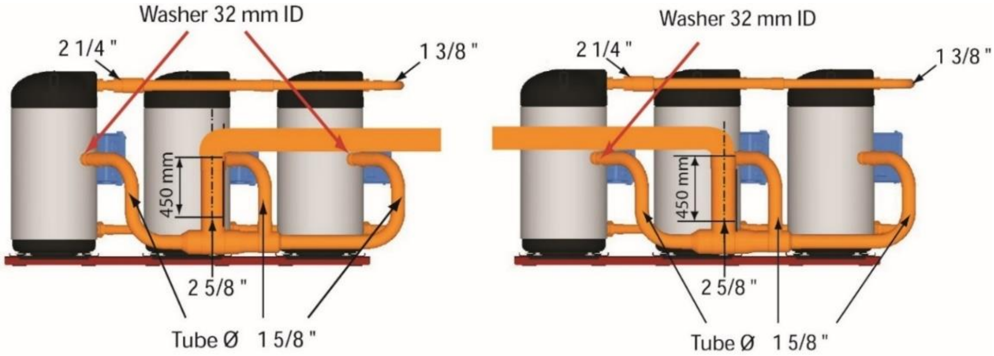


Figure 13: ZPY145*E, 705M*E, 885M*E, 1115M*E – Flow washer position depending on the gas flow direction of the main suction collector

***NOTE:* The contents of the figures above are for informational purposes. Please refer to the assembly outline drawings available from Application Engineering at Copeland. The Copeland drawings must be rigorously applied and tested in the system**

*4.4.4. Flow washer recommendations for Tandem and Trio assemblies with ZP725K**

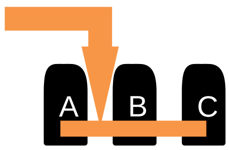
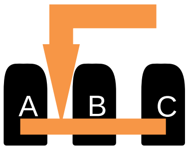
								
		Flow washer ID / Flow direction						
	Combination	Opposite (left) flow			Towards (right) flow			
Model	A+B+C	A	B	C	A	B	C	Frequency
ZPM169M*E	ZP485+ZP725 +ZP485	31	-	34	31	-	34	50-60 Hz
ZPY217M*E	ZP725+ ZP725+ ZP725	41	-	41	41	-	41	50-60 Hz
ZPU121M*E	ZP725 +ZP485	-	33		-	33		50-60 Hz
ZPT145K*E	ZP725+ ZP725	-	-		45	-		50-60 Hz
ZPM193M*E	ZP725+ZP485+ ZP725	-	35	-	-	35	-	50-60 Hz
ZPU111M*E	ZP725+ZP385	-	30		-	30		50-60 Hz

Table 8: Flow washer position and dimensions of ZP725K* combined with ZP385K* or ZP485K* compressors

***NOTE:* The contents of the table above are for informational purposes. Please refer to the assembly outline drawings available from Application Engineering at Copeland. The Copeland drawings must be rigorously applied and checked in the system.**

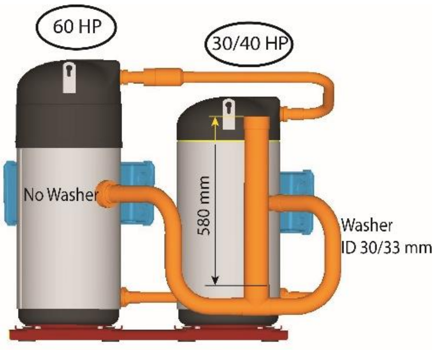
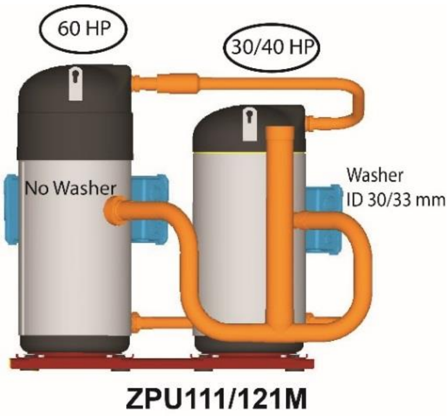


Figure 14: ZPU111/121M*E suction/discharge minimum height of the straight suction



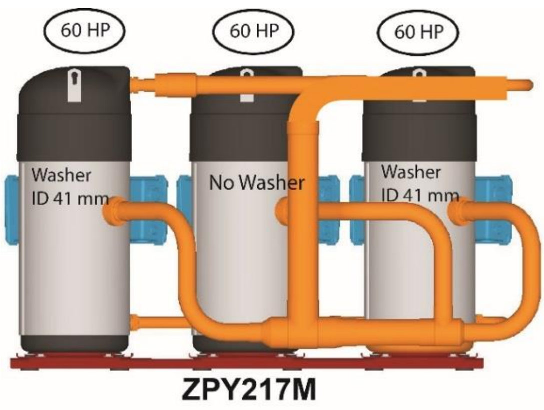
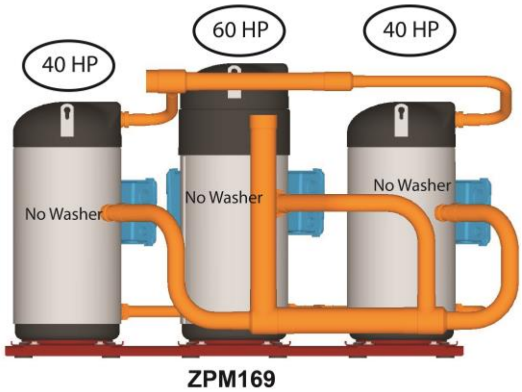


Figure 15: Flow washer position & dimensions for uneven Tandem ZPU111/121M*E & even Trio ZPY217M*E



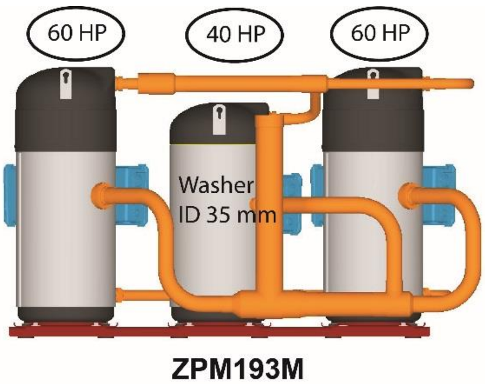
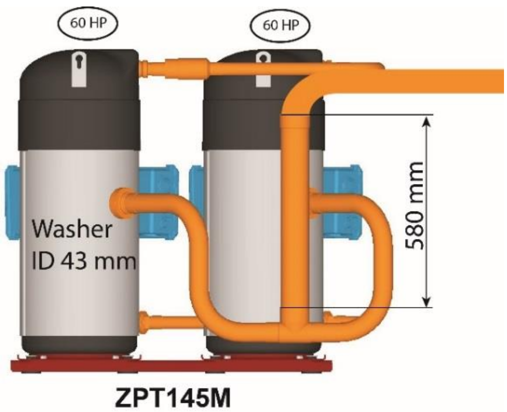


Figure 16: Uneven Trio assemblies ZPM169M*E & ZPM193M*E



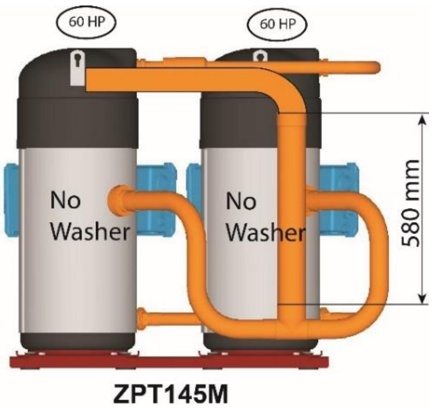


Figure 17: Flow washer position depending on the suction direction in even Tandem assemblies ZPT145M*E

4.5. Compressors mounting parts

All mounting parts have to be ordered separately as accessories. Some mounting parts are designed to mount the compressor onto the rails and some are designed to mount the rails onto the baseplate. Both types are required.

Compressors used in multiple assemblies have to be solidly mounted onto rails by means of either hard rubber or hard steel mounting parts. The reason for the solid mounting is to keep stresses in the tubing connecting the compressors at reasonable levels. The unit rails should be bolted to the installation base through anti-vibration mounts. The unit should be installed level to ensure proper equalization between the compressors.

Please refer to Technical Information TI_Scroll_Mounting_01 "Copeland scroll compressors - Mounting parts" for more information on mounting recommendations and mounting parts orders.

The three main methods used and approved by Copeland are shown in figures below:

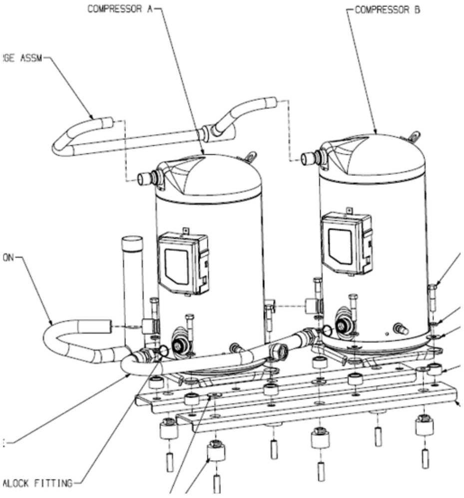


*Figure 18: Tandem assembly for models up to ZP182K**

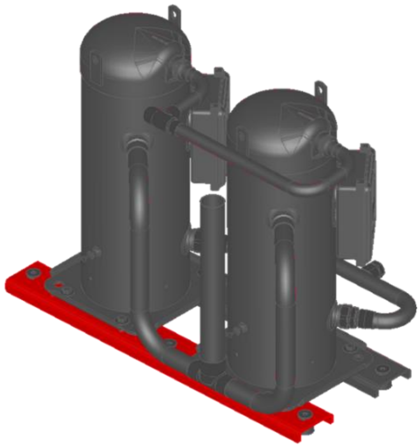


Figure 19: Tandem assembly for ZP232K & ZP292K**

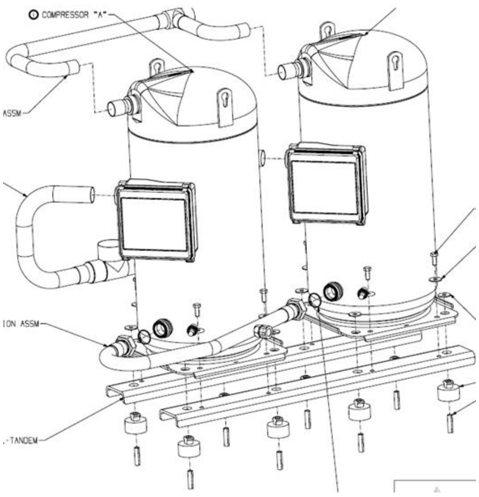


Figure 20: Tandem assembly for ZP385K & ZP485K**

For Tandem assembly, alternative design without an intermediate base or rails and with the connection of the compressors directly to the base of the unit either with hard or soft mountings is not recommended. This is because of the possible transmission of noise and vibration to the unit, or high stress on the tubes and compressor fittings at compressor start/stop.

For Trio assembly, intermediate rails must be used between compressors and unit base, with hard mounts (metal spacers) between compressors and rails, and soft mounts between rails and unit base. The hard mountings are necessary to avoid stress on the tubing and on the compressor fittings at compressor start/stop. The soft mountings are necessary to avoid the transmission of noise and vibration to the unit. The drawing hereunder shows an example of a typical Trio mounting design.

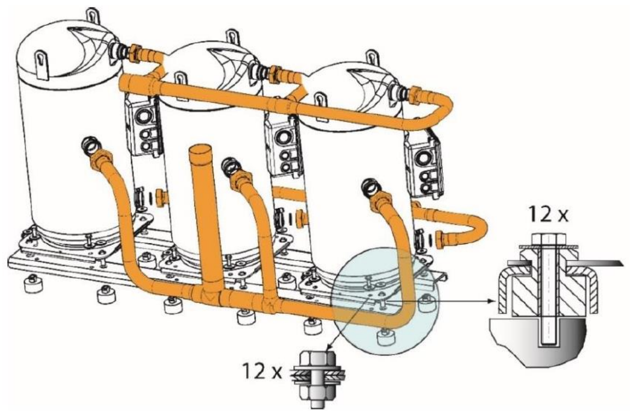


Figure 21: Trio assembly

4.6. Controls

The control of a unit shall comply with the following specifications:

- Any sequence of start/stop combination of compressors is allowed.
- For each individual compressor, the maximum number of starts should be limited to 10/hour.
- It is recommended to wait 5 seconds before starting or stopping another compressor.
- It is recommended not to start or stop 2 or 3 compressors simultaneously.
- It is recommended that the compressors alternate being the lead compressor. It prevents an undesirable situation where a compressor is idle for long periods during times of low-load operation.

These recommendations ensure an even lifetime for the compressors and optimum reliability for the unit.

4.7. Crankcase heaters and charge limits

Due to Copeland scroll compressors' inherent ability to handle liquid refrigerant in flooded conditions, a crankcase heater is required only when the system charge exceeds the following values:

ZP Tandem	Charge limit (kg)	ZR Tandem
ZPT84K*E to ZPT182K*E	5.5	ZRT96K*E to ZRT162K*E
ZPU195K*E / ZPU213K*E/ ZPU226K*E / ZPT208K*E / ZPT244K*E	5.4	-
ZPT286K*E	8.4	-
ZPU386K*E / ZPU414K*E / ZPU446K*E / ZPT464K*E / ZPT474K*E / ZPU524K*E / ZPT584K*E	10.8	-
ZPT180K*E to ZPT274K*E ZPU223K*E to ZPU285K*E	10.9	ZRT188K*E to ZRT288K*E
ZPU258K*E / ZPU276K*E	11.5	
ZPU302K*E to ZPU567K*E (except for ZPU530K*E) ZPT308K*E to ZPT364K*E	11.4	ZRT320K*E to ZRT380K*E ZRU315K*E to ZRU500K*E
ZPT470K*E / ZPU620K*E	13.6	ZRT500K*E to ZRU571K*E
ZPT590K*E to ZPT970K*E/ ZPU870K*E / ZPU617K*E / ZPU677K*E / ZPU717K*E / ZPU777K*E	16.3	ZRT620K*E to ZRU690K*E
ZP Trio	**Charge limit (kg)**	**ZR Trio**
ZPY273K*E	6.3	-
ZPY429K*E	9.8	-
ZPY309K*E to ZPY411K*E	16.3	ZRY324K*E to ZRY375K*E
ZPY462K*E to ZPY546K*E	18.3	ZRY432K*E to ZRY570K*E
ZPY696K*E / ZPY876K*E	12,6	-
ZPY885K*E to ZPY145M*E (even assembly) ZPM125M*E to ZPM135M*E (uneven assembly)	19.6	ZRY930K*E to ZRY114M*E

Table 9: Charge limits

If the system charge exceeds the recommended limit, the compressor may fill with refrigerant under certain circumstances and configurations. This flooded condition may cause excessive noise, or the compressor to lock and trip on protector several times before starting. A crankcase heater may be of benefit in the initial design or as a field remedy under these circumstances. The crankcase heater must be mounted below the oil level located inside the bottom shell.

The initial start in the field is a very critical period for any compressor because all load bearing surfaces are new and require a short break-in period to carry high loads under adverse conditions. **The crankcase heater must be turned on a minimum of 12 hours prior to starting the compressor.** This will prevent oil dilution and bearing stress on initial start-up. **It must remain energized during compressor off-cycle.**

For systems with a refrigerant charge greater than indicated a suction accumulator should be installed to protect compressors from liquid refrigerant flood-back.

4.8. Compressor oil quantity

Model	Displacement (m^3/h)	Oil quantity (litre)	$l/mm^3/h$
ZP24K5E-TFD	3.96	0.74	0.19
ZP29K5E-TFD	4.79	0.74	0.15
ZP31K5E-TFD	5.13	0.74	0.14
ZP36K5E-TFD	6.03	1.24	0.21
ZP42K5E-TFD	6.9	1.24	0.18
ZP54K5E-TFD	8.9	1.24	0.14
ZP61K5E-TFD	9.95	1.24	0.12
ZP72KCE-TFD	11.68	1.77	0.15
ZP83KCE-TFD	13.43	1.77	0.13
ZP91KCE-TFD	14.72	1.77	0.12
ZP104KCE-TFD	16.76	2.51	0.15
ZP122KCE-TFD	19.54	2.51	0.13
ZP143KCE-TFD	23.1	2.75	0.12
ZP154KCE-TFD	24.87	3.25	0.13
ZP182KCE-TFD	29.08	3.38	0.12
ZP232KCE-TED	36.57	4.44	0.12
ZP235KCE-TWD	37.79	4.67	0.12
ZP292KCE-TED	45.66	4.44	0.10
ZP295KCE-TWD	46.71	6.8	0.15
ZP385KCE-TWD	60.79	6.3	0.10
ZP485KCE-TWD	77.33	6.3	0.08
ZP725KCE-FWM	115.48	6.3	0.05

Table 10: Compressor oil quantity

4.9. Performance on Trios

	Cooling capacity	Power input
3 compressors running	3 x single -0.8 %	3 x single +0.8 %
2 compressors running	2 x single -1.4 %	2 x single +2.3 %
1 compressor running	Single -2.5 %	Single +2.9 %

These coefficients are applicable over the entire operating map. Refer to Copeland brand products Select software for single compressor performance data.

Sound power level*	
3 compressors running	Single +4.7 dBA
2 compressors running	Single +3 dBA
1 compressor running	Single

** At ARI for R407C, R410A, 50 Hz.*

4.10. Sound and vibration

Theoretically the sound power level of a Tandem configuration will be higher by 3 dB(A) than the sound power level of an individual compressor.

In order to minimize vibration transmission to the system, it is recommended to install flexible hoses or vibration absorbers between the Tandem assembly and the rest of the system, on the suction as well as on the discharge and injection lines.

5. Assembly procedure

5.1. Compressor handling

The plugs in the compressor line connections should be left in place until the compressors are assembled into the unit. This reduces the risk of contaminants and moisture getting into the compressors especially when they are charged with the more hygroscopic POE oil.

The discharge connection plug should be removed first before pulling the suction connection plug to allow the dry air pressure inside the compressors to escape. Pulling the plugs in this sequence prevents oil mist from coating the suction tube making brazing difficult. The copper suction tube should be cleaned before brazing.

5.2. Lifting and transportation

Lifting a Tandem or Trio assembly must be done in such a way that the lifting chains go straight up from the hanger tabs. If the compressors have two lifting tabs, both must be used for lifting.

It is important when lifting to prevent distortion of the pipework manifolds and rails. To avoid this, it is advisable to place, for example, a tailored wooden block between the compressor shells so as to provide support.

5.3. Rails and lifting of Trio assemblies

The use of an intermediate base or rails for mounting the compressors and the unit base is recommended. The Trio assembly must be handled with care. The use of a spreader bar is recommended, with each compressor connected to the bar in such a way that stress on the tubes and bending of the rails are avoided.

The use of clamps is recommended to give adequate support and stiffness to the Trio assembly during lifting. The clamps can be positioned around the compressor below the suction tube, and tightened with M10 bolts. They can be assembled and disassembled as required. To move the Trio assembly, use one chain for each lifting tab of the compressors.

5.4. Preparing for assembly

- Loosely mount the three compressors on the common base plate or rails, then tighten the mounting bolts to 1 to 5 Nm.
- Remove the rubber plugs from suction, discharge and gas-equalization connections just before the assembly to prevent moisture from entering the compressors. The rubber plug on the stub for TPTL, the insert on the stub for the oil-equalization line, or the sight glass cannot be removed at this point in order to avoid losing oil.

Rotalock adapter design

- Assemble the suction line and the discharge line (any sequence) with Teflon gasket, without tightening.
- Once the tubing is aligned, tighten to the following torques:

Connection	Torque (Nm)
M10	45 – 55
Rotalock 3/4"	40 – 50
Rotalock 1 1/4"	120 – 130
Rotalock 1 3/4"	170 – 180
Rotalock 2 1/4"	190 – 200
Sight glass external 1 3/4"	170 –180
Sight glass fitting TPTL	34 – 41
Mounting bolts 5/16", M9	27 max

Table 11: Torques

- Braze the tubes on the compressor in the following sequence:
  1. suction line
  2. discharge line
- Tilt the unit backward to prevent oil spillage from the oil equalization port. Remove the sight glass for oil equalization. Assemble the oil/gas equalization line (recommended torque 60 – 90 Nm).
- Tighten the connection of the compressor to the rails.
- Use the soft mounting parts for the installation of the Trio assembly onto the base of the system.

6. Single compressor failure

The question frequently arises as to the effect on the remaining compressor(s) in the event one compressor motor fails due to a motor burn. Unless the compressors are interlocked with a starting time delay relay, the compressor motors operate independently of each other, and the operative compressor(s) can continue to run, circulating refrigerant through the system. Extensive laboratory testing and experience where one compressor motor has suffered from a burn indicate that if units are equipped with adequate liquid line filter-driers and suction line filters at the time of failure, no harm is done to the operating compressor. There is little circulation of refrigerant and oil through the crankcase of the inoperative compressor(s), so any carbon, sludge, or other impurities will have little tendency to leave the scroll shell.

After a motor burn-out there will be some mixing of oil through the equalization line and possibly a small amount of acid will be undoubtedly in circulation in the refrigerant. Any acid and contaminants in circulation will be effectively removed if the system is equipped with an adequate liquid line filter-drier and a suction line filter.

It is likely that the pressure drop through the liquid line filter-drier will increase as contaminants are removed, the amount of increase being dependent on the filter-drier size and the nature of the motor burn. Although emergency operation is possible until replacement of the inoperative compressor, it is recommended that the replacement be made as soon as possible. Before removing the damaged compressor, the oil should be removed from all the compressors. When the replacement compressor is installed, it is also recommended that the suction line and liquid line filter-driers be replaced.

7. Additional technical information

Additional technical information can be found in the following documents available at www.copeland.com/en-gb:

- TI_Scroll_Mounting_01 "Copeland scroll compressors - Mounting parts"
- TI_Scroll_Sound Shell_02 "Copeland scroll compressors - Sound shell for "Summit" series - Installation instructions"
- TI_Scroll_Oil_02 "Copeland scroll compressors - Qualification for oil return, oil balancing and oil dilution"
- AGL_AC_ST_ZR_ZP_EN "Copeland scroll compressors for air conditioning"