Horizontal Scroll Compressors Application Manual

Sonyo Compressor (Dalian) Co., Ltd.

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Safety Instructions

The scroll compressor meets strict safety and operating standards. As the installer or service person, it is an important part of your job to read this instruction carefully before beginning.

	ELECTRICAL SHOCK HAZARD	**●Make sure the unit utilize grounded connection.** **●Disconnect all input power before servicing.** **●Install the cover of terminal box before energized.**
	EXPLOSION OR FIRE HAZARD	**●Remove the refrigerant before brazing operation.** **●Do not compress air or energize the compressor under vacuumed condition.** **●Use only approved refrigerants and refrigeration oil.**
	PERSONAL INJURY	**● Personal safety equipment must be used.**
	BURN HAZARD	**●Do not touch the compressor when it is running or stopping until it has cooled down.**

The detailed safety request in <Safety Request on the Use of Compressor> must be followed.

1.0 Structure and Operating Characteristics

1.1 Key Components

The C-SW series scroll compressors are horizontal type hermetic compressors and designed for mobile air conditioning applications.

The pressure inside of shell is high pressure (discharge pressure). Suction refrigerant gas enters into compression chamber directly and the motor is cooled by discharge gas. The motor is rigidly attached to the shell; Crankshaft is supported by main frame and sub-frame which are welded to the shell. Pump assembly consists of fixed scroll and orbiting scroll and Oldham ring. Orbiting scroll rotates on the surface of the main frame.

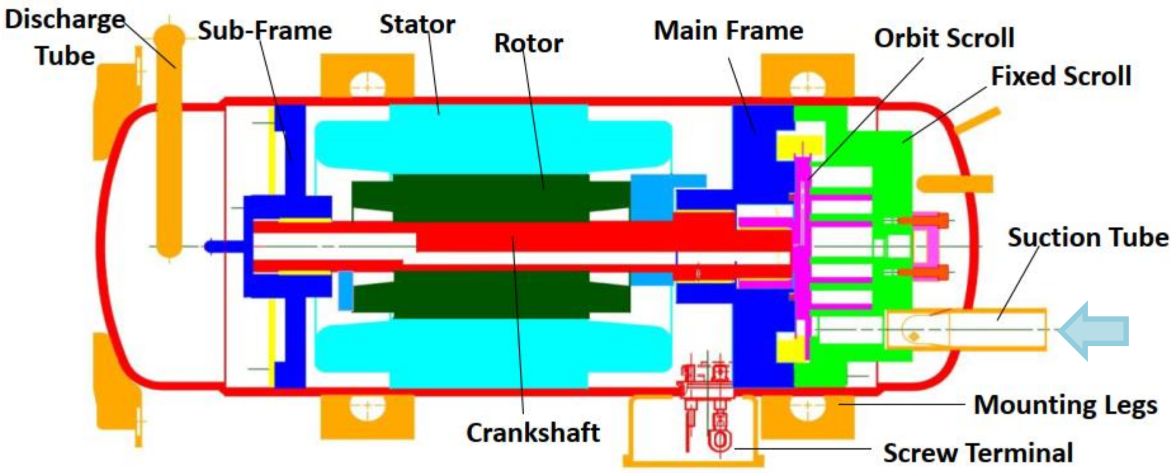


Figure 1-1 Horizontal Scroll Compressor Components

See a cutaway view of C-SW series compressor in Figure1-1.

1.2 Scroll Compressor Operating Characteristics

The C-SW series scroll compressors are designed with fixed eccentric and floating orbit scroll sealing, resulting in low sound level and minimal gas leakage and therefore excellent efficiency.

The Figure 1-2 below describes the scroll compression process:

First orbit; SUCTION gas enters at the perimeter of the scroll elements and is sealed as the scrolls rotate approximately one revolution.

Second orbit; During the COMPRESSION process, the gas is further compressed towards the center of the scroll elements to an intermediate pressure.

Third orbit; In the DISCHARGE orbit, the gas is further compressed to discharge pressure and then exits at the center through the discharge port.

With a three step simultaneous process of suction, compression and discharge and two gas pockets in each step that are 180 degrees apart, the compression process is balanced and very smooth, resulting in high efficiency, low sound/vibration and excellent reliability.

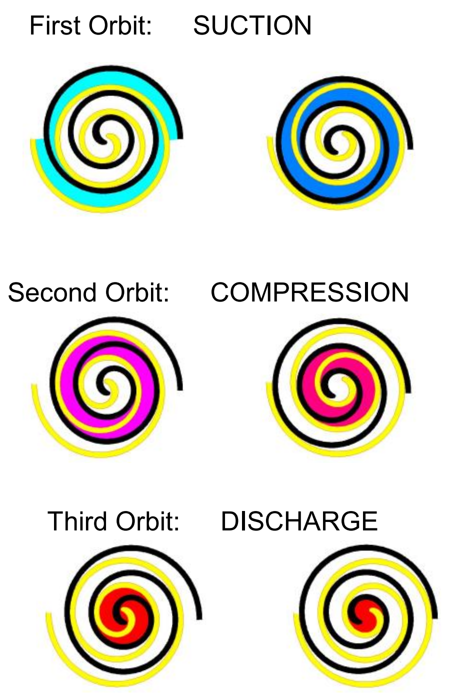


Figure 1-2 Compression Process

1.3 Compressor Design Pressure

The compressor's design pressure is shown in Table 1-1. The operating pressure in the system shall be lower than compressor design pressure.

Table 1-1 Compressor Design Pressure

Refrigerant	High Pressure Side MPa(G)/psig
R407C/R134a/R513A	3.3/479
R410A	4.15/602

1.4 Refrigerant Oil

To improve the reliability, the specified designed premium quality refrigerant oil is used in the compressor. The refrigerant oil containing foam suppressor has the excellent thermal stability and high durability for overload conditions.

1.4.1 Oil Type

Each type of refrigerant oil is specially designed for certain types of refrigerant and operating conditions, if additional oil charge is added in the field, Only specified oil should be used.

Table 1-2 Type of Oil

Refrigerant	R407C	R410A	R134a	R513A
Oil Model	FV68S			
Oil Type	Polyvinyl Ether（PVE）			

1.4.2 Functions of Refrigerant Oil

1) Lubricate the moving parts to reduce mechanical friction.

2) Absorb the heat generated by mechanical friction.
3) Prevent refrigerant leakage at sealing surface.
4) Rust proof.

1.5 Compressor Models and Motor Type

The C-SW series horizontal scroll compressors are designed for variable speed operation. A three phase, Induction type motor or a brushless permanent magnet motor is applied in this series.

The inverter compressor shall only be connected to specific inverter driver produced for this compressor. Voltage applied to the compressor terminal shall be within the range mentioned in the compressor specification.

Additionally, AC power voltage (1φ100V,200V,220V,3φ200V,380V etc.) shall never be supplied to the compressor terminal of DC Inverter models as the DC brushless motor in the compressor will be demagnetized.

The model list and motor type are shown in Table 1-3.

Table 1-3 Compressor Models and Motor Type

AC Inverter COMPRESSOR (with Induction motor)						ARI Condition			
Ref.	HP	New Model	Former model	Disp. cm3/rev	Input Voltage	Capacity kW 60rps	Capacity kW 90rps	IP Rating	Comment
R407C	5	4CW056MA01	C-SWS180H01C	55.7	200V	12.9	18.0	IP67	Annular legs
	7	4CW074NA01	C-SWS225H00C	74.4	400V	16.5	23.0	IP67	Annular legs
	7	4CW074MA01	C-SWS225H01C	74.4	200V	16.5	23.0	IP67	Annular legs
	7	4CW074MA11	C-SWS225H01F	74.4	200V	16.5	23.0	IP67	Annular legs big hole spacing
	10	T-SWS110H00A	——	110.0	400V	24.2	33.5	IP67	

Remarks: R407C models are applicable to R134a and R513A.

DC Inverter COMPRESSOR (with BLDC motor)						ARI Condition			
Ref.	HP	New Model	Former model	Disp. cm3/rev	Input Voltage	Capacity kW 60rps	Capacity kW 90rps	IP Rating	Comment
R410A	6	5CW042ZA11	——	42.3	400V	13.9	20.5	IP67	4 Poles Motor Annular legs
	10	5CW067ZA01	C-SWP330H02C	66.8	400V	22.1	33.2	IP67	4 Poles Motor Annular legs
	10	5CW067ZB01	——	66.8	400V	22.4	33.6	IP67	6 Poles Motor
	11	5CW073ZA02	——	73.4	400V	24.3	36.0	IP67	6 Poles Motor EVI
	12	5CW081ZA01	——	80.5	400V	26.0	40.0	IP67	6 Poles Motor

2.0 Refrigerating Circuit Design Considerations

2.1 Condensing Pressure and Evaporating Pressure

The recommended condensing pressure and evaporating pressure for R407C systems at standard conditions are shown in the table 2-1:

Table 2-1 Recommended condensing and evaporating pressure

Pressure	Cooling
High side MPa(G)	1.85~1.90
Low side MPa(G)	0.45~0.5

It is necessary to adjust the system if the high side pressure or low side pressure has relatively large deviation from the recommended pressure. Some reasons are listed in Table 2-2 for pressure deviation.

Table 2-2 Reasons of pressure deviation

Item		Low Side Pressure		
		Lower	Middle	Higher
High Side Pressure	Higher	<a>	--	<c>
	Same	--	OK	--
	Lower	<d>	--	<b>

Note: Higher: The tested pressure is higher than recommended pressure.
Lower: The tested pressure is lower than recommended pressure.
Same:The tested pressure is approximately same as recommended pressure.

<a> Too big of compressor size

<b> Too small of compressor size

<c> Too high of dry bulb temperature in the condenser side
Excessive refrigerant has charged in the system
Uneven refrigerant distribution in the circuits of condenser
Too low rotation speed of condenser fan

<d> Too low wet bulb temperature in the evaporator side
Uneven refrigerant distribution in the circuits of evaporator
Too low rotation speed of evaporator fan
Lack of refrigerant charge in the system
Too big superheating degree caused by improper size expansive valve or capillary

2.2 Suction Temperature

The suction temperature shall be higher than evaporator outlet temperature. (If there is a specific description in the compressor specification regarding to superheat, follow the contents.)

In order to prevent compressor from flooded back operation, a minimum suction superheating degree of 5K [10F] should always be maintained.

It is necessary to keep the proper superheating degree since too high superheating will cause the high discharge temperature and the decrease of refrigerant mass flow rate.

2.3 Discharge Temperature

The C-SW series compressor is with high pressure shell structure. Motor is cooled down by discharge gas. The discharge temperature shall be controlled lower than the limitation in the compressor specification.

The recommended discharge temperature is not higher than 95℃ under standard conditions. And under overload condition, shall not exceed 115℃. Discharge temperature is measured in the copper pipe on the end cap of compressor.

2.4 Sub Cooling Degree

The sufficient sub cooling degree can not only increase the cooling and heating capacity but also can keep the inlet of expansion valve or capillary full of liquid state refrigerant.

On the contrary, the insufficient sub cooling will cause flash gas occurring at the inlet of expansion valve, which will result in capacity reduction and increasing vibration, noise.

2.5 Liquid refrigerant flood back

Liquid refrigerant flood back can cause great influence to the reliability of compressor. When liquid compression, knocking noise, current surge, or undesirable vibration etc. occurs, implement the following countermeasures to prevent liquid refrigerant flood back.

1) Add suction accumulator
2) Decrease refrigerant charge amount
3) Change the operation mode
4) Install an internal heat exchanger.

Observe with the compressor with sight glasses supplied by Sonyo Compressor, and consult your account representative for the result.

2.6 Suction Accumulator

A suction accumulator is necessary to prevent the uncontrolled liquid flooding back.

The proper size suction accumulator can:
1) Prevent liquid refrigerant migrating to compressor
2) Prevent liquid refrigerant being sucked into compressor.

The suction accumulator used in the system should at least meet the requirements as follow:
1) The size of the accumulator must be greater than 60% total refrigerant volume.
2) To ensure well oil return, a Φ1.5~2.3 mm orifice is necessary in the suction accumulator.
3) Filter mesh must be used to prevent orifice being blocked when orifice is smaller than Φ2.0 mm

See a cutaway view of suction accumulator in Figure2-1

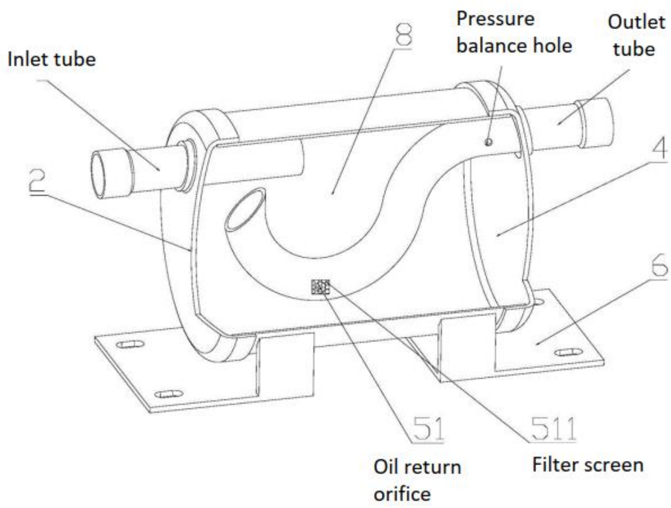


Figure 2-1 Suction Accumulator

2.7 Discharge Line Check Valve

Compared with vertical type compressor, the motor of horizontal type compressor is more inclined to be immersed by refrigerant, which will result in lower insulation resistance value and higher leakage current readings. This is not a safety issue and the insulation resistance value will be back to normal after a short period operation to redistribute the refrigerant through the system.

In order to prevent refrigerant migration to compressor during off cycle, a check valve should be installed in discharge line. The leak rate of check valve should be qualified by testing.

2.8 Suction Line Strainer

To prevent foreign particles coming in the compressor inside, it shall install the strainer with screen on the way to suction line piping. The strainer shall be more than 30mm in diameter and a screen mesh size of 100. In case that the suction line has an accumulator with screen, the strainer will not be required.

2.9 Dryer

A suitable sized filter dryer should be used to ensure the low degree residual moisture level in the refrigerating circuit, the molecular sieves type is recommended.

2.10 Oil separator

An oil separator is recommended to separate a major part of oil from compressor discharge gas and return it directly to compressor crankcase. The functions of oil separator including:

1) Improve the oil management and reliability of compressor;
2) For inverter compressors, the oil flow rate increases when rotation speed is high, more oil leaving compressor and lower the efficiency of heat exchanger, which will result in lower cooling capacity of system. In this case the use of oil separator will give a notable improvement for system performance；
3) The horizontal scroll compressors are designed with high pressure shell, the oil return pipe should go through capillary tube and connect with suction tube (before the suction accumulator) ；
4) A centrifugal type oil separator is recommended which has a stable oil separation rate in variable refrigerant flow rate conditions.

2.11 System Charge Limit

The proper system charge can keep the system parameters in the normal level, such as cooling and heating capacity, sub cooling degree, suction and discharge temperature, compressor's sump temperature, etc.

The refrigerant charge and refrigerant oil in the system should keep the ratio as follow:

Oil (kg)/ Refrigerant (kg)⩾0.35

Note: Specific gravity of the Oil using in R407C/R410A/R134a series compressors is 0.94

If oil/refrigerant ratio is lower than 0.35, it will cause dilution of oil and lack of lubrication inside of compressor.

So please inform us before the system being tested under 0.35>oil(kg)/refrigerant (kg) ⩾0.3 condition, some detailed advices will be given about oil level in compressor .

As a general requirement, oil (kg)/refrigerant (kg) >0.3 shall be kept.

2.12 Oil level of the compressor

The minimum oil level in the compressor shall comply with the requirements of the compressor specification to ensure the compressor reliability. When the oil is foamed, do not consider the foaming portion as oil level.

Low oil level will cause lack of lubrication to rotating parts and seriously affect the compressor reliability. Observe the oil level with the compressor with sight glass supplied by Sonyo Compressor, and consult your account representative for the result.

<<Example showed the oil level to keep>>

- level A : the lowest oil level during transition operation; (Distance to the Bottom 10mm)
- level B : the lowest oil level during stable operation; (Distance to the Bottom 38mm)
- level C : the highest oil level during stable operation; (Distance to the Top 15mm)

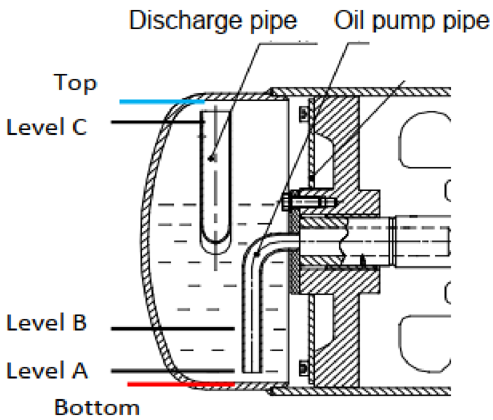


Figure 2-2

2.13 Operating Envelope

The operating envelopes of inverter compressors depend on the running speed. The envelope limitations are varied for different speed range, which are defined by mainly considering the limits of discharge temperature, compression ratio, lubrication and power limitation.

The operation of compressor shall be under the Operation Envelope that described in the compressor specification at all conditions. However, when operating conditions exceed the range described in the specification during transitional period such as during start up and defrosting, it may be judged by testing or checking the operating data.

2.14 Pipe surface stress

The stress of pipes connecting the compressor and other parts of the refrigeration systems, shall not be more than 12.26MPa when the compressor is operating, and shall not be more than 34.32MPa during 'start - stop'.

2.15 Allowable incline

The allowable incline shall not be more than 10°during operation.

2.16 Vibration

Since C-SW series compressors are designed with high back pressure shell, the oil level inside of crankcase is more stable during operation. The installation direction of the compressor could be perpendicular or parallel to the running direction of the vehicle.

Initial operation test for the system at full range of speed must be conducted to prevent vibration transmission into any lines attached to the unit.

3.0 Electrical Parts and Controller Design Considerations

3.1 Selection of Electrical Wiring

Voltage drop may occur due to the large current draw during compressor starting. The starting failure will occur if the starting voltage is under the range of compressor specifications. So it is necessary to select the proper size of electrical wire.

3.1.1 Voltage Drop

See Figure 3-1 for the explanation of voltage drop.

a) Set Voltage:
   The voltage applied to compressor terminals before compressor is started.
b) Starting Voltage:
   The voltage applied to compressor terminals when compressor is being started. When compressor is starting, the big starting current will cause the drop of voltage. It will be very hard to start compressor if the starting voltage is too low.
c) Running Voltage:
   The line voltage applied to compressor terminals when compressor is running stably. This running voltage is a little lower than set voltage.

   The big voltage drop happens in compressor starting process, it will cause the failure of starting if the starting voltage is lower than 85% of rated voltage.

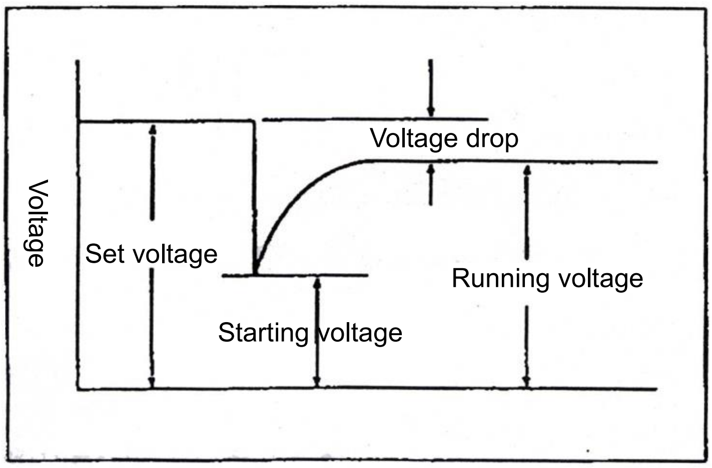


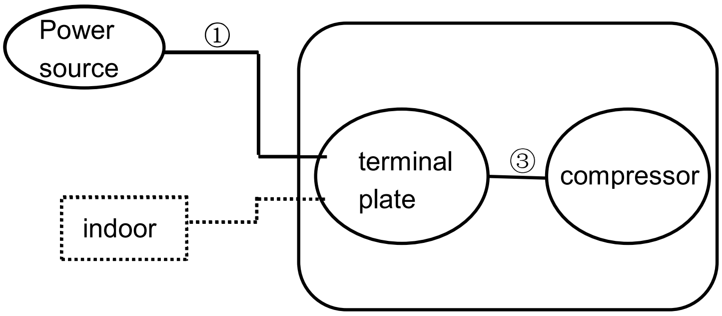
Figure 3-1 Voltage Drop During Compressor Starting

3.1.2 Selection of Electrical Wiring

The recommended wiring size is shown in the table 3-1.

Type of Unit

Window & Commercial Type Unit



Split Type (Separate Type)

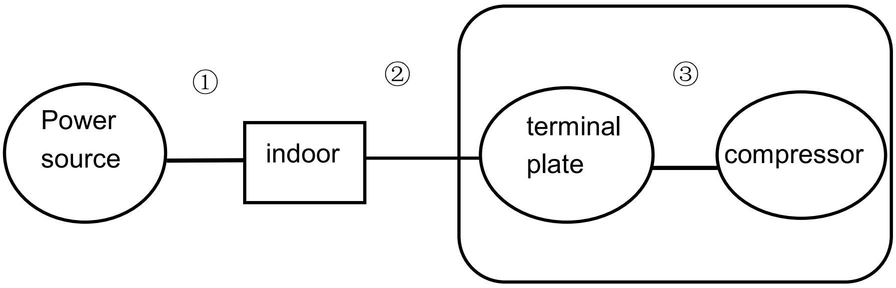


Table 3-1 SELECTION OF ELECTRICAL WIRING

Starting current (A)	Size of electrical wire （mm²）						
	Remark ① or Remark ①+② （heat-resistance Temperature: 60°C[140°F]: min.）						Remark③ （heat-resistance Temperature: 120°C[248°F] min.）
	5m max.	10m max.	15m max.	20m max.	30m max.	50m max.	1m max.
20max.	2.0	2.0	2.0	3.5	5.5	8.0	2.0
30max.	↑	↑	3.5	5.5	↑	14.0	↑
40max.	↑	3.5	5.5	↑	8.0	↑	↑
50max.	↑	↑	↑	8.0	14.0	22.0	↑
60max.	↑	5.5	↑	↑	↑	↑	↑
70max.	3.5	↑	8.0	14.0	↑	↑	3.5
80max.	↑	↑	↑	↑	22.0	30.0	↑
90max.	↑	↑	14.0	↑	↑	↑	↑
100max.	↑	8.0	↑	↑	↑	38.0	↑
110max.	↑	↑	↑	↑	↑	↑	↑
120max.	5.5	↑	↑	22.0	30.0	↑	↑
140max.	↑	14.0	↑	↑	↑	50.0	5.5
160max.	↑	↑	22.0	↑	↑	↑	↑
180max.	↑	↑	↑	↑	38.0	60.0	8.0
200max.	8.0	↑	↑	30.0	↑	↑	↑
220max.	↑	↑	↑	↑	50.0	80.0	↑
240max.	↑	↑	↑	↑	↑	↑	14.0

CAUTION OF GROUNDING:

The internal motor protector cannot protect the compressor against all possible failures.
Please be sure that the system utilizes the grounding connection when is installed in the field.

3.2 Selection of Inverter Driver

The function of inverter driver is to power the compressor, control the compressor running speed, protect compressor from abnormal situations and communicate with master controller.

Make sure to choose a suitable quality inverter driver which have been passing performance test with compressor.

A third-party driver can be used. To get the best system efficiency and reliability, consult your account representative to verify the match of driver setting and BLDC motor parameters.

The following factors should be considered when select a driver:

1) Driver size should match with maximum current of compressor;
2) Driver should have compressor protection functions including discharge temperature protection, over-current protection, reverse phase protection, loss of phase protection etc.
3) Driver should have function to skip some specific frequency range to avoid piping resonance.
4) Frequency limit control
   When the output current of driver increases to close to the over-current protection value, the compressor frequency should be reduced, and the compressor should be restricted from high-frequency operation to avoid frequent fluctuations.
   Compressor smoothly operation depends on a certain voltage input; the higher the speed, the higher the voltage required. During the operation, when the output voltage of the inverter is low, it should reduce the frequency and limit the compressor from high frequency operation to avoid stall and shutdown of compressor.
5) Electromagnetic noise may occur due to inverter characteristics. To adjust carrier frequency can reduce electromagnetic noise level

3.3 Starting and maximum current of compressor

Starting current and maximum current shall be within the range mentioned in the compressor specification. In the case of inverter compressor, if the current is over the limitation, DC brushless motor will be demagnetized and compressor will not be started.

The over current protection must be set on the inverter driver. The protection value setting is subject to compressor's demagnetization current. Once an over current occurs, the driver should shut down the compressor for more than 3minutes from next start up.

3.4 Starting of compressor

In the case of inverter compressor, operation at rather low frequency after starting is necessary to avoid insufficient lubrication due to low oil level.

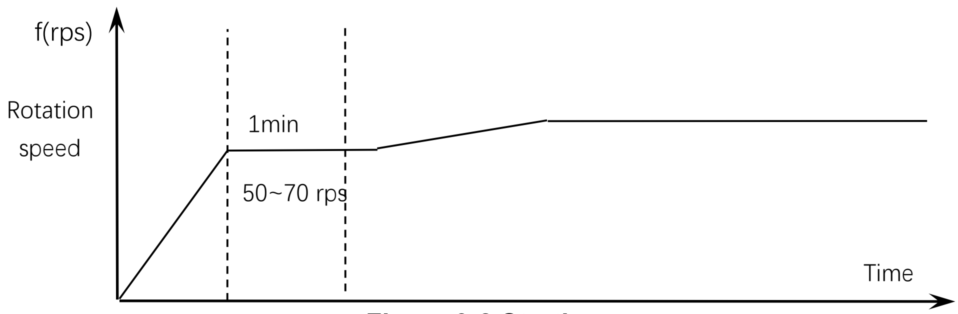


Figure 3-2 Starting

After the rotation speed attained at 50~70rps, it is necessary to keep the speed for one minute. Because it is to prevent the oil lack to sliding portion by oil level down at compressor-start. To check oil return, perform a test using a sight glass compressor supplied by us. Similar action also applies to restart operations after defrost cycle.

3.5 Stopping of compressor

When compressor needs to stop in high running speed, it is recommended to decrease the speed before compressor shutting off, in order to low down the impact to inverter, and avoid too much oil left in the system. In case of emergency stop, direct cut off of power supply can be done.

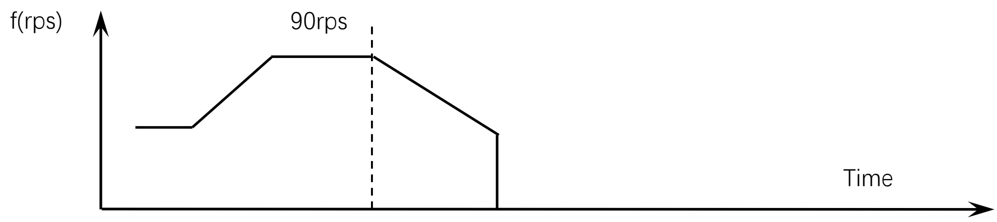


Figure 3-3 Stopping

3.6 Rate of revolution speed change

The rate of operation speed change of the inverter compressor can affect the reliability of compressor.

The rate of revolution speed change shall be within 1~3rps. This is to prevent the damage of sliding portion of bearing parts by rapid change of rotation.

The rate of speed change shall be determined after confirmation of compressor oil level, liquid back, and reliability. If there is a specific description in the compressor specification, follow the contents.

3.7 Defrost operation

Inverter compressors shall operate at low speed right before the start of defrost cycle and right before the end of defrost cycle. This will enable the oil to be retained in the compressor. To check oil return, perform a test using a sight glass compressor supplied by us.

3.8 Cautions of transition phase to lower speed operation

For inverter compressors, to prevent plunge of refrigeration capacity due to separation of fixed scroll and orbit scroll, pay attention to sharp drop of pressure difference and liquid back, when transferring to low speed operation of below1500 min^{-1}.

If there is a specific description in the compressor specification, follow the contents.

3.9 Caution for continuous low speed/high speed operation

When the inverter scroll compressor be operated at low speed or high speed conditions as described below, it is necessary to adjust the speed of inverter compressor to 50-60rps for more than 3minutes operation, then back to normal speed control logic according to cooling load.

1) Compressor speed ≤30rps , for more than 1 hour continuous operation;
2) 30rps< compressor speed ≤40rps, for more than 4 hours continuous operation；
3) Compressor speed ≥75rps , for more than 40 minutes continuous operation；

This recommendation is to keep the safe oil level inside of compressor and make sure the sufficient lubrication,

3.10 Avoid low compression ratio conditions

Compressor internal oil supply depends on internal oil pump and the rotation speed, do not run the compressor in the low compression ratio conditions with lower speed (especially 30~39rps).

If the cooling operation is required at lower ambient temperature condition, system should be designed to decrease the fan speed of condenser, and increase the compressor running speed, to maintain the proper compression ratio of compressor.

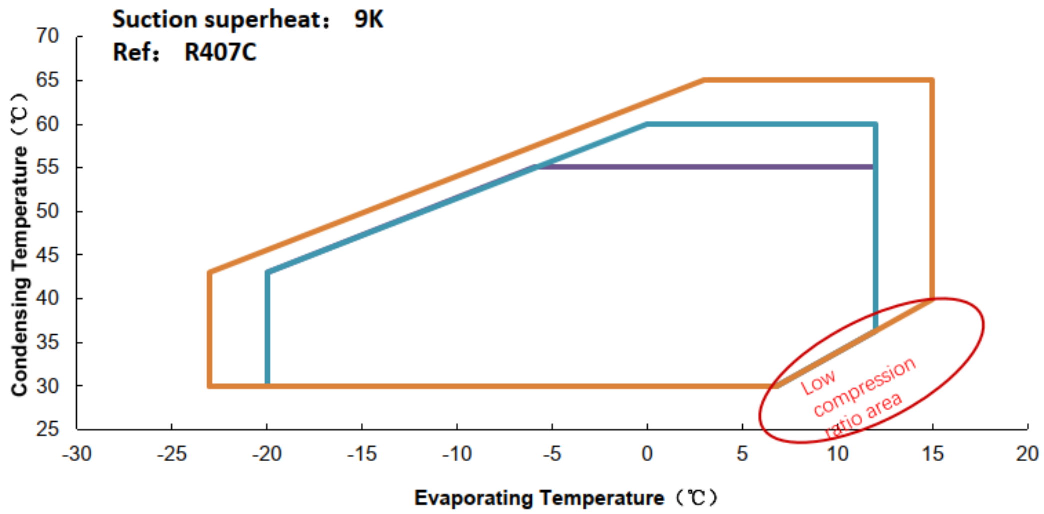


Figure 3-4

3.11 On/off cycle

The on/off cycle of compressor shall not be more than 6 cycles per hour.

The compressor should be operated continuously at least for 5 minutes after being turned on. Allow a minimum of 3 minutes shut-off time before restarting. Or restart the compressor after the pressure difference between high side and low side balances.

3.12 Rotation direction of compressor

Wiring shall be connected in accordance with the wiring diagram mentioned in the compressor specification. Otherwise the compressor will run into reverse operation and breakdown. Never do this.

3.13 Deep vacuum Operation

Scroll compressors should never be used to evacuate an air-conditioning or refrigeration system. As a high volumetric efficiency machine, compressor will achieve extremely low vacuums when the suction side is restricted, this may cause internal arcing at the electric terminal and the damage of compressor.

3.14 Caution on pump down operation

At the pump-down operation, the rotation speed of compressor shall be lower than 60rps.
The operation time shall not exceed a limit of 10minutes.

3.15 Protection Devices Required

For air-conditioning or heat pump unit, the following protective devices should be installed:

1) Reverse Phase Protector

Scroll compressor will only compress in one rotational direction. This is very important for three phase compressors since three-phase induction motor will run in either rotational direction equally depending on phasing of the power. Reverse rotation will result in excessive noise, and no suction / discharge pressure differential appears as well as no cooling effect in the suction line.

For three phase systems, mechanic device or reverse rotation module in the system control unit is necessary in preventing three phases compressor from running in the reverse rotational direction.

2) Discharge Gas Thermostat

The discharge temperature will rise rapidly if the compressor is running under the overload conditions or lack of refrigerant conditions.

The maximum discharge temperature should be maintained by a discharge thermostat.

For C-SW series, a copper well pipe is installed on the end cap of compressor, which is filled with heat conducting silicon to improve the heat transfer effect. The discharge thermostat shall be inserted into this well pipe and the tripping point must not exceed 115℃.

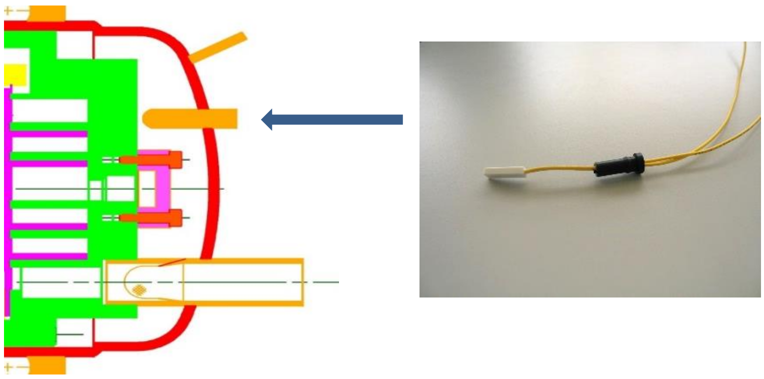


Figure 3-5 Discharge Thermostat Installation

3) Low Pressure Switch

The scroll compressors require a low-pressure switch to protect against loss of refrigerant conditions. The recommended settings are listed in Table 3-2.

Table 3-2 Low Pressure Switch Setting

Refrigerant	Cut-Off setting
R407C	7.3 psig (0.05MPa G)
R410A	22 psig (0.15MPa G)
R134a	4.3 psig (0.03MPa G)

The temperature in the scroll set and motor will rise rapidly due to loss of refrigerant charge. The low-pressure switch will react upon low pressure occurs in the system. Sometimes, the low-pressure switch will react in priority to the action of discharge thermostat or motor protector when the large amount of refrigerant leaks in the short time.

Do not operate the compressor in exceeding 30 seconds when running under 0.03MPa (G).

4) Crankcase Heater

The refrigerant is usually gathering in coldest point within the system during OFF cycle and the compressor might become the right one where most of liquid refrigerant centralized.

After a long OFF cycle, the refrigerant vapor may condense into compressor oil, when compressor restarts. the liquid refrigerant mixed with oil in foam status will lead to lubrication failures. The liquid refrigerant migration is also the cause of low insulation resistance of compressor.

Sonyo Compressor recommends crankcase heaters should be used for the system with high refrigerant charge volume. The crankcase heater of suitable power should remain the temperature of compressor bottom shell 11K higher than ambient temperature or reduce the oil level to specified level after 5 hours energizing.

The crankcase heater must be energized for a minimum of 5 hours prior to starting compressor.

5) High-Pressure Switch

The scroll compressors require a high-pressure switch in order to protect the compressor during blocked fan or fan failure conditions. The recommended settings are shown in Table 3-3

Table 3-3 High Pressure Switch Setting

Refrigerant	Cut-Off setting
R407C	464 psig (3.2MPa G)
R410A	602 psig (4.15MPa G)
R134a	348 psig (2.4MPa G)

4. 0 Assembly and Manufacturing Process Considerations

For safe installation and trouble-free operation of compressor and air-conditioning system, below instructions should be carefully read and strictly followed before beginning.

4.1 Removing Rubber Plug

Each compressor is shipped with a dry Nitrogen holding charge between 0.12~0.18MPa (G) (18~26 psig) and sealed with rubber plugs.

The compressor should be kept horizontal not less than 3 hours and not be declined while removing rubber plugs. The suction plug should be removed first before pulling the discharge plug to avoid loss of oil. Few refrigerant oil may be stored in the discharge tube, please take care when removing the discharge plug.

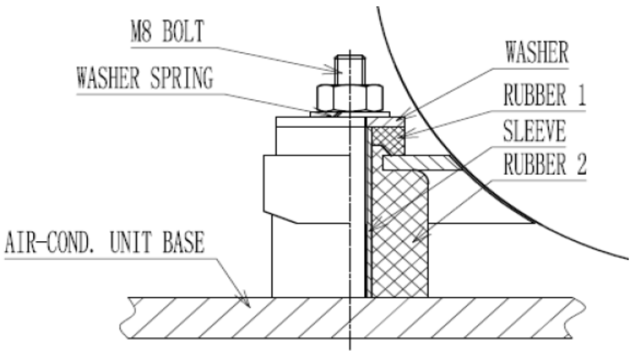
Compressor should be installed into system within 15 minutes after removing the plugs.

Do not use the compressor from which the discharge sound cannot be heard when removing rubber plugs.

4.2 Compressor Mounting

In mobile applications, for the consideration of tubing reliability, it is important to minimize the motion of compressor during operation. The mounting accessories (grommets and sleeves) that are supplied or specified by Sonyo Compressor should be used, as shown in Figure 4-1. The upper mounting rubber(rubber1) can reduce the up-down motion of compressor under vibration and shock conditions;

The mounting parts should be verified by test and based on applications. In severe cases, the vibration eliminators should be mounted in the compressor discharge and suction lines to reduce the vibration transferred from compressor to system tubing.



1.MATERIAL CR;
2.HARDNEES 50±5HS;
3.ELASTIC COEFFICIENT 109±15N/mm.

Mounting Torque:10-12N·m

1-Mounting Grommet 2-Mounting Sleeve

Figure 4-1 Mounting Parts for C-SB

4.3 Residual Moisture

System residual moisture level should be kept less than 200ppm. Normally if the vacuum degree of system can be achieved, the residual moisture level will also meet this requirement.

4.4 Tube Brazing

During brazing the system piping to the compressor, it is important to maintain the cleanliness inside the piping to prevent water, solid contamination and so on entering into the system. Do not bend the discharge or suction lines or force the piping into the compressor connections since this may increase piping stress and potential failure. See figure below for recommended materials and procedure.

4.4.1 Brazing material:

A silver-phosphorus and other silver brazing materials are recommended for all kinds metal brazing. A copper-phosphorus brazing material is also acceptable for copper brazing.

See Table 4-1 for recommended brazing materials.

Table 4-1: Recommended Brazing Material

Metal	Silver (%)	JIS Code	Brazing Temp.℃	JIS standard
Copper to Copper	4.8~5.2	BcuP-3	720~815	Z 3264
Copper to Steel with copper coated	35	BAg-2	700~845	Z 3261
*Copper to Steel *Steel with copper coated to steel *Steel to Steel	45	BAg-1	620~760	Z 3261

4.4.2 Nitrogen purge

During brazing the system piping to the compressor a Nitrogen purge with high purity (99.8% min.) must be used to prevent oxidation contamination. The nitrogen purge cannot be stopped until the piping temperature below 200℃. See Figure 4-2 below for recommended flow method of nitrogen purge.

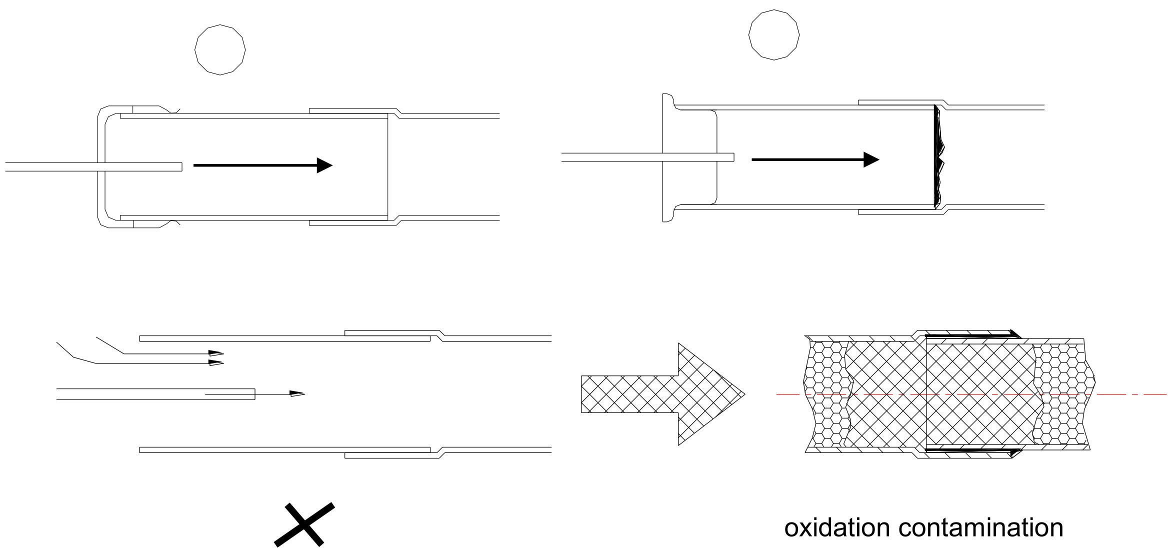


Figure 4-2 The flow method to prevent the oxidation contamination

4.4.3 The clearance and Insertion length of brazing parts (reference)

The recommended clearance and minimum insertion length of copper pipes are shown in the Table 4-2.

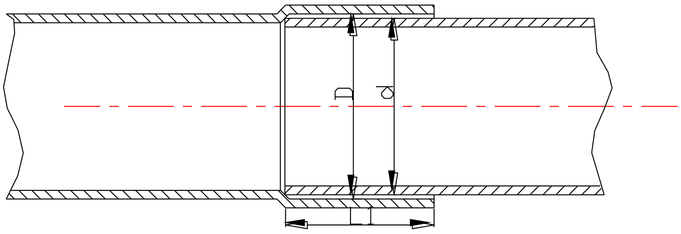


Table 4-2 The clearance and length

Piping O.D.(mm)	Minimum Insertion Length L1 (mm)	Clearance D-d (mm)
5~8	6	0.05~0.35
8~12	7	0.05~0.35
12~16	8	0.05~0.45
16~25	10	0.05~0.45
25~35	12	0.05~0.55
35~45	14	0.05~0.55

4.4.4 Brazing Procedures

See Figure 4-3 for brazing area.

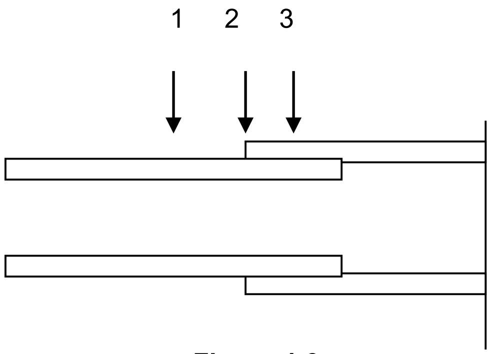


Figure 4-3

a) A double-tipped torch is recommended during brazing;
b) Clean the compressor tubing and system piping prior to assembly;
c) Apply heat to Area 1, moving the torch up, down and around the tube in order to heat it evenly. It will become dull orange in color.
d) Move the torch to area 2 until it reaches dull orange in color and heat that area evenly.
e) Add braze material to the joint while moving the torch around the joint to flow braze material evenly around the circumference.
f) After braze material flows around the joint, move to area 3, to draw the braze material into the joint. The time spent heating area 3 should be minimal, to keep excess braze material from entering the compressor.

4.5 Leakage Test

The enclosure strength test should be performed to check system leakage by means of charging pressurized nitrogen into the system. Pressurizing should be completed step by step instead of reaching the test pressure immediately.

1） Hold 0.5MPa pressure for 5 minutes to check whether the pressure is decreasing.
2） Hold 1.5MPa pressure for 5 minutes to check whether the pressure is decreasing.
3） Record the ambient temperature and pressure when the test pressure is attained (unit design pressure).
4） Ensure the system can hold the test pressure without decreasing for 24 hours. If pressure decreasing occurs in any step, leakage points should be checked and repaired immediately.

Note:
1) Never use refrigerant, oxygen, dry air, combustible and toxic gas as the test medium to avoid the risk of fire or explosion.
2）Charge the test gas both from the gas line and liquid line of the system simultaneously .
3）The design pressure should be in the scale of the pressure gauge .
4) Pressure may change ＋/－0.01MPa/℃ as the ambient temperature changes.

4.6 Evacuation

The system must be evacuated by a vacuum pump to remove the residual moisture and un-condensable gas. It is essential to connect the vacuum pump to both the high-pressure side and low-pressure side simultaneously to ensure that the system is completely evacuated.

It is necessary to confirm the vacuum degree of the system after removing the vacuum pump from the system. Sufficient vacuum degree means:

30 seconds after removing the vacuum pump	below 1.0Torr
24 hours after removing the vacuum pump	below 7.6Torr

Please select proper size of vacuum pump according to the above vacuum degree requirements.

Do not use compressor as a vacuum pump and NEVER energize the compressor under vacuumed conditions.

4.7 Refrigerant Charge

It is recommended that system charging be done using the weighted charge method, by adding liquid refrigerant to the condenser outlet side of system. Only gas refrigerant can be charged to compressor suction tube. Charging at the high and low pressure side of a system with gas simultaneously at a controlled rate is also acceptable. Do not exceed the manufacturer’s charge amount limit and NEVER charge liquid at suction side of compressor.

The excessive refrigerant charged in system will result in dilution of oil and lack of lubrication on sliding parts, in severe cases liquid refrigerant flooding back to compressor and compressor failure will occur.

4.8 Wiring Connections

The scroll compressors will only compress gas in the counterclockwise direction when viewed from the top. Since single phase motors start and run in only one direction, reverse rotation is not a major consideration. Three phase motors will start and run in either direction, depending on the phase angles of the supplied power. This requires care during installations to ensure the compressor is operating in the proper direction.

Verification of proper rotation is done by observing suction and discharge pressures when the compressor is operating. A decrease in discharge pressure and an increase in suction pressure indicate reverse rotation. In order to correct this situation, disconnect the power and switch any two power leads at the unit contactor. NEVER switch leads directly at the compressor.

Internal wiring of the compressor is consistent with the direction of rotation. As a result, once the correct phasing is determined for a specific system or installation, connecting properly phased leads to the same terminals should maintain proper rotation direction.

A phase monitor can be applied to ensure correct rotation when power is initiated. Each compressor is labeled with the appropriate sequence. As showed in wiring diagram, the line phases R (L1), S (L2) and T (L3) should be connected to terminals U, V and W, respectively.

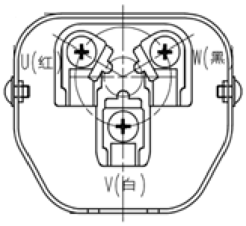
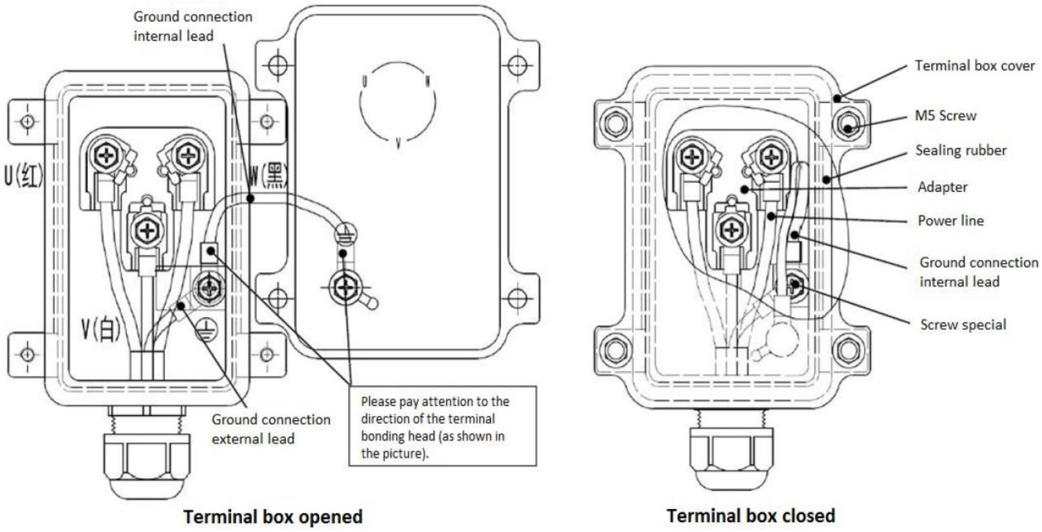


Figure 5-4 Compressor Terminal

4.9 Terminal cover and clip

The terminal cover and clip should be installed prior to operation of the compressor. To ensure the cover is properly installed, a double check should be done to make sure the lead wires are not pinched under it.

For the models with IP67 terminal box, the wiring connections and installation of sealing rubber, gland kit should follow the instructions in specification to ensure the sealing effect. An improper wire connection may cause an improper installation of the terminal box cover, and also cause the touch and cross of power line and ground lead.



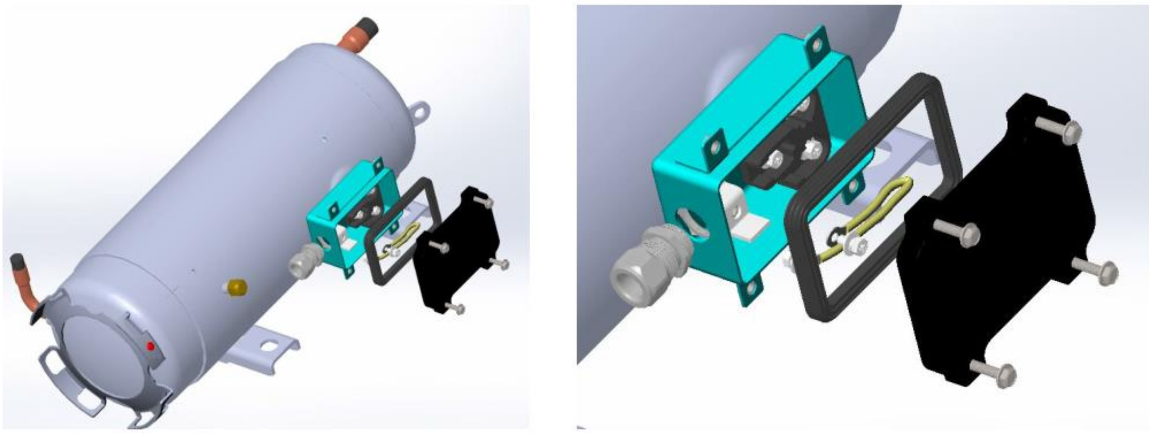


Figure 4-5

4.10 Preliminary Running

In order to lubricate the compressor movement parts, the compressor should be operated at least 3 seconds within 15min after refrigerant charged. Check the following items:

1) To check whether abnormal sound or abnormal tube vibration occurs.
2) To check whether refrigerant leaks from the connection part.
3) To check the cooling effect.

4.11 Start Compressor with Balanced Pressure

The OFF cycle setting of compressor should be at least 3 minutes which is the period to balance the high side and low side pressure of system. Especially for single phase models, starting the compressor with balanced pressure should be always followed.

4.12 Servicing Scroll Compressors

4.12.1 Compressor Functional Check

The following procedures should be followed to determine if the compressor is functioning properly:

1) Voltage of the unit should be measured and verified as correct.

2) An evaluation of the electrical system should be performed next. The motor should be checked by using continuity and short to ground testing. The internal motor protector should be given time to reset if a continuity break is found in the motor windings. External breakers and associated wiring should be checked.

3) Operation of indoor and outdoor fan/blower should be checked and verified as correct.

4) Check the refrigerant charge levels by connecting service gauges to the suction and liquid service valves and then turning on the compressor. Correlate the operating pressures to the system manufacturer specifications for the existing conditions under which the unit is operating.

5） On heat pump, check that the reversing valve is operating properly and verify that compressor current is within published compressor specifications at the proper operating conditions. If there is a significant deviation from current published specifications occurs (+/-15% or more) this may indicate a defective compressor.

4.12.2 System Evacuation

When evacuating a compressor in the field, it is extremely important to use a vacuum manifold set with at least 2 vacuum lines connected to the system. One line connected to the high side and the other connected to the low side of the system. This procedure is necessary to ensure the system is completely evacuated, since the scroll sets can seal under some non-energized conditions and thus isolate the high and low sides from each other. If there is refrigerant left in the system, this can create a hazard when unbrazing the piping. When compressor is replaced, the filter-dryer should also be replaced.

4.12.3 Remove the Failed Compressor

The preferred method of remove a compressor is to cut the connecting lines using a tubing cutter. However, unbrazing is also acceptable using the following precautions. Check to be sure all refrigerant has been evacuated using the procedure above in 4.12.2. If there is still refrigerant in the system, this when combined with the compressor oil can ignite if it comes in contact with a flame.

(1) Use the suitable welding machine or tools to remove the connecting pipes, screws, flanges or service valves;

(2) Check the oil in failed compressor. If oil is in black color (the normal color of oil for HFC models is colorless), if necessary to clean the system piping before installing new compressor.

4.12.4 Brazing Procedure

See figure below for the procedure for field servicing.

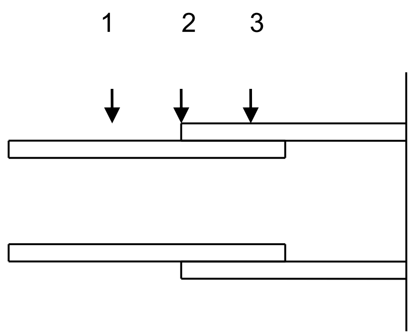


Figure 4-6

To disconnect:

1) Disconnect power and remove wires from terminal box.
2) Insure ALL pressure is out of the system (check high and low sides).
3) Heat areas 2 and 3 slowly and uniformly until braze material softens and the tube can be removed from the compressor fitting.

To Reconnect:
4) Recommended brazing material is specified in section 4.4.1.
5) Clean tube and fitting until shiny like a new penny.
6) Re-insert tube into fitting.
7) Heat tube uniformly in Area 1, moving slowly to area 2 until it reaches dull orange in color, apply the brazing material to the joint.

8) Heat the joint uniformly by moving the torch around the joint to flow braze material evenly around the circumference.
9) Slowly move the torch to area 3 to draw the braze material into the joint.
10) Do not overheat the joint. A cherry red color indicates overheating and can weaken the joint and fittings.

4.12.5 Compressor Replacement for Motor Burn Out

If a motor burn out is present, follow the procedure as below:

1) Evacuate the system per section 4.12.2.
2) Remove the compressor as outlined in sections 4.12.3 and then follow proper clean-out procedures as detailed in system instructions.
3) Replace the liquid line filter dryer and install a properly sized suction line filter dryer.
4) Run system and recheck pressure drop across suction filter dryer within 48 hours. If pressure drop is excessive, replace both the liquid line and suction line filter dryers.

4.12.6 Returning Failure Compressor

1) The failure compressor should be sealed on suction tube and discharge tube to prevent the refrigerant oil flowing out during transportation.
2) Please record the following items in a list: Compressor Model, Manufacturing Series Number, Air-conditioning Model and Air-conditioning Manufacturing Number, Failure Time, Failure Descriptions and Failure Reasons, etc.

   The field information should be returned together with compressor. It is strongly recommended to record as detailed as possible for the accurate failure analysis.

4.13 Other Precautions

1) Installation should be completed within 15 minutes after removing the rubber plugs.

2) Do not use the compressor to compress air.

3) Do not energize the compressor under vacuumed condition.

4) Do not tilt over the compressor while carrying it.

5) Do not remove the paint.

6) When compressor running, the phase voltages difference should be lower than 2% of the rated voltage.

5. 0 Troubleshooting

Problem	Check Point	Probable Causes
Compressor failure to start	Power source	Power source switch off
		Fuse blown
		Too low voltage at compressor terminals
	Wiring	Disconnection of wiring
	Control devices	Improper setting of temperature controller
		Protection devices trip (Discharge temp. High-Low pressure Switch etc.)
		Loss of Phase
		Wrong phase sequence
	Compressor	Internal motor protector trips
		Excessive liquid in compressor
		Inside components broken
		Motor burns out (windings broken or short to ground)
Compressor shut down shortly after starting	Power source	Failure of breaker
	Refrigerant circuit	High pressure side blockage
		Low pressure side blockage
	Electrical components	Failure of contactor (rapid fluctuation or contacts welded)
	Temperature controller	Temperature controller trips
	Compressor	Abnormal line voltage
		Motor winding overheating due to lack of phase
		Motor winding overheating caused by unbalanced voltage
		Motor winding overheating caused by loss of refrigerant
		Too high discharge pressure
		Too high suction superheating degree
		Non-condensable gas mixed in system
		Insufficient cooling for compressor
		Inside failure of compressor
Inverter Driver failure to start	Wiring	Miss-wiring or disconnection of wiring
	Components	Loosen or burned parts
	Driver Cooling	Insufficient cooling lead to overheating
	Compressor	Operation out of envelope

Problem	Check Point	Probable Causes
Abnormal running noise	Flooded-start	During off cycle, liquid refrigerant migrates to the compressor and mixed with lubricant oil
		Refrigerant overcharged
	Piping	Resonance vibration occurs
	Compressor	Electromagnetic noise of motor
		Lack of oil in the compressor
		Worn or broken components inside of compressor
		Contaminations mix in compressor
		Reverse rotation of compressor
		Feet of the compressor touch the system base
Compressor runs but with poor cooling effect	High discharge pressure	Non-condensable gas(or air) mixed in system
		Refrigerant overcharged
		Condenser fan failure
		Dirty or blockage of condenser coil
		Short air cycle
	Low discharge pressure	Insufficient refrigerant in system
		Leakage of refrigerant
		Too low ambient temperature
		Large air flow through condenser
		Liquid refrigerant flooding back
		Worn compressor
	High suction pressure	Too high of heat load
		Poor heat insulation
		Too low superheat setting of expansion valve
		Malfunction of expansion valve
		Incorrect installation of temperature sensor
		Defect compressor
	Low suction pressure	Too low of heat load
		Insufficient refrigerant charge
		Dirty or iced evaporator coil
		Blockage of expansion device
		Blockage of refrigeration circuit or leakage of refrigerant
Compressor Frosted/dew	------	Improper size of expansion valve
		Too low heat load
Smelly	------	Large amount of refrigerant leakage
		Overheating of electronic components
		Overheating of compressor shell