



RC Series Screw Compressors

Technical Manual



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INTRODUCTION

The HANBELL RC series semi-hermetic twin-screw compressor is developed especially for applications in air-conditioning and refrigeration. With a built-in high operating load design, each compressor is high efficiency and reliability in all working conditions such as thermal storage, heat pump system & refrigeration. Each compressor has the latest and advanced 5 to 6 Patented Profile design. Each unit is carefully manufactured and inspected by high precision THREAD SCREW ROTOR GRINDING MACHINE, CNC MACHINING CENTER, and 3-D COORDINATE MEASURING MACHINE. Each compressor at HANBELL follows the ISO 9001 certification quality system. This certification assures that each compressor is controlled under severe quality procedures and provides good service to all customers.

The new developing RC series compressors combined an α Balance Piston with separated radial and axial force bearings, oil cooler connector, liquid injection & economizer connector, PTC motor coil protection and discharge temperature protection & its controller, oil level switch and oil pressure differential switch and other accessories. These new designed can guarantee that the compressor has the best reliability, longest life of bearings during heavy duty running and high working operating condition.

This RC Technical Manual contains the required information for the handling, dimensions, installation, operation, applications and basic trouble-shooting etc. It's strongly recommended that the contents of this Manual should be referred carefully prior to handling, installation, and commissioning of RC compressor in order to prevent any unnecessary damage. Please contact HANBELL or its local distributors/agents for more information or further assistance.

1. Compressor Specifications

1.1 Scope : RC series screw compressors are inclusive of several different range with the models of RC10~RC11, RC12~RC17, RC18~RC21 and RC22~RC24 .

1.2 RC series compressors' specifications

1.2.1 RC series design specifications

Compressor	Displacement	m^3 / hr	RC10	RC11	RC12	RC13	RC14	RC15	RC15L	RC16	RC17
			118/98	165/137	207/172	233/193	309/257	352/293	384/320	490/407	567/471
	Rated Speed	rpm	3550/2950								
	Volume Ratio	Vi	2.2, 2.4, 2.6, 3.0, 3.5, 4.8								
	Capacity Control	%	3-steps, or 33%-100% continuous		4-steps, or 25%-100% continuous capacity control system						
Lubrication		Differential pressure feed lubricant									
Motor	Type		3 Phase, 2 Pole, Squirrel-Cage, Induction Motor								
	Starting -up		Y- Δ Starting								
	Frequency	Hz	60/50								
	Voltage	V	220, 380, 440, 460, 480 / 380, 400, 415								
	Insulation		Class F								
	Protection		PTC PROTECTION								
Lubricant Charge	Liter	7	7	7	8	14	16	16	15	18	
Oil Heater	W	150									
Hydrostatic Pressure Test	kg / cm ² G	42									
Weight	kg	260	270	390	435	540	620	620	760	830	

Compressor	Displacement	m^3 / hr	RC18	RC19	RC20	RC21	RC22	RC23	RC24	-	-
			670/545	735/598	952/774	1024/832	1310/1089	1536/1277	1832/1522	-	-
	Rated Speed	rpm	3550/2950								
	Volume Ratio	Vi	2.2, 2.4, 2.6, 3.0, 3.5, 4.8								
	Capacity Control	%	4-steps, or 25%-100% continuous capacity control system								
Lubrication		Differential pressure feed lubricant									
Motor	Type		3 Phase, 2 Pole, Squirrel-Cage, Induction Motor								
	Starting -up		Y- Δ Starting (RC 22~24 Direct starting/ Cross on line or Reactance Starting)								
	Frequency	Hz	60/50								
	Voltage	V	380, 440, 460, 480 / 380, 400, 415								
	Insulation		Class F								
	Protection		PTC PROTECTION								
Lubricant Charge	Liter	23	23	28	28	-	-	-	-	-	
Oil Heater	W	150									
Hydrostatic Pressure Test	kg / cm ² G	42									
Weight	kg	880	990	1220	1240	1490	1580	1630	-	-	

1.2.2 RC series compressors' performance datum

Model			RC10	RC11	RC12	RC13	RC14	RC15	RC15L	RC16	RC17
Refrigerant											
R22	Capacity	kW	116.1/96.5	156.7/130.2	198.5/164.9	223.8/186	296.7/251.3	349.5/290.4	380.6/316.3	476.6/396	572.8/475.9
	Power Input	kW	27.5/22.9	37/30.7	46.7/38.8	51.4/42.7	68.9/55.5	77.6/64.5	83.7/69.6	107.3/89.2	125.2/104
R134a	Capacity	kW	77.6/65.8	104.1/88.3	130.4/112.1	149.1/123.9	199.2/169.1	232.9/193.5	253.6/213	321.2/267	383/317.6
	Power Input	kW	17.6/14.8	23.4/19.6	29/24.5	32.3/26.9	43.4/36.6	49.1/40.8	53.5/45.4	68/56.5	80.7/67.1
R404A	Capacity	kW	114/94.7	152/126.3	191/158.7	218.4/182.3	292.1/242.8	336.9/280	366.9/304.9	468/388.9	551/457.9
	Power Input	kW	31.7/26.3	42/34.9	52.5/43.5	59/49.1	78.4/65.2	89.4/74.3	96.3/80.1	123.1/102.3	143.9/119.6
R407C	Capacity	kW	112.8/93.6	150.4/125	187.7/156	218.2/181.3	287/238.6	340/283.1	369.9/308	468/388.9	548.4/455.7
	Power Input	kW	27.3/21.9	36.2/29.1	44.2/36.3	50/40.9	67.1/54.3	74.7/62.1	81.4/67.4	104.6/85.2	119.9/99.6

Model			RC18	RC19	RC20	RC21	RC22	RC23	RC24
Refrigerant									
R22	Capacity	kW	668.8/555.8	736.3/611.8	962.2/799.6	1037.7/862.3	1404.6/1167.2	1653.9/1374.4	1889.7/1570.3
	Power Input	kW	147.7/122.8	162.2/134.8	209.8/174.4	225.8/187.7	302.9/251.7	354.9/294.9	401.4/333.6
R134a	Capacity	kW	451.2/375	495.5/411.8	645/536	694.8/577.4	918.6/763.3	1082.3/899.4	1227.4/1019.9
	Power Input	kW	95.3/79.2	104.5/86.9	135.3/112.4	145.6/121	190/157.9	222.9/185.2	250.1/207.8
R404A	Capacity	kW	643.5/534.7	708.4/588.7	924.4/771.2	998.3/829.6	1372.9/1140.9	1616.2/1343	1804/1499.1
	Power Input	kW	169.8/141.1	186.4/154.8	241/200.4	259.5/215.6	360.8/299.8	422.7/351.2	467.1/388.1
R407C	Capacity	kW	640.3/532.1	704.9/585.8	921.2/765.5	993.5/825.6	1371.9/1140	1615.3/1342.3	1802.8/1498.1
	Power Input	kW	141.5/117.6	155.3/129	200.9/167	216.2/179.7	298/247.6	349.1/290.1	385.8/320.6

RC series based on C.T.=40°C, E.T.=4°C, Sub cooling=5°C, Superheating=5°C

R404A, R407C C.T & E.T. indicate the dew point temperatures.

1.3 Installation

1.3.1 Compressor crate unpacking

When the compressor arrived at the warehouse, inspect the compressor with its crate outline if it's kept in good condition, then check all the compressor accessories whether it is put in order in the crate to meet the packing list. Contact HANBELL or local distributor/agent immediately if there is any item damaged or missing. The compressor was painted by the assigned color that is written in the original purchase order. Check the quantities and accessories attached in the crate if it's meet the order after unpacking the crate, and inform Hanbell or local distributor/agent if there is any mistake or any item missing and give the Compressor Serial Number. In order to prevent the penetration of moisture, air or impurities, the compressor has been charged with dry Nitrogen gas inside before shipment from Hanbell or local warehouse.

1.3.2 Cautions while handling the compressor

- a. Use Steel Ropes and eyebolts on top of the compressor to lift the compressor, see Figure 1.1. Figure 1.2 shows another way of using Safety Ropes. Any used rope should be capable to carry up the weight of at least 2 tons.

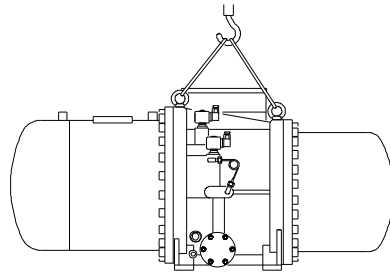


Figure 1.1 Lifting the compressor with steel rope

- b. In case there are no available eyebolts, then use 2 safety ropes with a minimum capacity of 2000 kgf loading available to lift the compressor. Refer to Figure 1.2. Shown below.

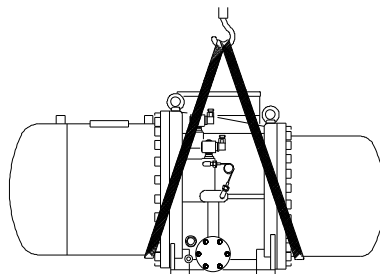


Figure 1.2 Lifting the compressor with 2 safety ropes

c. Cautions while lifting the compressor

- (1) Make sure that the steel rope does not touch the Solenoid Valves, Capillary, Oil Heater, Discharge Temperature Sensor, Power Terminals and other accessories to prevent from getting damage.
- (2) Use steel rope or safety ropes to lift the compressor only; do not use any rope without proof that its loading capability can lift up the compressor.
- (3) Make sure that the rope will not scratch the surface of the compressor while lifting the compressor.
- (4) Keep the compressor in horizontal position while lifting. Avoid letting the compressor to crash or fall down on the ground, hit the wall or any other event that may damage the compressor or its accessories.

1.3.3 Installation of the compressor's accessories

※Note : The compressor has been charged about 0.5 bar (7 psig) of dry Nitrogen gas inside before shipment, release the Nitrogen gas from the suction adapter or any Schrader valve before installing the compressor in the chiller.

a. Installation of the compressor electrical terminal box

The compressor electrical terminal box are fixed by 4 pieces of M12 bolts on top of the electrical terminal box cover; it is adjustable to the cable hole direction to meet the power cables' optimal connection direction in the chiller. Refer to the attached spare parts bag for the easier installation and keep the spare parts in the bag for future maintenance.

b. Installation of the service/stop valve (optional part)

Unpack the service/stop valve's carton then check all the parts inside if there is any part missing or incorrect in the packing list on the carton. Make sure that all the parts inside the carton are clean and be careful to put all parts back to the carton. The service/stop valve that put inside the carton box will be install in the compressor by using 4 pieces of bolts, use PTFE sealer to seal the adapter while tightening it. The required space for the future maintenance is recommended to consider for either troubleshooting or bearing replacement. The service/stop valve can be installed as shown in Figure 1.3 for the compressor's future easier service and maintenance.

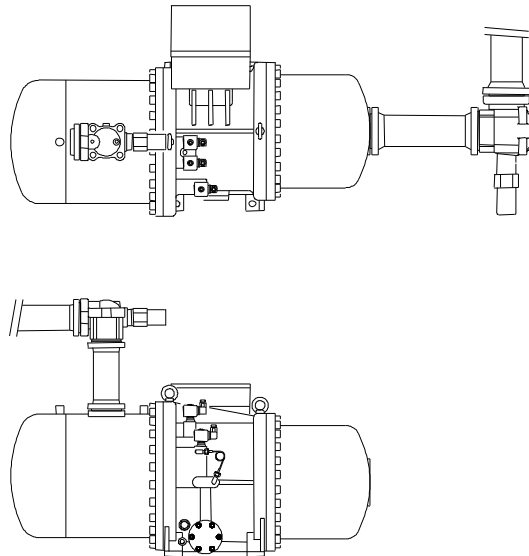


Figure 1.3 Service/stop valve recommended connection

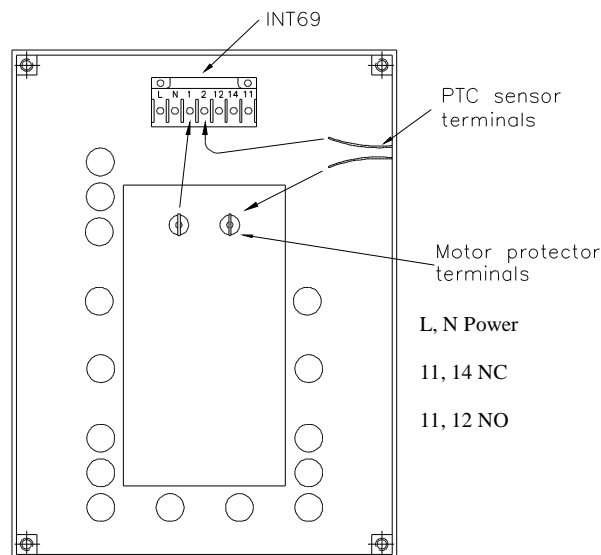
c. Liquid injection solenoid valve and expansion valve (optional accessories)

The liquid injection system can be installed or not, are depends on the application of the compressor and the system. However, it is necessary to consider the required space for the adjustment of expansion valve while the compressor are testing or running.

d. PTC discharge temperature protection

The RC series compressors have a standard PTC sensor located in the motor wiring and at the discharge side of the compressor. The controller is installed inside the electrical terminal box (INT 69, KRIWAN) as shown in Figure 1.4, it shows the connection of discharge and motor PTC sensors in series to the controller's corresponding terminal numbers.

Figure 1.4 PTC sensors & controller connection diagram



Follow the arrows indicated for wire connections.

e. Fig. 1.5 shows the compressor installation guide

f. Installation site of the compressor

- (1) Make sure that the chiller installation site or base are far enough from the heat source to prevent from heat radiation.
- (2) Install the compressor as close as possible to the electrical power supply for easier connection.
- (3) Reserve the required space to monitor the oil level and for the compressor convenient maintenance in the future.
- (4) Make sure that the frame or supporter are strong enough to prevent excessive vibration and noise while the compressor are running.
- (5) Keep good ventilation and low humidity condition in the plant room or installation site.
- (6) Reserve the enough space for the maintenance of the compressor.

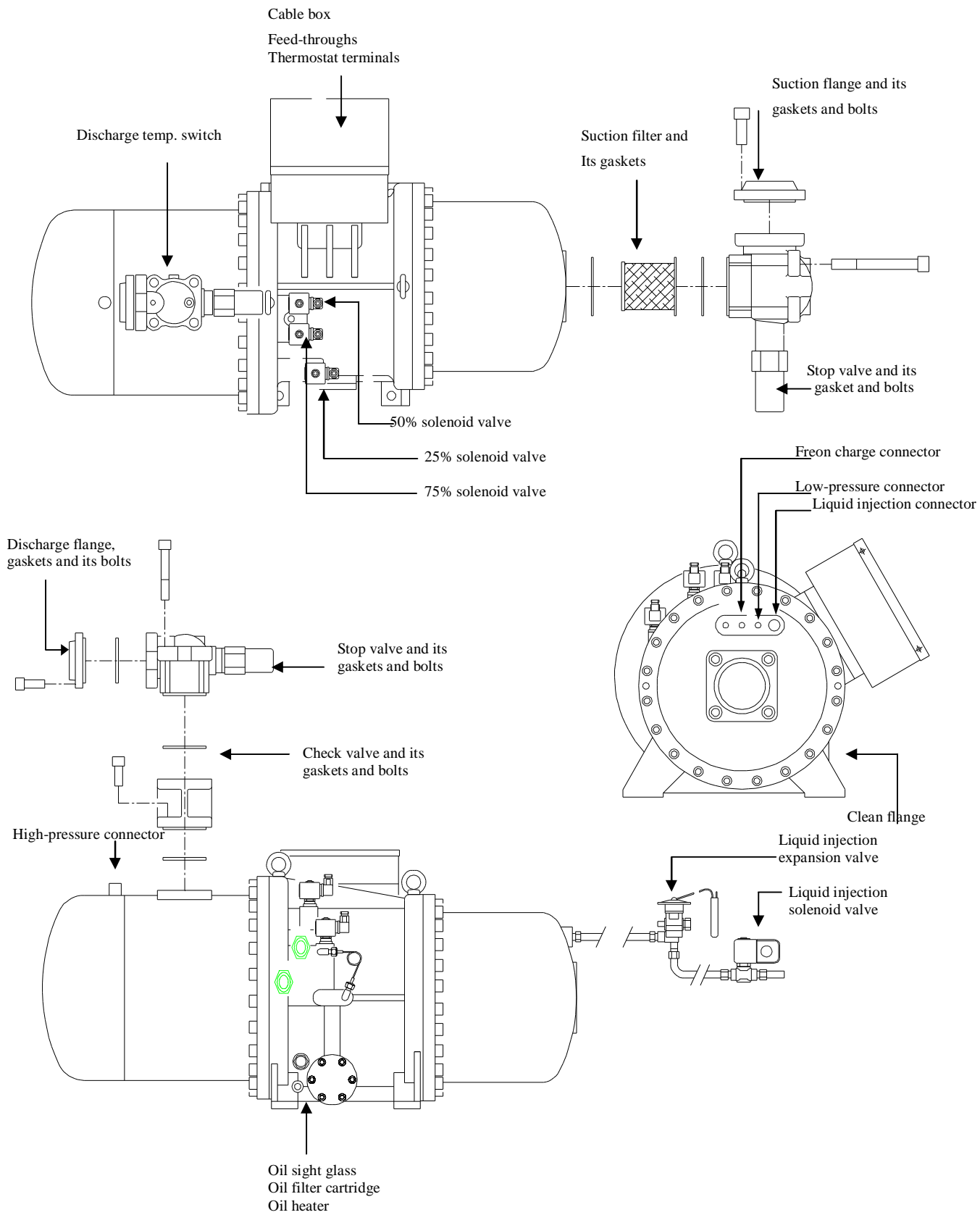
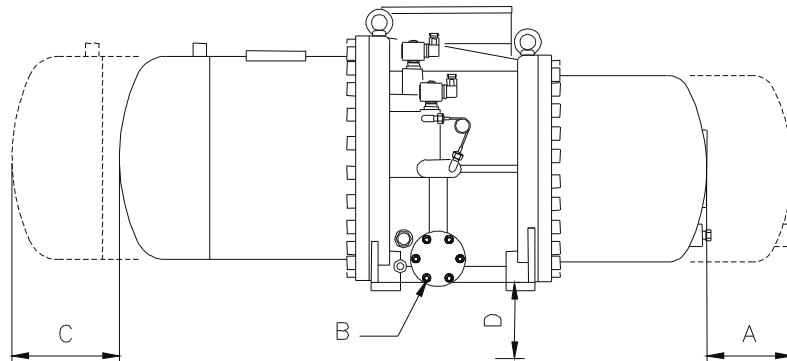


Fig 1.5 Compressor installation guide

1.3.4 Maintenance space

The required space for the compressor's future maintenance in the job site is recommended as shown in Table 1.1.



	RC10/ RC11	RC12	RC13	RC14	RC15/ RC15L	RC16	RC17	RC18	RC19	RC20	RC21	
A (cm)	41	41	46	47	51	54	59	60	60	65	65	
B. Outwards (cm)	28	28	28	28	28	28	28	35	35	35	35	
C (cm)	26	26	30	28	33	30	35	37	37	45	45	
D (cm)	15	15	15	15	15	15	15	---	---	---	---	
E (Suction filter) (mm)	103		143		153		210					
F (Oil filter) (mm)	200							232				

Table 1.1 Compressor recommended space for maintenance

- Reserve enough space for the connection and installation of the electrical terminal box, service/stop valves and solenoid valves on the compressor.
- Consider the compressors' future overhauling can be performed easily, all compressors' outside parts and electrical controller lines and terminal connection can be disassembled and re-assembled easily.

1.3.5 Attention on the compressor piping work

The unsuitable piping works done to the compressor could cause abnormal vibration and noise, pay more attention to the following illustrations to avoid the trouble that may happen in the future.

- The welding on the compressor with welding bar ingredient should include at least 15% of Argon, and the system should be charged inside over 28 Bar (R-22) for the system pressure testing.
- To avoid the compressors' harmonic vibration transferred by the structure and piping of the chiller while in operation, the cushion or shock absorber should be installed in the suction and discharge tube. The Cleanliness of the system should be kept after welding the piping to avoid any swarf or debris contained inside the system, because it may cause serious damage to the compressor during operation. Figure 1.6 shows a 6 to 8 mm shock Absorber installed under the compressor mounting pad to isolate the vibration and the noise transferred to other portions.

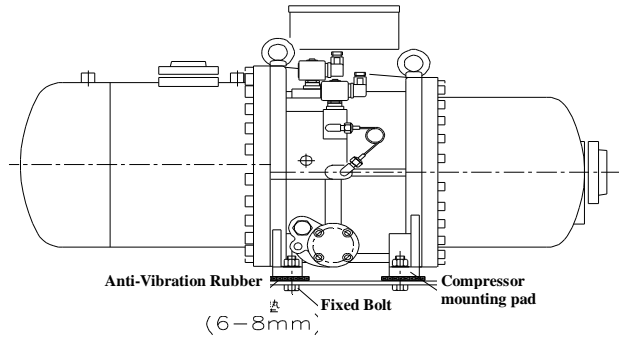


Figure 1.6 Absorber installation

- c. In order to reduce the vibration of the piping tubes, it is recommended to use the copper tube to be the suction and discharge tube of the piping. Copper tubes for suction and discharge pipes will be better to minimize vibration from the piping while the compressor are running. In case the steel tube are to be use in piping the system, then the suitable welding work is very important to perform to avoid any inner stress in the piping. This inner stress can cause harmonic vibration and noise that can reduce the life of the compressor.
- d. Remove the oxidized impurities, swarf or debris caused by welding in the piping tubes, if these impurities, swarf or debris are sunk into the compressor, the oil filter will be clogged resulting in the malfunctioning of lubrication system, bearings and the capacity control system.
- e. The material of suction and discharge flanges are forged steels and can be welded directly with piping connectors. After welding the flanges and pipes it must be cooled down by ambient air. Do not use water to cool down the pipes and flanges after welding. Water quenching is prohibited.

1.3.6 Principles of the electrical wiring

If the compressor is applied in low voltage of electricity, the following items should be considered seriously:

- a. Use conduit to insulate and protect the main power cables between the control panel and the compressor electrical terminal box.
- b. Press firmly each main power cable connecting head with bolts on each power terminal in electrical terminal box. Keep enough space and distance among the main power cable heads for electrical safety.
- c. Choose the suitable electrical accessories to meet the required critical running conditions. The AC-3 Contactor is recommended to meet the rated capacity of power. Select O.L protector with the response time in 15 Seconds while overloading is happening.
- d. Ensure that the electricity voltage drop between each two phases are less than 2%. If it is unavailable to reduce the length of the main power cable then the bigger diameter of main power cable should be chose. Please refer to Table 1.2.

Main power cable section area (mm ²)	8	14	22	30	38	50	60	80	100	125	150	200
Maximum continuous current (Amp)	55	80	100	125	145	175	200	230	270	310	360	425

* Maximum main power cable temperature is at 60°C. Maximum ambient temperature is at 35°C.

Table 1.2 Main power cable size vs. M.C.C.

- e. To avoid any accident to happened as the shortage of electricity power, it is required to follow the local Electrical Regulations to connect the wiring cable such as the grounding of the electrical terminal box, heater, compressor body, and any other electrical connections.
- f. The motor thermister and discharge thermister are the temperature sensors with quick response while the temperature approached the set point. The thermisters must be connected in series to a controller (INT69, KRIWAN) in the terminal box as a guard to protect the compressor. Alarm lamp for this protector is required to be embedded in the control panel as indicator. Any intention to short the controller for starting-up the compressor is prohibited especially in Hanbell. It is beyond Hanbell's responsibility to keep the warranty of compressor if the above action is found.

1.4 Outline Dimensions & Accessories

1.4.1 RC series compressors' Outline dimensions and drawings, refer to section 3.1.

1.4.2 Accessories

Table 1.3 RC Series Compressors' Accessories

NO.	ITEM	RC 10-11	RC 12-17	RC 18-21	RC 22-24
1	PTC Motor Thermister	○	○	○	○
2	PTC Discharge Thermister	○	○	○	○
3	Oil Level Switch	△	△	○	△
4	△P Switch	△	△	△	△
5	Oil Drain Valve	△	○	○	○
6	Liquid Injection Expansion Valve	△	△	△	△
7	Liquid Injection Solenoid Valve	△	△	△	△
8	Economizer Connector	○	○	○	○
9	Liquid Injection Connector	○	○	○	○
10	Motor Liquid Injection Connector	○	○	○	○
11	Oil Cooler Circuit	○	○	○	○
12	INT-69 Controller	○	○	○	○
13	IP-54 Control box	○	○	○	○
14	Non-asbestos gasket	○	○	○	○
15	Safety Valve	△	△	△	△

○: Standard △: Option

*All Accessories if installed in the compressor are based on the formal contract and order.

1.5 Commissioning and Operation

1.5.1 PRE-START CHECKOUT – Table 1.4 shown below is the required procedures to check out the compressor before starting-up.

Table 1.4 Pre-start Checkouts

Items	Things to be checked	States or standard values
1. Accessories	<ol style="list-style-type: none"> 1. Oil level 2. Time for heating the oil 3. System valves status 4. Solenoid valves 5. Capillary 	<ol style="list-style-type: none"> 1. Higher than the middle line of oil level sight glass 2. Turn on the oil heater at least 8hrs before starting 3. Opened 4. Fixed 5. No serious distortion or damaged
2. Electrical system	<ol style="list-style-type: none"> 1. Voltage of main power 2. Voltage of control circuit 3. Insulation resistance value of the motor between phase to phase and phase to ground. 4. Power terminals and wire cables' terminal connection. 5. Grounded 6. Capacity of electrical accessories 7. Settings of switches, sensors and controllers. 	<ol style="list-style-type: none"> 1. Electricity voltage should be kept within 5% to the rated voltage, instant maximum voltage drop while starting should be less than 10% to the rated voltage. 2. Standard voltage is 220V. Maximum voltage is 230V. If there is other demand, contact Hanbell. 3. Insulation resistance value should be above 5MΩ. 4. Power terminals are firmly fixed on terminal block and well insulated. Keep wire cables away from heat source and sharpened metal. Power terminals are fixed firmly and well insulated. Terminal screw and block are both required. 5. (Ruled by the local Electricity Regulations.) 6. Properly selected (or inquired by the system designer.) 7. Properly set (or inquired by the system designer.)
3. Piping system	<ol style="list-style-type: none"> 1. Outer piping system 2. Leakage test 3. Bolts to fix the compressor. 	<ol style="list-style-type: none"> 1. Fixed firmly. 2. No leakage. 3. Fix the compressor tightly.
4. Safety devices	<ol style="list-style-type: none"> 1. Motor coil sensor (thermister) 2. Discharge sensor (thermister) 3. Controller 	<ol style="list-style-type: none"> 1. Connected in series with discharge sensor to controller. 2. Connected in series with motor sensor to controller. 3. Closed circuit with N.C. & N.O.

1.5.2 Operation

- a. In addition to the pre-starting check out given in table 1.4, it is necessary to pay more attention to the auxiliary facilities while the chiller commissioning at the job-site and the periodic maintenance after the initial startup.
- b. In order to keep the capacity control smoothly under the low ambient temperature with the normal viscosity of oil, it is required to heat first the oil for at least 8 Hours before the next starting. The lower the ambient temperature is, the longer the time of heating the oil should be. The oil temperature should be Over 23°C before starting the compressor. Keep the oil heater energizing after the compressor shut down for preparation for the next startup, to keep the oil temperature over the minimum required value which is essential especially under Low

Ambient Temperature condition.

- c. Check that all the settings on each pressure switch are correct by adjusting the setting then push the button for reset.
 - d. Check if all the stop valves in the system are already opened.
 - e. Check if the setting on each timer relay is correct.
 - f. Inch (starting the compressor in a short time) the compressor one time by rotating the compressor to check the suction and discharge pressure gauges' value after the short running. The correct indication in gauges will be: downward for the suction pressure indicator and upward for the discharge pressure indicator. Be sure that the rotation of screw compressor is correct before starting up the chiller.
 - g. Contact HANBELL or local distributor/agent if any abnormal vibration or noise found while the compressor are running.
 - h. The running conditions of compressor after the commissioning at the factory or job-site should be adjusted as below:
 - the discharge temperature will be 20K above the saturated condensing temperature, the superheat of suction vapor should be Within 10K to the saturated evaporating temperature.
- 1.5.3 In case of a long-term shutdown required because of the retrofit of the system or overhauling the compressor, follow the above section 1.5.1 and 1.5.2 after re-installation of the system before starting-up again to ensure the safety and good running condition of the compressor.

1.6 Limitation

1.6.1 Limitation of operation

In area B and C of Fig. 1.7~Fig. 1.7.4 shows that the system should installed the liquid injection devices to cool down the compressor. Refer to section 1.13.2 and 1.13.15.

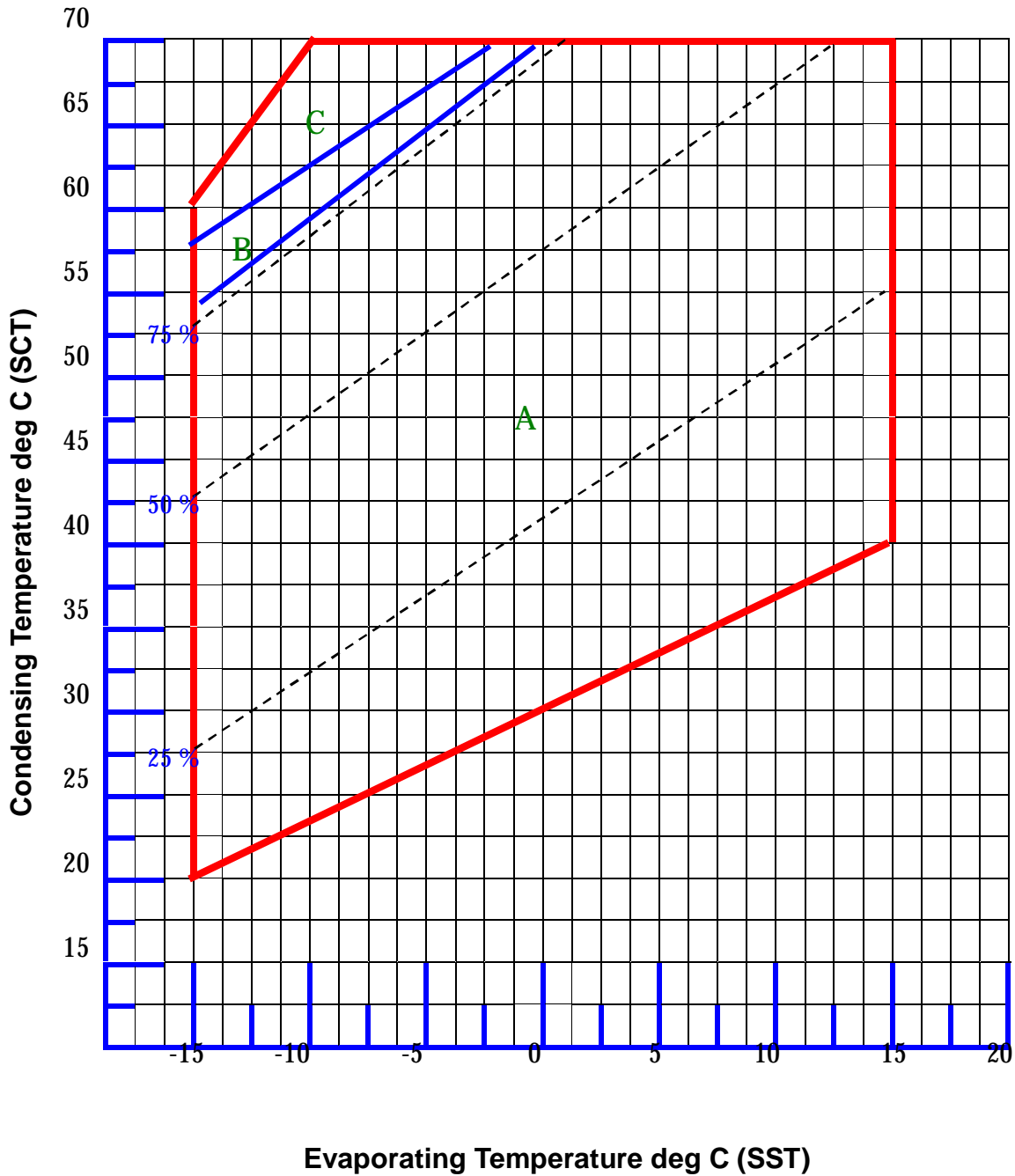


Fig. 1.7 R134a Limitation Diagram

- A: Normal Operation
- B: Oil Cooler or Liquid Injection
- C: Oil Cooler and Liquid Injection

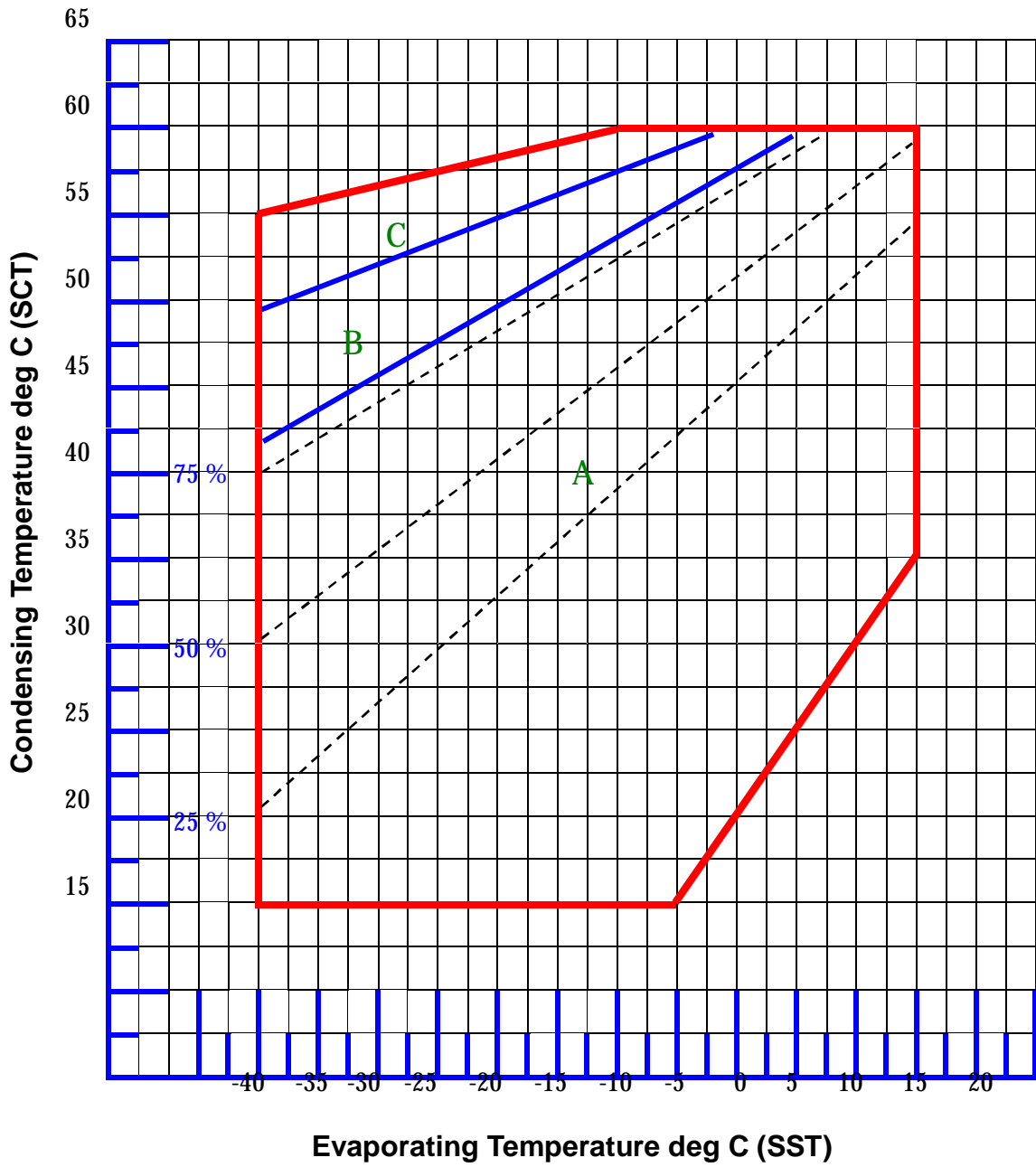


Fig. 1.7.1 R22 Limitation Diagram

- A: Normal Operation
- B: Oil Cooler or Liquid Injection
- C: Oil Cooler and Liquid Injection

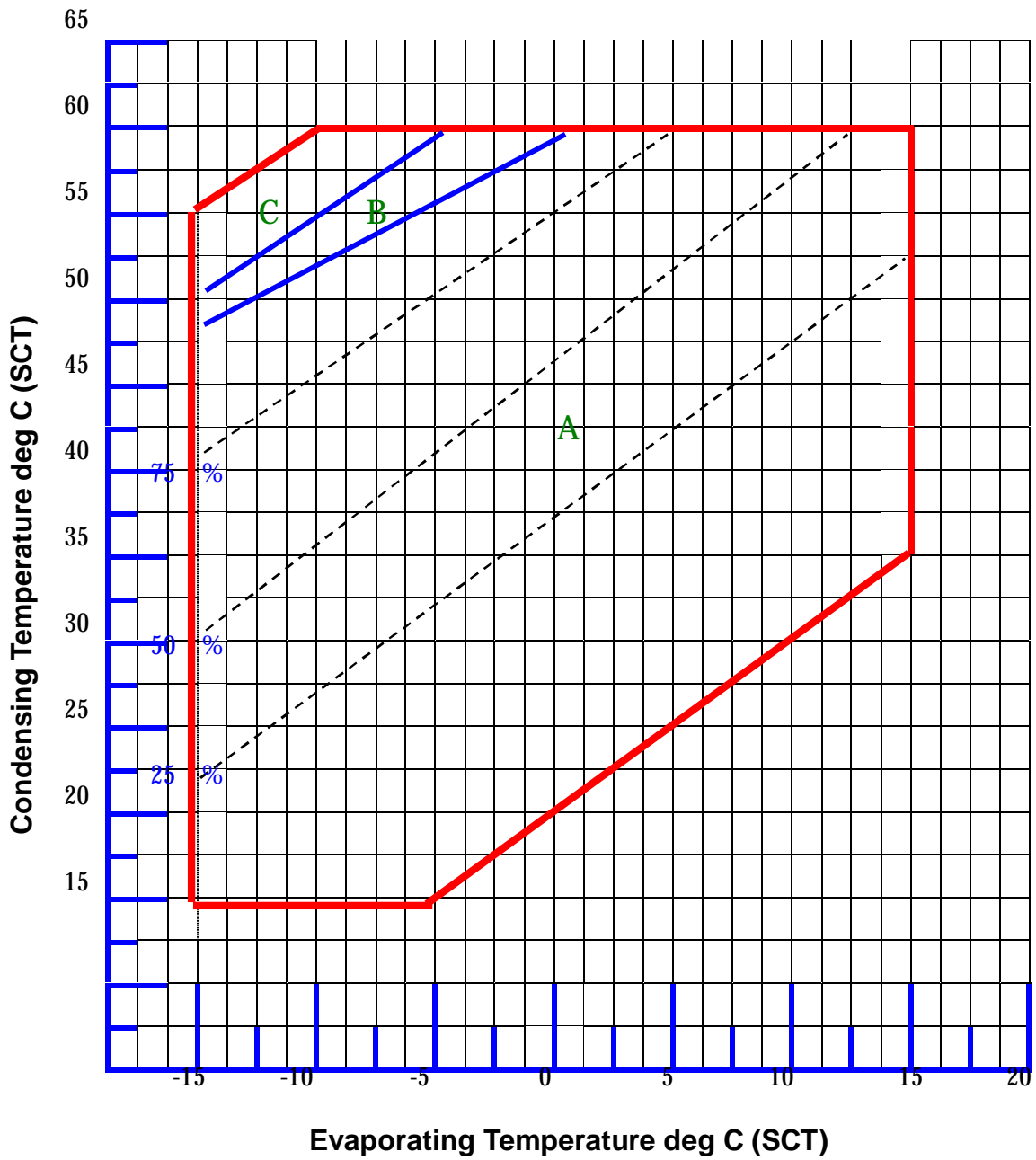


Fig. 1.7.2 R407c Limitation Diagram

- A: Normal Operation
- B: Oil Cooler or Liquid Injection
- C: Oil Cooler and Liquid Injection

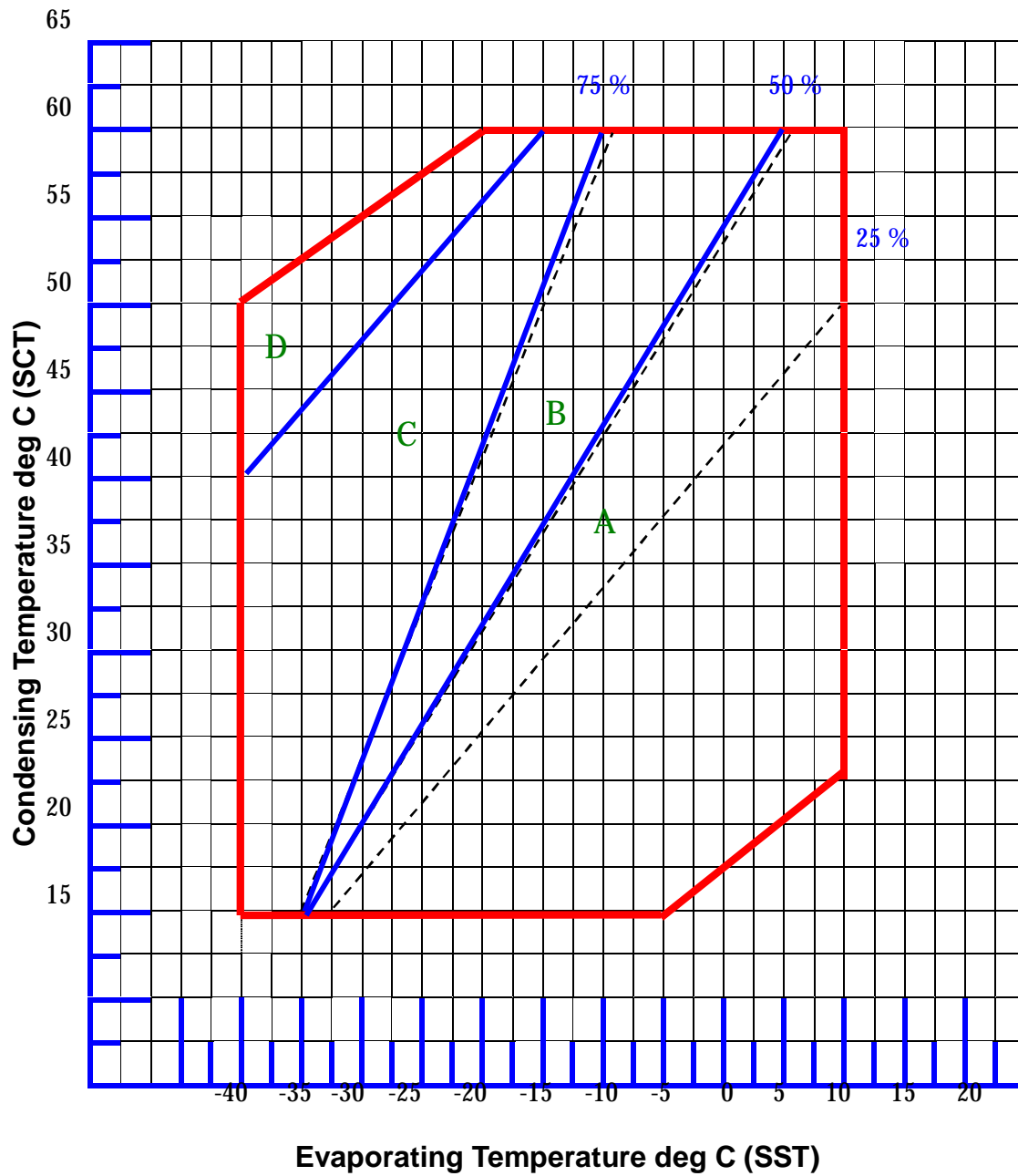


Fig. 1.7.3 R404A Limitation Diagram

- A: Normal Operation
- B: Oil Cooler or Liquid Injection
- C: Oil Cooler and Liquid Injection
- D: Check with HANBELL

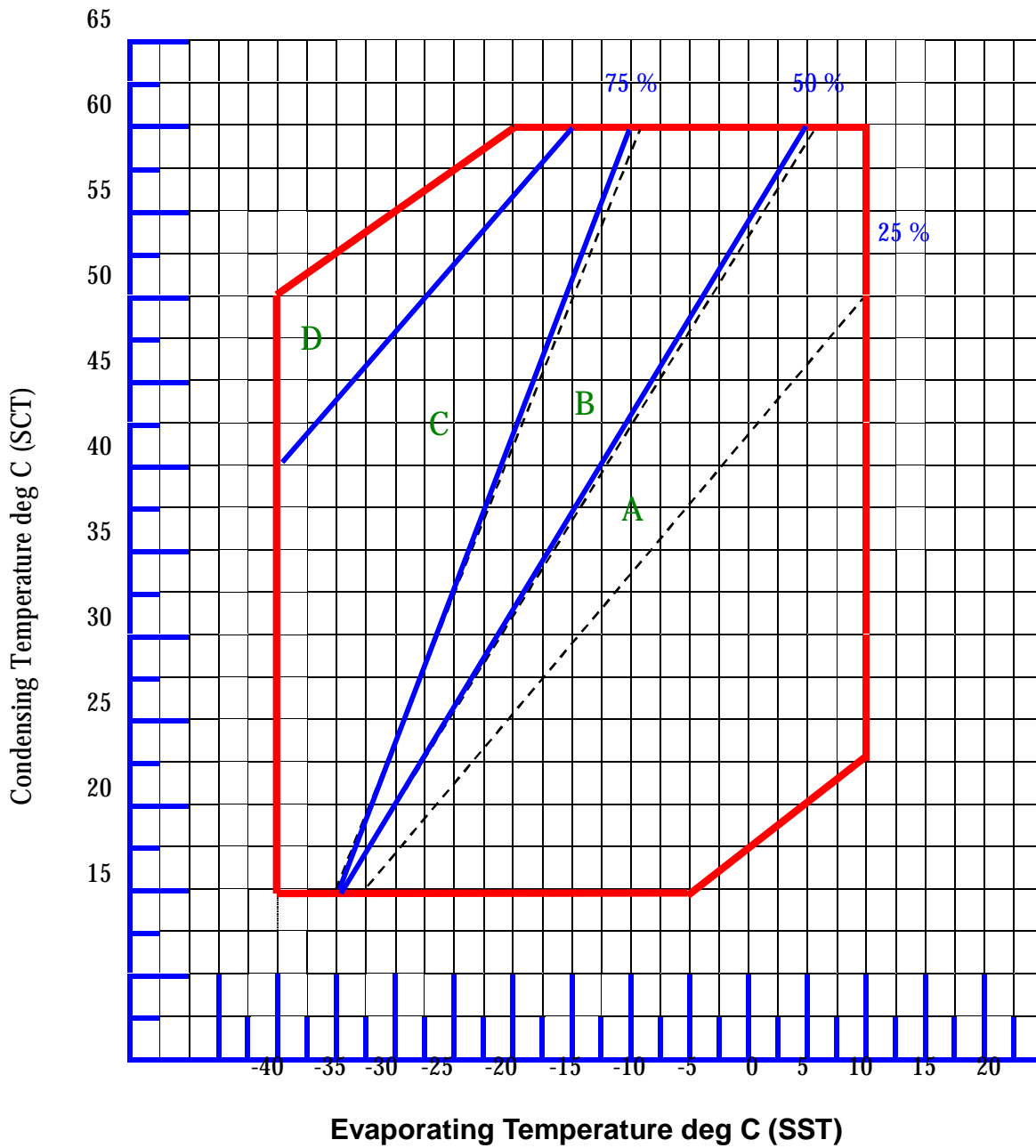


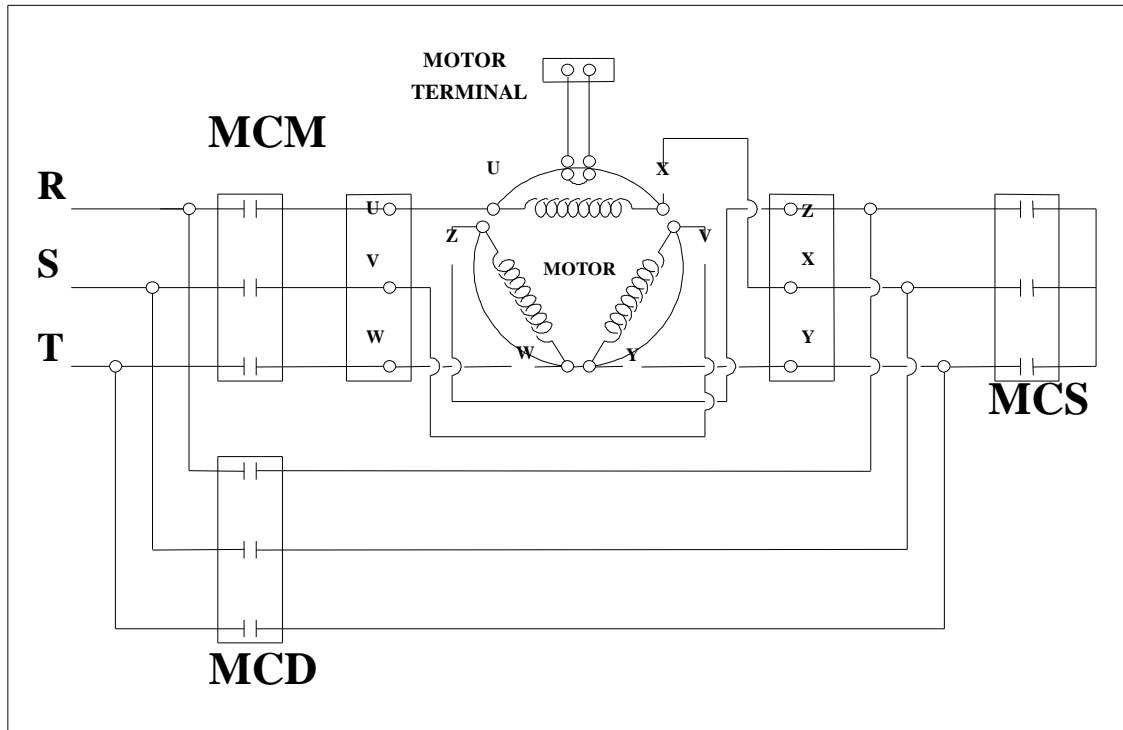
Fig. 1.7.4 R507A Limitation Diagram

- A: Normal Operation
- B: Oil Cooler or Liquid Injection
- C: Oil Cooler and Liquid Injection
- D: Check with HANBELL

1.6.2 Startup the compressor

Compressor motor designed for Y- Δ connection; refer to Figure 1.8 shown below for the connection of wiring.

Figure 1.8 Motor Connection Diagram



1.6.3 Startup Limitation :

Lowest starting voltage : The power voltage can not be lower than 10% to the rated voltage during the compressor starting-up period.

Maximum discharge pressure : $18 \text{ kg/cm}^2 \text{G}$ °

Minimum suction pressure : $6 \sim 8 \text{ kg/cm}^2 \text{G}$ °

※The loading of air-cooled heat pump system is much critical in operation than the water or air-cooled chiller, so it is necessary to load the compressor step by step after startup and also necessary to add the liquid injection devices for cooling the motor temperature and to control the discharge temperature.

※ If the starting condition is over the above limitation, the Direct Starting Connection will be recommended to start up the compressor.

1.6.4 Maximum designed discharge pressure : $28 \text{ kg/cm}^2 \text{G}$.

Maximum designed discharge temperature : 110°C .

1.6.5 Capacity control system

The RC series compressors have two kinds of capacity control i.e. 3-step (RC10~RC11 only)/4-step (RC12~RC24) and step-less (continuous) modulating capacity control design; 3-step/4-step capacity control means 100%-66%-33%/100%-75%-50%-25%; the 25% capacity step are normally for starting the compressor only, but if it is required to run the compressor at 25% capacity longer (RC12-RC24), then the liquid injection devices are essential for cooling the motor. Continuous modulating (step-less) capacity control which range from 100%-33% (RC10-RC11)/100%-25% (RC12-RC24). (The controller for step/step-less are exclusive to the compressor standard accessories, i.e. it is optional for customer to select. Hanbell also offers micro controller for customers' application in chillers, contact Hanbell local agent/distributor for more information)

1.6.6 Starting current of compressor

Definition of the Starting Current : The current of motor coil (stator) energized with rated frequency and voltage during locked the motor rotor, so the starting current is the same as so-called locked rotor ampere (LRA).

Starting current of RC compressors (LRA):

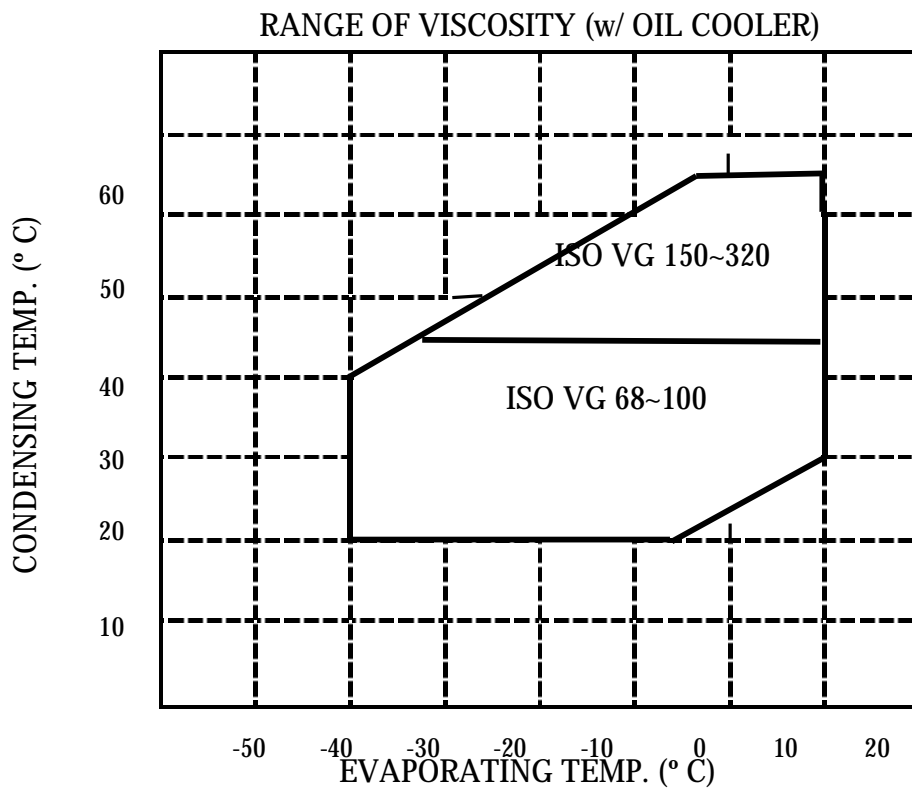
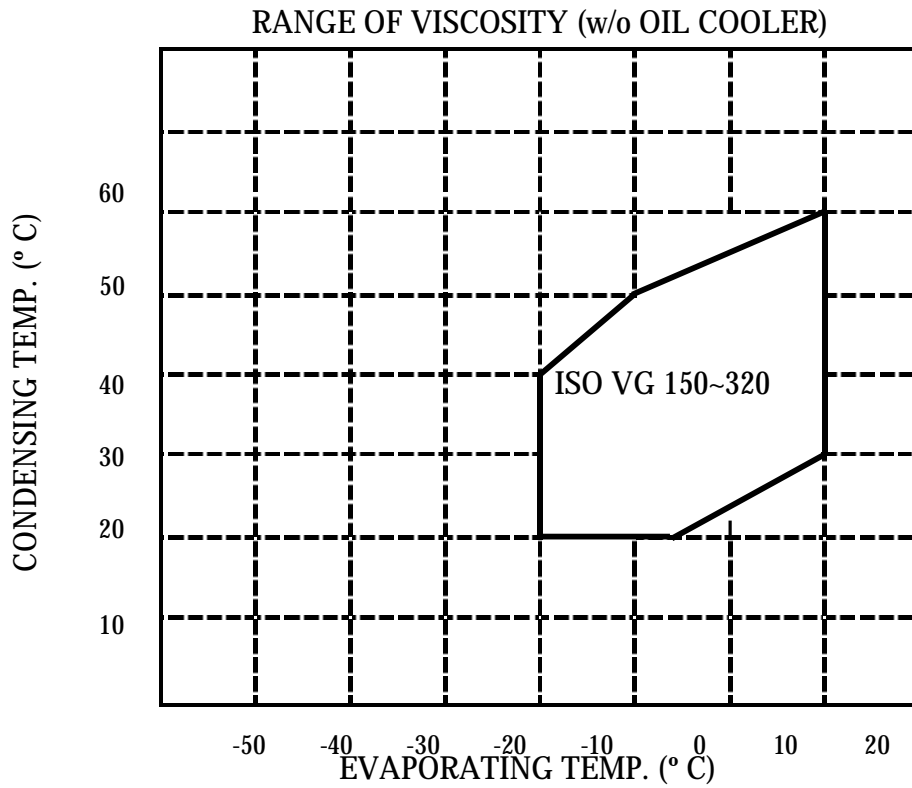
R22, R404A, R407C, R507A

Model	380V, 60Hz	380V, 50Hz	Model	380V, 60Hz	380V, 50Hz
RC10	300	250	RC17	1120	1030
RC11	330	275	RC18	1350	1195
RC12	410	340	RC19	1805	1385
RC13	540	445	RC20	2365	1650
RC14	600	510	RC21	2365	2100
RC15	815	710	RC22	2345	2255
RC15L	815	710	RC23	2945	2830
RC16	885	765	RC24	3065	2945

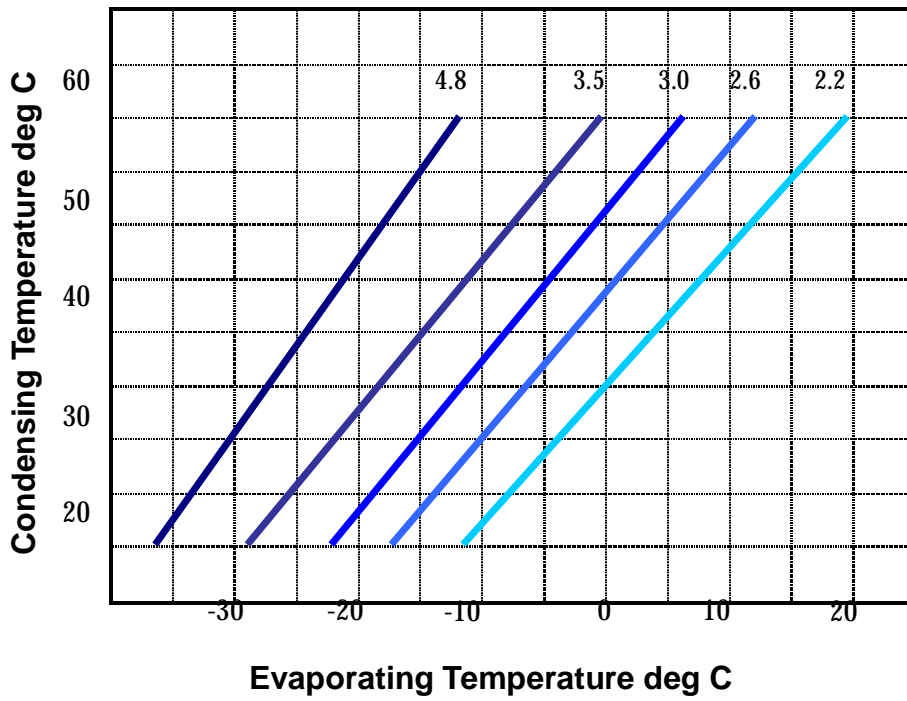
[Please refer to the latest HANBELL SELECTION PROGRAM for more information!](#)

The current value measured by the ampere meter during starting the compressor are different to the above corresponding value, because the starting peak value while starting the compressor can not be caught by the ampere meter easily and precisely. Normally the value of LRA Will Be approximately 3.0~3.5 Times the rated current, it is available to catch the starting peak value by using the clamp which has the peak hold function button.

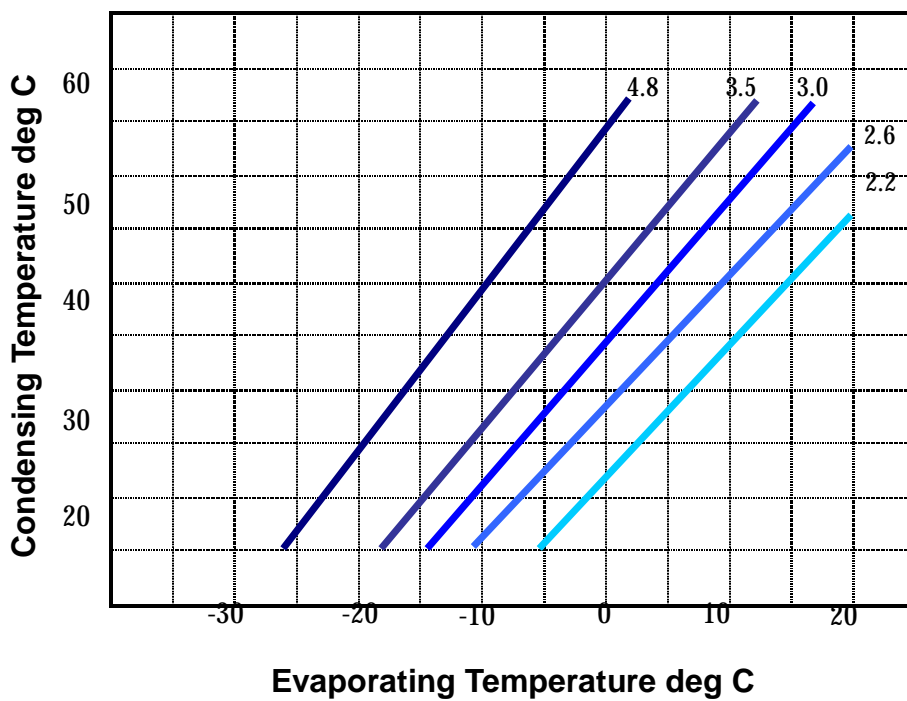
1.6.7 The Screw Compressor Apply Different Viscosity under Various Running Condition



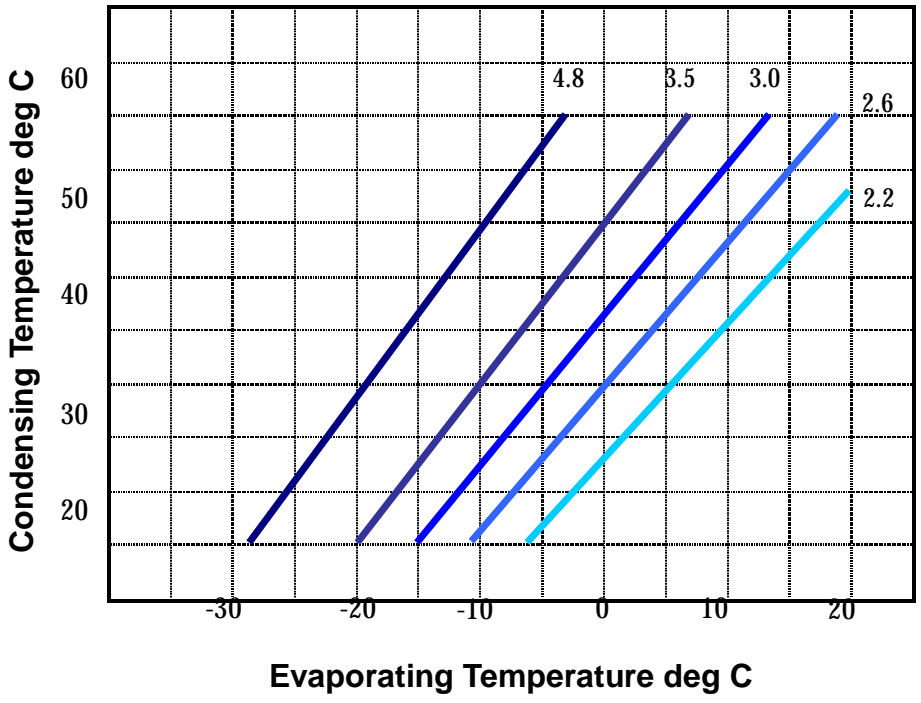
1.6.8 The Screw Compressor Vi Selection Diagram



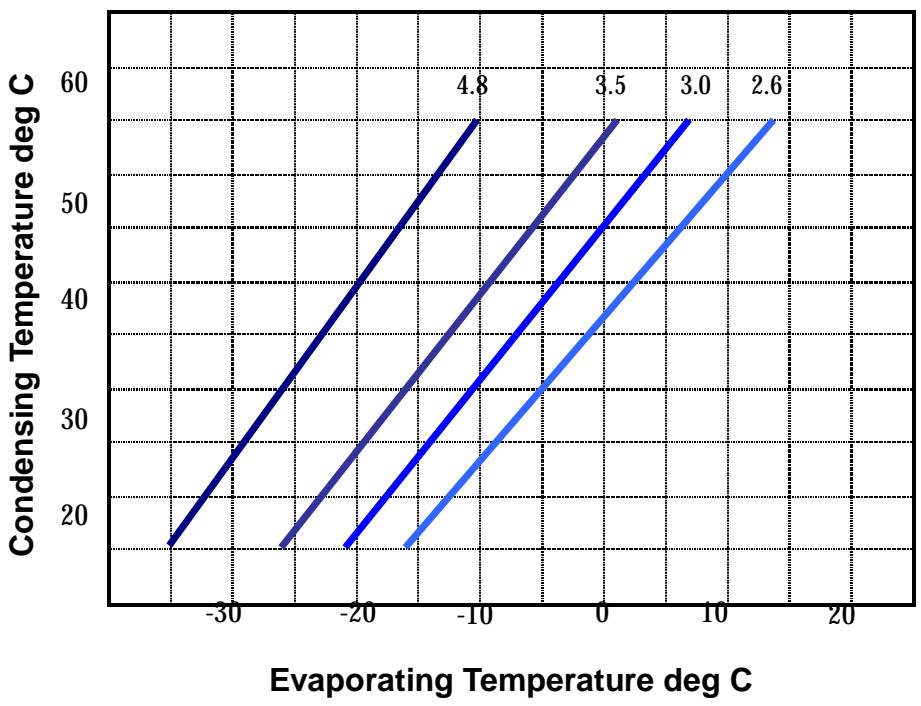
R22 Vi Selection Diagram



R134a Vi Selection Diagram



R407C Vi Selection Diagram



R404A Vi Selection Diagram

1.7 Electrical data

Please refer to the latest HANBELL SELECTION PROGRAM for more information. Or, contact our sales engineer first. The e-mail address are sales@hanbell.com and service@hanbell.com.

1.8 The running restraint of compressor

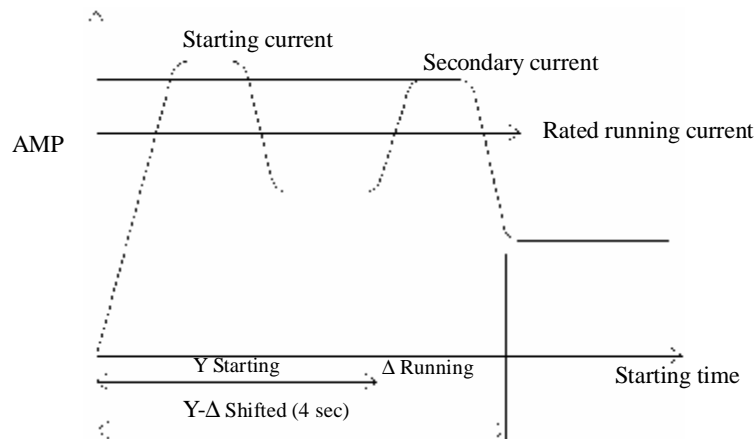
1.8.1 Compressor restart frequency

The restart counts for the models of RC10 ~ RC16 are recommended below 6 times in one hour, i.e. the startup count of the motor is not allowed to be over 6 times in one hour; as to another models of RC17 ~ RC21 are recommended not to be over 4 times in one hour, and models of RC22~RC24 are recommended not to be over 3 times in one hour.

1.8.2 During the anti-recycling period of starting-up the compressor, each time interval for re-starting the compressor is recommended to follow the above illustration.

1.8.3 Heat the oil by heater continuously after shutting down the compressor.

1.8.4 The starting for the Y start is usually set at 4 ± 1 seconds, and the maximum allowable shift time from Y to Δ is 40 msec. It is advisable to change the Y starting time upon the different working condition at the job-site in accordance with the current variation of Y starting. It is recommended that the duration of the Y starting is not over 15 seconds at the step of 25% capacity.



1.8.5 Supply power :

- Voltage : Long-term running => Rated voltage $\pm 5\%$.
- Instant running=> Rated Voltage $\pm 10\%$
- Frequency : Rated frequency $\pm 2\%$.
- Phase current unbalance : The difference in phase current between the biggest phase current differential and smallest phase current differential is required to be less than 3%. If

the phase current unbalance happens, change the supply power of any of the two phases to ensure the trouble caused by motor or by primary supply power. In case the trouble was caused by primary supply power then shut down the chiller immediately to do the troubleshooting and then restart the chiller. In case the trouble was caused by motor then contact HANBELL or local distributor/agent.

- e. The region where the power electricity is unstable, install an additional Hi-Low Voltage protector to ensure the safe running of the compressor.

1.8.6 Phase voltage unbalance : $\pm 2.25\%$.

1.8.7 The range of ambient temperature : -10°C to 55°C (If the compressor running at the ambient temperature over 50°C , it is recommended to install the liquid injection and the oil cooler devices to cool down the motor and reduce the discharge temp).

1.8.8 Control voltage :

- a. The standard sub control Voltage is 220V on Hanbell screw compressors.
- b. The motor coil inserted with a thermister in each phase connected with the discharge temperature thermister in series to the INT69 protector (KRIWAN) terminal T1 and T2; the standard voltage of INT69 protector is 220V, voltage 110V is optional.
- c. The oil heater and the capacity control solenoid valves voltage is 220V.

* If the sub control Voltage of 110V or other is required, list the special voltage in order for further identification and preparation of the part.

1.9 Protection switch

Table 1.7 shows the list of protection switches, which are essential to protect the compressor and operate safely. Follow the protection switches listed in table 1.7 to ensure the compressor running under normal condition. It is not allowed to change or short any protector terminals arbitrarily to damage the compressor. If HANBELL or its representative finds this incorrect action, HANBELL doesn't have the warranty responsibility.

Table 1.7 Compressor protection switches
(for different application)

Protection switch	Set point
Motor wiring temperature protector	Cutout 120°C , Cut in 75°C
High discharge temperature protector	Cutout 110°C , Cut in 60°C
Phase reversal protector	Phase reversal when power on
Hi-Low pressure protector	Highest pressure $25\text{Kg}/\text{cm}^2\text{g}$
Phase failure protector	Phase failure when comp starting or running
Motor overload relay	Set by a related application value, any setting should be tripped in 15 sec.
Hi-Low Voltage protector	Rated Voltage $\pm 10\%$
Oil level switch	Oil level lower than the floating ball
Oil pressure differential switch	Cutout $2.5\text{Kg}/\text{cm}^2\text{g}$

1.10 Quality assurance

All RC semi-hermetic screw compressors are put through strict quality and performance tests prior to delivery. However, for any reason if a defect found on compressor within one year after the completion of installation and commissioning at the first job-site or within eighteen months from the date of delivery from HANBELL, HANBELL will repair it for free. HANBELL, however, will not be responsible if the compressor does not operate properly for any of the following reasons: 1). Damaged caused by shipment, natural disaster, war, etc. 2). Damaged caused by improper operation or maintenance that is not in accordance with the HANBELL Technical Manual or instruction, 3). Damaged caused by modification of any part on or connected to the compressor, and/or 4) damaged caused by the improper maintenance or repair by a non-authorized repair technician. HANBELL will also not responsible for any accident which may happened to personnel while installing, setting up, operating, maintaining, and/or repairing the compressor.

1.11 Troubleshooting and maintenance schedule

1.11.1 The troubleshooting table is shown below for the reference:

Table 1.8 Troubleshooting table

PROBLEMS	PROBABILITY CAUSES
1. Sudden trip of motor thermister/sensor.	<ol style="list-style-type: none"> 1. Low suction pressure or high suction temperature (lack of refrigerant or clogged suction filter.) or high suction superheat. 2. Motor overload. No liquid injection devices or any liq. inj. device failure. 3. Motor wiring thermister failure. 4. Unstable electricity system or failure. 5. Bad motor coil causing the motor temp to rised rapidly.
2. Compressor unable to load	<ol style="list-style-type: none"> 1. Low ambient temperature or high oil viscosity. 2. Capillary clogged. 3. Modulation solenoid valve clogged or burnt. 4. Internal built-in oil line clogged. 5. Piston stuck-up. 6. Oil filter cartridge clogged.
3. Compressor unable to unload.	<ol style="list-style-type: none"> 1. Modulation solenoid valve clogged or burnt. 2. Piston rings worn off or broken, or cylinder damaged resulting leakage. 3. Lubrication oil insufficient. 4. Leakages at discharge cover plate end side. 5. Solenoid valve voltage misused. 6. Piston stuck-up. 7. Capacity control logic unsuitable.

Table 1.8 Troubleshooting (continued)

PROBLEMS	PROBABILITY CAUSES
4. Poor insulation of motor	<ol style="list-style-type: none"> 1. Bad compressor motor coil. 2. Motor power terminal or bolt wet or frosty. 3. Motor power terminal or bolt bad or dusty. 4. Bad insulation of magnetic contactors. 5. Acidified internal refrigeration system. 6. Motor coil running long time continuously under high temperature. 7. Compressor restart counts too many times.
5. Compressor starting failure or Y- Δ starter shifting failure.	<ol style="list-style-type: none"> 1. Slide valve piston unable to go back to its 25% original position. 2. Voltage incorrect. 3. Voltage drop too big when starting the comp or magnetic contactor failure. 4. Motor broken down 5. Phase failure. 6. Motor thermister sensor trip. 7. Incorrect supply power connection. 8. Y- Δ timer failure. 9. Discharge stop valve closed. 10. In anti-recycling period. 11. Improper connection between node terminal of Y- Δ wiring.
6. Abnormal vibration and noise of compressor.	<ol style="list-style-type: none"> 1. Damaged bearing. 2. Phenomenon of liquid compression. 3. Friction between rotors or between rotor and compression chamber. 4. Insufficient lubrication oil. 5. Loosen internal parts. 6. Electromagnetic sound of the solenoid valve. 7. System harmonic vibration caused by improper piping system. 8. External debris fallen into the compressor. 9. Friction between slide valve and rotors.
7. High discharge temperature.	<ol style="list-style-type: none"> 1. Insufficient refrigerant. 2. Improper of expansion valve. 3. Condenser problem of bad heat exchange. 4. Refrigerant overcharged. 5. Air in refrigeration system. 6. Insufficient lubrication oil. 7. Damaged bearings. Mutual friction of rotors. 8. Improper Vi value. No system extra cooling devices. (Liquid Injection or oil cooler)

1.11.2 Maintenance schedule

Maintain the compressor periodically in accordance with the schedule shown in table 1.9. Authorized technician from HANBELL should perform the replacement of piston rings and bearings. DO NOT LET these task performed by a technician without proper training. Contact HANBELL or local distributor/agent for assistance or replacement arrangements.

TABLE 1.9 Maintenance schedule

CHECK POINTS	TIME PERIOD							
	1000 hrs	2500 hrs	5000 hrs	10000 hrs	15000 hrs	20000 hrs	25000 hrs	30000 hrs
Electrical insulation				∨		∨		∨
Oil filter cartridge				∨		∨		∨
Suction filter								∨
Capacity Control Piston rings								△
Oil level	∨	∨	∨	∨	∨	∨	∨	∨
Motor thermal protector			∨	∨	∨	∨	∨	∨
Bearings				∨		∨		∨/△

∨ check or clean, △ replacement

1.12. Liquid injection devices selection

1.12.1 Recommendation table for expansion valves

Model	System without oil cooler		System with oil cooler	
	Low temp expansion V/V	Hi- temp expansion V/V	Low temp expansion V/V	Hi- temp expansion V/V
RC-11	ALCO, 3HW	DANFOSS	ALCO, 1HW	DANFOSS TXI-2
RC-12		TXI-2		
RC-13		FUJIKOKI. JBE		
RC-14	ALCO, 5HW	ALCO, 935-D	ALCO, 3HW	FUJIKOKI. JBE ALCO, 935-D
RC-15				
RC-16		FUJIKOKI. JBE		
RC-17		ALCO, 935-E		

* Equip the system with solenoid valve and temperature switch when selecting the Lo-temp expansion valve. For heat pump system or low temperature application, it is recommended to install liquid injection devices to cool down the compressor motor and reduce the discharge temperature. Above table is the recommendation table for selecting the liquid injection expansion valve for the models of RC11 to RC17; in case the working condition is different from the above table, please contact local distributor/agent for more information.

1.12.2 Piping of expansion valve

a. Lo-temp type expansion valve (ALCO, SPORLAN etc.)

Control the lift of the expansion valve by the suction superheat directly.

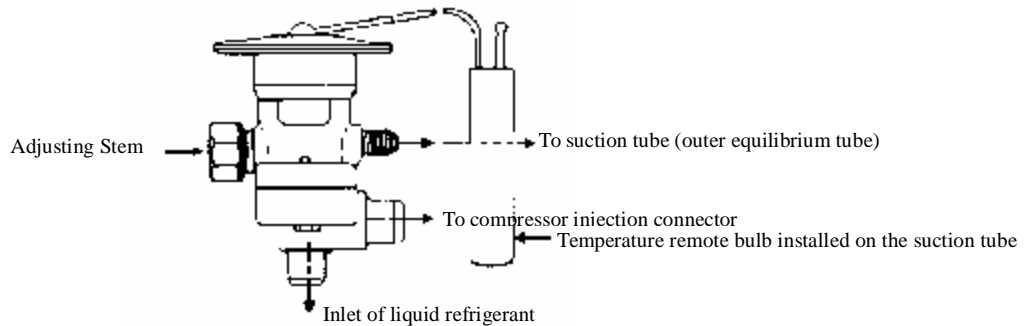


Fig 1.11 Installation of low-temp expansion valve

b. Hi-temp type expansion valve (FUJIKOKI, ALCO, DANFOSS etc.)

To sense the discharge temperature by bulb

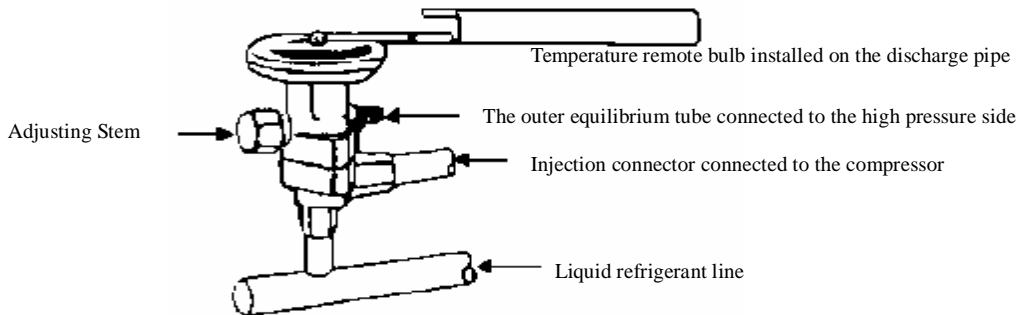


Fig 1.12 Installation of high-temp expansion valve

- c. In case of the liquid injection devices required to be piped to inject the liquid refrigerant into the middle pressure position of the compression chamber, the low-temp type of expansion valve should be installed in accordance with the illustration given in fig. 1.11 and, the high-temp type of expansion valve should be installed in accordance with the illustration given in fig.1.12.

1.13 Application, illustration, and caution

1.13.1 Application of liquid injection (refer to 1.13.2)

- a. Because the working condition of air-cooled chiller and heat pump chiller are higher than the water-cooled chiller, so the loading of the air-cooled chiller and the heat pump chiller is heavy while working at the required conditions. In Limitation Diagram shown in section 1.6, the compressor motor temperature and its compression chamber temperature will be very high almost approaching the setting of motor thermister and discharge temperature thermister which often resulted in the trip of the sensors under the above working conditions causing the chiller to shut down.

The purpose of installing a liquid injection system is to prevent the compressor from overheat, the system installed an expansion valve with tube piped between the liquid line

and compressor for cooling down the compression chamber and motor to ensure the compressor to run continuously and safely.

- b. The suction superheat should be controlled between 5K~10K for the application of air-cooled and heat pump chillers by means of the expansion valve devices. These devices can be adjusted by the stem of the expansion valve to control the suction superheat by means of refrigerant flow rate. When the initial startup, the loading of the chiller will be heavy due to the high temperature of chilled returned water/air, so the liquid injection devices capacity should be selected enough to reduce the overheat of the compressor.
- c. When the compressor applied in the low temperature system (E.T. $\leq -10^{\circ}\text{C}$), the compression ratio is high at this condition, also the discharge temperature will be very high. Therefore the use of liquid injection system is essential. The design of the liquid injection system for low temperature application which is similar to the illustration shown in fig. 1.12; and it could also be injected into the compression chamber by liquid injection from the liquid line for reducing the discharge temperature such as shown in fig. 1.12. It is also necessary for the customers to use the liquid injection system to cool down the motor due to the suction gas at this condition, which often have high superheat even higher than 15K.
- d. Another liquid injection system is applied to the high temperature expansion valve, which is equipped with a high temperature remote bulb (sensor) to detect the discharge temperature. When the discharge temperature exceeds the set point (80°C), the expansion valve will open proportionally to inject the liquid refrigerant into the compression chamber to cool down the compression chamber and control the discharge temperature.

SUGGESTION : On air-cooled and heat pump system, when the motor wiring and discharge temperature of compressor approaches 105°C , it is recommended to used the liquid injection devices to prevent the trip of temperature controller (INT69, KRIWAN) and keeping the compressor to run continuously. The setting of discharge temperature for the liquid injection solenoid valve is 80°C , and when the discharge temperature reaches this value the solenoid valve will open proportionally. The expansion valve is also adjustable upon the actual working condition, for compressor's long-term running, the allowable highest discharge temperature will not be over 95°C .

METHOD : Control the expansion valve by opening its remote bulb (high temp type, opening proportional) or discharge temp switch plus expansion valve's remote bulb (low temperature type); when the discharge temperature exceeds the set point it will open the liquid injection solenoid valve (low temp type), and then the liquid refrigerant inject into the compressor through the expansion valve. There are two connectors of the liquid injection port on compressor: one connector is in front of the compressor motor, and the

other connector is on the compression chamber.

! For more detailed information of liquid injection applications, contact Hanbell local distributor/agent.

1.13.2 Liquid injection system

1. Liquid injection system applied with low temperature expansion valve.

Normally, the low temp liquid injection expansion valve devices, which are, consist of solenoid valve, temperature switch and expansion valve. This device can sense the discharge temperature of the compressor, the solenoid valve will open when the discharge temperature over 80°C , and the liquid refrigerant will inject into the compressor motor side or in the compression chamber.

There are two connectors for the liquid injection system to pipe: one is in front of the motor, and the other is in the middle of the compression chamber. The front connection has the functions for reducing the compressor motor temperature and discharge temperature. The latter can reduce the discharge temperature and increases the compression efficiency. Consider first what the working condition needed and then adopt where to connect the liquid injection. General speaking, the heat pump system or the high superheat system (refrigeration system) are recommended to connect the liquid injection in front of the motor; and the air-cooled system or the low suction superheat system are recommended to connect the liquid injection in the compression chamber side.

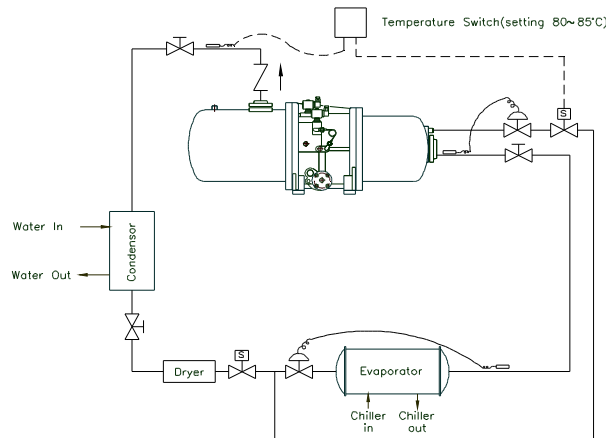


Fig 1.13 Liquid injection (low temp type) connected to the front of motor

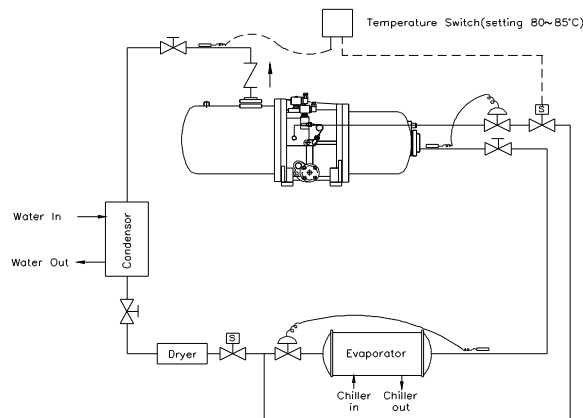


Fig 1.14 Liquid injection (low temp type) connected to the compressing chamber

2. Liquid injection system applied with high temperature expansion valve

Select the high temperature expansion valve, which can sense the discharge temperature with its remote bulb. This can control the opening of expansion valve proportionally, and can reach the best cooling effect; it will control the compressor discharge temperature at an optimal situation of around 80°C.

It can also install an additional solenoid valve or service valve in front of the high temperature expansion valve for the maintenance purposes. The solenoid valve will be opened while starting the compressor, and it also can be added a stop valve in piping for the system maintenance. The equilibrium tube of high temperature expansion valve should be connected to the high - pressure side to counter the internal pressure.

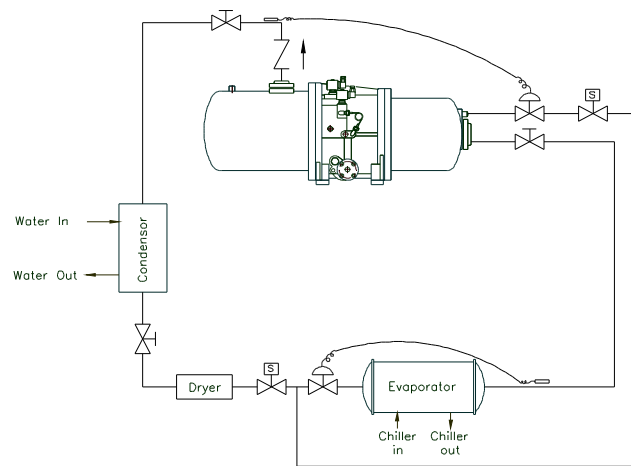


Fig 1.15 Liquid injection (high temp type) connected to the front of motor

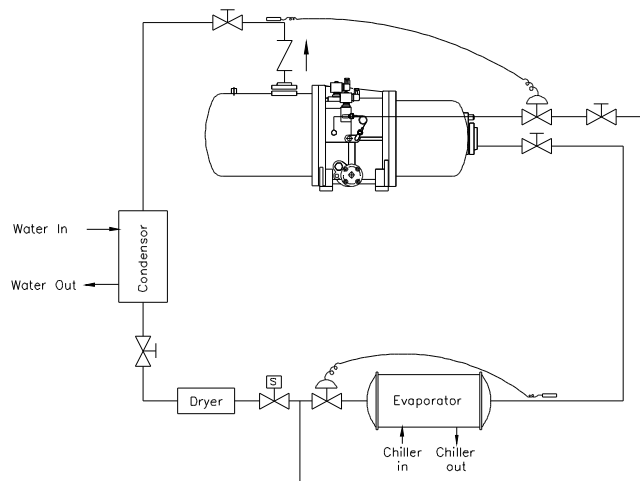


Fig 1.16 Liquid injection (high temp type) connected to the compressing chamber

1.13.3 Starting the compressor (refer to diagram 1.17)

The loading of the compressor is very heavy when applied in air-cooled or heat pump chiller especially at each initial starting. Because of the heavy loading, it will take long time to pull down the loading in the system to the required condition. During this period the compressor loading is always heavy, so it is very easy for the protector of the compressor to trip and shut down the chiller. In order to prevent from this situation to happened, the starting sequence of the chiller should be set upon the following steps:

The compressor starts at 25% (33%) capacity and keeps running at least 30 seconds, then switches it to 50% (66%) capacity and keeps running for 3 ~ 5 minutes, and then switches it to 75% capacity (RC10-RC11 omitted) and keeps running again for 3 ~ 5 minutes, and then finally switches it to 100% capacity and keeps running. Upon the different loading, it normally needs to take about 7 minutes from starting the compressor to the full load for cooling the chilled returned water/air temperature to the required set point. When the compressor reached the full load, the technician can adjust the starting time to meet the actual loading status to let the compressor operate at the best condition.

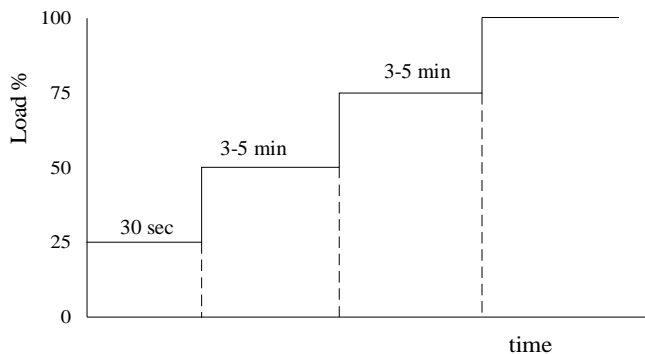


Fig 1.17 Starting sequence of compressor (depends on different working condition)

The compressor Y-Δ starting time should also be considered except for the above mentioned starting sequence; it will be set about 3~5 seconds of the Y start then shift to delta running, but there will be some difference owing to the different design of the chiller and the different manufacturer of the compressor. It should adjusted the starting time as per initial testing of the chiller.

The shortest restart time after the compressor shutdown are shown in Table 1.10, the slide valve should be ensured at 25% (33%) position before per restart. If the compressor restarts in short time after shutdown, the starting current will be very high because of the heavy load resulting in the trip of NFB.

Table 1.10 Shortest restart time after compressor shutdown.

MODELS	SHORTEST RESTART TIME (min.)
RC10 ~ RC15L	3
RC16 ~ RC17	8
RC18 ~ RC21	15
RC22 ~ RC24	20

If the compressor used with Y- Δ starter, it should be connected to three contactors of M.S.D. for switching. Be careful that mechanical & electrical interlock problem might occur while the contactors switching, and prevent from short circuit to happened in the control circuit. If the contactor rusted or damaged, it will produce noise while the compressor starting or running. These above situations are dangerous to the compressor motor, so it is essential to maintain or replace the contactor immediately.

The compressor load duration from starting 25% (33%) to the full load 100% are depends on the working condition and the system loading. If the system could reach the required working condition very fast, then the compressor loading can start from 25% (33%) to 100% directly. On the contrary, the compressor should start upon 25% - 50% - 75% - 100%/33%-66%-100% sequence to prevent the compressor from overloading.

Remember that the oil volume in the capacity control cylinder of RC17 to RC24 is needed to fill with more oil. Meanwhile, it needs to take time to ensure if the slide valve are back to its 25% position absolutely while a full load shutdown happened, hence it should take 15 – 20 minutes at least to restart the compressor. For reaching the above situation easily and quickly, another method is to open the 25% (33%) solenoid valve for about 30 seconds unloading of the compressor before shutting down the chiller. This can assure that the compressor can restart at 25% (33%) position next time, so it can restart the compressor easily in just a short time after confirmation of the system Hi-Lo pressure balanced. In order to prevent the chiller from shutting down because of the power loss or power failure, the restart time of the compressor should be set 15 minutes at least to prevent from the compressor under unbalance system with a heavy starting load.

1.13.4 Application of thermal/ice storage system

The Evaporating Temp of THERMAL/ICE STORAGE is generally at the range of -10°C ~ -15°C ; here compression ratio will be bigger if the above application used. Also the discharge temperature of compressor will be higher, it often resulted in the trip of discharge temperature protector. In order to prevent the compressor from getting damaged, and ensure the compressor running smoothly, it should be added a liquid injection system on compressor to prevent it from approaching the discharge temperature limit.

Because the evaporating temperature of thermal/ice storage system is low, the lubrication oil often accumulates in the evaporator and not returning to the system. So it is recommended to add an extra 2nd oil separator between the compressor discharge pipe and condenser, the separated oil in 2nd oil separator will be pushed back to the middle pressure side of compression chamber, it will also reduce the oil carryover to the system.

Moreover, the working condition in this application is higher, so it is recommended to add an oil cooler to cool down the oil temperature, which can prolong the compressor

bearings' life and reduce the discharge temperature as well.

If the thermal/ice storage adopted the half-storage type, it should be considered the compressor discharge temperature and return oil problem at the same time for this application. The compressor should work under dual working conditions: i.e. THERMAL/ICE STORAGE & AIR CONDITIONING. Therefore the system design should considered that the compressor are working at two different conditions and must have to considered the following problems that may encounter:

- a. The liquid injection system and compressor discharge temperature control.
- b. The return oil problem while the compressor unloading.
- c. The viscosity of lubrication oil and return oil problem.
- d. The dual expansion valves' selection.

1.13.5 Economizer system application

The compressors are equipped with a middle pressure injection port/connector where the vapor injection from economizer can be connected to increase the compressor efficiency. Refer to section 3.2.2 Diagram plotted economizer Correction Factor for the system incretion of the efficiency/capacity and input power.

1.13.6 HFC new refrigerants' applications (R-134a, R-407C, R-404A)

HFC-134a new refrigerant can be applied in RC series compressor, the function is similar with the HCFC-22; but when HFC-134a is applied in RC series compressor, the refrigeration capacity and motor output power will reduce by about 33% compared to HCFC-22. It should be more careful to utilize the HFC-134a system as it used special Ester lubrication oil (refer to the list in Table 2.2) in which moisture absorption capability is stronger than the mineral oil. So if the chiller system is opened, it should be closed again in the shortest time (3 days) and be vacuumed it again as soon as possible. The system should be closed in the shortest time and then do the pressure test, filled in the lubrication oil then vacuumed it to prevent the lubrication oil from getting exposed to the atmosphere too long and absorbing much moisture from atmosphere.

HFC-407C & HFC-404A are blend with non co-boiling point refrigerants existing the dew point and bubble point situation. It should be paid more attention to the design of the evaporator, and their lubrication oil should used the POE Ester like in HFC-134a. It is suggested to fill the lubrication oil into the system at the last stage for chiller assembly while using the blend of R-134a, R-407C, R-404A. That is, at the vacuum stage to charge-in the oil to prevent the lubrication oil from absorbing the moisture and being contaminated during assembling.

If the system expected to be changed the refrigerant from R-22 into HFCs, the whole components of the system should be considered again except the changing of lubrication oil from the system. For example, the size of expansion valve, changing of drier, the capacity of condenser and evaporator.

1.13.7 Check valve installation

In order to prevent the gas from flowing back to the screw compressor while the chiller is shutdown, the compressor should be installed a check valve at the discharge side. The check valve of HANBELL is designed with gravity type as a standard, which is installed at the discharge port of the compressors' oil separator; it is put in the discharge tube after oil separator with vertical installation.

1.13.8 Phase reversal protector

The screw compressor is very sensitive to the reversal of rotation, so it should be confirmed the phase sequence of electricity main power before the compressor start running. In order to prevent the damage of compressor from phase reversal, it should be added a Phase Reversal Protector. There are two options explained below:

- a. Add a Phase Reversal Protector in the electrical control interlock circuit.
- b. Add a high/ low-pressure differential switch. It will shut down the compressor if the low pressure is higher than the high pressure while starting the compressor.

The above two methods will confirmed whether the phase sequence are correct or not, it will shut down the compressor immediately when the power sequence reversal. Meanwhile, it will also ensures the low pressure descending and the high pressure ascending in the system. Otherwise, it has to be changed any of the two phases of the main power cable to correct the phase sequence and re-start the compressor again.

RC18, RC19, RC20 & RC21 types have two oil sight glasses, one is oil level sight glass, and another one is oil line sight glass. The technician could check whether the lubrication oil is sufficient or not from the oil level sight glass. If the oil line sight glass has large quantities of refrigerant with bubble, it means the oil level is insufficient, and the technician should shut down the chiller to check the oil level again from the oil level sight glass. It is very easy for the bearings to get damaged if the lubrication oil line is full of refrigerant, which can clean the bearings without oil because the refrigerant is a very good detergent.

1.13.9 The oil level of lubrication oil

Asides from lubricating the bearings and compression chamber, the lubrication oil also controls the capacity control system for the compressor. It has oil sight glasses on both sides of the compressor to check whether the oil level is keeping above the bottom of sight glass or not. There is an oil sight glass on compressor each side, the upper and the lower limitation of oil level in the compressor for models RC14, RC15, RC16 and RC17 (RC10-RC13 option). All of Hanbell screw compressors will be added the extra 3 liters of lubrication oil to the standard amount. It could be higher or lower to the oil level on the oil sight glasses while the compressor running, so the technician can check the lowest level of

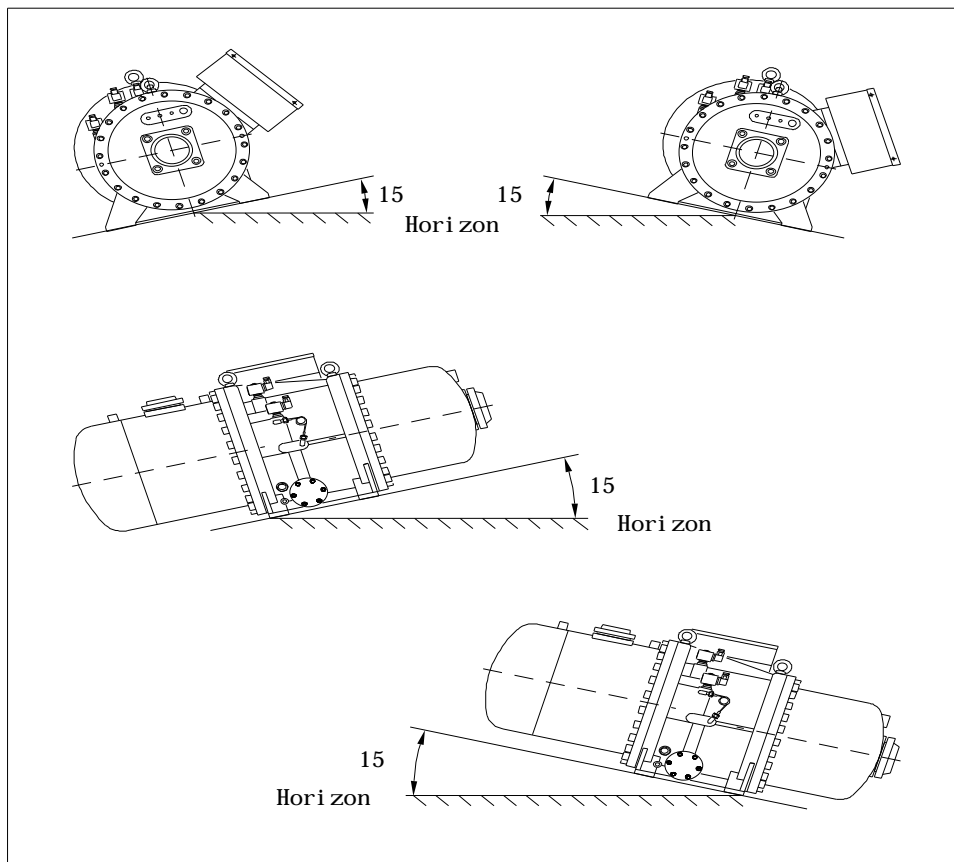
the oil while the chiller is running or check the oil level while the chiller shutdown beside the standard oil level. For flooded evaporator application, it is necessary to calculate the extra oil amount in the compressor aside from the evaporator capacity, otherwise it will be easy to shut down the compressor for the sake of low oil level caused by insufficient oil.

* NOTE : In case the chiller system with a very long piping, it is necessary to calculate the additional amount of oil needed so that the compressor will have sufficient oil.

1.13.10 The limitation of oblique angle for installing the compressor

Refer to Figure 1.18, it shows the limitation of oblique angle for the installation of the compressor. In case the oblique angle is too large, it is very easy to shut down the compressor because of the low oil level. For special application, if the oblique angle of the compressor are installed larger than the standard angle like application in the ship, fishing boat etc. contact Hanbell or local distributor or agent for more information to meet the requirement.

Fig 1.18 Maximum Permissible Oblique Angle



1.13.11 Cleaning of the system and oil change after the compressor motor burnt out

In case the motor burned out, the refrigerant should be reclaimed from the system entirely by the local environmental Regulations. It is necessary to drain first all the oil and vacuum the system then charge dry Nitrogen into the system before replacing the new components. This procedures can prevent the system from contamination due to the acidity and moisture

during the replacement. It should be recharged the system with new refrigerant, oil, and check whether the lubrication oil is sufficient and whether the drier has been changed prior to the installation of new components. After the setting up of all the switches and protectors then try to run it for one hour, then shut down the compressor and change new lubrication oil, drier, and reclaim the refrigerant and recharge new ones, then restart the chiller for running. After one week of running, it should be changed the lubrication oil and drier again to ensure that there is no acid material and moisture inside the system.

1.13.12 Oil filter cleaning and oil pressure differential switch application

The suction filter and oil filter should be cleaned together after repairing the compressor for every try-run. It could prevent the compressor from getting damaged caused by the large pressure drop which may result in the possibility of motor burnt, bearing damaged or irregular action of slide valve. And it also can be added an oil pressure differential switch to prevent the compressor from getting any damaged due to the oil filter clogged.

1.13.13 Other warnings

- a. The oil heater should be kept heating after the compressor shutdown. This can keep the temperature of lubrication oil above the standard, especially when the ambient temperature is very low. Also the lubrication oil temperature should be controlled carefully, it has been applied in the different system as per different condition. The lowest temperature of the lubrication oil before starting-up the compressor should be maintained 15K higher than the ambient temperature.
- b. Inspect the insulation of compressor motor periodically, especially at the initial startup after installation of the chiller package and the first startup at every year as well. Do not start the compressor if the insulation value of motor is lower than $5M\Omega$, if the motor insulation value under standard, contact the authorized technician immediately.
- c. Do the leakage test after each repaired of the compressor to ensure that there is no leakage of refrigerant.
- d. Replace the whole set of bearings and re-adjust the discharge clearance of male and female rotors whenever executing the damaged bearings maintenance.
- e. In application of low temperature refrigeration system or thermal/ice storage system, be sure to keep the electrical power terminals from the condensing water forming at motor side of compressor. For electrical safety reason, it is necessary to clean the power terminals periodically or cover the power terminals with insulation silicon if frost forming seriously at the job site.
- f. Normally the running temperature at the discharge side will be 20°C higher than the saturated condensing temperature in the condenser. By application of liquid injection system, it is easy to prevent the discharge temperature from getting too high. Too much liquid in the discharge side will cause lower discharge temperature.

Although the structure design of screw compressor can stand the liquid compression

in a certain time, but also necessary to avoid the liquid refrigerant into the lubrication system as it will cause failure of lubrication (as viscosity of lubricant becomes lower) and reduce the bearings' life in the same time. The bearings' life is related to the discharge temperature, so the system needs to be designed in a well control of compressor discharge temperature. Whenever the discharge temperature is out of normal situation, it has to find out the reason and control the system back to normal condition to reduce the discharge temperature.

g. Setting of torque wrench

Table 1.11 below shows the setting of torque wrench while reassembling the compressor during maintenance.

Table 1.11 Setting of torque wrench

	Torque (kg-cm)
1 1/2" Flange and Check valve	1000
2 1/2" Flange and Check valve	1000
3" Flange	2000
4" Flange	2000
5" Flange	2000
Cleaning Flange	850
Oil Filter Joint	850
Power Bolt	900

※ Above setting values are suitable for 7T, 8T bolts

1.13.14 Application of the 2nd oil separator.

There are 3 ways for oil returning to the compressor from the external 2nd oil separator:

1. Oil level control valve – Install the oil level control valve in the 2nd oil separator, the valve will be opened to let the oil returning back to the compressor while the oil level rise to the setting of high level switch.
2. Solenoid valve and Timer – Install the solenoid valve to the oil returning piping which can be controlled periodically with on/off by a relay timer to open/close the oil returned.
3. Solenoid valve and stop valve – Install the stop valve to the oil returned piping and adjust it to get the suitable oil flow rate back to compressor while the first initial startup. The solenoid valve will only be opened/closed when the compressor start/stop.

※ A solenoid valve installed between the 2nd oil separator and compressor in oil returned piping is required to prevent the high pressure oil/gas to pass through the compressor low pressure side while the compressor shutdown.

The oil returning position on the compressor can be selected either from the connector at the motor side or from the connector at middle pressure side of the compression chamber.

It is also allowed to connect the oil piping to the suction tube if the two connectors of the compressor are used for another applications.

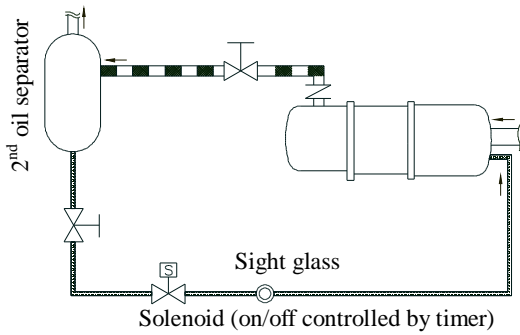


Fig 1.19 Returned oil controlled by solenoid valve (to motor side)

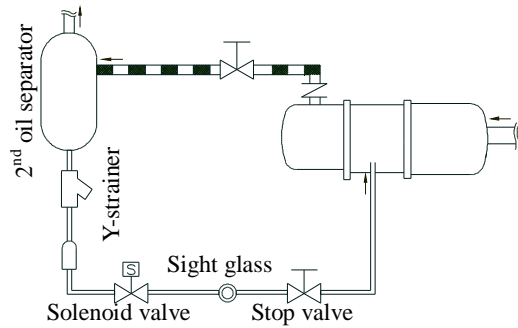


Fig 1.20 Returned oil controlled by solenoid +stop valve(to middle pressure side)

1.13.15 Application of oil cooler

1. Application of oil cooler – RC series

Replace the standard accessories of RC compressor (oil filter, oil filter flange, cleaning cover) into the special type, then follow the drawings shown on page 37 for oil cooler piping.

Application of oil cooler

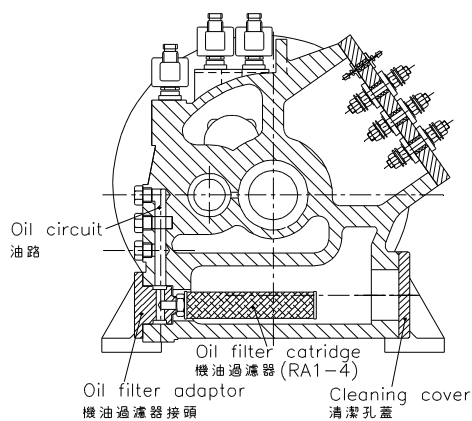


Fig 1.29 RC12-15 oil system circuit

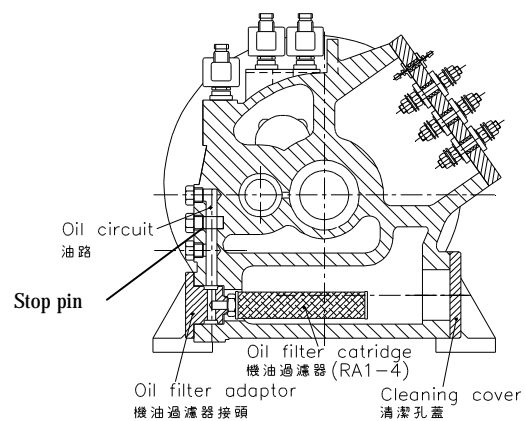


Fig 1.30 RC12-15 oil cooler connecting diagram

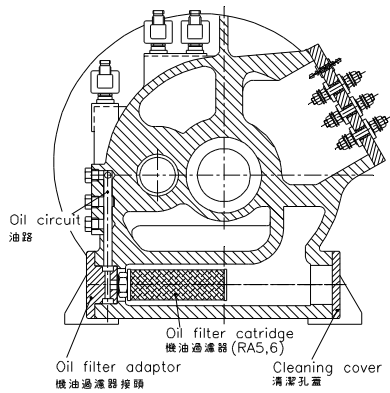


Fig 1.31 RC16, 17 oil system circuit

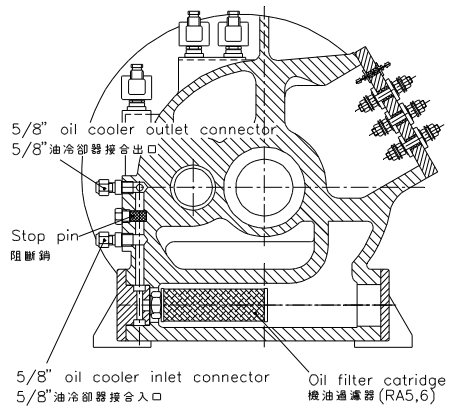


Fig 1.32 RC16, 17 oil cooler connecting diagram

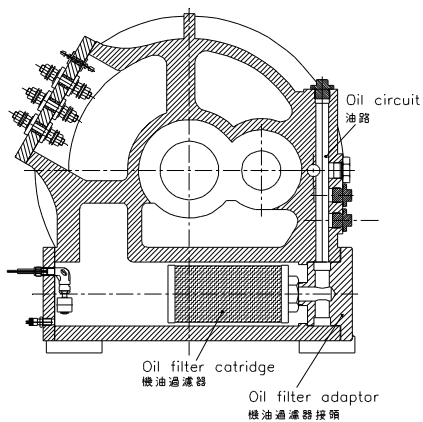


Fig 1.33 RC18-21 oil system circuit

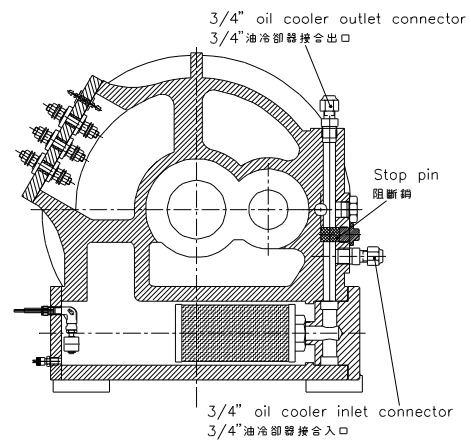


Fig 1.34 RC18-21 oil cooler connecting diagram

2.The heat load of oil cooler/liquid injection in different working conditions – RC series

Unit: Kcal/hr

E.T , C.T	Hz	RC-10	RC-11	RC-12	RC-13	RC-14	RC-15	RC-15L	RC-16
0°、50℃	50	3096	4016.2	4970.8	4575.2	6656.4	4953.6	4755.8	7998
0°、55℃	50	7120.8	9434.2	11816.4	12194.8	16821.6	16649.6	17432.2	24071.4
-10°、45℃	50	3199.2	4179.6	5194.4	4988	7112.2	5942.6	5934	9150.4
-15°、45℃	50	4497.8	5934	7421.8	7542.2	10483.4	10036.2	10414.6	14680.2
-20°、45℃	50	5512.6	7327.2	9184.8	9580.4	13158	13321.4	14026.6	19109.2

* While the discharge temp. kept at 90 °C / 194°F ; based on refrigerant: R-22

Refer to the latest HANBELL SELECTION PROGRAM for more information!

Unit: Kcal/hr

E.T , C.T	Hz	RC-17	RC-18	RC-19	RC-20	RC-21	RC-22	RC-23	RC-24
0° 、 50°C	50	6484.4	8832.2	9331	10449	10879	19556.4	21560.2	21138.8
0° 、 55°C	50	25499	31166.4	33875.4	42363.6	45253.2	67664.8	78079.4	85372.2
-10° 、 45°C	50	8367.8	10844.6	11592.8	13682.6	14430.8	29764.6	33763.6	35604
-15° 、 45°C	50	15144.6	18705	20270.2	25094.8	26754.6	53793	62100.6	68077.6
-20° 、 45°C	50	20605.6	25017.4	27244.8	34296.8	36696.2	76256.2	88580	98452.8

* While the discharge temp. kept at 90 °C / 194°F ; based on refrigerant: R-22, 50 Hz
 Refer to the latest HANBELL SELECTION PROGRAM for more information!

The size of oil cooler can be selected using the above table of heat load. Both of shell & tube type and plate heat-exchanger type oil coolers are suggested to apply to the compressor. The following 3 types of cooling piping are also recommended.

a. Cooling by refrigerant (The refrigerant comes from the liquid line and back to the middle pressure connector)

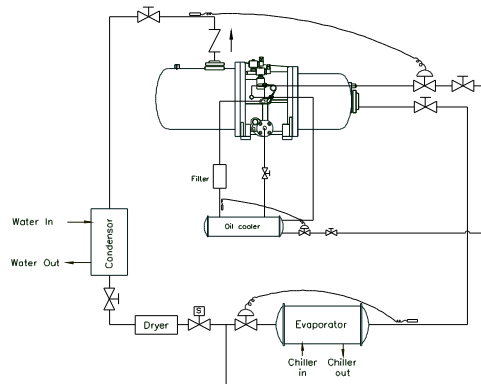


Fig 1.35 Oil Cooling By Refrigerant (refrigerant cooled)

b. Cooling by ambient air

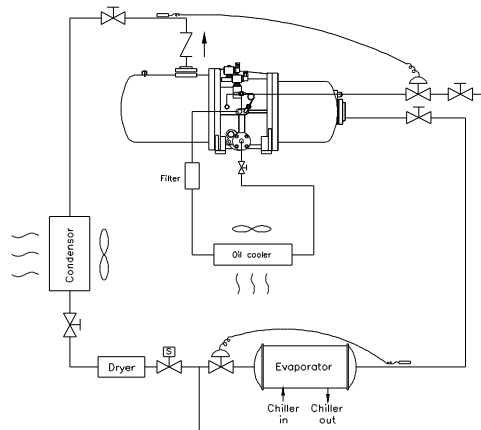


Fig 1.36 Oil Cooling By Ambient Air (air-cooled type)

c. Cooling by cooling water

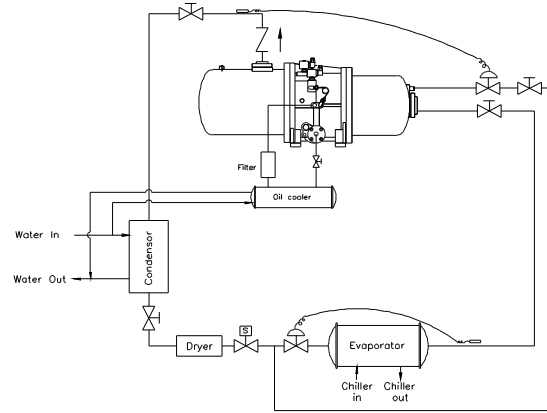


Fig 1.37 Oil Cooling By Water (water-cooled type)

1.13.16 The delay timer with oil level switch

When selecting the oil level switch as a protector of the compressor, it needs to prevent the floating bowl of oil level switch to trip and shut down the compressor. Because of the oil foaming or surging in the oil tank, so it needs to add a delay timer in oil level switch circuit with around 60~90 seconds delay to ensure whether a real low oil level happened.

1.13.17 The delay time of 4E relay

The high sensitivity of 4E Relay could shut down the compressor while an unstable electricity power happened suddenly, so a delay time for alarm with 3~5 seconds trip delay is recommended to the control circuit.

1.13.18 Liquid refrigerant in the suction side

If the liquid refrigerant accumulates in the evaporator and compressor suction side during the compressor shutdown, it will cause abnormal noise in the beginning (a few minutes) of next startup. For the long term running, liquid compression does not only reduce the bearings' life but it also deform the rotors. Once the above situation happened, it must to find out the reason and solve it. (Only qualified technician can do the troubleshooting of the system)

1.13.19 Application of rack & parallel system

In the rack or parallel system (multi-compressors in a chiller package with common condenser, common evaporator or common oil separator), it is possible to happen the unequal-distribution of returned oil from the evaporator that could cause low oil level in one or more of the compressors. Be sure to install the oil level switch inside each compressors and oil flow switch installed in each oil return line to ensure the returned oil in each compressor with normal oil level.

1.13.20 Pump down

DO NOT do the pump down on the chiller during the routine running except for the

temporary maintenance or a long-term shutting down. When doing the pump down of the system, be sure to take notice of the items listed below:

1. Note that the discharge temperature rises suddenly while pumping down, then stop the pumping down temporarily if the discharge temperature switch trip.
2. The lowest suction pressure is not less than 0.5 kg/cm² G.
3. Note the START/STOP frequency while pumping down should be less than 6 times per hour.
4. If the pumping down has continue for over 3 minutes, it is not yet pull down the suction pressure lower than 0.5kg/cm² G, stop the pumping down temporarily and check the liquid line valve whether it is entirely closed. Note that the pumping down should be done not over 5 minutes each time to avoid the overheat of the motor due to the less amount of refrigerant gas in the suction side.

1.13.21 The wiring of electrical power terminals

The power terminals of HANBELL compressor are made from ceramic materials and well insulated more than 1000M Ω . Be careful connecting the wirings and follow the list below:

1. The ceramic part on the power terminal should not be tighten by hitting, otherwise the insulation of power terminal could be degraded.
2. Follow the drawing shown below for the wiring to prevent the power terminal from being damage.
3. The setting of the torque wrench for tightening the copper nut of terminal bolts should be set less than 500 kg-cm.

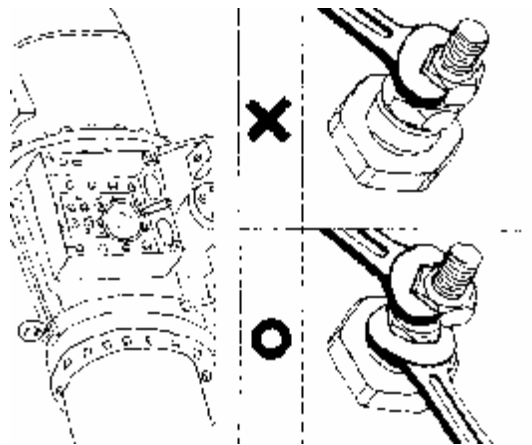


Fig 1.38 Correct way to tighten the power terminal

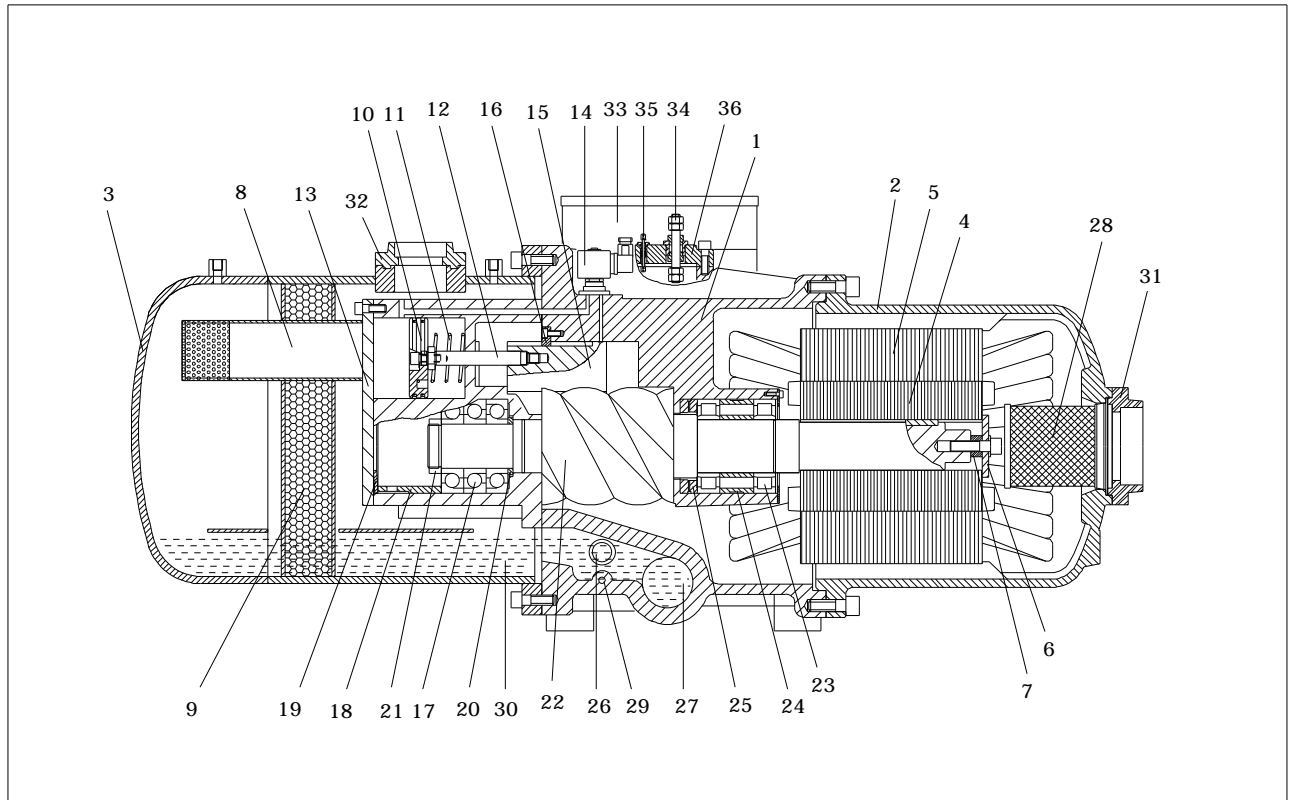
NOTE: The insulation of ceramic power terminal is very easy to be degraded by water, so DO NOT take the leakage testing by immersing the whole compressor in the water. Shut down the chiller firstly for service if the insulation value of power terminal is lower than 5M Ω .

2. General Description

2.1 Construction

Fig. 2.1 shows Hanbell screw compressor construction with index.

FIG. 2.1 Construction Of Compressor



Index to fig. 2.1

- | | |
|--------------------------------|---|
| 1. Compressor casing | 20. α -Balance piston |
| 2. Motor casing | 21. Bearing slot nut |
| 3. Oil separator | 22. Male rotor |
| 4. Motor rotor assembly | 23. Suction bearings |
| 5. Motor stator assembly | 24. Suction bearings inner/outer
spacer ring |
| 6. Motor rotor washer | 25. Oil guiding ring |
| 7. Motor rotor spacer ring | 26. Oil level sight glass |
| 8. Oil separator baffle | 27. Oil filler cartridge |
| 9. Oil separator cartridge | 28. Suction filter |
| 10. Piston | 29. Oil heater |
| 11. Piston spring | 30. Refrigeration Lubricant |
| 12. Piston rod | 31. Suction flange |
| 13. Bearing seat's cover plate | 32. Discharge flange |
| 14. Modulation solenoid valve | 33. Cable box |
| 15. Modulation slide valve | 34. Power bolt |
| 16. Slide valve key | 35. Thermostat terminals |
| 17. Discharge bearings | 36. Motor cable cover plate |
| 18. Discharge fixed ring | |
| 19. Disc spring | |

2.2 Capacity control system

The RC series screw compressors are equipped with either 3-step/4-step capacity control system or continuous (stepless) capacity control system. Both of the capacity control systems are consist of a slide valve, piston rod, cylinder, piston and piston rings. The slide valve and the piston are connected by a piston rod. The principle of operation is using the oil pressure to drive the piston in the cylinder. See Fig 2.2 (next page), the lubrication oil flows from the oil sump through the oil filter cartridge and capillary then fills into the piston cylinder due to the positive oil pressure bigger than the right side of spring force plus the high pressure gas. The positive pressure differential causes the piston to moved toward the right side in the cylinder. When the slide valve moves toward the right side, the effective compression volume in the compression chamber increases. This means the displacement of refrigerant gas also increases as a result, the refrigeration capacity also increases. However, when any of the step solenoid valve (for 3-step/4-step capacity control system) is energized, the high pressure oil in the piston cylinder bypasses to the suction port causing the piston and the slide valve to moved toward the left slide, then some of the refrigerant gas by pass from the compression chamber back to the suction end. As a result, the refrigeration capacity decreases because of the reduction of displacement of refrigerant gas flowing in the system.

The piston spring is used to push the piston back to its original position, i.e. 25% position in order to reduce the starting current for the next starting-up. If the compressor started at full load capacity it may result in a higher starting current that could damage the compressor motor seriously. The capillary is used to maintain and restrain a suitable amount of oil flow into the cylinder. The modulation (stepless) solenoid valves (SV1 and SV2) are controlled by a micro controller with the temperature sensor to modulate the piston position smoothly with stable output of capacity.

If the oil filter cartridge, capillary, or modulation solenoid valves are not working very well in the capacity control system, this may result in the abnormality and ineffectiveness of the capacity control system.

2.2.1 4-step capacity control system (See FIG 2.2)

There are two (RC10-RC11) or three (RC12-RC24) solenoid valves equipped on the compressor that control the compressor capacity from dead stop (33%/25%) to full load (100%). They are 25%/33% capacity, 50%/66% capacity, 75% capacity (RC10-RC11 omitted) and 100% capacity. There are three normally closed solenoid valves that are used to control the various required capacity. For the compressor when selecting for 3-step/4-step capacity control system, it is usual to used the sequence of 33%-66%-100% /25%-50%-75%-100% to load the capacity of compressor and to used the sequence of 100%-66%-33%/100%-75%-50% to unload the capacity. If 25% capacity is essential to be kept running for a long time, the problem of oil return, motor cooling, high discharge temperature, and other problems should be considered seriously to control by adding the accessories such as liquid injection devices.

a. 25% (33%) capacity

When solenoid valve of SV1 is activated, the high pressure oil in the cylinder bypasses

directly to the suction port, so the piston are held to its initial position. Be sure to take 30 seconds at least after every starting of the compressor at this low capacity stage. After that, the compressor could be loaded gradually.

b. 50% (66%) capacity

When solenoid valve of SV3 is energized by the temperature controller the 25%/33% (SV1) solenoid value will de-energized simultaneously, the high-pressure oil in the oil tank flows into the cylinder due to the closing of 25%/33% valve that pushes the piston moving toward the position where a hole also drains the oil back to the suction port at exactly 50%/66% position then the piston are held there.

c. 75% capacity (RC10-RC11 omitted)

When solenoid valve of SV2 is energized, the 75% capacity solenoid valve will perform the same way as mentioned above.

d. 100% full load

When all the two/three modulation solenoid valves are de-energized, the high-pressure oil flows into the cylinder continuously to push the piston toward the right side gradually until the slide valve touches the end side of the compression chamber and the piston also reaches its dead end entirely where no bypass of compression gas occurred. So full load is achieved.

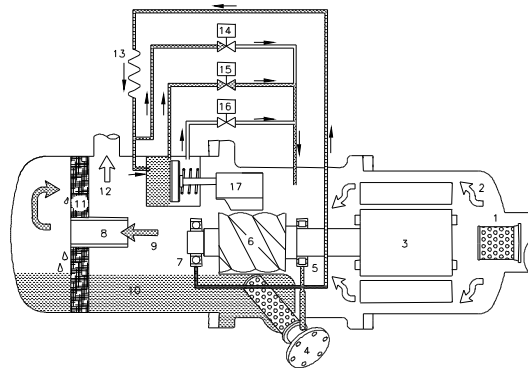


Fig 2.2 4-Step capacity control system

No.	Component	No.	Component
1	Suction filter	10	Lubricant
2	Gas in (low pressure)	11	Oil separator cartridge
3	Motor	12	Gas out(high pressure without oil)
4	Oil filter cartridge	13	Capillary
5	Suction bearings	14	Solenoid valve (25%/33% of full load),SV1
6	Male rotor	15	Solenoid valve (50%/66% of full load),SV3
7	Discharge bearings	16	Solenoid valve (75% of full load),SV2
8	Oil separator baffle	17	Slide valve
9	Gas out (high pressure with oil)	*	For RC10~11 the SV2 omitted

RC10 ~RC11 Capacity control system	SV1	SV3
100% of full load	off	off
66% of full load	off	on
33% (for start)	on	off

RC12 ~ RC21 Capacity control system	SV1	SV2	SV3
100% of full load	off	off	off
75% of full load	off	on	off
; 50% of full load	off	off	on
25% (for start)	on	off	off

2.2.2 Continuous capacity control system (See FIG 2.3)

In continuous (stepless) capacity control system, a normally open solenoid valve (SV2) and a normally close solenoid valve (SV1) are equipped to the inlet and outlet of piston cylinder respectively. These two solenoid valves are controlled by the chiller temperature controller or micro controller, refrigeration capacity control hence can be modulated at anywhere within 33% - 100% (RC10~11 only)/25% - 100% (RC12~24). Therefore, it is available to control the capacity output in stable condition by modulating the inlet of SV2 and outlet of SV1 alternatively.

The continuous (stepless) capacity control system needs to be associated by a micro controller (option) such as the MCS (Hanbell micro controller for chiller control), Saginomiya, DANFOSS, CAREL, HONEYWELL as well as PLC with LCD displayer etc. All of the above controllers are suitable to control the system in a suitable condition by a suitable pulse.

It is very important for any controller to control the load and unload in stable condition. For a smooth modulation, HANBELL suggests to install an additional orifice valve in the oil line while a fast speed of loading and unloading happened.

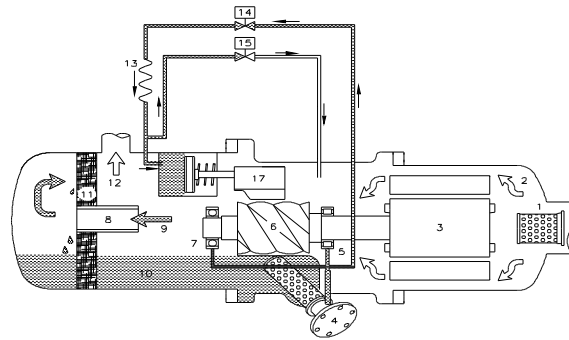


Fig 2.3 Continuous capacity control system

No.	Component	No.	Component
1	Suction filter	10	Lubricant
2	Gas in (low pressure)	11	Oil separator cartridge
3	Motor	12	Gas out(high pressure without oil)
4	Oil filter cartridge	13	Capillary
5	Suction bearings	14	Solenoid valve (normally open), SV2
6	Male rotor	15	Solenoid valve (normally closed), SV1
7	Discharge bearings	16	
8	Oil separator baffle	17	Slide valve
9	Gas out (high pressure with oil)		

	SV1	SV2
Start	On	On/Off
Loading	Off	Off
Unloading	On	On
Stable	Off	On

2.3 The method of replacing 4-step capacity control into stepless control.

The 4-step control system is one of the capacity control in RC series; whenever it is required to be changed into stepless control system, follow the illustrations shown below -

1. Additional parts: Continuous solenoid valve and an orifice plate.

2. Procedures:

- (1) Release the compressor pressure; remove the capillary first from oil inlet on the compressor side-edge then loosen the 90° elbow.
- (2) Install the continuous solenoid valve SV2 and the capillary again as shown in the figure below.
- (3) Remove the 33%/25% solenoid valve (SV1) temporarily and install the orifice plate first then put the 33%/25% solenoid (SV1) again on the orifice plate and then tighten it as shown in the figure.
- (4) Disconnect the circuit to SV2 (66%, RC10-RC11)/SV2 & SV3 (50% & 75%, RC12-RC24) or remove the solenoid valve then install the cover plate on it.

3. Cautions:

- (1) Check the oil flow direction marked “1→2” on SV2 continuous solenoid valve body whether the direction are correct or not.
- (2) Be sure that there is no leakage after the replacement.
- (3) Used the stepless controller to control the solenoid valve of SV1 (unload), SV2 (load).
- (4) Set the optimal activated pulse within 0.5~1 second of SV1 (unloading) and SV2 (loading) that is recommended, and the time interval to hold the SV1 and SV2 that can be adjusted within 5~30 seconds for getting a steady and smooth modulation.

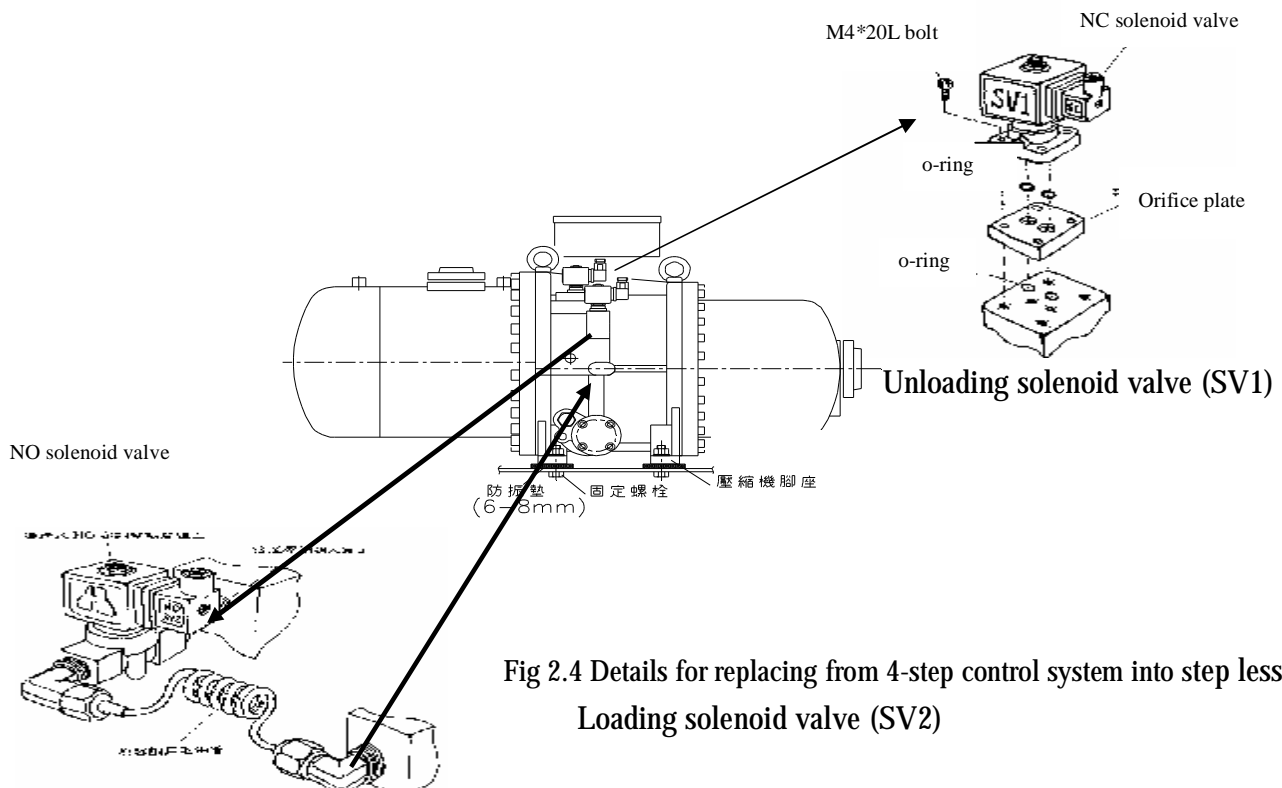


Fig 2.4 Details for replacing from 4-step control system into step less Loading solenoid valve (SV2)

2.4 Lubricant

The main functions of the lubrication oil in the screw compressor are lubrication, internal sealing, cooling and capacity control. The positive oil pressure in the cylinder pushes the piston and the slide valve that is connected by a piston rod to moved forward and backward in the compression chamber. The design with positive pressure differential lubrication system in the RC series is available to omit an extra oil pump in the compressor.

The bearings used in RC compressor required a small but steady quantity of oil for lubrication; the oil injection into the compression chamber creates an oil sealing film in the compression housing for increasing the efficiency and absorbing a part of heat of compression.

In order to separate the oil from the mixed refrigerant gas, an oil separator is required to ensure the least amount of oil carried into the system. Pay more attention to the oil temperature which has a very significant factor to the compressor bearings' life. High oil temperature will reduce the oil viscosity and cause the poor lubrication and heat absorption in the compressor as well. The oil viscosity is recommended to keep over $15 \text{ mm}^2 / \text{s}$ at any temperature. If the compressor operated under the critical condition, then an extra oil cooler is required. Some high viscosity oil is recommended to apply to the high working condition. It happens more often that the return oil from evaporator is insufficient due to the high viscosity of oil which is difficult to be carried back, that causes the loss of oil in the compressor. If the system encounters the oil return problem then an extra 2nd oil separator is recommended to be installed between the compressor discharge tube and condenser.

Each of HANBELL RC12-RC21 compressors equipped two oil sight glasses as a standard (the models from RC10-RC11 for second sight glass are optional), one is the oil high level sight glass, and the other is the oil low level sight glass. The normal oil level in the compressor oil tank should be maintained above the top of the low oil sight glass and in the middle level of high oil sight glass when compressor is running. It is recommended strongly to install the optional accessory of oil level switch to prevent from getting low oil level in the compressor.

Flooded chiller or DX type chiller with long distance piping that is recommended to install a 2nd oil separator to reduce the oil carryover into system.

Warnings:

- a. Use only qualified oil and do not mix different brand of oil together. Different kinds of refrigerant should match different kinds of oil, note that some synthetic oil are incompatible with mineral oil. The oil filled into the compressor should be totally cleaned up the system, fill the compressor with oil during the initial startup then re-fill the oil again to ensure that it is completely clean.
- b. For the chiller system using a synthetic oil be sure not to expose the oil to atmosphere for a long time, it is also necessary to vacuum the system completely when installing the compressor.

- c. Table 2.1 shows the oil replacement standard. Each compressor at HANBELL charges standard quantity of oil. (Table 2.2 shows specified oil that is suitable to RC compressor)
- d. In order to take out the moisture from the system, it is suggested to clean the system by charging it with dry Nitrogen then vacuum the system as long as possible. It is essential to change the new oil into the system especially after the motor burned out, the acidity debris are still remain inside the system so follow the procedures mentioned in changing the oil to overhaul the system. Check the oil acidity after 72 hours of operation and then change it again until the oil acidity is in the standard value.
- e. Contact local distributor/agent for concerning unqualified oil to be used.

TABLE 2.1 OIL REPLACEMENT STANDARDS

Item	Value	Item	Value
Color , ASTM	Above 6.0	Total acid number mg KOH/g	Above 0.5
Particle Matters mg/100ml	Above 5.0	Copper Strip 100°C/3hrs	Above 2.0
Viscosity 40°C	Variation±10% or more	Moisture ppm	Above 100

Table 2.1 is the recommendation condition for changing the oil.

2.4.1 Changing oil

Lubrication oil is one of the most important factor in the system in order to maintain the good operating, lubricating, cooling, sealing and driving the capacity piston of the compressor. Following is the probable problems existing in the system that should be faced:

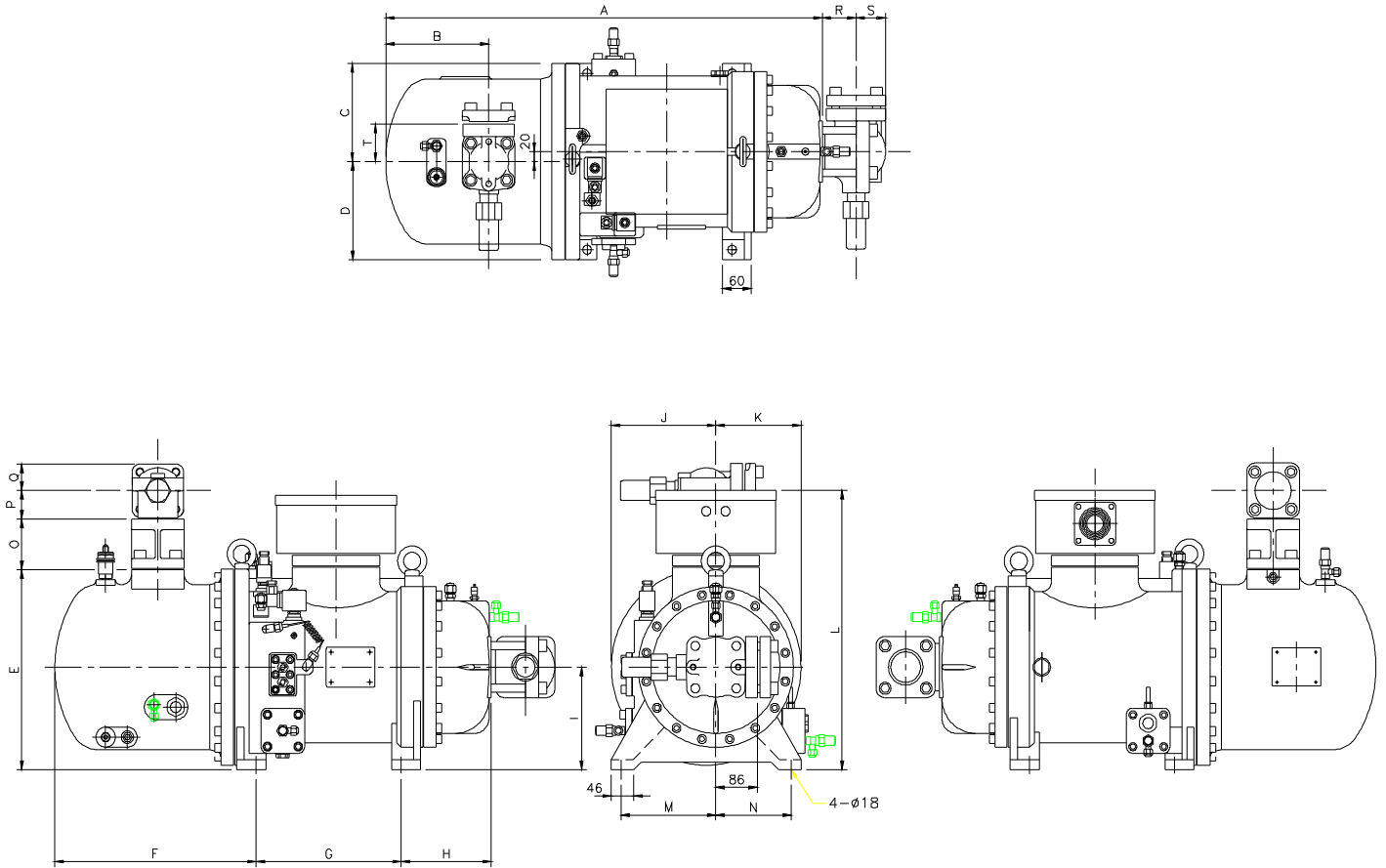
1. Contamination of oil by debris or swarf causes the oil filter to clogged.
2. Acidified of system due to moisture can cause corroded motor.
3. System spoiled of oil due to compressor running at long duration of high discharge temperature causes bearings life to shorten.

Below are the list of time period in changing the lubrication oil of the system:

1. Change oil periodically: Check the lubrication oil for every 10,000 hours of continuous running. For the first operation of the compressor, it is recommended to change oil and clean oil filter after running at 20,000 hours. Because of the piping debris or swarf that may be accumulated inside the system after the continuous operation, it is necessary to check the oil after 2,500 hours or after one year of running. Check the system whether clean or not and then change the oil every 20,000 hours or after 4 years running while the system is operated under good condition.
2. Avoid the debris or swarf to clogged in the oil filter, this may caused bearings failure, an optional oil pressure differential switch are recommended to be installed. The switch will trip when the oil pressure differential reaches the critical point between the primary and secondary sides. The compressor will automatically shut down to prevent the bearings from getting damaged due to the lack of lubricating oil.
3. If the compressor discharge temperature often keeps higher and approaching the critical point, then the oil will spoiled gradually in a short time, so check the oil character every 2 months if possible. It is necessary to change the oil if the character of the oil is out of the standard. In case it cannot check the oil character periodically, then change the oil after 4 years of installation or after 20,000 hours continuous running.
4. Acidified of lubrication oil causes the reduction of bearing's life and motor's life. Check the oil acidity periodically and change the oil if the oil acidity value measured lower than PH6. Change the deteriorated drier periodically if possible to keep the systems' dryness.
5. Refer to the oil changing procedures especially after overhauling the system due to motor burned out. Check the oil quality monthly or periodically and change the oil if the oil is out of standard specs, it is necessary to take care of the oil quality and systems' cleanliness and dryness periodically.

3. RC Series Outline Drawings

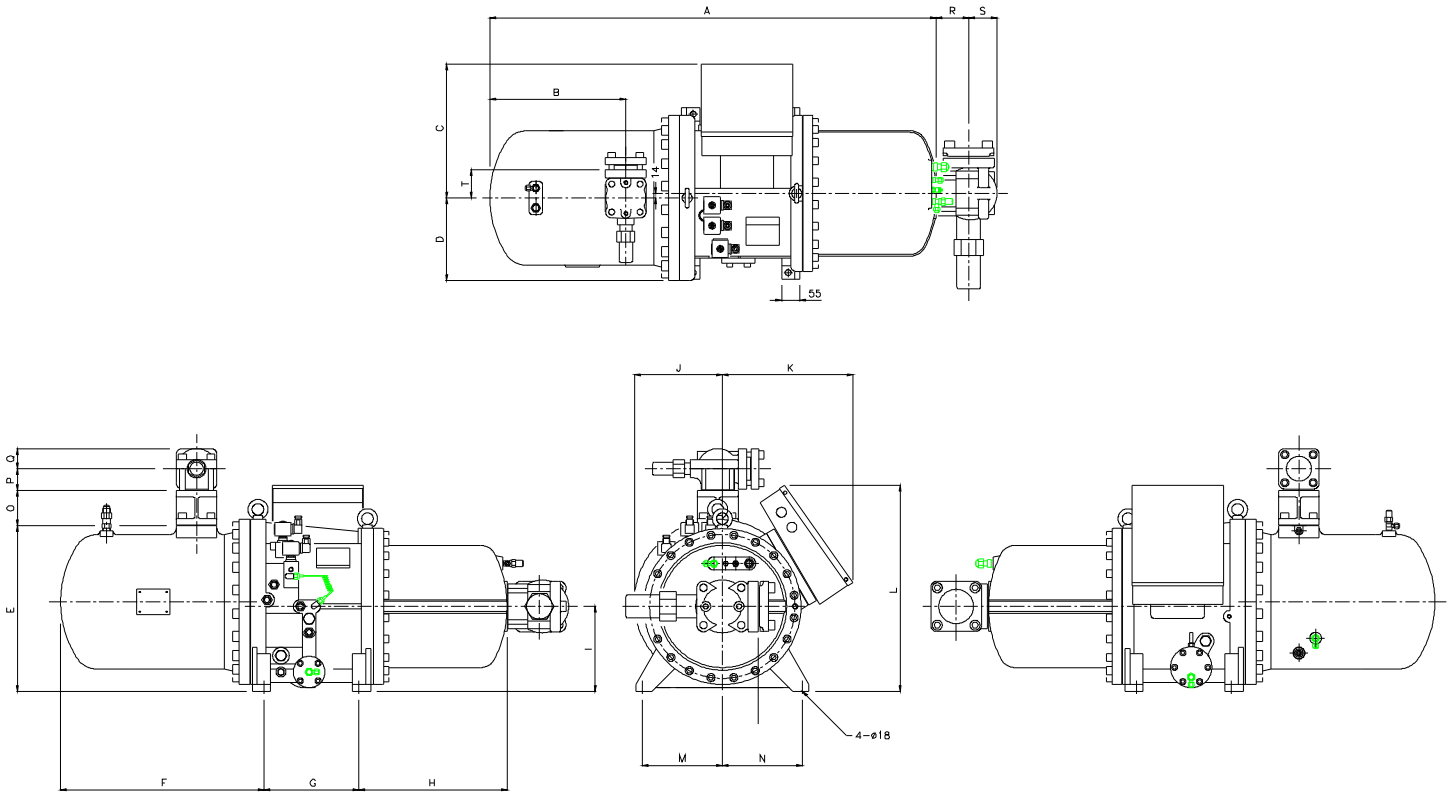
3.1 RC10~RC11 Outline Drawing



DIMENSION										UNIT: mm
Model	A	B	C	D	E	F	G	H	I	J
RC10-RC11	903	213	196	196	400	416.5	300	186.5	205	216

DIMENSION										UNIT: mm
Model	K	L	M	N	O	P	Q	R	S	T
RC10-RC11	176	558.5	196	156	101	56.6	53	70	61	75

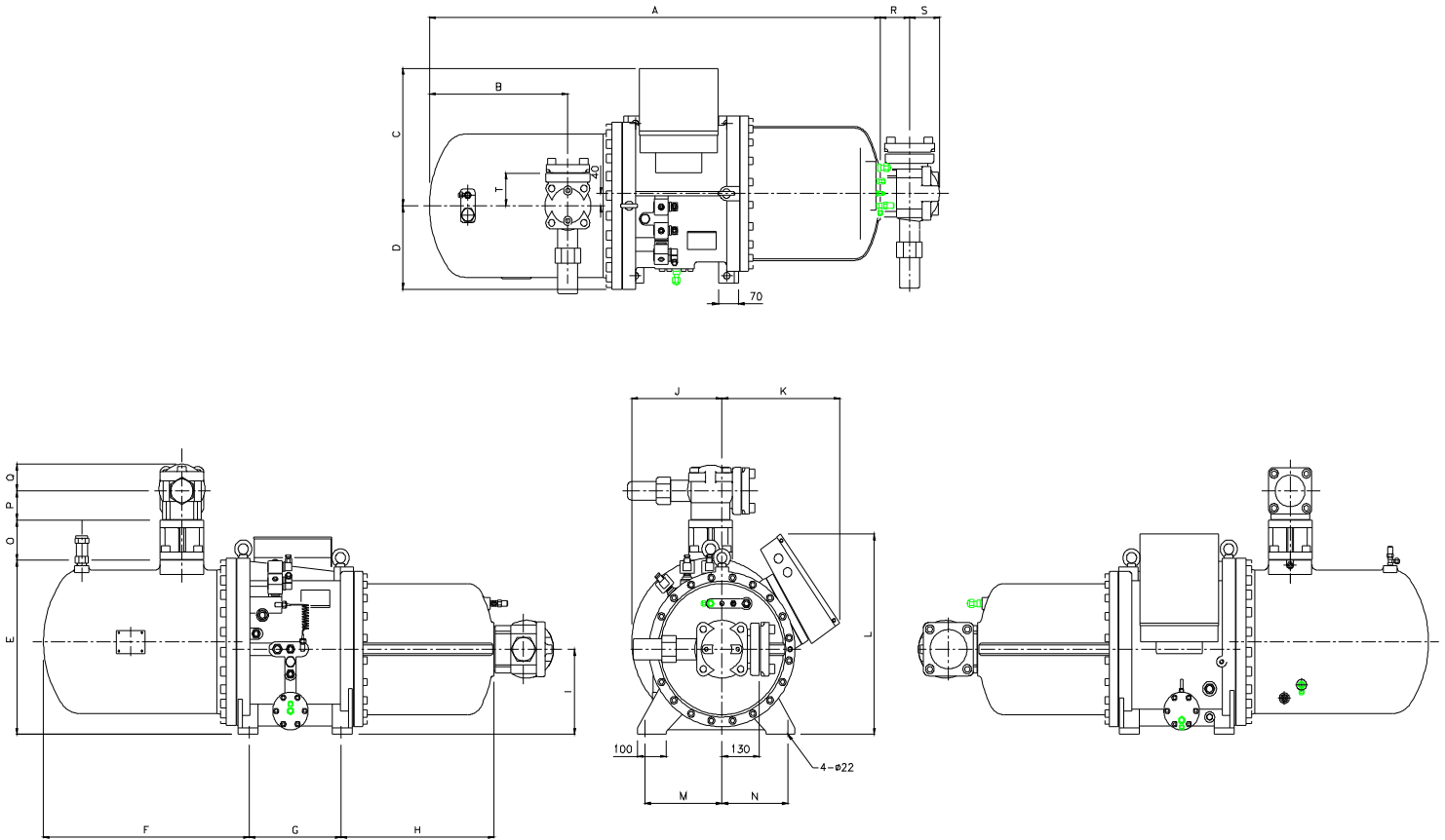
3.1.1 RC 12~RC17 Outline drawing



DIMENSION											UNIT: mm
Model	A	B	C	D	E	F	G	H	I	J	
RC12	1042	310	378	229	447	501	200	341	225	245	
RC13	1150	345	378	229	447	536	228	386	225	245	
RC14	1217	365	405	250	502	567	251	399	257	264	
RC15/15L	1339	408	405	250	502	610	285	444	257	264	
RC16	1334	392	453	275	553	613	288	433	275	315	
RC17	1459	440	453	275	553	661	320	478	275	315	

DIMENSION											UNIT: mm
Model	K	L	M	N	O	P	Q	R	S	T	
RC12	362	592	225	225	101	57	53	82	69	75	
RC13	362	592	225	225	101	57	53	82	69	75	
RC14	391	624	240	240	106	67	61	97	85	86	
RC15/15L	391	624	240	240	106	67	61	97	85	86	
RC16	413	655	270	230	120	82	68	103	105	95	
RC17	413	655	270	230	120	82	68	103	105	95	

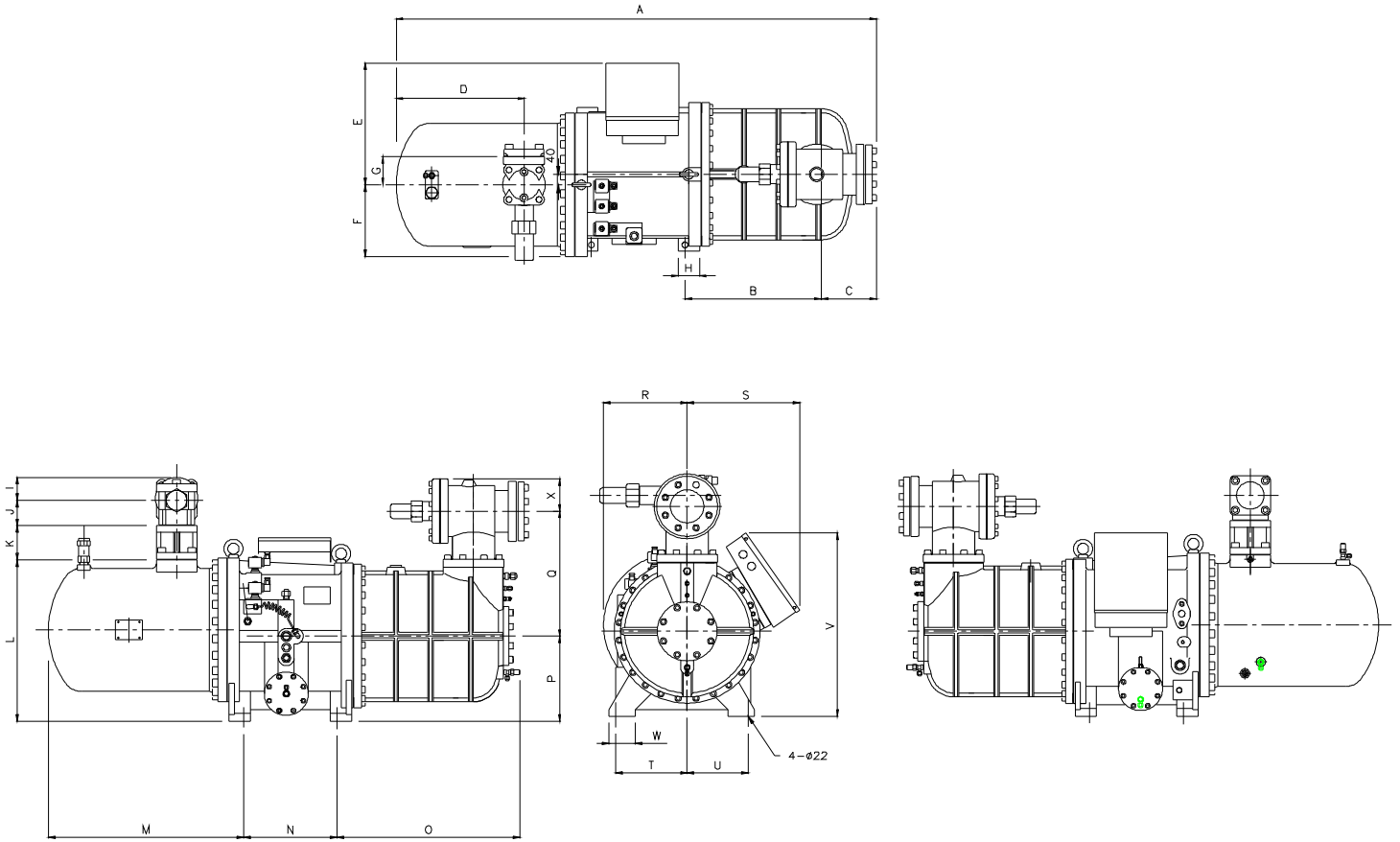
3.1.2 RC18 Outline drawing



DIMENSION											UNIT: mm	
Model	A	B	C	D	E	F	G	H	I	J	K	L
RC18	1576	484	451.5	275	572	720	320	536	280	315	411.5	659

DIMENSION										UNIT: mm	
Model	M	N	O	P	Q	R	S	T			
RC18	270	230	131.5	96.5	88	103	105	107			

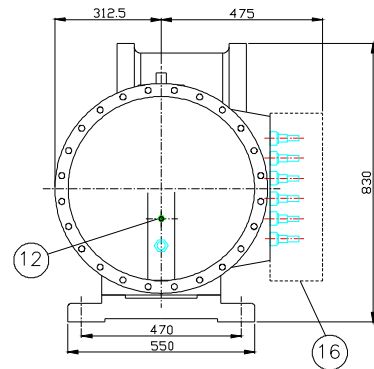
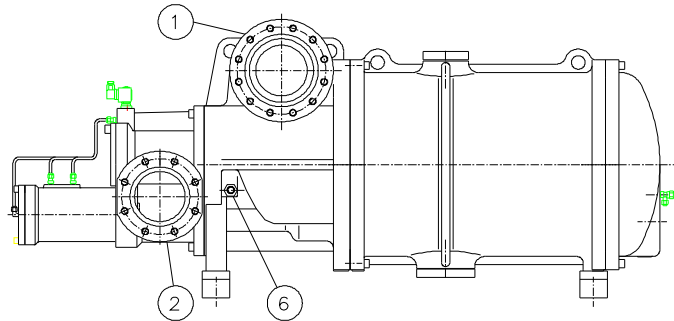
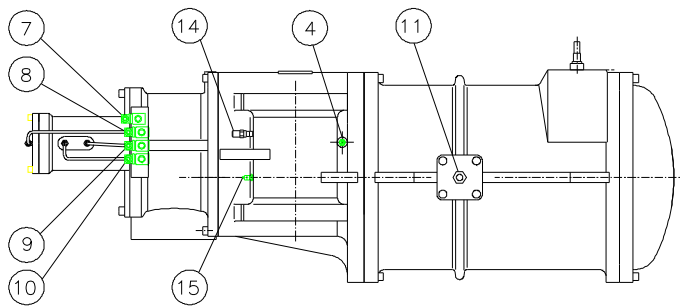
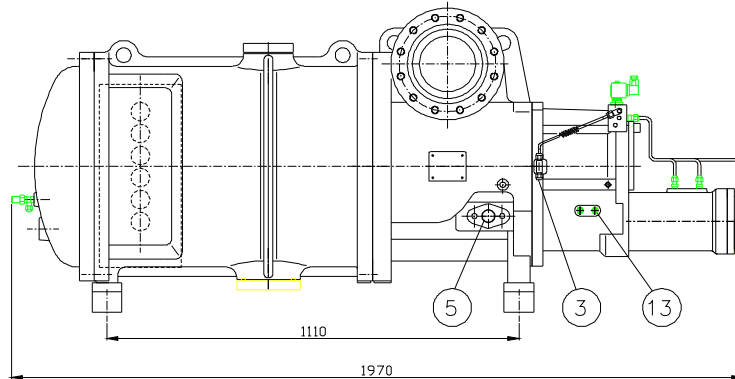
3.1.3 RC 19~RC21 Outline drawing



DIMENSION												UNIT: mm	
Model	A	B	C	D	E	F	G	H	I	J	K	L	
RC19	1812.5	514.5	208.5	484	466	275	107	80	88	96.5	131.5	617	
RC20~21	2033.5	584.5	208.5	560	466	275	130	80	105	103	131.5	617	

DIMENSION												UNIT: mm	
Model	M	N	O	P	Q	R	S	T	U	V	W	X	
RC19	736.5	353	690	325	478.5	315	426	270	230	701	100	124	
RC20~21	822.5	418	760	325	478.5	315	426	270	230	701	100	124	

3.1.4 RC22~RC24 Outline drawing



- | | |
|--|-------------------------------------|
| 1. Suction Flange | 9. Modulation S.V. (50%) |
| 2. Discharge Flange | 10. Modulation S.V. (75%) |
| 3. Oil Inlet Connector | 11. Liquid Injection Connector |
| 4. Oil Inlet Connector | 12. Stop Valve-Middle pressure side |
| 5. Economizer Connector | 13. Stop Valve-High pressure side |
| 6. Liquid Injection Connector | 14. Stop Valve-Low pressure side |
| 7. Modulation S.V. (Oil feed solenoid valve) | 15. Refrigerant Charge Connector |
| 8. Modulation S.V. (25%) | 16. Cable Box |

3.1.4 External oil separators for RC22~RC24

There are two types of optional external oil separator for RC22~RC24; the users can select these two different designs of oil separator to install in the chiller

3.1.4.1 Vertical Type

Item	Name	Specification	Q'ty
1	Outlet flange	5"	1
2	Inlet flange	5"	1
3	Save valve	400 PSI	1
4	High oil level sight glass		1
5	Low oil level sight glass		1
6	Oil inlet connector	1/4"	1
7	Oil temp. protector	90°C	1
8	Oil outlet port	1"	1
9	Oil regulation valve	1/4"	1
10	Low oil level switch		1
11	Oil heater	150 W	1

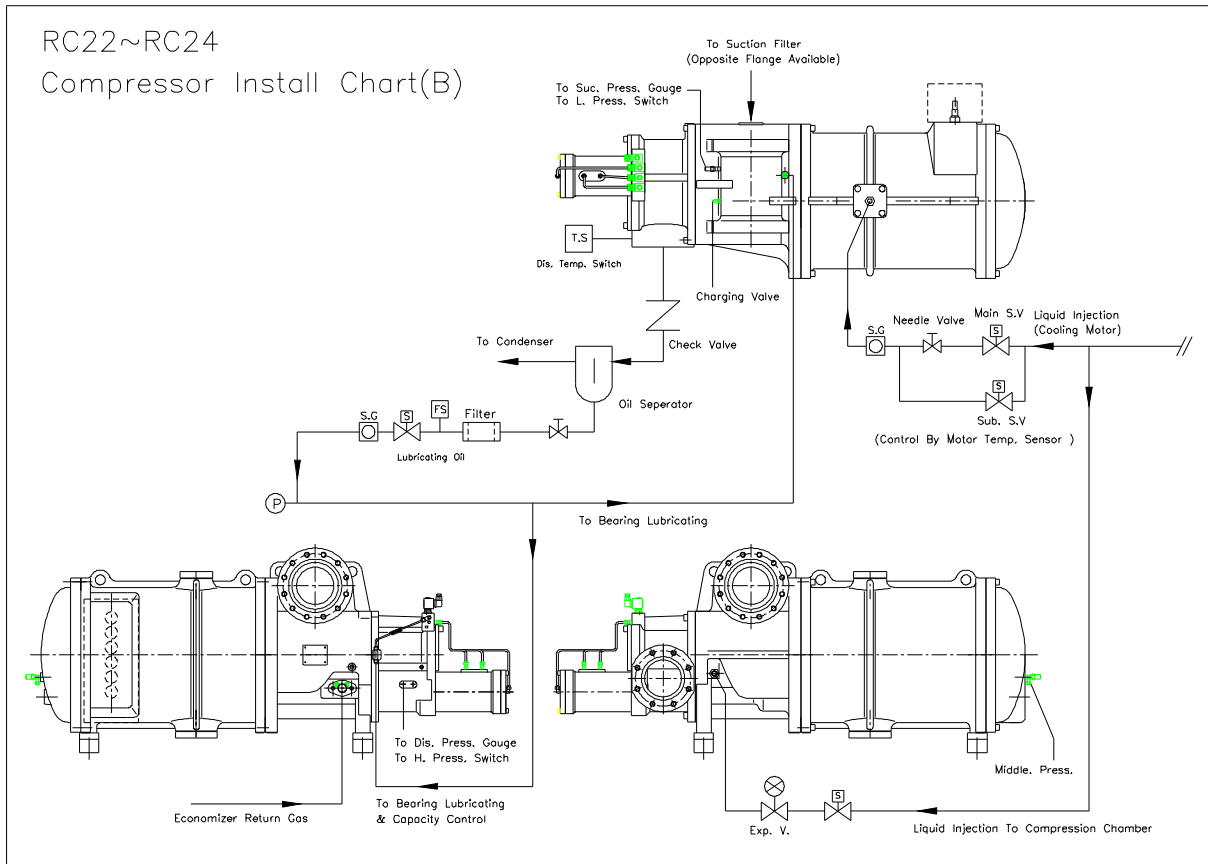
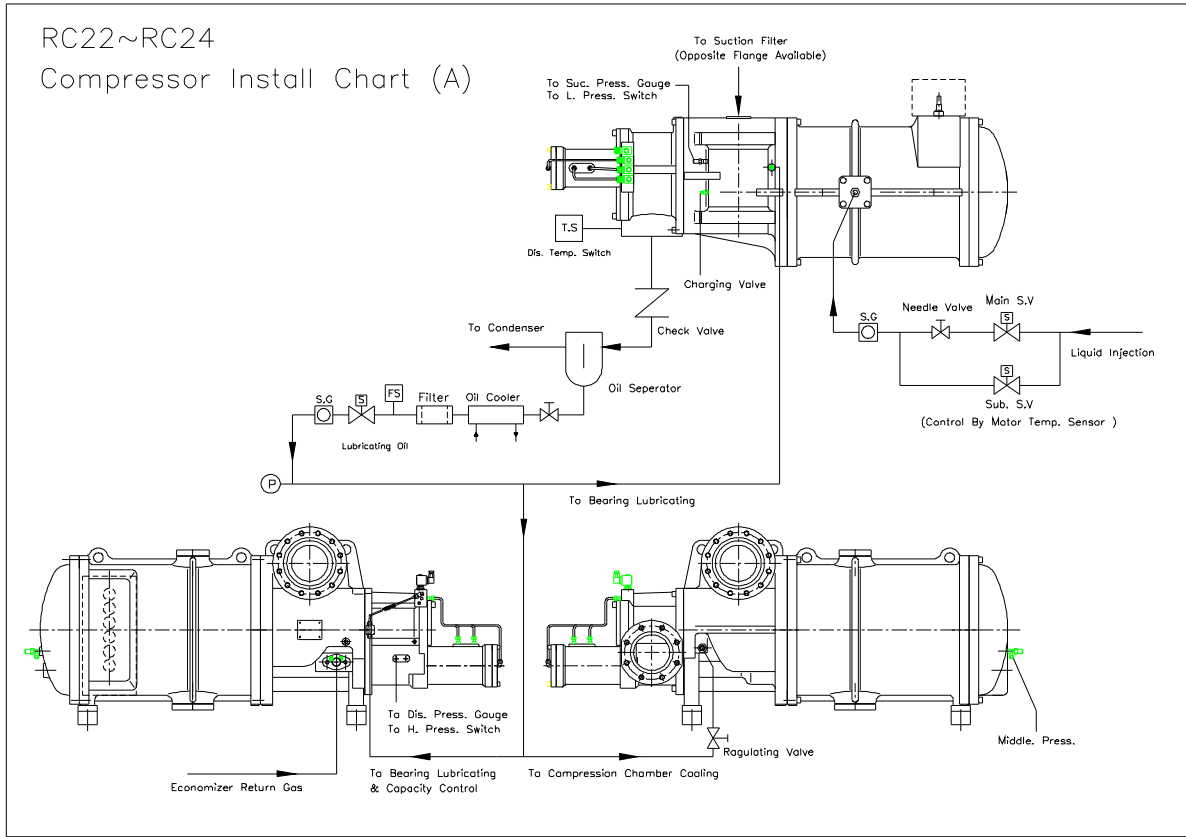
Models	A	B	ØD
RC22	2005	995	Ø609.6
RC23	2205	1095	
RC24	2405	1195	

3.1.4.2 Horizontal Type

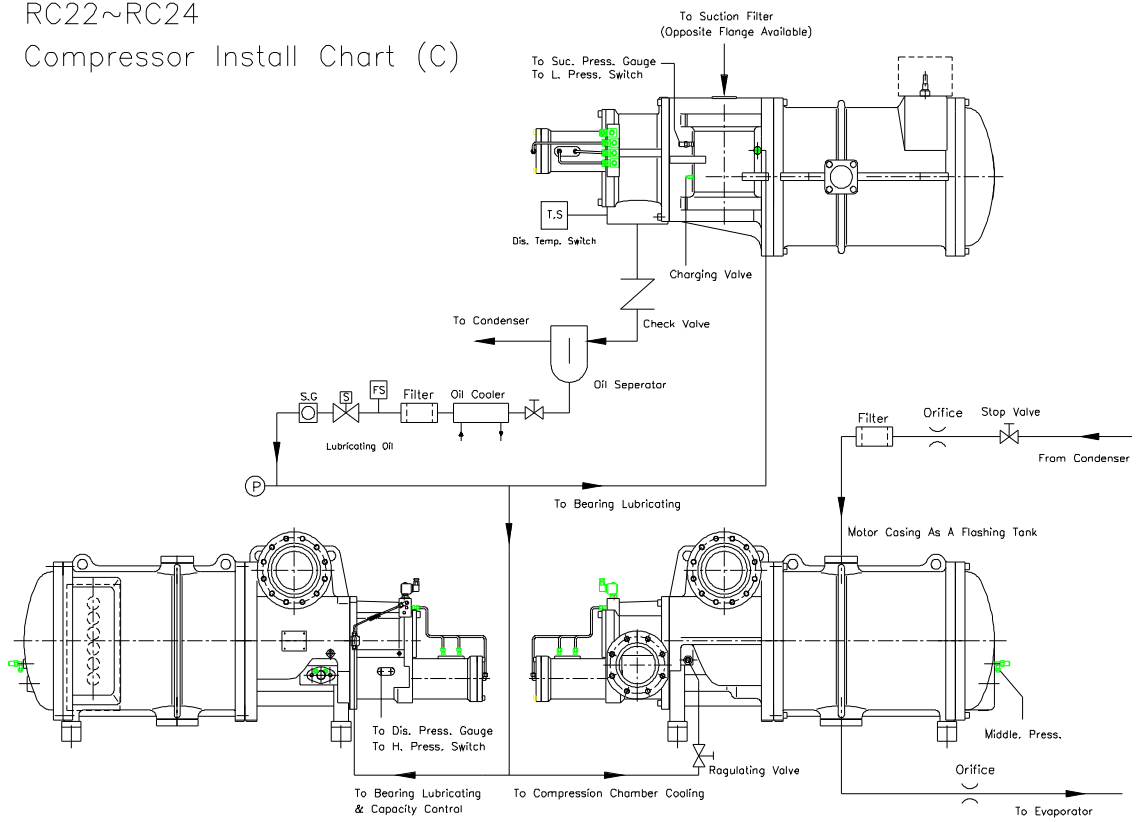
圖次	品名	規格	數量
1	Outlet tube	5"X6.6t	1
2	Inlet tube		1
3	Save valve	PF1-1/2"	1
4	oil sight glass		2
5	Steel body	24"x12ix1200L	1
6	connector	NPT1/4"	2
7	oil Temp. sensor	NPT1/8"	1
8	Elbow tube	1"	1
9	connector	PF1"	1
10	Steel tube	1"	1
11	Oil heater tube		1
12	Hanger		2
13	Base		2
14	Oil level switch		1

3.1.5 Compressor Installation Chart for RC22~RC24

There are three different suggestions of compressor installation for RC22~RC24.

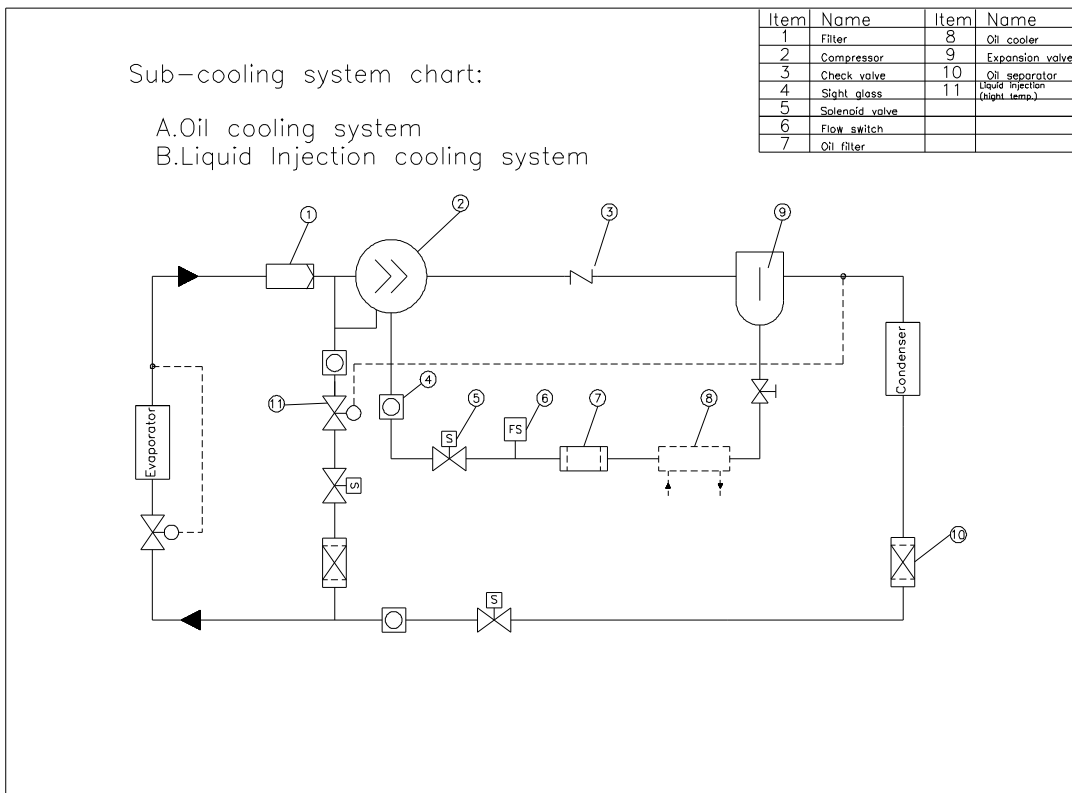
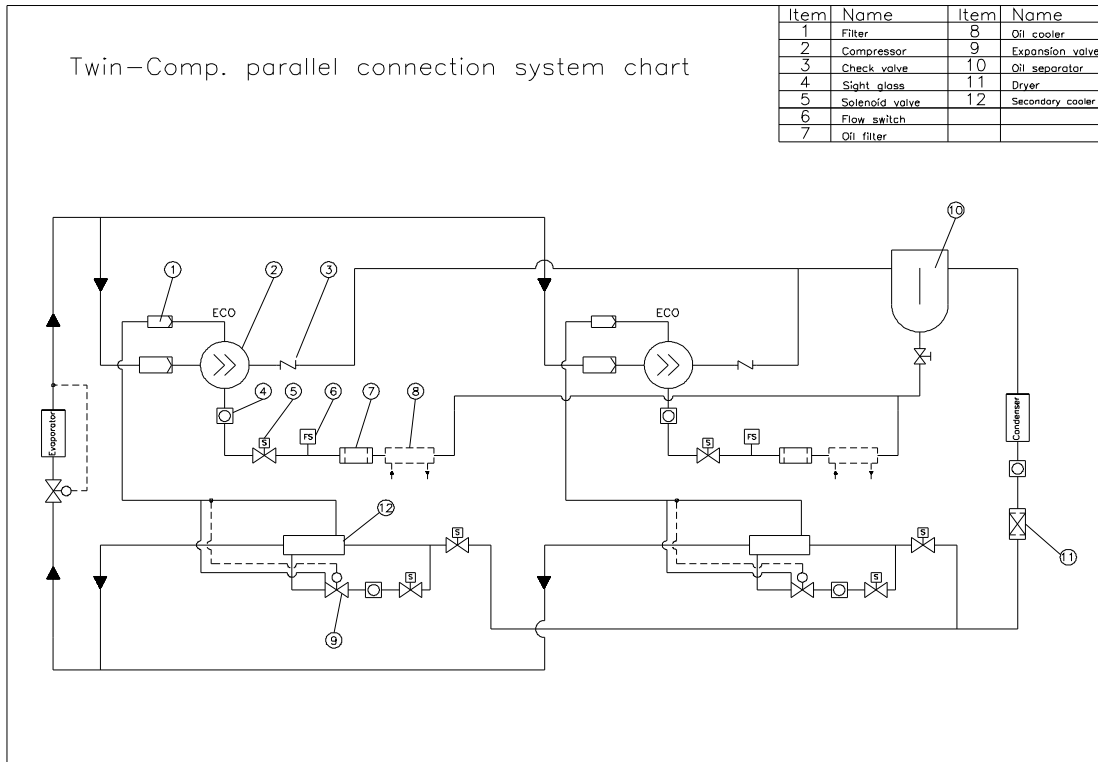


RC22~RC24
Compressor Install Chart (C)



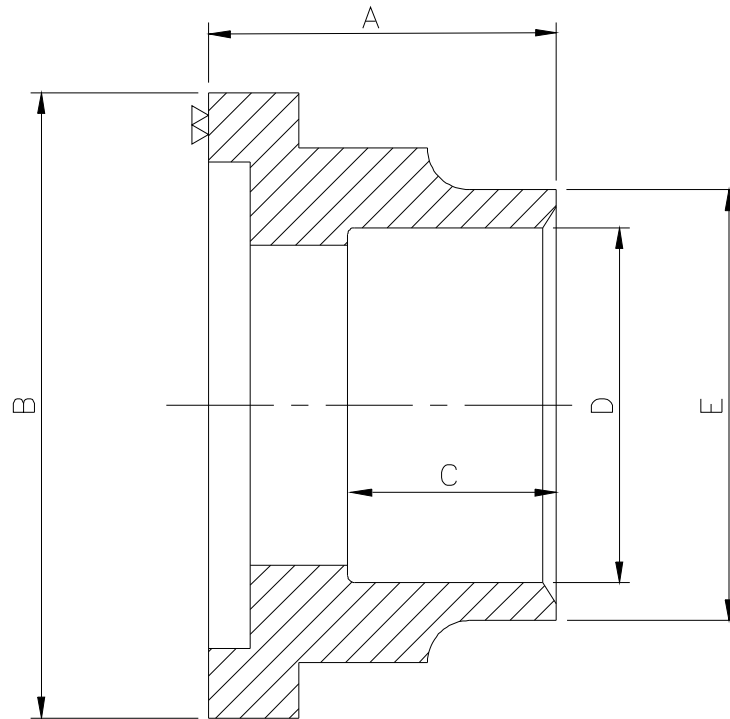
3.1.6 Rack system circuit

There are 4 Rack system circuits shown below for reference. The accessories installed in the system are the minimum, if there is more applications or protections required, contact Hanbell or local distributor/agent for more information or further confirmation.



3.1.4 Outline dimension of discharge and suction Coupling Tube for RC series

Fig 3.3 Specification and dimension of standard Coupling Tube



Model	Standard Discharge Coupling Tube		Standard Suction Coupling Tube	
	Steel pipe	Copper pipe	Steel pipe	Copper pipe
RC10	1 1/2 ²	1 5/8"	2 ²	2 1/8"
RC11	1 1/2 ²	1 5/8"	2 ²	2 1/8"
RC12	1 1/2 ²	1 5/8"	2 1/2 ²	2 5/8"
RC13	1 1/2 ²	1 5/8"	2 1/2 ²	2 5/8"
RC14	2 ²	2 1/8"	3 ²	3 1/8"
RC15	2 ²	2 1/8"	3 ²	3 1/8"
RC15L	2 ²	2 1/8"	3 ²	3 1/8"
RC16	2 1/2 ²	2 5/8"	4 ²	4 1/8"
RC17	2 1/2 ²	2 5/8"	4 ²	4 1/8"
RC18	3 ²	3 1/8"	4 ²	4 1/8"
RC19	3 ²	3 1/8"	5 ²	5 1/8"
RC20	4 ²	4 1/8"	5 ²	5 1/8"
RC21	4 ²	4 1/8"	5 ²	5 1/8"
RC22	5 ²	5 1/8"	6 ²	---
RC23	5 ²	5 1/8"	8 ²	---
RC24	5 ²	5 1/8"	8 ²	---

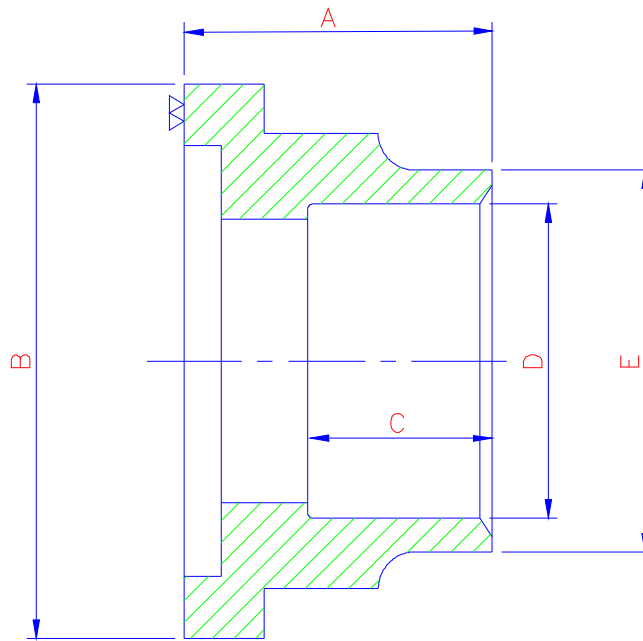
*Specifications of 1 1/2", 2 1/2", 2", 3", 4", 5", 6", 8" are the steel tubes (pipes); the other sizes are the copper tubes (pipes).

Specification and dimension of standard flanges (Coupling Tube)

	Materials and Sizes of pipes		Dimension of standard flanges (Coupling Tube)				
			A	B	C	D	E
Suitable for Discharge flange of RC10~RC13	Copper	1 5/8 ²	52	75	35	41.6	52
		1 3/4 ²				44.8	55
		2 ²				51.1	62
		2 1/8 ²				54.3	65
	Steel	1 1/4 ²				43.3	58
		1 1/2 ²				49.3	64
Suitable for Discharge flange of RC14~RC15L And Suitable for Suction flange of R10 ~ RC11	Copper	1 3/4 ²	50	90	30	44.8	55
		2 ²				51.1	62
		2 1/8 ²				54.3	65
		2 1/2 ²				63.8	74
		2 5/8 ²				67	77
	Steel	1 1/2 ²				49.3	64
		2 ²				61.3	76
Suitable for Discharge flange of RC16~RC17 And Suitable for Suction flange of R12 ~ RC13	Copper	1 5/8 ²	60	110	35	41.6	52
		1 3/4 ²				44.8	55
		2 ²				51.1	62
		2 1/8 ²				54.3	65
		2 1/2 ²				63.8	74
		2 5/8 ²				67	77
	Steel	1 1/2 ²				49.3	64
		2 ²				61.3	76
		2 1/2 ²				77.2	90
Suitable for Discharge flange of RC18~RC19 And Suitable for Suction flange of RC14 ~ RC15L	Copper	2 ²	66	120	45	51.1	62
		2 1/8 ²				54.3	65
		2 3/8 ²				60.7	71
		2 1/2 ²				63.8	74
		2 5/8 ²				67	77
		3 ²				76.6	87
		3 1/8 ²				79.8	90
	Steel	2 ²				61.3	76
		2 1/2 ²				77.2	92
		3 ²				90.2	103
Suitable for Discharge flange of RC20, RC21 And Suitable for Suction flange of RC16 ~ RC18	Copper	3 ²	76	145	50	76.6	87
		3 1/8 ²				79.8	90
		3 5/8 ²				92.4	103
		4 ²				102	112
		4 1/8 ²				105.1	116
	Steel	3 ²				90.2	105
		3 1/2 ²				102.8	117
		4 ²				115.6	128

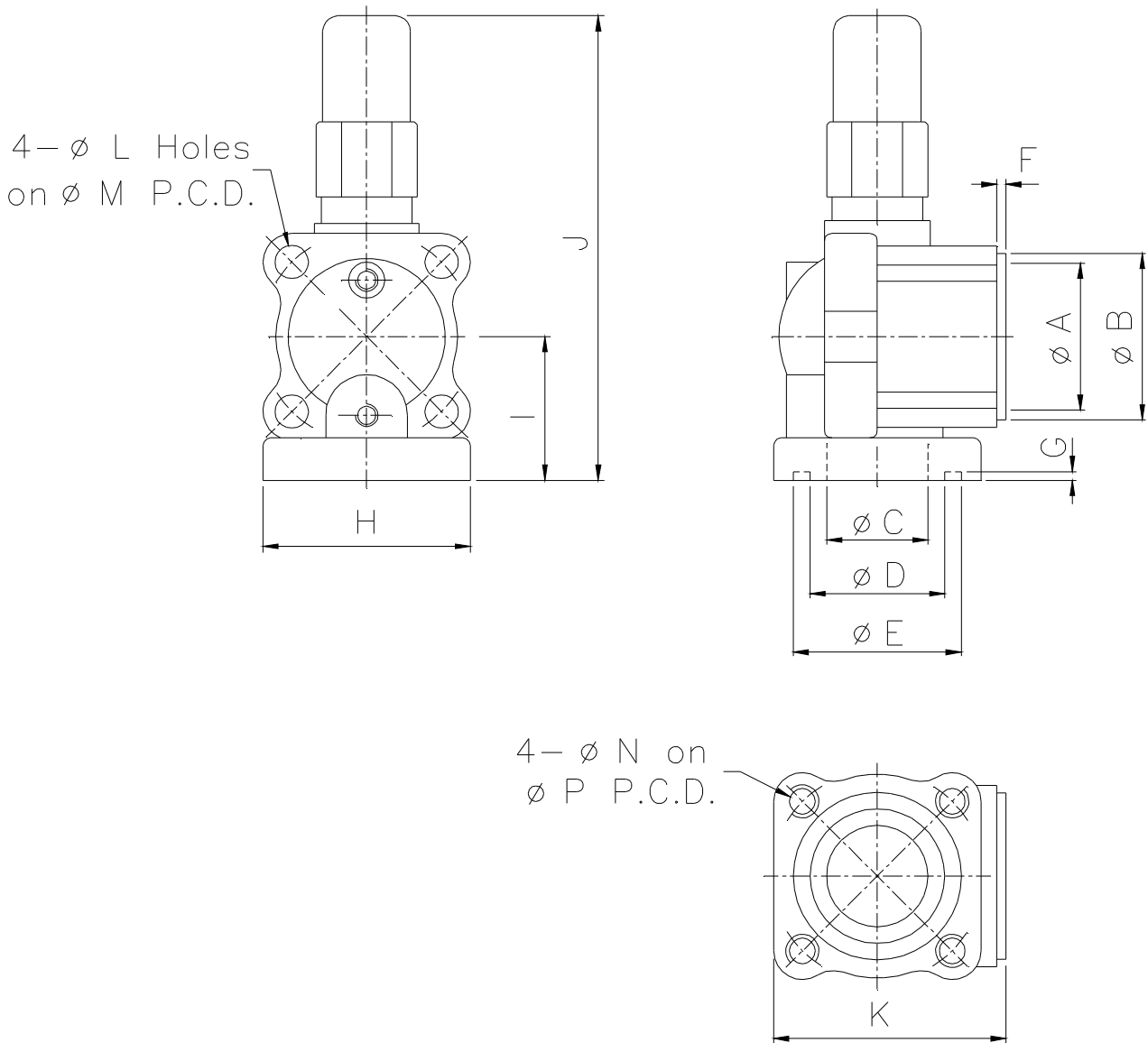
	Materials and Sizes of pipes		Dimension of standard flanges (Coupling Tube)				
			A	B	C	D	E
Suitable for Discharge flange of RC22~RC24 And Suitable for Suction flange of RC19 ~ RC21	Copper	4 1/8 ²	80	174	35	105.1	121.2
		5 1/8 ²				130.5	147
	Steel	4 ²				115.6	134
		5 ²				141.3	154
Suitable for Suction flange of RC22	Steel	5 ²	75	215	40	141.3	154
		6 ²				166.7	196
Suitable for Suction flange of RC23~RC24	Steel	6 ²	75	215	40	166.7	196
		8 ²				218	241

Fig 3.3 Specification and dimension of standard Flange (Coupling Tube) Drawing



3.1.4 Specification and dimension of stop (service) valves

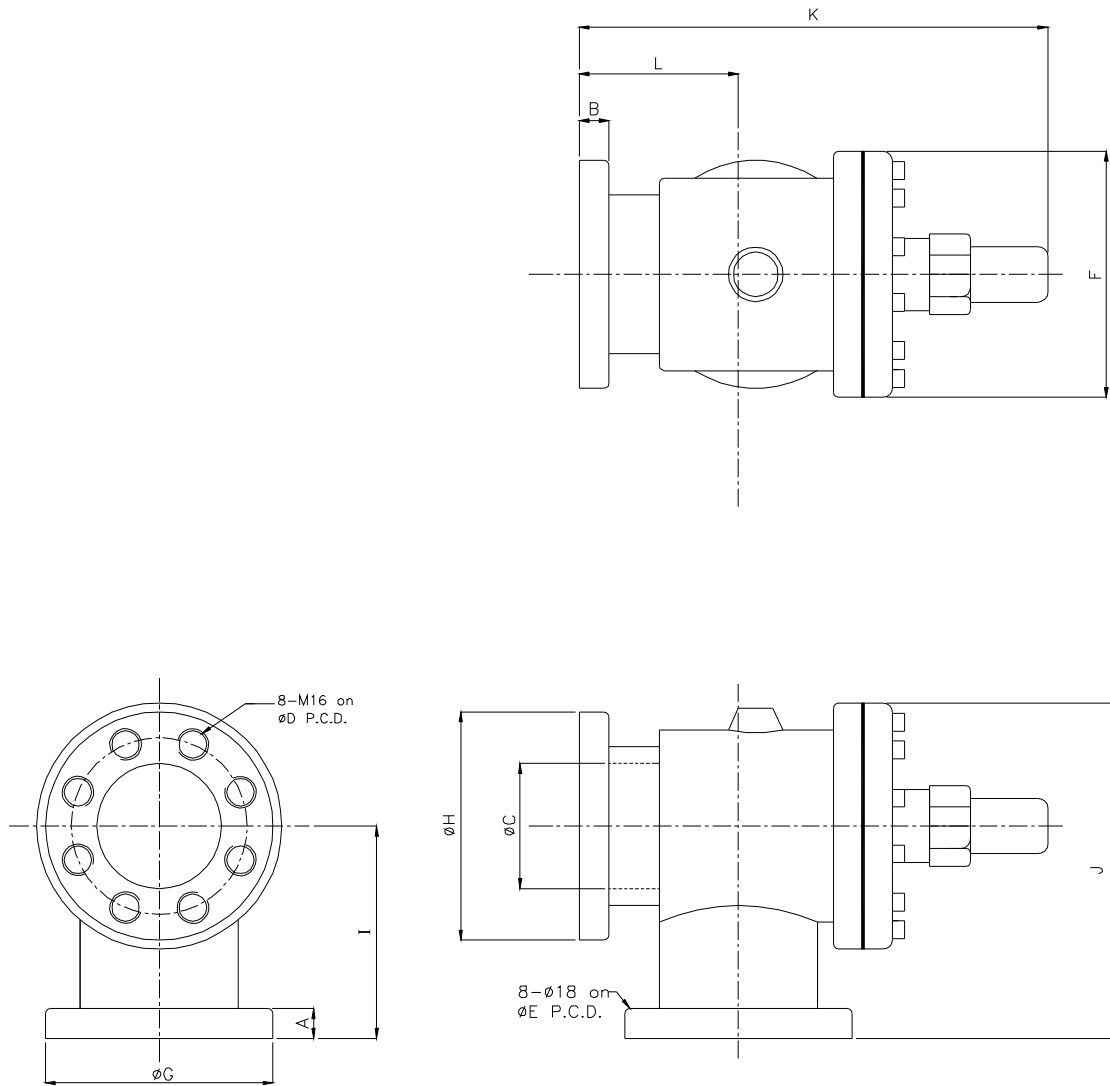
Fig 3.4 Specification and dimension of stop valves



Models	Dia.	Dimensions														unit: mm	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	
RV-40	1 1/2 ²	60	75	36	59	76	6	5	106	75	256	115	18	105	M16x2	105	
RV-65	2 1/2 ²	90	110	67	89	111	6	5	137	95	307	153	18	140	M16x2	140	
RV-80	3 ²	100	120	80	99	121	6	5	154	117	398	177	22	160	M20x2.5	160	
RV-100	4 ²	125	145	105	124	146	6	5	171	130	445	201	22	185	M20x2.5	185	

Maximum working pressure	Hydrostatic pressure test	Refrigerant	Temperature range
28 kg / cm ² G	42 kg / cm ² G	HFC, HCFC	- 40°C ~150°C

Fig. 3.4.1 Specification and dimension of stop valve

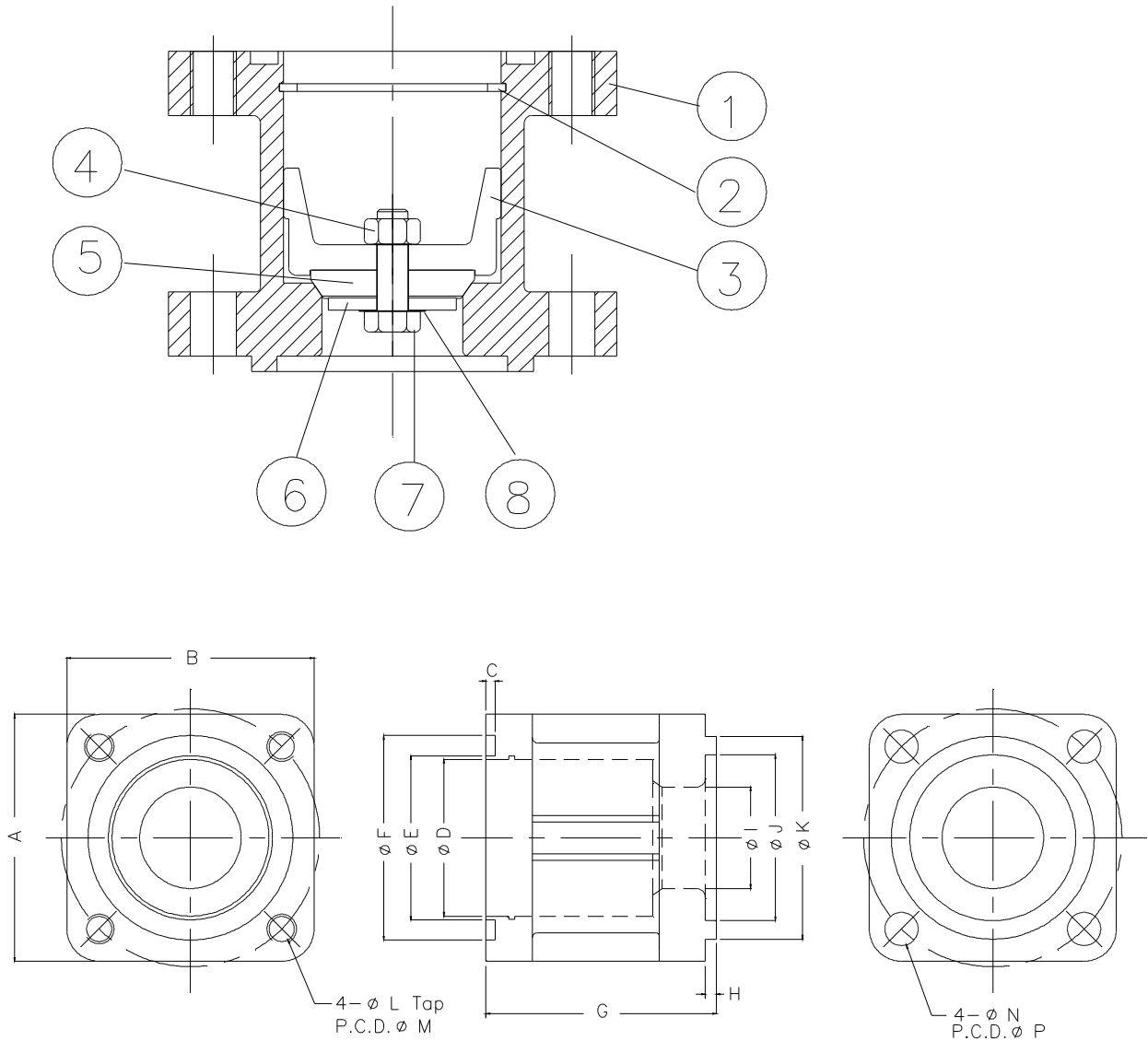


Models	Dia.	Dimensions											unit: mm
		A	B	C	D	E	F	G	H	I	J	K	L
RV--120	5 ²	30	30	126	178	194	248	230	230	214	338	474	161

Maximum working pressure	Hydrostatic pressure test	Refrigerant	Temperature range
28 kg / cm ² G	42 kg / cm ² G	HFC, HCFC	- 40°C ~150°C

3.1.5 Specification and dimension of check valves

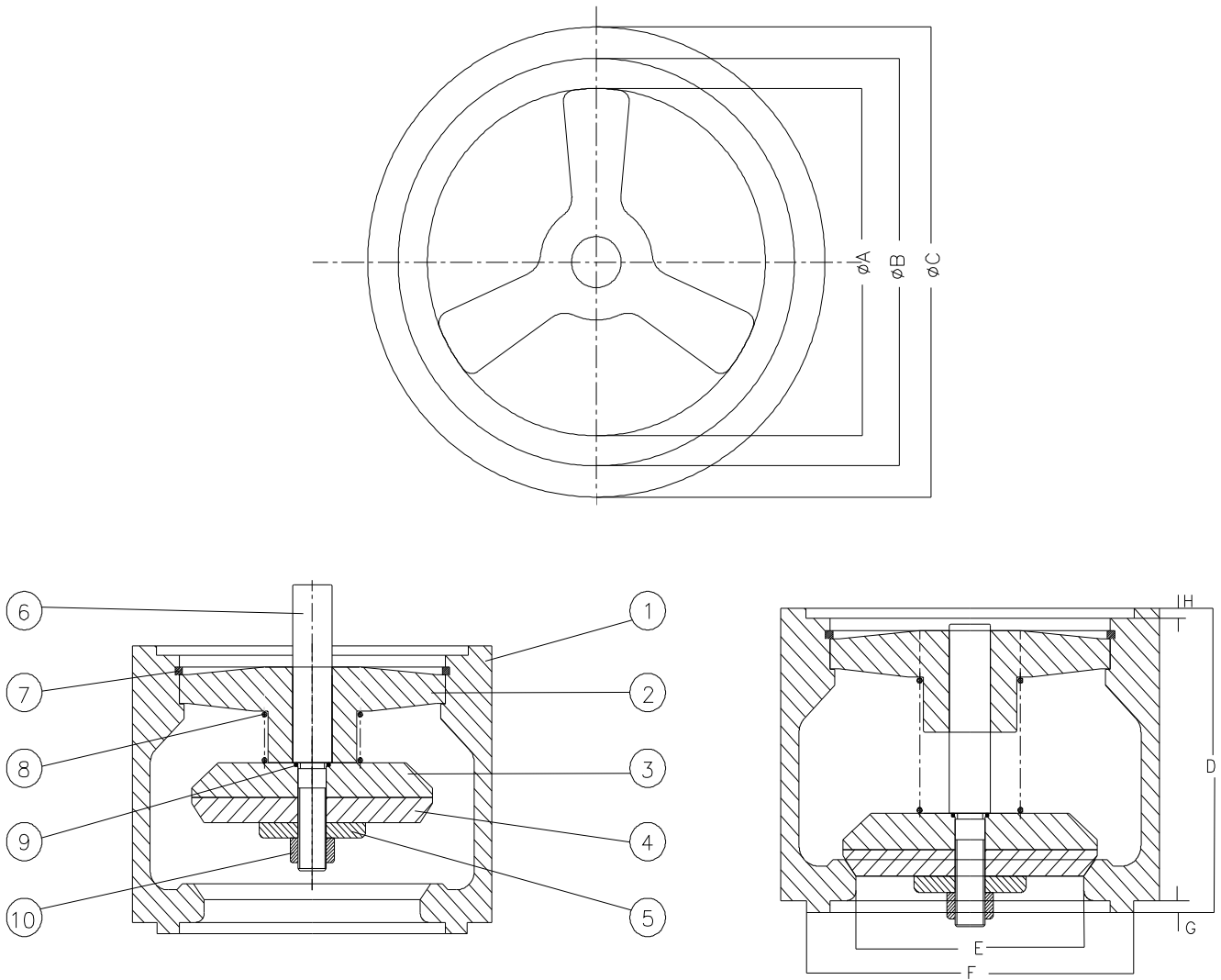
Fig 3.5 Specification and dimension of check valves



Dia.	Dimension											unit: mm			
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P
1 1/2 ²	109	109	5	55	59	76	105	6	34	60	75	M16x2	105	18	105
2 1/2 ²	134	134	5	85	89	111	125	6	55	90	110	M16x2	140	18	140
3 ²	153	153	5	95	99	121	135	6	66	100	120	M20x2.5	160	22	160
4 ²	171	171	5	120	124	146	135	6	80.5	125	145	M20x2.5	185	22	185

No.	1	2	3	4	5	6	7	8
Item	Body	C clipper	Guide seat	Nut	Valve plate	Gasket	Bolt	Washer

Fig. 3.5.1 Specification and dimension of check valve



Diameter	Dimension								Unit: mm
	A	B	C	D	E	F	G	H	
5"	150	176	203	150	122	175	6	5	

No.	1	2	3	4	5	6	7	8	9	10
Item	Body	Guide	Valve Plate	Gasket	Valve Plate	Rod	C clipper	Spring	O-ring	M16-bolt

3.2 System with Economizer

HANBELL screw compressor can be fitted with an additional middle connection for economizer operation. With this form of operation, refrigeration capacity and also system efficiency can be

improved by means of a sub-cooling circuit or two-stage refrigerant expansion.

Based on HANBELL extensive research a special design of the Economizer connection has been developed so that the connection causes no additional back flow losses during compression. As a result of this, compressor capacity is fully retained in all operating conditions.

3.2.1 Principle of operation

As opposed to the reciprocating operation of a piston compressor, the compression in a screw compressor takes place only with one flow direction. When the rotors turn, refrigerant vapor is pressed into the rotor grooves by the opposing rotor teeth and transported to end wall of the corresponding working space. In this phase, the volume is steadily reduced and the vapor is compressed from suction pressure to condensing pressure.

The pressure at the additional middle connection is at a similar level to the intermediate pressure with a two-stage system. As a result of these features, a screw compressor of this design can be combined with an additional sub-cooling circuit or an intermediate pressure vessel (flash type sub-cooler) for two-stage expansion. These measures result in a clearly increased refrigeration capacity due to additional liquid sub-cooling, especially with high pressure ratios. The power consumption of the compressor increases slightly compare to the additional work that takes place at a better level of efficiency.

3.2.2 System with Economizer (sub-cooler)

With this form of operation, a heat exchanger (refrigerant sub-cooler) is used to sub-cooled liquid refrigerant. The sub-cooling is achieved by injecting a part of the refrigerant from the condenser through an expansion device in counter flow into the sub-cooler, which then evaporates due to the absorption of heat. The superheated vapor is pulled into the compressor at the Economizer connection and mixed with the vapor, which is already slightly compressed from the evaporator.

The sub-cooled liquid is at condensing pressure with this form of operation, the pipeline to the evaporator does not therefore require any special features, aside from insulation. The system can be generally applied. Figure 3.6 shows the system with Economizer, sub-cooler.

3.2.3 System with Economizer (flash type)

The liquid sub-cooling is achieved with this form of operation by reducing the boiling point pressure in an intermediate pressure vessel (flash type sub-cooler) arrange between condenser and evaporator. This physical effect leads to the cooling of the liquid down to the boiling point, due to evaporation of part of the liquid. To stabilize the pressure of the vessel, a regulator is used which at the same time controls the quantity of vapor flowing to the Economizer connection of the compressor.

This form of operation gives the most economical thermodynamic performance due to direct heat exchanging. As the intermediate pressure is reduced to the boiling point temperature this system should only be used with flooded evaporators. Figure 3.7 shows the system with Economizer, flash type sub-cooler.

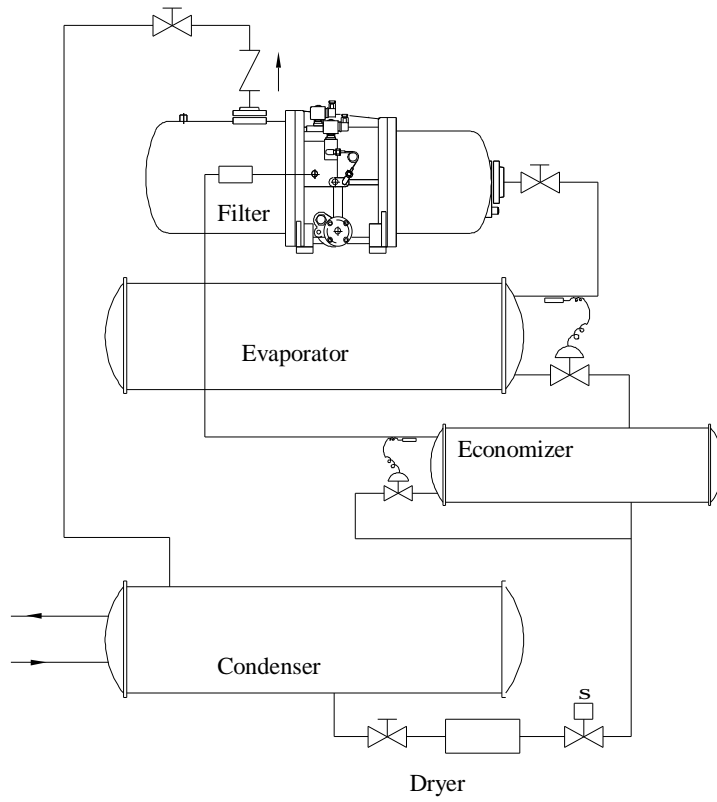


Fig 3.6 System with Economizer (sub-cooler)

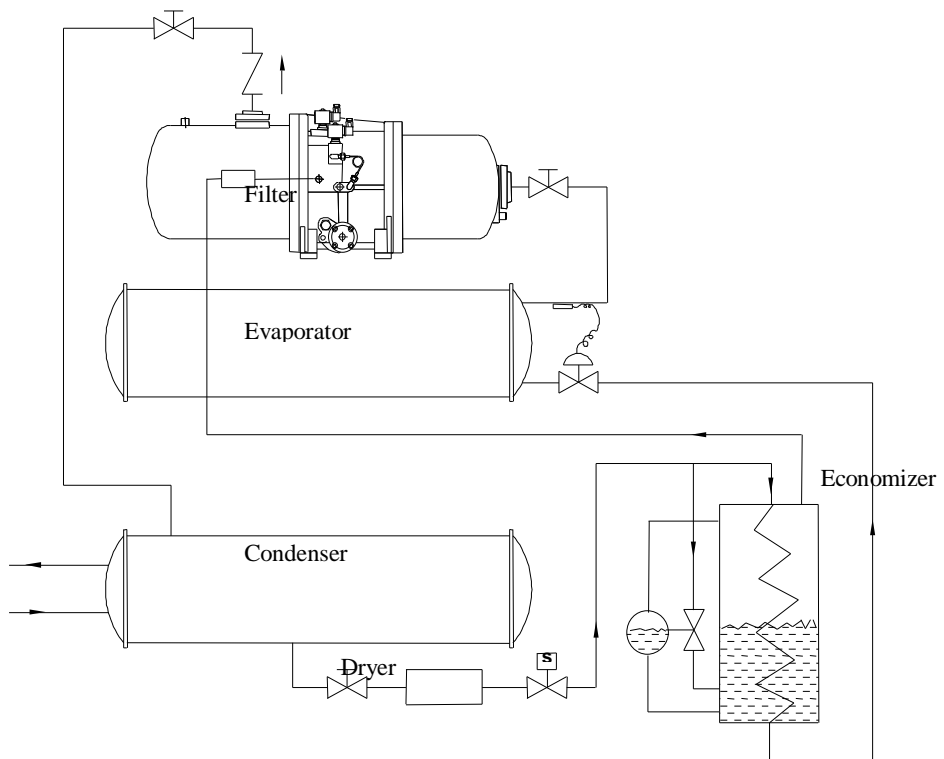
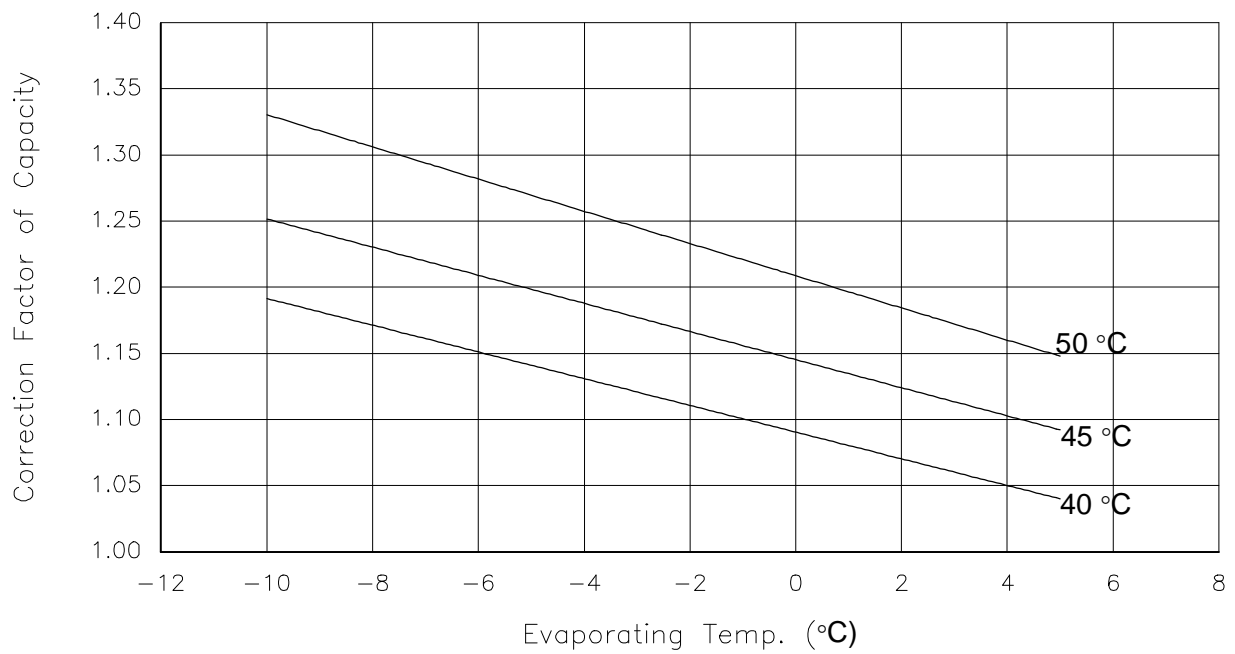
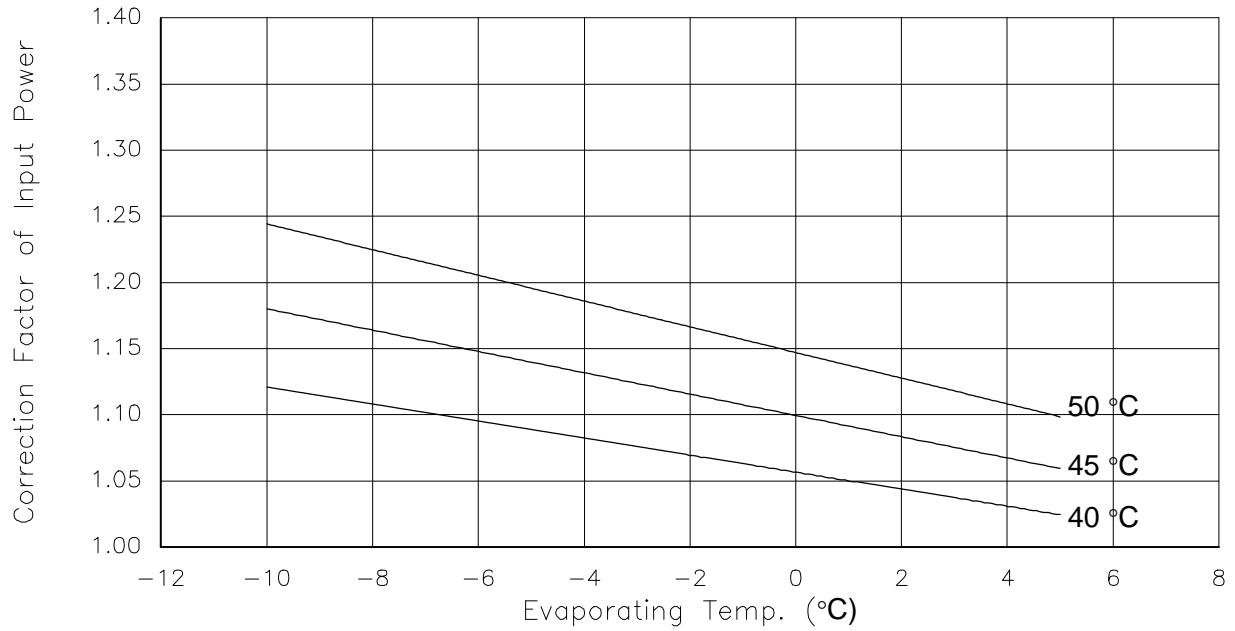


Fig 3.7 System with Economizer (flash type sub-cooler)

3.2.4 Figure of Economizer correction factor

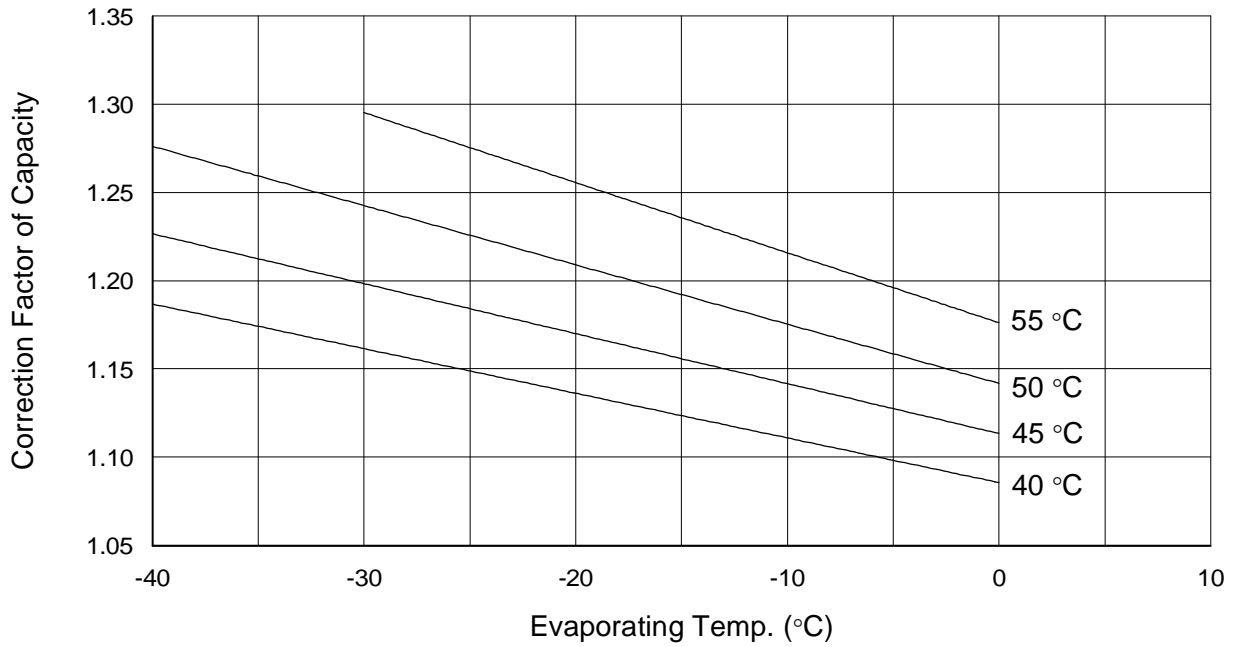
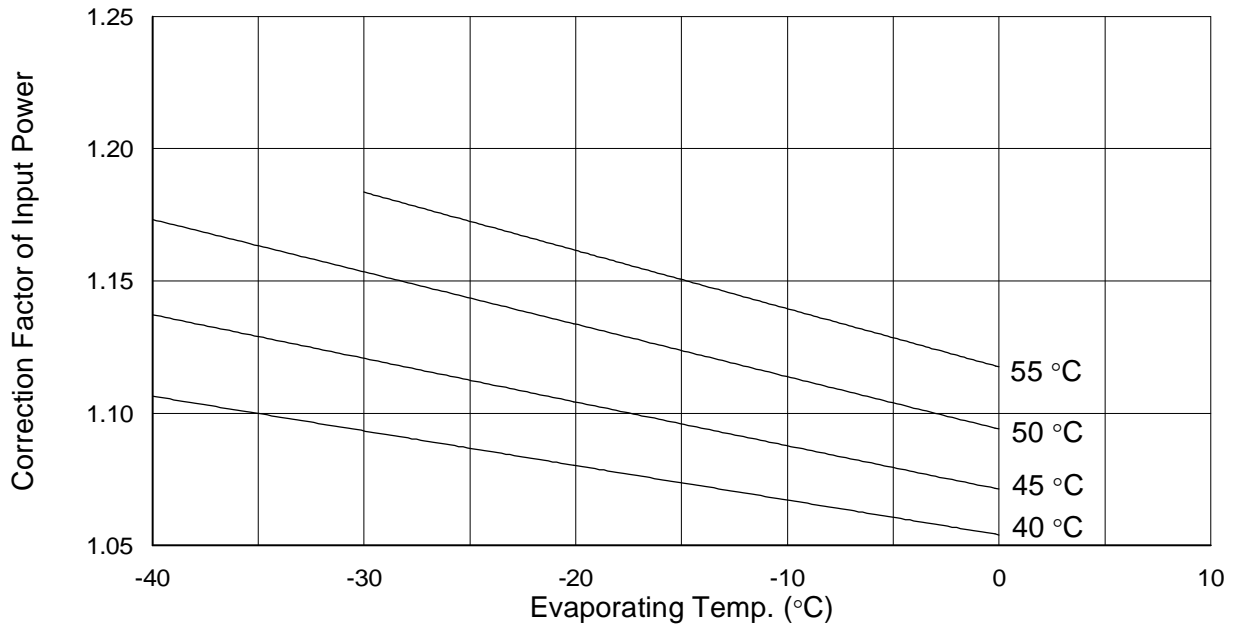
Economizer Performances

Refrigerant R134a



RC Series Economizer Performances

Refrigerant R22



RC Series Economizer Performances

Refrigerant R407C

