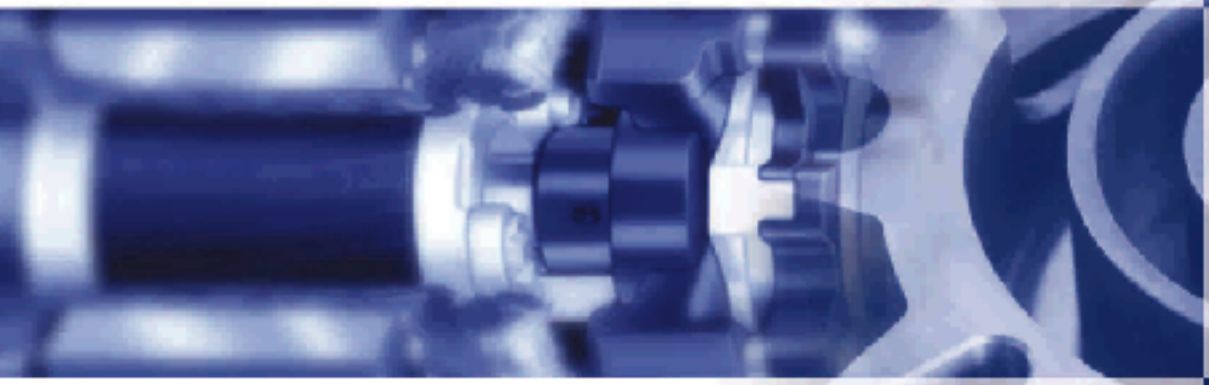
Copeland Scroll



Horizontal Scroll compressors for Refrigeration

Application Guidelines

EMERSON
Climate Technologies

Contents

1 Introduction

The Copeland Scroll™ compressor – using the compliance principle - has been under development at Copeland since 1979 and is the most efficient and durable compressor Copeland has ever developed for air-conditioning, refrigeration and heat pump applications. It offers very low vibration and sound levels and is tolerant to stresses caused by liquid slugging, flooded starts, and debris commonly found in refrigeration systems.
Available product range in this family is from 2.0 to 6 HP. For detailed information, please, refer to the Copeland Selection Software accessible free of charge from the Copeland Website at www.ecopeland.com or printed performance brochures.
These guidelines are not meant to replace the system expertise available from system manufacturers.

2 Nomenclature

The model numbers of Copeland Scroll compressors have been designed to include a coded nominal capacity at ARI operating conditions in BTU/h at 60 Hz.
All refrigeration scroll compressors are charged with polyolester oil, which is indicated by the letter “E”.

Model Designation

Z	S	H	30K	4	E	-	TFD	-	551
1	2	3	4	5	6		7		8

1 Z = compressor family: Z = Scroll

2
- S = High / Medium Temperature
- F = Low Temperature
- B = High / Medium Temperature

3 H = Horizontal Orientation

4 nominal capacity [BTU/h] @ 60 Hz and ARI conditions using multipliers "K" for 1000 and "M" for 10 000

5 - model variation

6 - POE oil

7 - motor version

8 - bill of material number
- 550: Brazed stubs, oil sight glass, schraeder connection for oil fill, or drain, and Discharge thermostat
- 551: Rotalock threaded stubs, oil sight glass, schraeder connection for oil fill, or drain, Discharge thermostat.
- 555 Rotalock threaded stubs, oil sight glass schraeder connection for oil fill, or drain, Discharge thermostat and DTC Valve. (ZF Compressors only).
- 556: Brazed stubs, oil sight glass schraeder connection for oil fill, or drain, Discharge thermostat and DTC Valve. (ZF Compressors only).

3 Qualified Refrigerants

R404A is qualified for all horizontal refrigeration scroll compressors.
ZBH compressors are also qualified to operate with R407C. R404A and R134a.
Data availability should be checked with Copeland Selection software.
It is essential that the glide with refrigerant blends (primarily R407C) be given careful consideration when adjusting pressure and superheat controls.

The application envelopes for each refrigerant are shown in section 31 and Copeland Selection software.

4 Lubrication

The oil level should be maintained at mid-point of the sight glass. If an oil regulator is being used the level should be set within the top half of the sight glass.
An internal positive displaced oil pump, draws oil from the compressor base via a dip tube for lubrication of the bearings.
The compressor is supplied with an initial oil charge. The standard oil charge is a Polyolester (POE) lubricant ICI Emkarate RL 32 CF (32 cSt). In the field, the oil level could be topped up with either ICI Emkarate RL 32 CF or Mobil EAL Arctic 22 CC. The values can be taken from Copeland's brochure.
They must be operated with these specific oils only. Under no circumstances are polyolester oils to be mixed with mineral oil and/or alkyl benzene when used with chlorine-free refrigerants.
Ester oil behaves extremely hygroscopically (see figure 1), and this influences the chemical stability of the oil.
The number of start/stop cycles should be limited to 10 per hour. A high cycling rate will pump oil into the system and may lead to lubrication failure. Oil leaves the compressor at start up regardless of the low oil carry over of the Scroll. Short running time is insufficient to return the oil to the compressor and possibly results in a lack of lubricant.

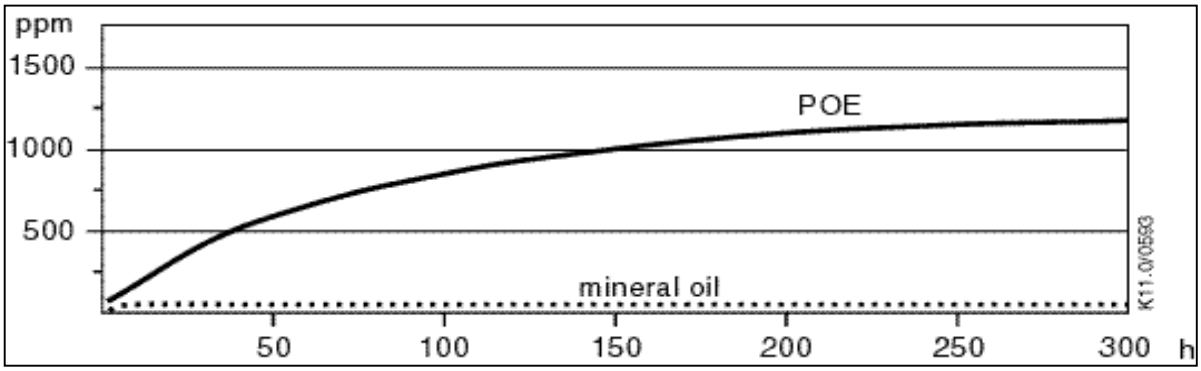


Figure 1: Absorption of moisture in ester oil in comparison to mineral oil (ppm) by weight at 25°C and 50% relative humidity. h = hours

It must be considered that the entire system will be coated with oil to some extent. Oil viscosity changes with temperature. System gas velocity changes depending on temperature and load. In low load conditions gas velocity may not be high enough to return oil to the compressor. System piping should be designed to return oil under all operating conditions, including part loads.
The system should be evacuated down to 0.3 mbar/ 0.22 Torr or lower. If there is uncertainty, as to the moisture content in the system, an oil sample should be taken from various points and tested for moisture. The residual moisture in the installation should be brought below 50 PPM by good evacuation practice (refer to section 25 System Evacuation and Charging Procedure) and the use of a suitable filter drier (solid core XH9 or higher is recommended).
Sight glass/moisture indicators currently available can be used with the HFC refrigerants and lubricants; however, the moisture indicator will indicate the moisture content of the refrigerant. The actual moisture level of POE could be higher than the sight glass specifies. This is a result of the high hygroscopicity of the POE oil.

5 Liquid Injection

For low temperature applications ZFH models, liquid injection is required to keep discharge gas temperatures within allowable limits.
The compressor is supplied with a 13/16" UNF diameter injection stub to accept a DTC (Discharge temperature control) valve for liquid injection. The same DTC valve can be used for all compressors and approved refrigerants.
Inside the compressor, injection takes place into two distinct pockets of the scroll involute without influencing the suction process. Injection increases the mass flow through the system slightly.

The ZFH compressor (BOM 555 and 556) incorporates a thermal well in the discharge cap, to accommodate the DTC bulb, combined with a valve cap.

The Copeland DTC valve is equipped with a custom bulb profile, which must be installed in the thermal well of the top cap of the compressor, sensing the temperature closest to the discharge port. The DTC valve injects only when cooling is needed and in the required amounts. The connection to the liquid line is a 3/8" braze

Valve Specifications
Set Point: 89.4°C ± 2.4°C (193°F ± 5°F)
Liquid Line Connection: 3/8"

Valve Installation

The valve bulb must be installed in the discharge cap thermal well to adequately control discharge temperatures. The valve should be tightened on the injection fitting to a torque of 24-27 Nm (216-245 in. lbs.) It is also reccommended that the valve is located perpendicular to the compressor orientation, in relation to the liquid inlet to the DTC valve, however it will function properly in any orientation. The capillary tube connecting the valve to the bulb should be positioned at least 13 mm away from the side of the scroll body to avoid contact during operation.
An insulating cap is supplied with the DTC Valve, which is applied over the DTC sensing bulb. The valve cap could be replaced with thermal grease, if misplaced. This grease should be applied (minimum of 6 mm thick) to insulate and protect the valve. It is recommended to spread a thin film of thermal grease around the DTC Valve bulb before installing into the top cap well. We also recommend that a shut off valve in the liquid line is installed before the DTC valve, for ease of service.(See Fig. 2: Compressor valve assembly procedure)

Compressor or Valve Service

Replacing a ZF compressor using the DTC Valve: We recommend replacing both the DTC Valve and the compressor at the same time. If the the existing DTC valve is not replaced, then the removable valve filter should be cleaned and/or replaced.

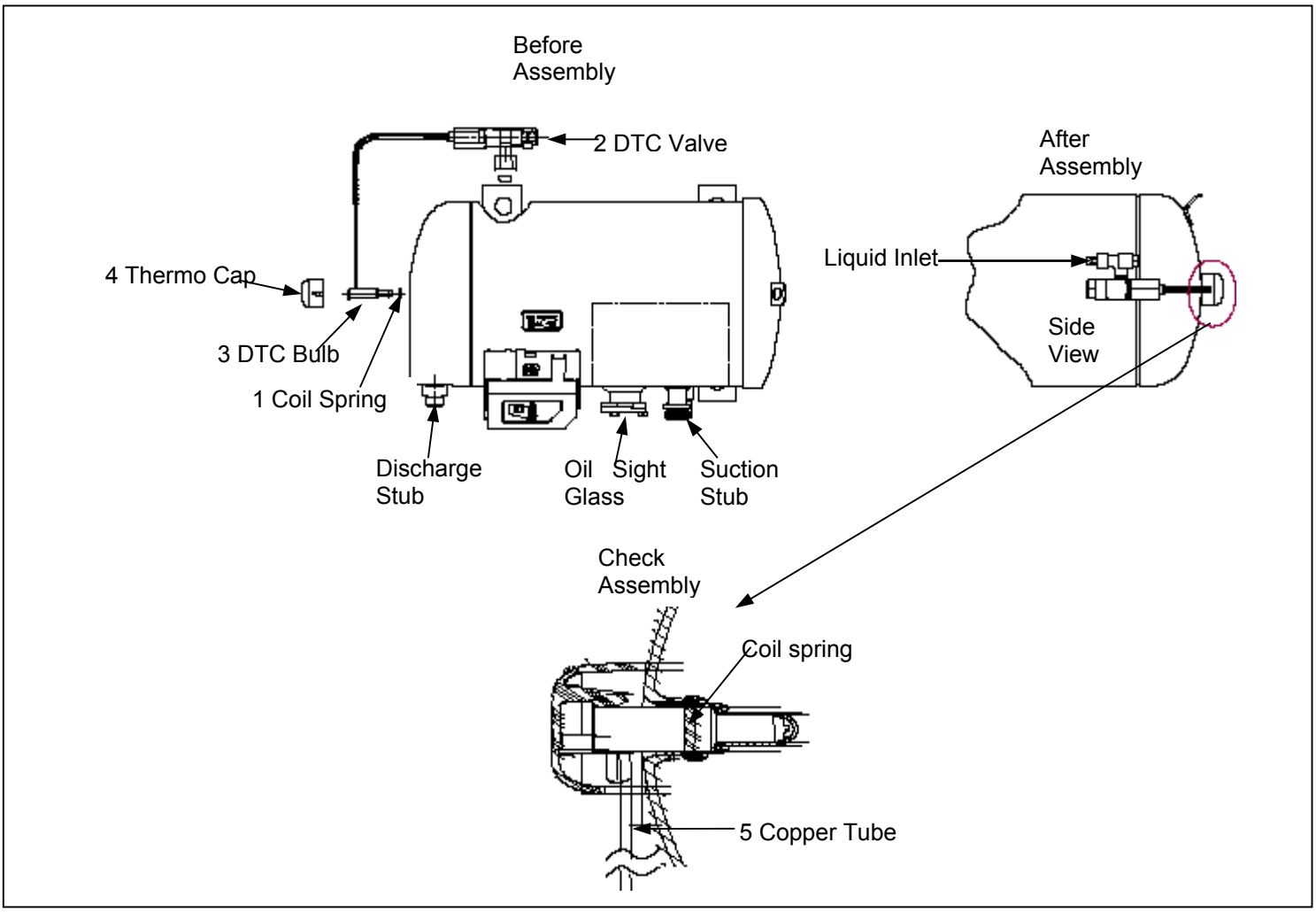


Figure 2: DTC valve assembly procedure
Legend to Fig.2:

1 Verify coil spring is seated in the 'Groove' located in the well on top of the compressor.
2 Thread the Discharge Temperature (DTC) valve onto the injection stub on the side of the compressor
3 Press the DTC bulb into the well on top of the compressor until the DTC bulb seats in the well.
4 Snap the Thermo. cap onto the DTC bulb on top of the compressor
5 The copper tube from the DTC bulb should be approximately 0.125mm (1/8") from the compressor body.

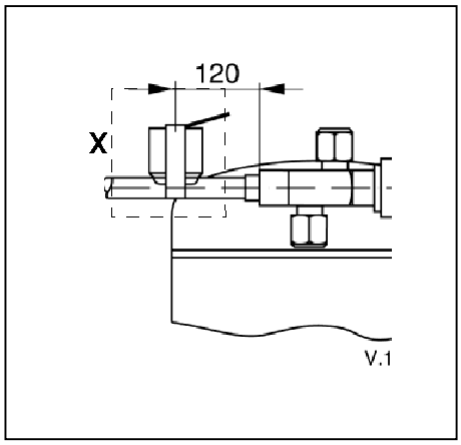
6 Refrigerant Migration

Due to the Scroll's inherentability to handle liquid refrigerant in flooded start and defrost cycle operation, an accumulator may not be required. For single compressor systems with extremely large charges greater than 4,5 kg, an accumulator is recommended. Excessive liquid refrigerant flood- back during normal off cycles, defrost cycles, or steady operation can dilute the oil in any compressor causing inadequate lubrication and bearing wear. Proper system design will ensure maximum compressor life.
Due to the high starting torque of three phase Scroll compressors any excessive amounts of refrigerant that have migrated into the shell during stand-still periods must be driven out of it prior to start-up. Crankcase heaters are required on outdoor systems where the charge limits exceed the above value. Crankcase heaters should also be used when compressor packs are installed outdoors.

7 Crankcase Heaters

Equipment for heating the oil in the crankcase is necessary if the system configuration enables large amounts of refrigerant to condense in the compressor and be absorbed by the oil. At the high temperature produced by the heater refrigerant is constantly vaporised and problems in oil supply are reduced. The wrap around band heater should be positioned between the left-hand side of the oil sight glass and the electrical box (see fig. 2 DTC valve assembly procedure).

8 Discharge Temperature Protection



Internal discharge temperatures reached under some extreme operating conditions such as loss of refrigerant injection charge or extremely high compression ratio could cause compressor damage.
For this reason Copeland recommends THERM-O-DISC thermostat 37TJ31 X 1976E on all horizontal refrigeration scroll compressors.
This thermostat has a cut-out setting of 99 °C ± 4 K with 28 ± 5 K closing differential and should be installed approximately 120 mm from the discharge valve outlet (see figure 3).
In order to avoid improper functioning due to false readings this thermostat needs to be insulated (see "X" in figure 3).

Figure 1: Discharge Line Thermostat Location

9 Standard Motor Protection

Conventional inherent internal line break motor protection is provided with all horizontal refrigeration scrolls.

10 Mufflers

Flow through Copeland Scroll compressors is continuous and has relatively low pulsations. External mufflers, previously applied to piston compressors, may not be required for Copeland Scrolls. Because of variability between systems, however, individual system tests should be performed to verify acceptability of sound performance.

11 Low Ambient cut-out

A low ambient cut-out is not required to limit heat pump operation.

12 Pressure Controls

Both high and low pressure controls are required and the following working pressures are recommended:
For ZFH models, the normal minimum setting should be 0.3 bar (R404A)
Maximum is 21 bar.
For ZSH and ZBH models operating without liquid injection, the LP cut out should be set as high as possible, normal minimum 0.6 bar.
Both the high and low pressure controls are required and the following working pressures are recommended:
Low min:0.3bar, max. 21 bar. High :max 28 bar.
The high-pressure maximum is 28 bar.

13 Internal Pressure Relief Valve

There is an internal pressure relief valve for all horizontal scroll compressors, which opens at a differential pressure of 28 bar ±3 bar between high and low pressure sides.

14 Pump Down

To control refrigerant migration a pump down system could be used. The discharge check valve with refrigeration scroll compressor is designed for low leak back and will allow the use of a pump down without the addition of an external check valve.
If the compressor is stationary for prolonged periods, refrigerant could migrate into the compressor and therefore a crankcase heater must be installed.
If constant cold air is drawn over the compressor, this could make the crankcase heater ineffective, and therefore a pump down system is recommended.
For ZBH models, care should be taken because the scroll sets will unload at a pressure ratio of approximately 10:1. If the unit fails to pump down, the pump down pressure should be reset to a higher value. The low pressure control differential for all models needs to be reviewed since a relatively lower volume of gas will re-expand from the discharge plenum of the compressor into the low side on shut down.

15 Shut-Off

The horizontal refrigeration scroll has a high volumetric efficiency valve in the discharge port, which stops the scroll sets rotating in reverse, consequently no noise is apparent.

16 Starting

During the very brief start-up, a short metallic sound is audible, resulting from initial contacting of the spirals and is normal.
No start assist devices are required for single-phase compressors, even if a system utilises non-bleed expansion valves. Due to the design of the Copeland Scroll, the internal compression components always start unloaded even if sys-tem pres-sures are not balanced. In addition, since internal compressor pressures are always balanced at start-up, low-voltage starting characteristics are excellent for Copeland Scroll compressors. Moreover, if low voltage conditions exist at start up, protector trips could result.

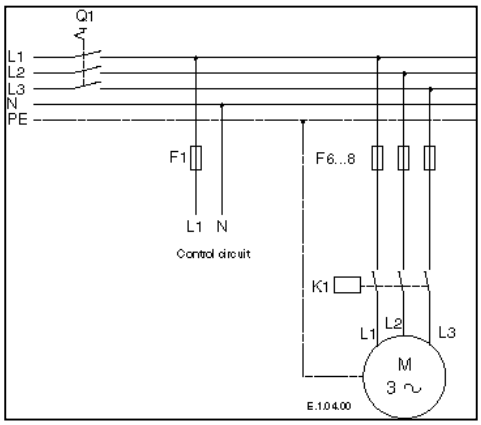
17 Deep Vacuum Operation

Do not run a Copeland scroll compressor in a deep vacuum. Failure to heed this advice can result permanent dam-age to the compressor.

18 Electrical Installation

Independently from the internal motor protection, motor protection devices (fuses and circuit breakers) indicated by F6...8 have to be installed before the compressor as shown in figure 4. Selection of the circuit breakers, fuses have to be carried out according to VDE 0635 or DIN 57635 or IEC 269-1 or EN60-269-1.
Motor insulation material class is “B” according to VDE 0530 or DIN 57530 The Fusite connections are marked as in figure 5.

19 Three Phase Models



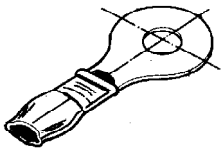
Scroll Models compressors, like several other types of compressors, will only compress in one rotational direction. Direction of rotation is not an issue with single-phase compressors since they will always start and run in the proper direction. However, three- phase compressors will rotate in either direction depending upon phasing of the power to L1, L2 and L3. Since there is a 50/50 chance of connecting power in such a way as to cause rotation in the reverse direction, it is important to include notices and instructions in appropriate locations on the equipment to ensure proper rotation direction is achieved when the sys-tem is in-stalled and operated. Recommended wiring diagrams are shown in fig. 4.

Figure 4: Power Circuit three phase compressor

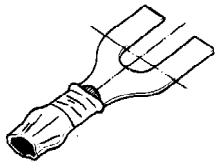
Verification of proper rotation direction is made by observing that suction pressure drops and discharge pressure rises when the compressor starts. Reverse rotation results in a sound level above that with correct rotation direction, as well as substantially reduced current draw compared to tabulated values and after several minutes of operation the compressor's internal protector will trip.
All three-phase compressors are wired identically internally. As a result, once the correct phasing is determined for a specific system or installation, connecting properly phased power leads to the same terminals should maintain proper rotation direction.

20 Cable Connectors

Model	TFD	TF5
All Horizontal refrigeration scroll models	B/C	B/C



B Ring Tongue



C Spade

Figure 5: Cable Connectors

The above table lists recommended types of cable connectors to be used for the various electric terminals of the compressors. "A" must fit 1/4" or 6.3 mm tab sizes. "C" are to be selected for #10 studs or diameters of 5mm respectively. Cable sizes are to be selected according to DIN ISO 0100, IEC 364 or national regulations.

21 Compressor Functional Check

No scroll compressor should be started with the suction service valve closed to check how low the compressor will pull suction pressure. This type of test may actually damage a refrigeration Scroll compressor, rather, the following diagnostic procedure should be used to evaluate whether the Scroll compressor is functioning properly.

- Proper voltage to the unit should be verified.
- Normal motor winding continuity and short to ground checks will determine if the inherent overload motor protector has opened or if an internal short to ground has developed. If the protector has opened, the compressor must cool sufficiently to reset.

- With service gauges connected to suction and discharge pressure fittings, turn on the compressor. If the suction pressure falls below normal levels the system is either low on charge or there is a flow blockage in the system.

- **Single Phase compressors**
  If suction pressure does not drop and discharge pressure does not rise to normal levels, either the reversing valve or the compressor is faulty. Use normal diagnostic procedures to check operation of the reversing valve.

- **Three Phase Compressor**
  If suction pressure does not drop and discharge pressure does not rise to normal levels, reverse any two of the compressor power leads and reapply power to make sure compressor was not wired to run in reverse direction. If pres-sures still do not move to normal values, the compressor may be faulty. If the compressor is in a circuit containing a reversing valve, this item may be faulty Reconnect the compressor leads as originally configured and use normal diagnostic procedures to check operation of the reversing valve. If the reversing valve checks out satisfactorily, then the compressor current draw should be compared to published compressor performance data at the compressor operating conditions (pressures and voltages) and significant deviations (more than ±15%) from published values may indicate a faulty compressor.

22 High Potential Testing

Copeland subjects all scroll compressors to a high voltage test after final assembly.
Since high voltage tests lead to premature ageing of the winding insulation, we do not recommend additional tests of that nature. They may also be carried out with new machines only.
If it has to be done for any reason disconnect all electronic devices (e.g. motor protection module, fan speed control, etc.) prior to testing. The test voltage of 1000 V plus twice the nominal voltage is applied for 1 - 4 seconds between motor winding (each one of the phases) and the compressor shell: The maximum leak current limit is approximately 10 mA. Repeated tests have to be performed at lower voltages.
Caution: Do not carry out high voltage or insulation tests if the compressor housing is under vacuum. Copeland Scroll compressors are configured with the motor down and the pumping components at the top of the shell. As a result, the motor can be immersed in refrigerant to a greater extent than hermetic reciprocating compressors when liquid refrigerant is present in the shell. In this respect, the scroll is more like semi-hermetics (which have horizontal motors partially submerged in oil and refrigerant). When Copeland Scroll compressors are high potential tested with liquid refrigerant in the shell they can show higher levels of leakage current than compressors with the motor on top because of the higher electrical conductivity of liquid refrigerant than refrigerant vapour and oil. However, this phenomenon can occur with any compressor when the motor is immersed in refrigerant. The levels of current leakage do not present any safety issue. To lower the current leakage reading the system should be operated for a brief period of time to redistribute the refrigerant to a more normal configuration and the system high potential tested again.

23 Motor Codes

Code	50 Hz	60Hz	Connection
	Volt ± 10%/~/Hz	Volt ± 10%/~/Hz	
TF5	200-220/3/50	200-230/3/60	Y
TFD	380-420/3/50	460/3/60	Y

24 Installation

For single operation, four rubber vibration absorber grommets are supplied with each compressor (see fig. 6). They dampen the start-up surge of the compressor and prevent sounds and vibrations from being transmitted to the compressor base during opera-tion to a large extent. The metal sleeve in-side is intended as a guide to hold the grommet in place. It is not designed as a load-bearing member, and excessive torquing can crush the sleeve. Its inner diameter is approximately 8.5 mm to fit e.g. an M8 screw. The mounting torque should be 13 ± 1 Nm. It is critically important that the grommet is not compressed. A clearance space of approximately 2-mm between the bottom of the washer and the top of the grommet spacer is recommended. For multiple or parallel operation please refer to guidelines C6.2.5/0901-0702/E.

25 Shut-off Valves and Adapters

Horizontal refrigeration scroll compressors are delivered either with brazed connections or threads for Rotalock shut off valves. Brazed pipework can also fit compressors with Rotalock connections using adapters “A” and “B” in either straight or angled “C”. (See fig. 7 and spare parts list ZFH/ZSH and ZBH)

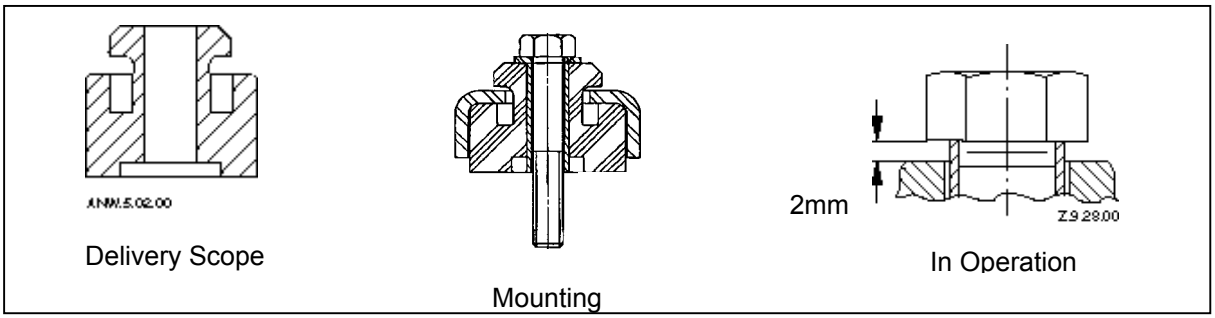
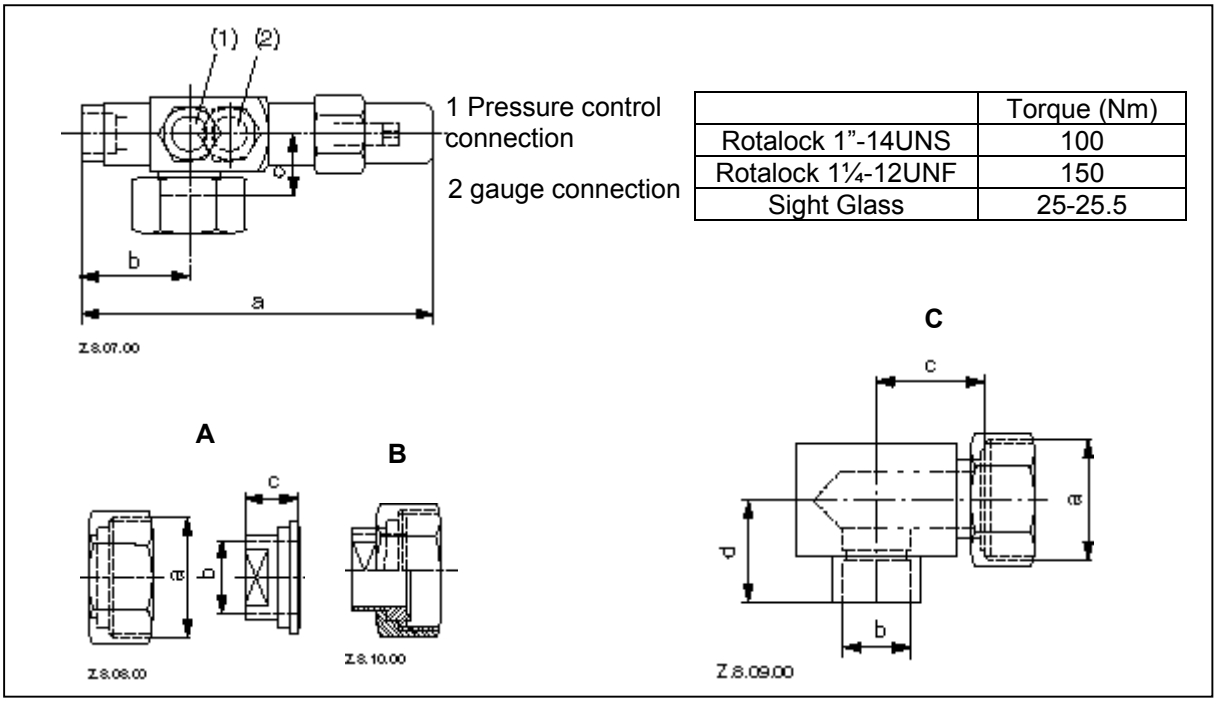


Figure 2: Mounting parts for single operation



	Torque (Nm)
Rotalock 1”-14UNS	100
Rotalock 1¼-12UNF	150
Sight Glass	25-25.5

Figure 7: Shut off valves and adapters

26 Shell Temperature

Under rare circumstances caused by failure of system components such as the condenser or evaporator fan, or loss of charge, and depending on the type of expansion control, the top shell and discharge line can briefly but repeatedly reach temperatures above 177°C as the compressor cycles on its internal protection devices. Care must be taken to ensure that wiring or other materials, which could be damaged by these temperatures, do not come into contact with the shell.

27 System Evacuation and Charging Procedure

Before the installation is put into commission, it has to be evacuated with a vacuum pump. During the initial procedure, suction and discharge shut-off valves on the compressor remain closed. The installation of adequately sized access valves at the furthest point from the compressor in the suction and liquid line is advisable. Pressure must be measured using a vacuum pressure (Torr) gauge on the access valves and not on the vacuum pump; this serves to avoid incorrect measurements resulting from the pressure gradient along the connecting lines to the pump.

These valves could also be used to measure the operating pressures to ensure there are no excessive pressure drops in the suction line and liquid line, which will also give an indication that the expansion device receives full bore liquid, ensuring the system performs at its most efficiently.
Evacuating the system only on the suction side of a Scroll compressor can occasionally result in a temporary no-start condition for the compressor. The reason for this is that the floating seal could axially seal with the scroll set, with the higher pressure on the floating seal. Consequently, until the pressures equalize, the floating seal and scroll set can be held tightly together.
The installation should be evacuated down to 0.3 mbar/ 0.22 Torr or lower. Subsequently, the factory holding charge of dry air in the compressor is released to the ambient. The shut-off valves are opened and the installation, including the compressor, are once more evacuated as described after the system has been recharged with dry nitrogen.
Highest demands are placed on the leak proof design of the installation and also on the leak testing methods. (Please refer to EN378).
Rapid charging on the suction side of Scroll compressors can occasionally result in a temporary no-start condition for the compressor. The reason for this is that if the flanks of the spirals happen to be in a sealed position, rapid pressurization of the low side without opposing high side pressure can cause the spirals to seal axially. Consequently, until the pressures eventually equalize, the spirals can be held tightly together, preventing rotation. The best way to avoid this situation is to charge on both the high and low side simultaneously at a rate, which does not result in axial loading of the spirals. The maximum charging rate can be determined through simple tests.

28 Unbrazing System Components

If the refrigerant charge is removed from a scroll-equipped unit by bleeding the high side only, it is sometimes possible for the scrolls to seal, preventing pressure equalization through the compressor. This may leave the low side shell and suction line tubing pressurized. If a brazing torch is then applied to the low side while the low side shell and suction line contains pressure, the pressurized refrigerant and oil mixture could ignite when it escapes and contacts the brazing flame. To prevent this occurrence, it is important to check both the high and low side with gauges before unbrazing, or in the case of repairing a unit on an assembly line, bleed refrigerant from both the high and low side. Instructions should be provided in appropriate product literature and assembly (line repair) areas.

29 Compressor Replacement

In the case of a motor burn, the majority of contaminated oil will be removed with the compressor. The rest of the oil is cleaned through use of suction and liquid line filter dryers. A 100% activated alumina suction filter drier is recommended but must be removed after 72 hours. It is highly recommended that the suction accumulator be replaced if the system contains one. This is because the accumulator oil return orifice or screen may be plugged with debris or may become plugged shortly after a compressor failure. This will result in starvation of oil to the replacement compressor and a second failure.
When a single compressor or tandem is exchanged in the field, a major portion of the oil may still be in the system. While this may not affect the reliability of the replacement compressor, the extra oil will add to rotor drag and increase power usage.

See Section 24 for Rotalock valve, flange fittings, sight glass, and mounting bolt torques values.

30 Suction Line Noise and Vibration

Copeland Scroll compressors inherently have low sound and vibration characteristics. However, in some respects, the sound and vibration characteristics differ from reciprocating compressors and, in rare instances, could result in unexpected sound complaints with plain air-conditioning systems. One difference is that the vibration characteristic of the Scroll compressor, although low, includes two very close frequencies, one of which is normally isolated from the shell by the suspension of an internally suspended compressor. These frequencies, which are present in all compressors, may result in a low level “beat” frequency, which can be detected as noise coming along the suction line into a house under some conditions. Elimination of the “beat” can be achieved by attenuating either of the contributing frequencies. This is easily done by using one of the common combinations of design configuration described below.
A second difference of the Copeland Scroll compressor is that under some conditions the normal starting motion of the compressor can transmit an “impact” noise along the suction line. This phenomenon, like the one described above, also results from the lack of internal suspension, and can be easily avoided by using standard line isolation techniques as described below.

- Tubing configuration: small shock loop in the horizontal plane.
- Service valve: “angled valve” fastened to unit/wall
- Suction muffler: not required

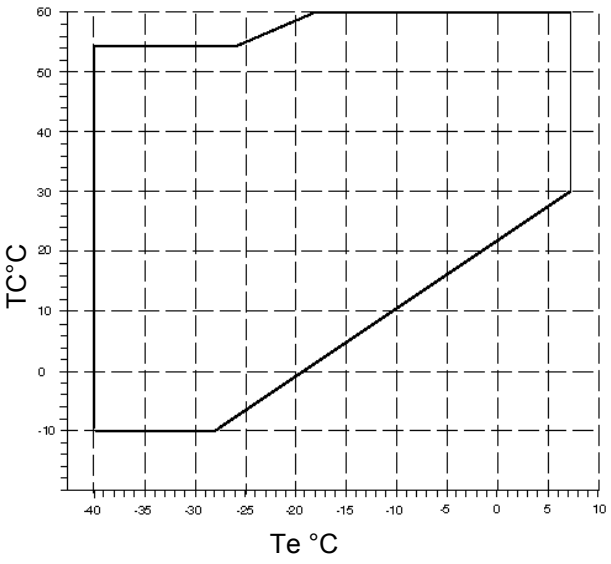
Alternative configuration:
- Tubing configuration: small shock loop
- Service valve: “straight-through” valve fastened to unit/wall
- Suction muffler: may be required

31 Application Envelopes

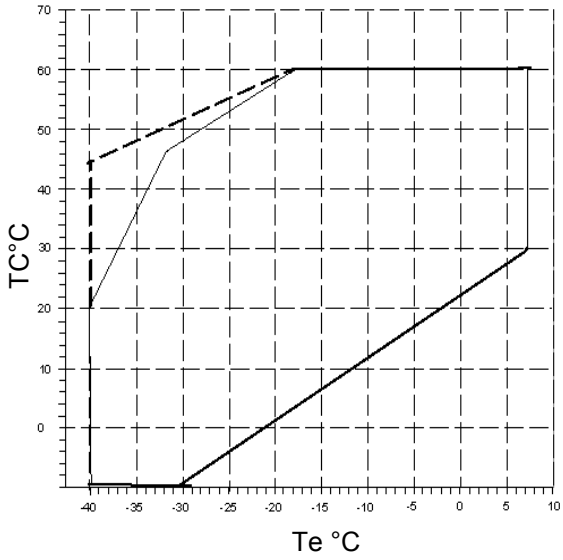
Note: All application envelopes are for 25°C Suction Gas Return conditions unless otherwise stated.

R404A/R507

ZFH 06 to ZFH 18

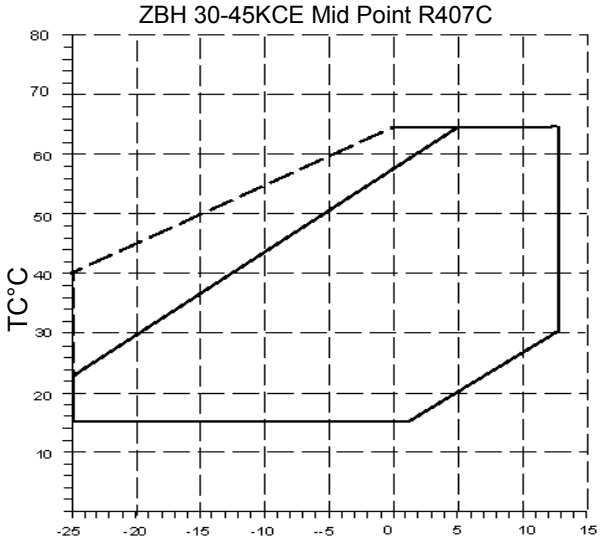


ZSH 21K4 to ZSH 45K4



R407C (Mid)

ZBH 30-45KCE Mid Point R407C



10K Suction Superheat