Copeland®

R410A
Air Conditioning Scroll

Application Guideline

Air Conditioning

Contents

1. Introduction

The new model family of "ZP" compressors is designed for high pressure R410A refrigerant, a chlorine free replacement for R22. R410A operates at approximately 50 to 70 percent higher pressure at the same saturated temperatures than R22. Several design changes had to be made to the scroll compressors to accommodate the operating differences between R22 and the new refrigerant. These will be covered later in the guidelines. The new models include an internal pressure relief valve, an internal discharge gas temperature sensor, and a device to limit the shut down noise caused by scroll reversal. The compressor shell thickness was increased to handle the higher required pressures.

2 Nomenclature

The model numbers of Compliant Scroll compressors include the nominal capacity at standard operating conditions. Please refer to the product literature for details pertaining to other information contained in the model number.

3 How a Scroll Works

The scroll is a simple compression concept first patented in 1905. A scroll is an involute spiral which, when matched with a mating scroll form, generates a series of crescent-shaped gas pockets between the two members . During compression, one scroll remains stationary (fixed scroll) while the other form (orbiting scroll) is allowed to orbit (but not rotate) around the first form. As this motion occurs, the pockets between the two forms are slowly pushed to the centre of the two scrolls while simultaneously being reduced in volume. When the pocket reaches the centre of the scroll form, the gas, which is now at a high pressure, is discharged out of a port located at the centre of the fixed scroll. During compression, several pockets are being compressed simultaneously, resulting in a very smooth process. Both the suction process (outer portion of the scroll members) and the discharge process (inner portion) are almost continuous.

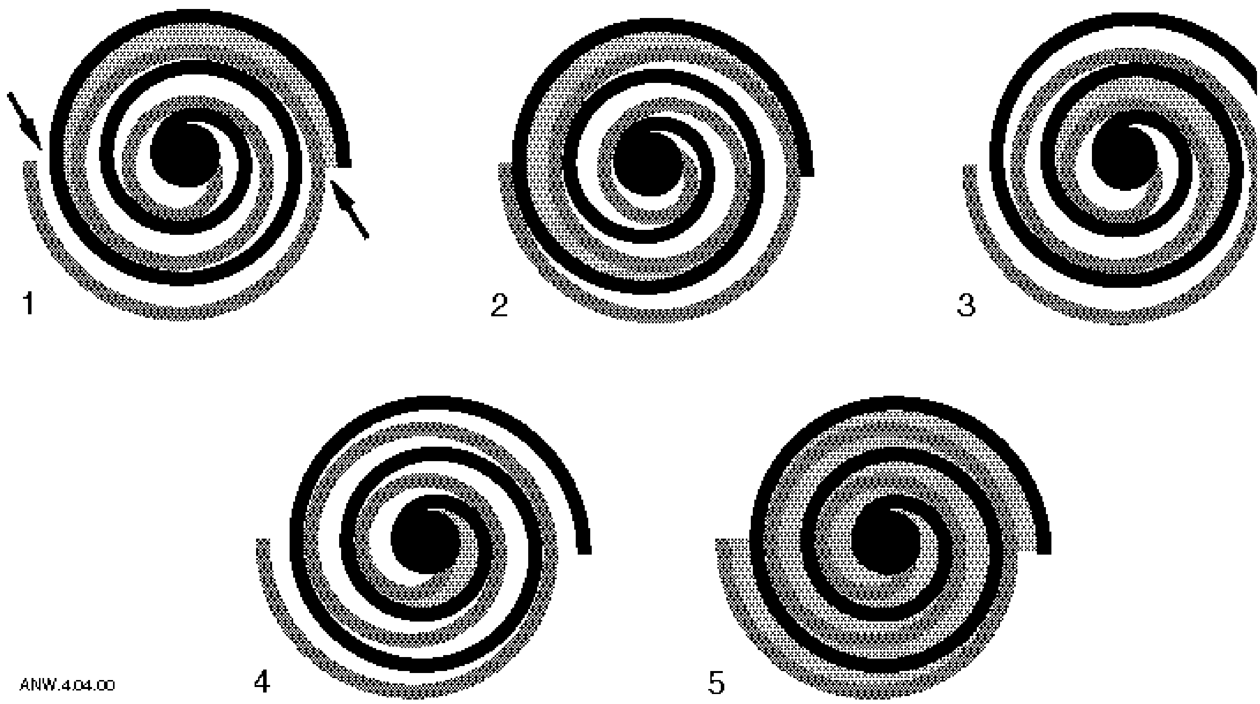


Figure 1

Operating principles of the Compliant Scroll are described in part 3.

Field Replacement of a "ZP" Compressor

The ZP**K*E-XXX Scroll compressor is a unique design for R410A refrigerant and **must never** be replaced with a "ZR" family scroll compressor. The "P" in the model number designates that this compressor has a housing designed for the higher pressure encountered with R410A. **Use of a compressor that is not specifically designed for R410A may cause shell rupture and personal injury.** R410A has greater enthalpy per unit volume than R22. For this reason the displacement is smaller vs. motor power in the "ZP" scroll than an equivalent capacity R22 compressor. Using an R22 compressor in a R410A system may cause the compressor to stall. Conversely using a "ZP" compressor in an R22 system would result in a drastic system capacity reduction.

Observe figure 1 for the following:-

1 Compression in the scroll is created by the interaction of an orbiting spiral and a stationary spiral. Gas enters the outer openings as one of the spirals orbit.

2. The open passages are sealed off as gas is drawn into the spirals.
3. As the spiral continues to orbit, the gas is compressed into two increasingly smaller pockets.
4. By the time the gas arrives at the centre port discharge pressure has been reached.
5. During operation, all of the gas passages are in various stages of compression at all times, resulting in almost continuous suction and discharge of the refrigerant.

4 Application Considerations

The Compliant Scroll is a unique type of compressor with which there are a number of application characteristics which are different from the traditional reciprocating compressor., these are detailed folllowing on.

4.1 Accumulators

Due to the Compliant Scroll's inherent ability to handle liquid refrigerant in flooded start and defrost cycle operation, an accumulator is not required for durability below system charge levels listed in the Scroll Compressor Application Diagram (**Table 1**). However, large volumes of liquid refrigerant which repeatedly migrate to the compressor during normal off cycles or excessive liquid refrigerant floodback during steady operation can dilute the oil in any compressor to the point that bearings are inadequately lubricated and wear may occur. To test for these conditions, see the section entitled EXCESSIVE LIQUID REFRIGERANT FLOODBACK TESTS at the end of this Bulletin. If an accumulator is used it is recommended that it be sized to hold from 50% to 70% of the system charge. The oil return orifice in the accumulator should be around 1,4 mm. See **"Excessive Liquid Floodback Tests"** and **Figure 2** to determine the effectiveness of the accumulator.

4.2.1 Crankcase Heaters - Single Phase

Generally a crankcase heater is not required for single phase compressors. When the system charge exceeds the recommended limit, the compressor may fill with refrigerant under certain circumstances and configurations. This may cause excessive clearing noise, or the compressor may lock up 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.

4.2.2 Crankcase Heaters - Three Phase

A crankcase heater is required for three phase compressors when the system charge exceeds 4,5 kg. and free liquid drainage into the accumulator cannot be arranged by piping (as in figure 3) during the off cycle (See **Table 1**).

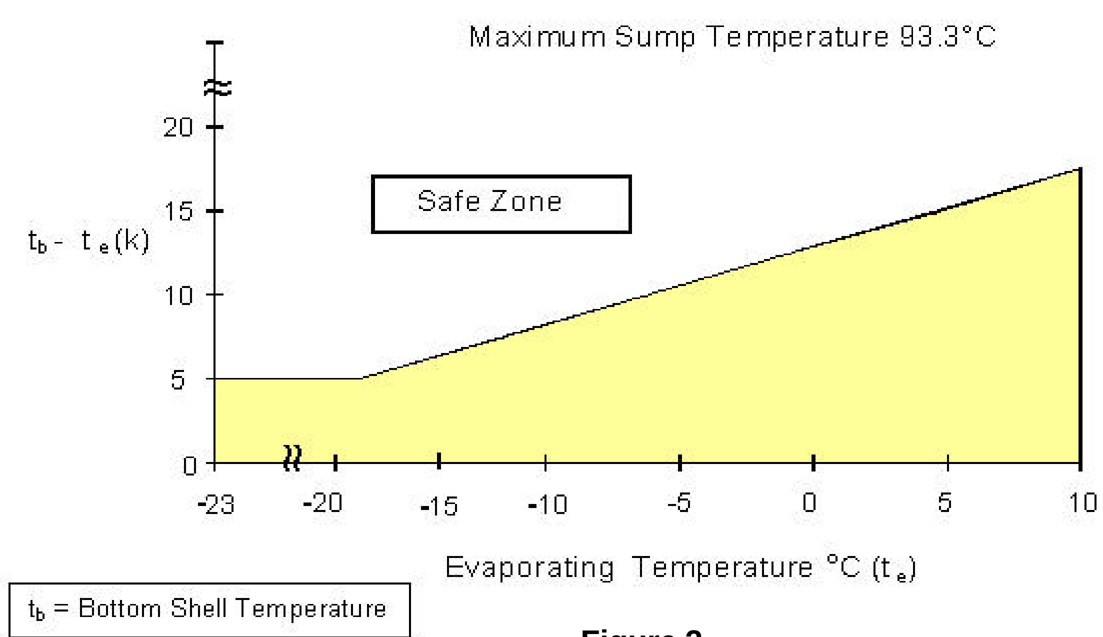


Figure 2

To prevent flooded start damage on 3 phase Scrolls due to off cycle migration, the accumulator may be configured on some systems to allow free drainage from the compressor to the accumulator during the off cycle. When the above configuration is not possible (see **figure 3** below), a crankcase heater is required.

4.3 Reversing Valves

Since Compliant Scroll compressors have very high volumetric efficiency, their displacements are lower than for comparable capacity reciprocating compressors. As a result, Copeland recommends that the capacity rating on reversing valves be no more than 1.5 to 2 times the nominal capacity of the compressor in order to ensure proper operation of the reversing valve under all operating conditions.

The reversing valve solenoid should be wired so that the valve does not reverse when the system is shut off by the operating thermostat in the heating or cooling mode. If the valve is allowed to reverse at system shut off suction and discharge pressures are reversed to the compressor. This results in a condition of system pressures equalising through the compressor which can cause the compressor to slowly rotate until the pressures equalise. This condition does not affect compressor durability but can cause unexpected sound after the compressor is turned off.

4.4 Discharge Termperature Protection

The internal discharge gas over temperature protection for the Quantem and Quest ZP and ZR compressor is a thermo-disc that opens a gas passage from the discharge port to the suction side near the motor protector when the discharged gas reaches a temperature of 146°C. The hot gas then causes the motor protector to trip shutting down the compressor.

4.5 Standard Motor Protection

Conventional inherent internal line break motor protection is provided.

4.6 Lubrication

The “ZP” compressors arrive with polyolester (POE) oil 32MMMPOE (3MA). To top up the oil in the field use Mobil Arctic EAL22CC or Emkarate RL32CF. See nameplate for original oil charge shown in litres, a field recharge is from 0,05 to 0,1 litres less. POE oil absorbs moisture much quicker and to a greater degree than standard mineral oil. The compressor must not be left open longer than 15 minutes during replacement. During installation the system must be swept with an inert gas such as nitrogen to keep moisture from entering the compressor and prevent the formation of oxides.

4.7 Filter Drier

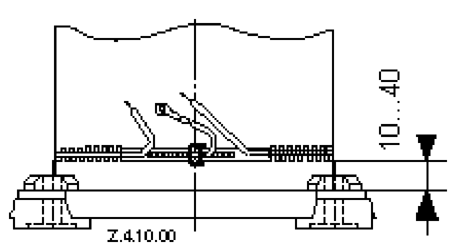
The use of a filter drier is required on all systems using POE oil. After a burn-out a 100% Activated Alumina filter drier may be used in the suction line for acid clean up, but the filter must be removed after 72 hours.

4.8 Mufflers

Refrigerant flow through scroll compressors is almost continuous and has relatively low pulsations. External mufflers where they are normally applied to piston compressors today may not be required for scroll because of variability between systems. However, individual system tests should be performed to verify acceptability of sound performance especially with reversible heat pumps. When no testing is performed mufflers are recommended with reversible heat pumps.

4.9 Low Ambient Cut-Out

Low ambient cut-outs are not required to limit heat pump operation.



Crankcase Heater Location

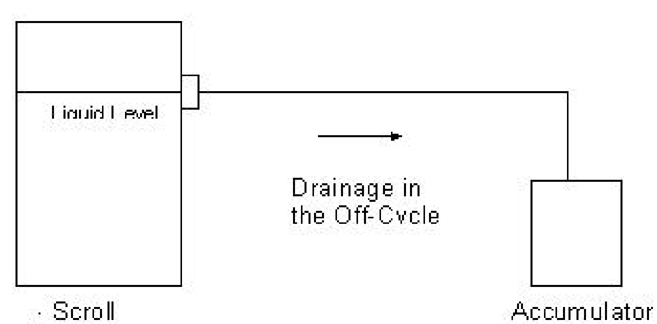


Figure 3

4.10 Pressure Controls

ZP Compliant Scroll Compressors have internal pressure relief valves that open at a discharge to suction differential pressure of 38 to 43 bar.

4.11 Shut-Off

A low mass, disc type, check valve in the discharge tube of the compressor prevents the discharge gas from equalizing back through the scroll. This valve is not designed to be used for pump down because its higher leak rate may cause the compressor to recycle too often.
The "ZP" scroll compressors incorporate a device which prevents reverse rotation and eliminates the shut-off noise associated with earlier scrolls. Since the scroll cannot reverse, it may take two minutes for the high pressure gas trapped in the dome of the compressor to bleed down before the compressor can restart.

4.12 Deep Vacuum Operation

"ZP" scrolls incorporate internal low vacuum protection, the floating seal unloads when the pressure ratio exceeds approximately 10:1. Compliant Scroll compressors should never be used to evacuate a refrigeration or air conditioning system.

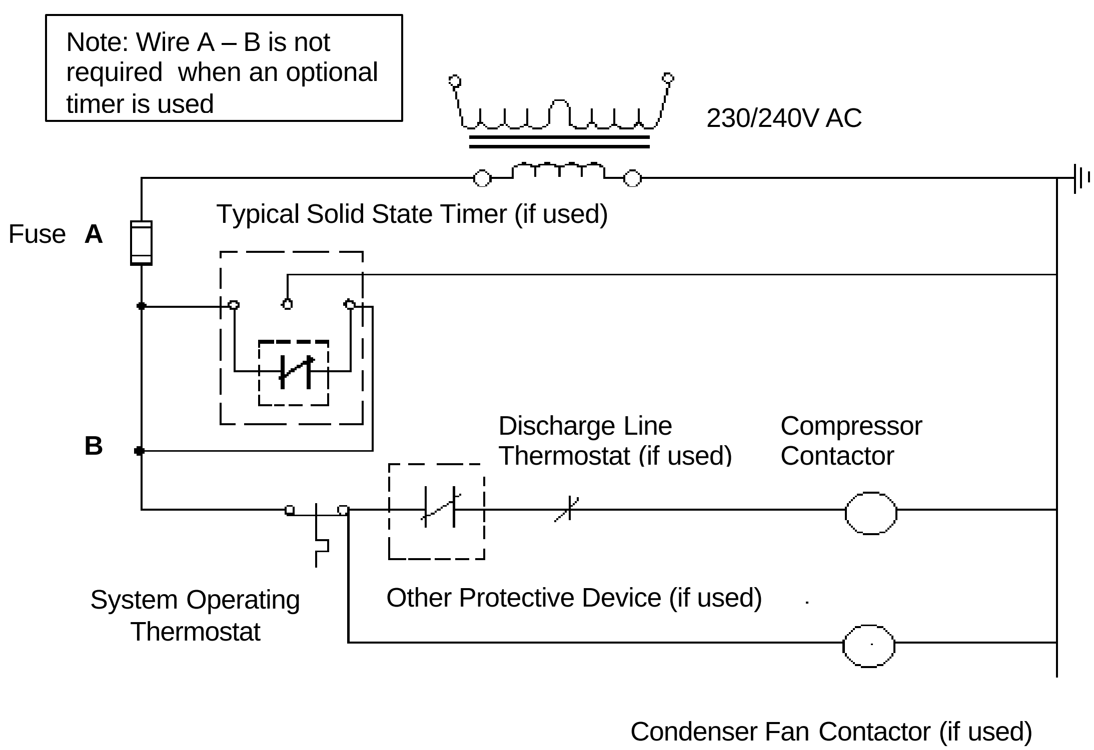
4.13 Brief Power Interruptions

Time delay is not required on three phase models to prevent reverse rotation due to power interruptions. Single phase "ZP" scroll compressor incorporate a clutch that prevents backward rotation. Because of this device a time delay is no longer required on this model, however the scroll will stall and trip on protector during a brief power interruption. Should a time delay be used see figure 4 for specification.

5 Electrical Installation

5.1 Single Phase Models

Start assist devices are not required even if a system utilizes non-bleed expansion valves. Due to the inherent design of the Compliant Scroll the internal compression components always start unloaded even if system pressures are not balanced. In addition since internal compressor pressures are always balanced at startup low voltage starting characteristics are excellent for



Timer Delay Relay Specifications:

Figure 4

Timer Opens; 1 Electrical cycle (0.013 sec with 50 Hz operation) after power is removed.
Timer Closes; 5 Minutes (±20%) later whether the power is restored or not.

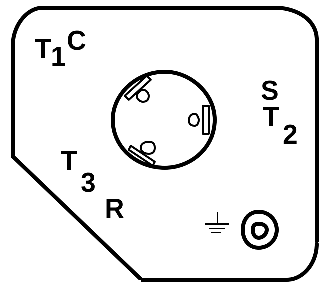
Compliant Scroll compressors. “ZP” Scrolls require two minutes off time to restart after shut-off to allow for internal equalization of pressure. (See paragraph on “Shut-off Sound” and “Brief Power Interruptions” for explanation)

5.2 Three Phase Models

Scroll 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. 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 system is installed and operated. When the compressor is started the correct direction of rotation can be confirmed by observing that the suction pressure falls and the discharge pressure rises. Reverse rotation results in an elevated sound level as well as substantially reduced current draw compared to tabulated values. There is no negative impact on durability caused by operating three phase Compliant Scroll compressors in the reversed direction for a short period of time. However, after several minutes of operation the compressor’s internal protector will trip. Reverse operation for over one hour may have a negative impact on the bearings.
All three phase scroll 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 Fusite terminals should maintain proper rotation direction.

5.3 Fusite

The orientation of the pins on the Fusite for Compliant Scroll compressors is shown below and is also shown inside the terminal box.



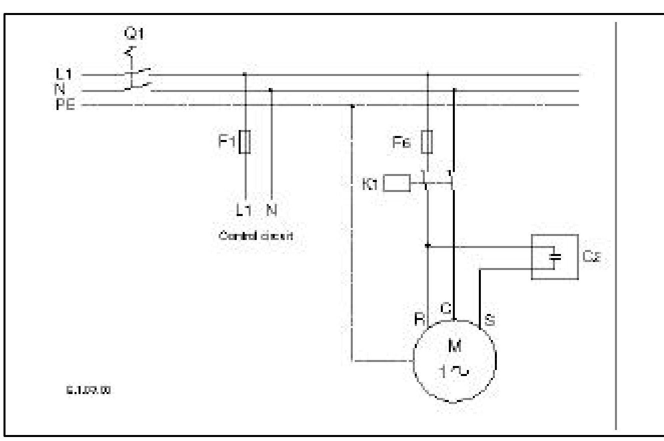
Motor Terminal (Fusite) Connections

6. Compressor and System Tests

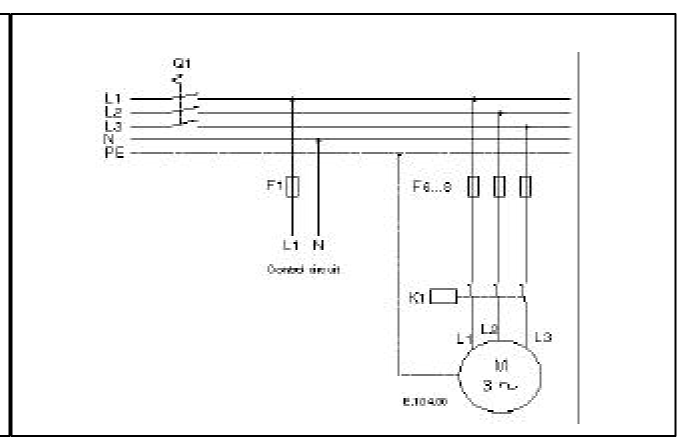
6.1 Compressor Functional Check

Since Compliant Scroll compressors do not have internal suction valves or dynamic discharge valves which can be damaged it is not necessary to perform functional compressor tests where the compressor is turned on with the suction service valve closed to check how low the compressor will pull down the suction pressure. This type of test may actually damage a Compliant Scroll compressor (also other types of compressors).
The following diagnostic procedure should be used to evaluate whether a Compliant Scroll compressor is functioning properly.

1. The correct voltage to the unit should be verified.
2. The normal checks of motor winding continuity and short to ground should be made to determine if the inherent overload motor protector has opened or if an internal short to ground has



Power Circuit Single-Phase



Power Circuit Three-Phase

developed. If the protector has opened the compressor must be allowed to cool sufficiently to allow it to reset.

3. Proper indoor and outdoor fan operation should be verified.
4. 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.

5a Single Phase Compressors
If the suction pressure does not drop and discharge pressure does not rise to normal levels either the reversing valve (if so equipped) or the compressor is faulty. Use normal diagnostic procedures to check operation of the reversing valve.

5b Three Phase Compressors
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 the compressor was not wired to run in reverse direction. If pressures still do not move to normal values either the reversing valve (if so equipped) or the compressor is faulty. Reconnect the compressor leads as originally configured and use normal diagnostic procedures to check operation of the reversing valve.

6. If the reversing valve (if so equipped) functions correctly then the compressor current drawn must be compared to published compressor performance curves at the compressor operating conditions (pressures and voltages). Significant deviations (±15%) from published values may indicate a faulty compressor.

6.2 Excessive Liquid Floodback

The following tests are for those system configurations and charge levels identified in **Table 1** where special testing is needed to eliminate the use of an accumulator.

6.2.1 Continuous Floodback

To test for excessive continuous liquid refrigerant floodback it is necessary to operate the system in a test room at conditions where steady state floodback may occur (low ambient heating operation).
Thermo-couples should be attached to the suction and discharge lines (approximately 15 cm from the shell) as well as the sump (middle of the bottom) of the compressor and insulated. If the system is designed to be field charged it should be overcharged by 15% in this test to simulate overcharging commonly found in field installations.
The system should be operated at an indoor temperature of 21°C and outdoor temperature extremes (-18°C or lower) in heating mode which produces floodback conditions. The compressor suction and discharge pressures and temperatures should be recorded. The system should be allowed to frost up for several hours (disabling the defrost control and spraying water on the outdoor coil may be necessary) to cause the saturated suction temperature to fall to –30°C or below. The compressor sump temperature must remain above saturated suction temperature as shown in **Figure 2** or design changes must be made to reduce the amount of floodback.

6.2.2 Repeated Floodback

To test for repeated excessive liquid floodback during normal system off-cycles perform the "Field Application Test". Obtain a sample compressor with a sight tube to measure liquid level in the compressor. Set the system up in a configuration with the indoor unit elevated several metres above the outdoor unit with 8m of connecting tubing and no traps between the indoor and outdoor units. If the system is designed to be field charged, the system should be overcharged by 15% in this test to simulate overcharging commonly found in field installations. Operate the system in the cooling mode at the outdoor ambient, on/off cycle times, and number of cycles specified in **Table 2**. Record the height of the liquid in the compressor at the start of each on cycle, any protector trips, or any compressor stalls during each test.
After the last test if no oil shows in the sight tube continue running the compressor then monitor the time until the first oil reappears. Review the results with Copeland Application Engineering to determine if an accumulator is required or changes need to be made to the system.

Table 2
Field Application Test

Operate the system as it would be operated in an actual field installation cycling the unit on and off for the times indicated at each ambient, for the number of cycles stated.

Outdoor Ambient (°C)	30	35	40
System On-Time (Minutes)	7	14	54
System Off-Time (Minutes)	13	8	6
Number of On/Off Cycles	5	5	4

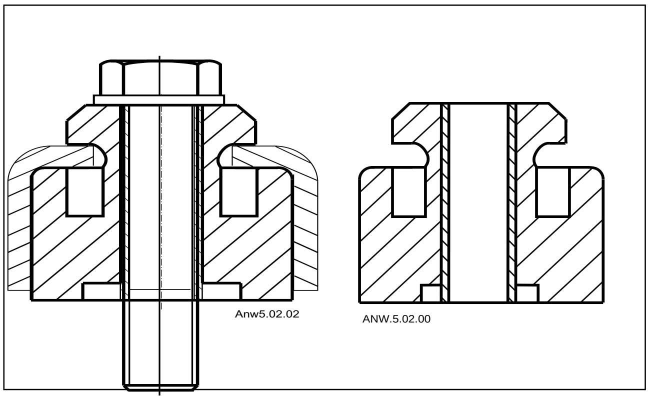
6.3 Hipot Testing

Compliant Scroll compressors are configured with the motor below the compressor. As a result when liquid refrigerant is within the shell the motor can be immersed in refrigerant to a greater extent than within hermetic reciprocating compressors. In this respect the scroll is more like semi-hermetic compressors (which have horizontal motors partially submerged in oil and refrigerant). When

Compliant Scroll compressors are Hipot tested and liquid refrigerant is in the shell they can show higher levels of leakage current than compressors with the motor on top. However this phenomenon can occur with any compressor when the motor is immersed in refrigerant. The level of current leakage does 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.

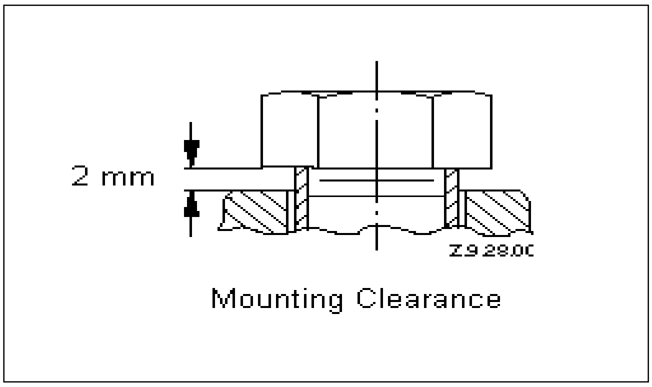
7. Installation

Four vibration absorber grommets are supplied with each compressor (see diagram **Mounting Parts** below). They dampen the start-up surge of the compressor and to a large extent prevent sound and vibration from being transmitted to the compressor base during operation. The metal sleeve inside 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. It's inner diameter is approximately 8.5 mm to fit e.g. an M8 screw. The mounting torque should be 13 + 1Nm. It is critically important that the grommet is not compressed. A clearance space of approximately 2mm between the bottom of the washer and the top of the grommet spacer is recommended. (diagram **"Mounting Clearance".)**



Mounting Parts

ZP23K3 - ZP54K3 Ident No. 800 08 02

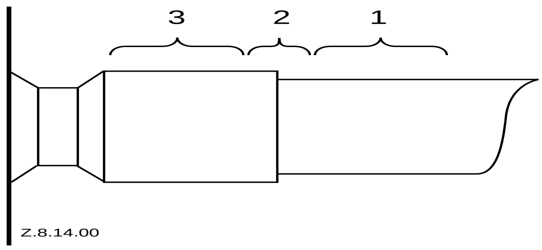


7.1 Service

Compliant Scroll compressors have copper plated steel suction tubes. These tubes are far more rugged and less prone to leaks than copper tubes used on other compressors. Due to the different thermal properties of steel and copper, brazing procedures may have to be changed from those commonly used. See **Figure 5** and **New Installations** for field brazing procedures.

7.1.1 New Installations

- The copper-coated steel suction tube on scroll compressors can be brazed in the same manner as any copper tube.



Suction Tube Brazing

Figure 5

- Recommended brazing materials: A copper/ phosphorous or copper/phosphorous/silver alloy rod should be used for joining copper to copper whereas to join dissimilar or ferric metals a silver alloy rod either flux coated or with a separate flux would be used.
- Clean the suction tube fitting I.D. and suction tube O.D. prior to assembly.
- Using a double-tipped torch apply heat in area 1. As tube approaches brazing temperature, move torch flame to area 2.
- Heat area 2 until braze temperature is attained, moving torch up and down and rotating around tube as necessary to heat tube evenly. Apply the solder to the joint while moving the torch around the joint to allow the fluid flow of the solder around the circumference.
- After the solder flows around the joint, move torch to heat area 3. This will draw the solder material down into the joint (capillary action). The time spent heating area 3 should be minimal.
- As with any brazed joint, overheating may be detrimental to the final result.

Note: During installation whilst brazing, the system should be swept with an inert gas such as oxygen free nitrogen at a very low pressure to prevent the formation of oxidation within the pipework and fittings.

7.1.2 Field Service

To disconnect:

- Heat joint areas 2 and 3 slowly and uniformly until solder softens and tube can be pulled out of the suction fitting.

To reconnect:

- Recommended brazing materials: A copper/ phosphorous or copper/phosphorous/silver alloy rod should be used for joining copper to copper whereas to join dissimilar or ferric metals a silver alloy rod either flux coated or with a separate flux would be used.
- Re-insert tube into fitting.
- Heat tube uniformly in area 1, moving slowly to area 2. When joint reaches brazing temperature, apply solder.
- Heat joint uniformly around the circumference to allow the solder to flow completely around the joint.
- Slowly move torch into area 3 to draw solder into the joint. Do not overheat.

Note: During installation whilst brazing, the system should be swept with an inert gas such as oxygen free nitrogen at a very low pressure to prevent the formation of oxidation within the pipework and fittings.

7.2 Shut-Off Valves and Adaptors

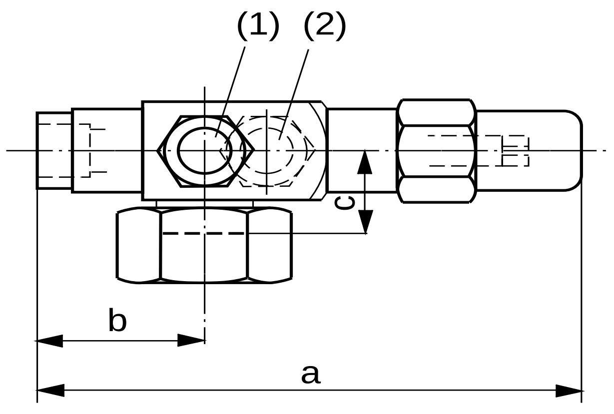
The Scroll compressors can be delivered with brazing connections to Rotalock (see below).

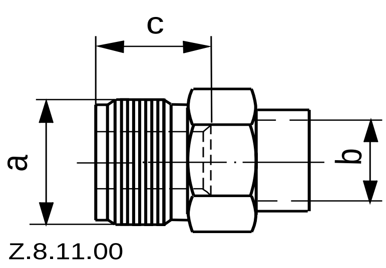
8 Shell Temperature

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 in contact with the shell.

9 System Charging Procedure

Rapid charging only on the suction side of a scroll equipped system or condensing unit can occasionally result in a temporary no start condition for the compressor. The reason for this is that if the flanks of the compressor happen to be in a sealed position rapid pressurization of the low side without opposing high side pressure can cause the scrolls to seal axially. As a result until the pressures eventually equalize the scrolls 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 scrolls. The maximum charging rate can be determined through simple tests.





(1) Pressure control connection
(2) Gauge connection

Straight Adaptor Brazing to Rotalock

	Model	Threaded stub	Tube size	Dimensions a	Dimensions b	Dimensions c	Ident No. Shut-Off Valve	Ident No. Seal
Discharge Valve	ZP23K - ZP54K	1" x 14	5/8" (16 mm)	107.5	37.0	20.0	285 23 65	249 59 28
Suction Valve	ZP23K - ZP54K	1 1/4" x 12	7/8" (22 mm)	132.0	42.0	27.0	706 77 24	249 59 39

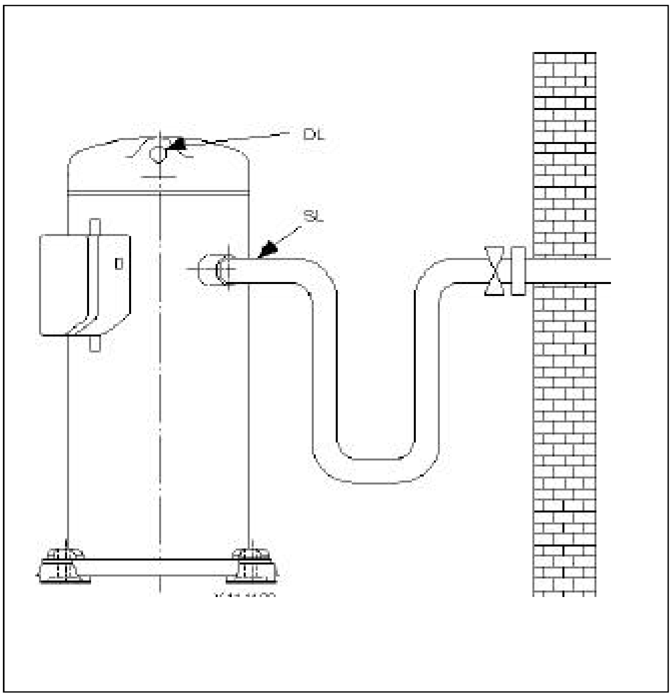
Straight Adaptor Brazing to Rotalock	Model	Dimensions a	Dimensions b	Dimensions c	Ident No. Adaptor	Ident No. Seal
Discharge Valve	ZP23K - ZP54K	1" x 14	1/2" (13 mm)		802 68 99	249 59 28
Suction Valve	ZP23K - ZP54K	1 1/4" x 12	3/4" (19 mm)	24	801 43 58	249 59 39

10 Unbrazing System Components

If the refrigerant charge is removed from a scroll 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 pressurised. 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. To prevent this occurrence it is important to check for pressure on both the high and low side with manifold gauges before applying heat, or in the case of repairing a unit on an assembly line remove refrigerant from both the high and low side. Instructions should be provided in appropriate product literature and assembly (line repair) areas.

11 Suction Line Noise and Vibration

Copeland Compliant 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. 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 that can be detected as noise coming along the suction line into the housing 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 configurations described below. A second difference of the Compliant Scroll is that under some conditions the normal rotational starting motion of the compressor can transmit an ‘impact’ noise along the suction line. It may be particularly pronounced in three phase models due to their inherently higher starting torque.This phenomenon, like the one described previously also results from the lack of internal suspension and can be easily avoided by using standard suction line isolation techniques as described below.



Suction Tube Design

Recommended Configuration

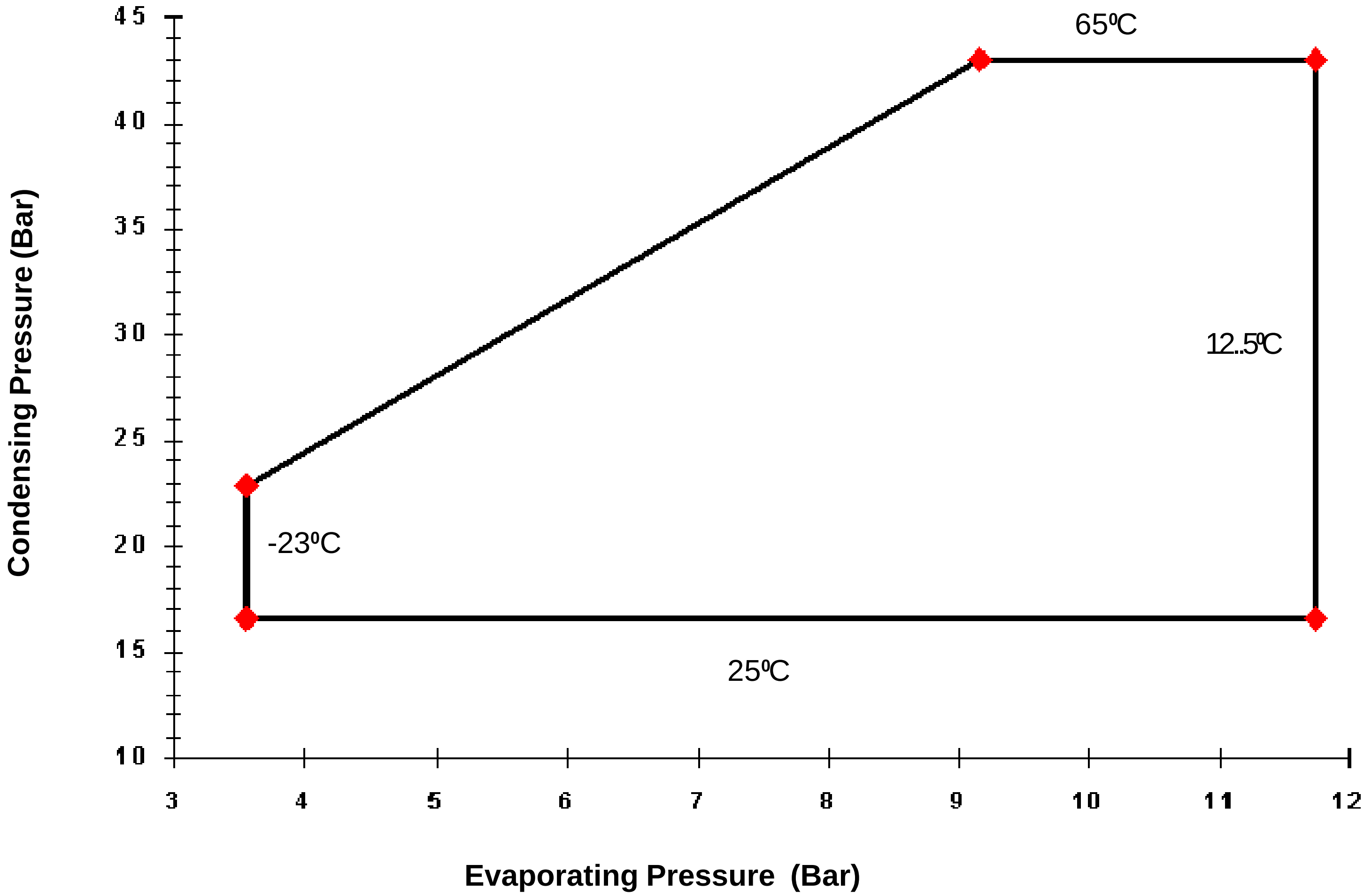
- Tubing Configuration: small shock loop
- Service Valve: “angled valve” fastened to unit/wall
- Suction muffler: not required

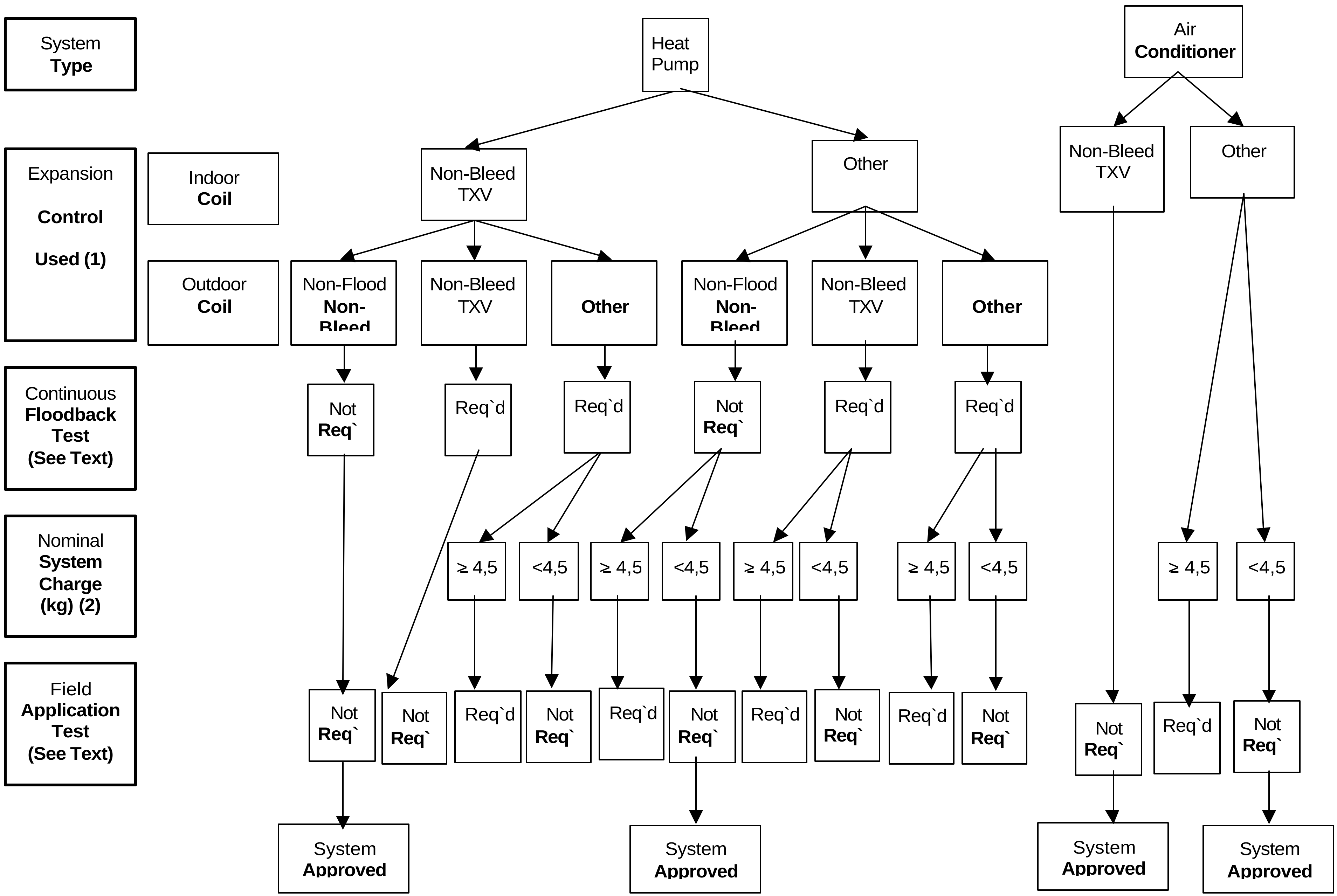
Alternate Configuration

- Tubing Configuration: small shock loop
- Service Valve: “straight through” valve fastened to unit/wall
- Suction muffler may be required (acts as dampening mass)

The sound phenomena described above are not usually associated with reversible heat pump systems because of the isolation and attenuation provided by the reversing valve and tubing bends.

12 Application Envelope





(1) Other includes bleed-type TXV's, capillary tubes, and fixed orifices
(2) „Nominal System Charge" is defined as the design charge for a system (consisting of an indoor , outdoor unit & connecting tubing) with 25 m connection lines.
(3) An allowance has been incorporated into this value to account for long lines (up to 40 m) and system overcharging as is commonly found in field installations.